University of Strathclyde
Department of Economics

The Overall Economic Impact of Higher Education Institutions (HEIs) on their Host Sub-regions: Multi-sectoral Analysis for the City of Glasgow

by

Kristinn Hermannsson

Presented in fulfilment of the requirements for the degree of Doctor of Philosophy

2012

University of Strathclyde Business School

Declaration of authors rights

Signed:

Date:

Abstract

This dissertation explores the overall economic impact of Higher Education Institutions (HEIs) at a sub-regional level in Scotland. By focussing on the overall economic impacts I seek to consider both demand side impacts (expenditures) and supply side impacts (e.g. human capital, knowledge, wider impacts). The analysis focuses on the City of Glasgow and how it interacts with the wider metropolitan area (the rest of Strathclyde) and the rest of Scotland.

In order to analyse the interregional demand-side impact of HEIs a novel 3-region Input-Output table is constructed, which identifies the role of commuting in driving wage and consumption flows between the regions. Several applications are undertaken: the interregional expenditure impact of HEIs; the interregional expenditure and displacement impact of students' consumption expenditures; the interregional distribution of public funding for HEIs; the impact of HEIs in the West of Scotland matching the performance of HEIs in the rest of Scotland at complementing their public funding with external income; and the interregional "balanced expenditure" impact of HEIs. The “balanced expenditure“ analysis augments traditional impact study methods to explicitly acknowledge the binding budget constraint of public spending. This is particularly relevant for devolved governments, like in Scotland, where income is composed of a block grant from the central government.

A CGE-model of the City of Glasgow is constructed in order to analyse the supply-side impact of a rising share of graduates in the working age population. For this I draw on a range of evidence on wage premia and how this can be interpreted as an indicator of graduate productivity. For Glasgow I estimate that a long run rise in the share of graduates will lead to an increase in labour productivity that triggers a significant long-run boost to Gross Regional Product (GRP). A range of sensitivities are explored.

Acknowledgements

I would like to express sincere gratitude to my supervisors, Professors Kim Swales and Peter McGregor, at the Fraser of Allander Institute and the Department of Economics, at the University of Strathclyde. Writing a dissertation under their supervision has been an enjoyable and rewarding experience and I am extremely grateful for the time and energy they have committed to this project. Their commitment to quality work and scholarly citizenship is an example I can only aspire to. During my course of study, pursuit of eclectic interests has not only been tolerated but encouraged. This has led to various additional works such as analysing the impact of HEIs in Malawi (with support from the Icelandic International Development Agency) and writing reports for the Tripartite Advisory Group on Higher Education (appointed by Universities Scotland, Scottish Funding Council and the Scottish Government) and the Glasgow Economic Commission. These varied experiences have provided me with valuable lessons.

As a PhD student I have been actively embedded within a wider research project taking place at the Fraser of Allander Institute: the Overall Economic Impact of Higher Education Institutions on Regional Economies (grant reference: RES-171-25-0032). The project is one of nine within a larger initiative funded by the Economic and Social Sciences Research Council (ESRC) and the four regional higher education funding councils: Higher Education Funding Council England (HEFCE), Higher Education Funding Council Wales (HEFCW), Department for Employment and Learning Northern-Ireland (DELNI) and the Scottish Funding Council. I am thankful for the financial assistance provided by this project, and also for financial support from the Fraser of Allander Institute, University of Strathclyde. Furthermore, this dissertation has benefitted from work undertaking with funding from the Scottish Government and the Centre for Public Policy for Regions (CPPR). Without these funding sources, the research in this thesis would not have been achievable. For access to data I am grateful to the University of Strathclyde and the Higher Education Statistics Agency (HESA), which provided me with data at discounted student rates.

Various people have provided comments and feedback on different aspects of this work at different stages. I would therefore like to extend my gratitude for helpful comments and advice to participants at the: Scottish Economic Society annual conference in Perth Scotland 2009, Scottish Graduate Program in Economics CGE-workshop in Stirling Scotland 2009, the 7th International Triple Helix Conference in Glasgow Scotland 2009, the annual conference of the Regional Science Association International British and Irish Section in Limerick Ireland 2009, Regional Studies Association annual international conference in Pécz Hungary 2010, European Regional Science Association annual international conference in Jönköping Sweden 2010; the annual conference of the Regional Science Association International British and Irish Section in Glasgow Scotland 2010, Universities and their Regional Impacts – Making a Difference to the Economy and Society in Edinburgh Scotland 2010 and Regional Science Association International British and Irish Section annual conference in Cardiff Wales 2011. This work has also benefitted from the feedback of attendees at various departmental seminar presentations in the Department of Economics and a brown bag seminar at the Fraser of Allander Institute. Furthermore, I am thankful to two anonymous referees and the Editor-in-Chief, Dr Arnoud Lagendijk, at Regional Studies and three anonymous referees and the Editors at Environment and Planning A, for their valuable comments on journal submissions related to the research of this dissertation.

A number of my colleagues in the Fraser of Allander Institute and further afield provided vital assistance in the writing of this dissertation. Professor Robert Wright and Dr Irene Mosca generously shared results from their own work. Furthermore I gratefully acknowledge Robert's advice and encouragement at various stages of this process. Ursula Kelly has generously shared data and been an invaluable intermediary in obtaining data from various sources within the University of Strathclyde. Furthermore, Ursula and Professor Iain McNicoll have generously provided me with results from their earlier work. Patrizio Lecca provided me with the GAMS code for the AMOS model and volunteered his assistance in adapting this model to the case of Glasgow. I am grateful to Katerina Lisenkova for our numerous discussions on the labour market impacts of education and access to her models used for Scotland. Grant Allan furnished me with a range of documents and files on previous work on interregional IO-analyses and the construction of Social Accounting Matrices (SAMs) within the Fraser of Allander Institute. These were invaluable starting points for the work presented here. I have also benefitted from numerous discussions with Dr Michelle Gilmartin both on practical matters regarding the PhD process as well on Computable General Equilibrium (CGE) modelling in general. For everything else there is Isobel Shepherd, our administrator in the Fraser of Allander Institute, who knows how to sort out most things within the University of Strathclyde.

I am grateful to all my colleagues in the Fraser of Allander Institute for the convivial and often jovial working atmosphere they foster. In particular, credit is due to Stewart Dunlop who is indefatigable in facilitating banter across the corridor on the 7th floor of the Sir William Duncan Building. Similarly, Cliff Lockyear's dark wit can be counted on to lighten the mood. Furthermore, Matthew Winning has been a most amiable cohabitant in Room 7.15 for the past three years.

Working in an environment of trust is a great privilege and has the added benefit of aiding productivity. Doing academic work, it is invaluable to be able to reflect freely and not be burdened by petty politics and strategic behaviour towards ones colleagues. I know this work environment cannot be taken for granted and am grateful for the citizenship demonstrated by my colleagues.

Finally, I am hugely grateful to my family, friends and loved ones for their support during my studies and, in particular, for forgiving my period of neglect during the later stages of writing this dissertation.

Table of Contents

1 Introduction

Higher education (as other forms of education) has economic consequences, both for the individuals who experience it as well the society in which they live. Existing evidence suggests that these impacts are important at various levels, ranging from the personal and pecuniary to the social and intangible – everything from personal income and economic growth to the characteristics of the society that we live in.

The application of economic analysis to various aspects of education dates back at least to the work of Adam Smith[1] who recognised the skills of the population[2] as one of the manifestations of an economy's capital stock. The modern literature on the economics of education as a special sub-field spans approximately half a century (De Meulemeester & Diebolt, 2004), stretching back to Schultz (1961) who argued for public intervention to facilitate human capital accumulation and Becker (1964), who presented a model of investment in human capital analogous to investment in physical capital. Since then the field has grown to include a huge literature encompassing broad topics ranging from the role of education in influencing economy-wide outcomes, such as in economic growth and development; labour market outcomes and the functioning of school systems and individual institutions[3].

The idea that education policy of any kind should reflect economic perspectives is contested. For some a consideration of these issues erodes the sanctity of education as an activity that is undertaken for the quest of knowledge for its own virtue rather than pragmatic reasons. For others the state intervention typically used to promote access to education is an ideological aberration. In addition to these fault lines, at the time of writing, the United Kingdom is

---

[1] De Meulemeester and Diebolt (2004) suggest early precedents can be found in the work of William Petty but that Smith was the first clearly to articulate the concept of human capital.
[2] "the acquired and useful abilities of all the inhabitants or members of the society. The acquisition of such talents, by the maintenance of the acquirer during his education, study, or apprenticeship, always costs a real expense, which is a capital fixed and realized, as it were, in his person. Those talents, as they make a part of his fortune, so do they likewise of that of the society to which he belongs" (Smith, 1776, book II, ch.1, para. 17).
[3] See for example Johnes & Johnes (2004) for an overview of different strands of education economics.

experiencing a rise in sceptical attitudes towards higher education[4]. In activist circles a self-sufficiency movement[5] is sceptical of the value of higher education and advocates the development of 'directly' applicable skills such as farming and crafts. These are arguable fringe views, however, among the less radical, anecdotes about graduates who cannot find employment in the cyclical downturn cast doubt on the value of higher education[6]. Employers further seem disillusioned about increasing participation further with the Confederation of British Industry (CBI, 2009) arguing for an abandonment of the Government's target for a 50% participation rate in higher education[7]. Arguably therefore, this is a relevant time to reflect on the existing evidence base for the economic impact of higher education, to reconsider why we invest in higher education and to draw on the evidence in an attempt to improve methods for the appraisal of higher education policy.

This dissertation focuses on the economic impact of HEIs at the sub-regional level and explores issues concerning their potential role in economic development. Although the analysis is based on the case of higher education, in many instances the methods are applicable to other levels of education given that the necessary evidence is available. Conversely, a number of effects associated with HEIs have not been document for other types of education institutions, such as knowledge spillovers. Furthermore, different types of impacts are to some extent linked to different levels of education. For example when considering wider impacts, a well-known link between education and fertility rates that is important in the case of less developed countries (LDCs) is

---

[4] Interestingly this seems to echo the zeigeist of the 1970's, a previous period of scepticism about the ability of education investment to facilitate economic growth and social advancements (see section 1.2 in De Meulemeester and Diebolt 2004).

[5] These groups anticipate drastic changes in production and consumption patterns, following depletion of accessible oil reserves . These concerns are presented by public speakers such as Dr. Chris Martenson who has reached large audiences via his website: http://www.chrismartenson.com/about

[6] On November 1st 2010 the BBC reported graduate unemployment at its highest rate since 1993. (http://www.bbc.co.uk/news/education-11652845). However, as we will see in Chapter 2, studies that compare unemployment rates across skills levels typically find graduates to suffer lower unemployment rates than non-graduates. For example, Houston *et al* (2002) show how education level is positively associated with likelyhood of employment for Scotland, while Barret (2010, figure 8, p. 22) demonstrates how the employment level of less skilled has been worse affect by the recent downturn (falling further as well as from a lower base than high skilled groups).

[7] This was 1 of 24 high-profile recommendatations published in a report by the CBI in September 2009 (CBI, 2009) Their motivation for this recommendation was that priority should be given to funding at the School level. This could well be an efficient tradeoff, however the rationale was not further explained.

primarily associated with the secondary education of women (see: section 2.3). As different types of education have different impacts the ultimate goal would be an optimization of the net benefits provided by the whole of the education mix given a budget constraint. However, this is not yet feasible given limitations of the evidence base and an underdevelopment of methods to synthesize partial effects to arrive at an estimate of overall impacts. This dissertation seeks to contribute by providing a summary of the evidence base, refining available impact methods focussing on the system-wide effects of higher education and applying them to the sub-regional case of the City of Glasgow.

The geographical definition of the sub-region allows a study of various features of HEIs' impacts that are more clearly evident at the local level due to their geographic concentration (such as expenditure impacts and human capital accumulation in HEI-intensive sub-regions) but are more subdued when picked up in national averages. Furthermore, demand- and supply conditions of the economy can be quite different at national, regional and sub-regional levels. For example it has been suggested, based on strong natural rate assumptions, that HEIs have no expenditure impact at the national level[8].

First of all we need to ask the question, do HEIs have a sub-regional economic development role? As the review of the evidence base reveals the answers is in the affirmative. HEIs have a number of positive economic benefits for the national economy, but are even more important for the local economies where they are concentrated.

Secondly, we should ask whether the economic impact is anything more than what Florax (1994) referred to as a 'military base' effect, i.e. the demand stimulus provided by the expenditure of money from the central government? Again, this can be answered *a priori* by referring to existing work. Looking at demand side impacts, HEIs draw on income sources that are additional to

---

[8] See Hermannsson *et al* (2010b) for a discussion of this point.

government funding and strengthen a region's export base[9]. Perhaps more importantly, HEIs also stimulate the supply side of their host (and other) economies through a variety of effects such as accumulations of skills and knowledge (but also wider socioeconomic impacts as we shall discussion in Section 2.3), which appear to be particularly important over longer time horizons.

In order to formulate an informed policy about the role of HEIs in regional (as well as national) policy, these broad answers need to be refined. Therefore I seek to address the following questions:

- **How big are the overall economic impacts of HEIs in Glasgow City relative to the local city economy?**
- **Over what time horizons are these impacts expected to manifest themselves?**
- **What are the uncertainties relating to the realisation of these impacts?**
- **What are the key parameters that affect the level of the impacts and what is the range of potential outcomes?**

I address these questions by applying a suite of multisectoral models, which capture the impacts of Glasgow HEIs at a range of geographic levels from Glasgow City Council to Scotland as a whole.

It should be noted from the outset that in the context of Scotland, HEIs do not constitute the entire higher education system. In addition to the 20 HEIs examined here Scottish Further Education Colleges (FECs) produce graduates with university level qualifications. As I illustrate further in Section 3.2.4. there were 160,870 FTE students at Scottish HEIs in 2005/2006. That same year there were 47,706 (out of a total of 366,289) students studying for higher

---

9 E.g. tuition fees of foreign students and external research grants. For a further discussion of the export intensity of Scottish HEIs see Hermannsson *et al* (2010a,b,c).

education qualifications at FECs[10]. This amounts to approximately quarter of all students in higher education in Scotland. The higher education activities of FECs are not accounted for in the demand-side analysis of HEI impacts. However, they enter in the supply side analysis as the graduate population projections are based on actual observations of the Scottish labour market from the labour force survey. It is not possible to distinguish what share of graduates in Glasgow are derived from FECs and what from HEIs, but it is clear that not all of the impact of human capital accumulation can be attributed to HEIs, credit is due to FECs as well.

In the next chapter I review the existing literature on the overall economic impacts of HEIs. The section starts by exploring demand-side impacts and then proceeds to catalogue the variety of supply-side and spatial impacts, before taking a preliminary look at available methods to synthesize different supply- and demand side impacts.

The third chapter details how the economic database is constructed. This includes several stages. First, the education sector in the official Scottish Input-Output tables is disaggregated to identify a separate sector for HEIs as a whole and then for each of the Scottish HEIs. Location quotients are then used to implement a spatial disaggregation of the augmented table into two regions; Glasgow and the rest of Scotland.

In Chapter 4 I draw on a variety of statistical sources to provide a descriptive analysis of HEIs in Glasgow, their students and graduates, the Glasgow economy and its labour market. The aim of the chapter is to provide a description of Glasgow HEIs and their locality, which forms a backdrop to subsequent analysis.

The Input-Output tables I present in Chapter 3 are used in Chapter 5 to analyse the demand-side impact of Glasgow HEIs under a variety of assumptions,

---

[10] Data obtained from the Infact Database of the Scottish Funding Council: http://www.sfc.ac.uk/statistics/further_education_statistics/infact_database/infact_database.aspx

including "balanced expenditure multipliers" (Hermannsson *et al,* 2010 b, c). The balanced expenditure multiplier is an approached derived from conventional output impact multipliers to estimate the expenditure impacts of partially funded activities while acknowledging the binding budget constraint of public expenditures (as is the case for the devolved UK regions). For the case of HEIs I analyse their balanced expenditure impacts assuming public funding for higher education displaces other public expenditures 1 for 1 within the sub-region as well as assuming a weighted displacement to reflect the difference in relative size of the HEIs sector and the public sector in Glasgow compared to Scotland as a whole. This distinction is particularly important at the sub-regional level. In Hermannsson *et al* (2010b) it was assumed that under a binding budget constraint for Scotland as a whole, each pound saved in HEIs could then be spent on other public activities. At the sub-regional level, a decision by the Scottish Parliament in Holyrood to shift resources from one item of public expenditure to another may not impact each sub-region uniformly. For example Glasgow's HEIs sector is disproportionately large relative to other (at least partially) publicly funded activities. Therefore a shift of public resources to or from HEIs would impact a sub-region like Glasgow more distinctly than Scotland as a whole. A further consideration to the relative size of the HEIs sector vis-á-vis public services is the local HEIs sectors' dependency on public funding. As is revealed by Hermannsson *et al* (2010c) the reliance of individual HEIs in Scotland on Scottish Government funding varies significantly, from 88% for the case of Bell College to 37% for St Andrews. The five Glasgow HEIs vary from 76% for Glasgow Caledonian to 51% for the University of Glasgow (with the Glasgow School of Arts at 71%, the RSAMD at 66%, and Strathclyde at 58%).

Chapter 6 introduces Computable General Equilibrium (CGE) models as a tool that can be used to capture the supply-side impacts of HEIs as well as the demand-side impacts. In order to calibrate the model I construct a Social Accounting Matrix (SAM) for Glasgow, based on the IO-table discussed in Chapter 3. I present CGE-simulations of the impact of accumulating skills over time in the Glasgow labour market. A range of assumptions have to be adopted in order to calibrate the transmission mechanism from a gradual accumulation of human capital (via increases in the share of graduates in the working age population) to improvements in labour productivity, which the model is then used to translate into an overall economic impact. I draw on a broad range of sources from labour and education economics (presented in Chapter 2) to motivate my base-case scenario and input ranges for sensitivity analyses. Furthermore, a range of parametric sensitivity analyses are undertaken, since, as is common in applied policy analysis, especially for local economies, the evidence base on structural parameters is limited.

2 Existing literature on the economic impact of HEIs

The aim of this chapter is to summarise the literatures on the economic impacts of Higher Education Institutions (HEIs) in order to provide a broad understanding and overview of current knowledge. This literature review underpins subsequent chapters and is drawn on to motivate and support their analyses. I attempt to identify the methodological strengths and limitations of different approaches without burdening the presentation with unnecessary detail. In any case, most of the sub-literatures discussed here have been comprehensively reviewed in the past so those sources are referred to for methodological detail. Various survey articles, and even books, capture one or more of the strands of literature concerned with the impacts of HEIs. These include: a wide ranging work by the Centre for Public Policy for Regions' (CPPR) Network on the Overall Impact of HEIs on Regional Economies (CPPR, 2006)[11]; a comprehensive report commissioned by Universities Scotland (McClellan *et al*, 2006), McMahon's (2002, 2009) contributions to our understanding of the wider economic impacts of education; and various chapters in the International Handbook on the Economics of Education (Johnes & Johnes eds., 2004). None of these however suffice on their own to provide a holistic overview of the current understanding of the economic impacts of HEIs.

The structure of the chapter moves from discussing the various partial effects of HEIs upon their host economies to considering recent attempts to draw on these to estimate the overall impact of HEIs. I adopt the taxonomy of dividing the overall impact of HEIs into demand and supply side impacts. From the demand side HEIs are viewed as any other production sector, which impacts on the economy through purchases of inputs and wage payments. Similarly students are treated like tourists, affecting the economy through consumption

[11] The report includes four review articles: I. The overall impact of Higher Education Institutions on Regions: A Critical Review (P McGregor, K Swales and D McLellan) II. University-to-Industry-to Regional Economy Knowledge Transfer: A Literature Review and Gap Analysis (D McLellan, I Turok and R Botham). III. Graduate Labour Market Issues (R. Wright) IV. Determinants of Regional Growth (R Harris)

expenditures. The supply-side analysis examines how HEIs and their graduates directly stimulate the productive capacity (supply-side) of the economy through a range of channels such as increasing skills in the labour market, exchange of knowledge and attraction of high skill activities. Furthermore, in looking at the benefits of higher education I follow McMahon (2009) in classifying these along two axes, private or public and market or non-market.

It is evident that the literatures documenting the economic impacts of HEIs have evolved around the data that are available for researchers to analyse. Some of these fields are very rich and include numerous studies for different geographies and time periods, such as work on the demand side impact and the rates of return to human capital. Other fields are less rich and in some cases there are examples of one-off studies which have not been repeated in other settings such as the spatial econometric work of Andersson *et al* (2004, 2005) documenting the impact of HEI activity upon regional labour productivity.

Finally, it should be noted that this chapter is based on, but elaborates upon, previous work commissioned by the Scottish Further and Higher Education Funding Council (SFC), the Scottish Government and Universities Scotland on behalf of the Tripartite Advisory Group (TAG) on higher education in Scotland, published as Hermannsson & Swales (2010).

2.1 Demand side impacts

The demand side impacts of HEIs (arising from their role as employers and as purchasers of local intermediate goods) refer to the economic impacts (employment, output etc) contingent upon the spending of the institutions, their students and visitors. These studies account for the relevant direct spending and then use a demand-driven economic model (i.e. Keynesian multiplier, Input-Output) to estimate the knock-on impacts of the HEIs' activity. These models identify exogenous final demand, which drives additional endogenous activity through a multiplier process. In this restricted approach, the focus is on HEIs as an exogenous demand stimulus to their local economies.

The remainder of this section describes the methodology of HEI impact studies and summarises their findings, especially with regards to Scotland. Finally I critically examine some of the assumptions underlying these impact studies, the selection of appropriate counterfactuals and the interpretation of their results.

2.1.1 Impact studies and HEIs

Regional impact analyses are frequently employed to capture the total spending effects of institutions, projects or events. In addition to simply identifying the direct spending injection of the studied phenomenon, multiplier, or "knock-on", impacts are estimated by summing up subsequent internal feedbacks within the economy (see Loveridge (2004) for a review)[12].

Most regional demand-driven models (e.g. Export base, Keynesian multiplier, Input-Output) make a crucial distinction between exogenous and endogenous expenditures. Exogenous expenditures in these models are taken to be independent of the level of activity of the relevant economy; endogenous variables are primarily driven by the overall level of income or activity within the economy. Specifically, demand for intermediate inputs and often consumption demand are taken to be endogenous. Other elements of final demand (exports, government expenditure, investment) are taken to be exogenous[13]. There is then a clear causal pathway from exogenous to endogenous expenditure.

In addition, interpreting the results of these demand driven models rests on the assumption that the supply-side of the economy operates in a passive way. At the regional level, conventional multiplier analyses can be validated by either of two sets of conditions. In the short and medium runs this would be where there is general excess capacity and regional unemployment. In the long-run, it is where factor supplies effectively become infinitely elastic, as migration and

---

12 For a more detailed account of the methodology of impact studies and regional multipliers see e.g.: Miller & Blair (2009), Armstrong & Taylor (2000).

13 The distinction between endogenous and exogenous activity depends on the model and the application. In particular, what is exogenous and what is endogenous to the model does not have to correspond with what is 'inside' and what is 'outside' the region in spatial terms.

capital accumulation ultimately eliminate any short-run capacity constraints (McGregor *et al,* 1996)[14].

The derivation of the multipliers draws on the notion of exogenous expenditure driving endogenous activity. In the standard Leontief Input-Output approach total activity within the economy can be described in terms of an equation where the total output of each industry equals final demand, which is exogenous, times multipliers as represented by the Leontief inverse. This can be summarised as:

$$\boldsymbol{q} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{f}$$

where $\boldsymbol{q}$ is a vector of gross outputs, $\boldsymbol{f}$ is a vector of final demands and $\mathbf{(I\text{-}A)^{-1}}$ is the Leontief inverse (where **I** is the identity matrix and A is a matrix of technical coefficients)[15]. The output multiplier for each sector is the change in total output for the economy as a whole resulting from a unit change in the final demand for that sector. It can be found as the sum of columns of the Leontief inverse. This allows a convenient expression for the gross output q_i attributable to the final demands f_i for the output of sector i:

$$\boldsymbol{q_i} = \boldsymbol{m_i f_i}$$

Where m_i is the output multiplier for sector i.

Multipliers can be derived to relate a variety of activity outcomes, such as employment, income, output or GDP, to exogenous changes in demand. Although a number of variants can be applied the Type-I and Type-II demand-driven multipliers are typical for Input-Output based impact studies. Type-I multipliers incorporate the increase in demand for intermediate inputs, and

---

14 The nature of the regional economy naturally governs the realism of such an assumption. One limiting case is the example of the island economy of Jersey where the institutional framework restricts migration so that supply-side crowding out can be expected even in the long run. See Learmonth *et al* (2007).

15 The Leontieff model is further explored in Chapter 5.1.1. For an overview of Input-Output methodology see Miller & Blair (2009).

treat household consumption as exogenous. Type-II multipliers also include induced consumption effects as endogenous For further details see: Hermannsson *et al* (2010a), Miller & Blair (2009, Ch. 6).

Estimating these demand side impact of HEIs raises two main issues in practice; determining the multiplier and identifying to what extent the spending of the HEIs is an additional (exogenous) injection to the economy under consideration. In the Scottish context deriving the multiplier is relatively straightforward given the availability of regularly updated Input-Output tables (although these need significant modifications in order to derive multipliers specifically for the HEIs, as is discussed in section 3.2.2). A trickier task is to determine to what extent the HEIs, and related, expenditures represent an exogenous injection to the regional economy. Here we face challenges both with regards to institutional as well as student spending.

2.1.2 **Mainstream practice in HEI Impact studies**

An extensive literature estimates the impact of HEI spending on the host economy solely through demand side effects. Florax (1992) lists over 40 studies of the regional economic impact of HEI expenditure and much has been published since. McGregor *et al* (2006) summarise the methods and findings of the main UK studies. A number of studies have been conducted for Scottish HEIs, as is shown in Table 1, and the most recent work derives from the Overall Impact of Higher Education Institutions on Regional Economies project at the University of Strathclyde[16] (see Hermannsson *et al* 2010a, b, c, d, e, f, g).

Almost all of these studies have been conducted using models that imply an entirely demand driven economy with a passive supply side. Most studies, especially earlier ones, are based on Keynesian income-expenditure models e.g. Brownrigg (1973), Bleaney *et al* (1992), Armstrong (1993) and Battu, *et al* (1998)

[16] It is one of nine projects conducted under the Impact of Higher Education Institutions on regional economies initiative. The initiative ran for 3 years from 2007- 2010 with support from the Economic and Social Research Council (ESRC) in partnership with the Scottish Funding Council (SFC), Department for Employment and Learning (DEL) in Northern Ireland, the Higher Education Funding Council for England (HEFCE) and the Higher Education Funding Council for Wales (HEFCW).

whilst a smaller number use straightforward or extended Input-Output (IO) modelling and extensions thereof, e.g. Blake & McDowell (1967), Harris (1997), Kelly *et al* (2004) and most recently Hermannsson *et al* (2010a,b). McGregor *et al* (2006) argue that, although less frequently applied, the IO analysis is methodologically superior to Keynesian income-expenditure models. However the latter might be used in circumstances where rough estimates are considered sufficient or IO accounts are not available or cannot be constructed with the resources available.

The fundamental relationships on which demand driven models rest is the interrelation between local businesses and households and their links to the rest of the economy. In this case a university is a source of spending in a region. It buys supplies, either locally (from suppliers who themselves have a certain propensity to import) or imports them directly from external suppliers. Most of the university's staff reside locally and spend a part of their income on local services, which in turn will generate more activity. Furthermore, a university will attract students from outwith the region whose spending is an additional source of demand.

Table 1 Overview of main Scottish HEI impact studies

Subject of study	Multiplier value	Geographic boundary	Source of multiplier value
St. Andrews University (Blake & McDowell, 1967)	1.45 (Household income)	St. Andrews (pop. 10,000)	Input Output table
Stirling University (Brownrigg, 1973)	1.24 - 1.54 (Income)	Parts of Sterling and Perth (pop. 96,000)	Brown et al (1967), Greig (1971)
Strathlcyde, Stirling and St. Andrews Universities (Love & McNicholl, 1988)	1.34, 1.43, 1.36 (student spending)	Scotland	Brownrigg & Greig (1975), McNicholl (1981)
Aberdeen, Dundee and Stirling Universities (Love & McNicoll, 1990)	2.18 (output), 1.75 (GDP), 1.95 (employment)	Scotland	Scottish Input Output Tables (1979)
Aberdeen University (Battu et al, 1998)	1.46 (spending), 1.61 (employment)	North East of Scotland	Greig (1971), Brownrigg (1971), McGuire (1983), Harris et al (1987)
Strathclyde University (Kelly et al, 2004)	1.63 (output), 1.38 (employment)	Scotland	Input Output table
Strathclyde University (McNicholl, 1993)	2.15 (output), 1.66 (Income)	Scotland	Scottish Input Output Tables (1989), Survey
Scottish HEIs (1) (McNicoll et al, 2003)	1.76 (output), 1.7 (employment)	Scotland	Scottish Input Output Tables (Hybrid, 1994-5)
Scottish HEIs (2) (McNicoll et al, 1999)	1.73 (output), 1.42 (employment)	Scotland	Scottish Input Output Tables (SLMI, 1997)
Scottish HEIs (3) (McNicoll et al, 2004)	1.6 (output), 1.4 (employment)	Scotland	Scottish Input Output Tables (2004)
HEI impacts projects (Hermannsson et al, 2010a,b,)	1.3 (output type I), 2.1 (output type II)	Scotland	Scottish Input Output Table (2004)

Table 1 presents a summary of multiplier values found in academic studies of the impact of HEIs and their students in Scotland. These studies differ in the type of multiplier they report, the approach used to derive the multiplier values and the geographical definitions of the studies. Unsurprisingly therefore, the multiplier values generated differ somewhat and are in most cases not directly comparable[17]. A variety of multipliers can be derived to link a particular exogenous change to changes in a number of economic outcome metrics. The Output multipliers relate changes in final demand to the change in gross output. Therefore, an output multiplier of 1.76 implies that a £1 increase in the final demand of the HEIs sector leads to an economy-wide change in output of £1.76. The stated employment multipliers show the economy-wide change in employment caused by a unit increase in direct employment. The household income multiplier used by Blake & McDowell (1967) is slightly unusual, but appropriate for their small borough application, where they relate changes in the total output of the University of St. Andrews to changes in local household income. The income multipliers used by Brownrigg (1973) relate exogenous changes in regional income to the overall change in regional income[18].

The spending of HEIs and their students generates demand for the outputs of different sectors in the economy, which will in turn generate knock on effects in other sectors. There will be an increase in the demand for intermediate inputs plus increased consumption demand as employment and household income rise. These further sources of expansion are known as the indirect (intermediate demand) and induced (consumption demand) effects. Type I multipliers incorporate only indirect effects whilst Type II multipliers encompass both indirect and induced impacts.

The impacts are typically stated in terms of Output, GDP and employment. Output and GDP are two different metrics to gauge the overall activity in the economy. Output constitutes the total value of <u>all</u> goods and services, including intermediate goods, produced within the boundaries of an economy and can be thought of as the 'turnover' in the economy. GDP (expenditure view) is defined as the total value of all <u>final</u> goods and services produced within an economy

[17] Except perhaps in the most recent studies based on the Scottish Input-Output tables.
[18] Where regional income is equivalent to GDP as derived by the expenditure method. For further details on Keynesian multiplier models see Chapter 1 in Armstrong & Taylor (2000).

and thereby counts the 'value added'. The small qualification of 'final' is important in this context as GDP eliminates the double counting where the output of one sector is used as an intermediate input as products and services move between producers in the supply chain. GDP (income view) can also be defined as total factor incomes (wages and other value added) generated in the economy.

The first step in implementing an impact study is to estimate the relevant direct spending of the institution and its students. This is essentially an accounting exercise. Available data are used to determine the amount of direct spending in the local economy that can be attributed to the presence of the HEI in question and to identify the composition of expenditure, in terms of the employment of labour and capital, imports or intermediate inputs from other sectors. Typically with HEIs the largest part of spending is on wages.

The extent of student spending should ideally be based on survey evidence, but sometimes finance office estimates are used as a proxy. Ideally surveys should be used to determine the sectors to which student spending is directed and the extent to which it occurs within the host region. Alternatively, information on general household spending can be used as a proxy. Tuition spending is typically excluded to avoid double counting as this has already been included as part of the institutional spending. The amount and pattern of expenditure by a 'representative' student can be multiplied by the overall number of students at an institution to derive the overall direct spending of the student population. However there is often a valid case for estimating the impact of distinct student groups, such as overseas students, separately.

Local students are generally expected to have a different expenditure impact than incoming students. As incoming students are unambiguously 'additional' to the local economy, their spending can be treated as an exogenous stimulus to demand in the host region. For various reasons it is argued that the spending of local students is different in both nature and magnitude (e.g. because many live with parents). But it is also questioned to what extent, if at all, such expenditure should be counted in an impact study. At one extreme, the counterfactual can be adopted that in the absence of an HEI all local students would have chosen to reside within the local community anyway and to forego higher education, either entering the labour market or becoming unemployed. Under such an assumption their net impact within a demand driven model is limited if not precisely zero[19]. At the other extreme it could be assumed that in the absence of an HEI the local students would have moved away to obtain higher education elsewhere. In this case, the expenditure by local students would have otherwise been removed from the local economy. Therefore if a local HEI acts to retain them, then it can be argued that their spending is additional to the local economy.

Hermannsson *et al* (2010b) propose instead that only the additional (exogenous) expenditure of local students should be included in the impact study. Drawing on student expenditure survey by Warhurst *et al* (2009) they subtract non-additional (endogenous) incomes from student expenditures (further details are presented in the next section). I further explore the role of student expenditures in Chapter 5, where I examine both the positive impacts of students as they provide a stimulus to their local economy, as well as their negative effects through displacement of expenditures.

Some studies have gone beyond student impacts to estimate the spending of visitors (i.e. conference guests) whose arrival can be attributed to the presence of the HEIs (see Kelly *et al*, 2004). Although there can be examples where this is relevant, as previously noted, caution should be applied when attributing impacts of wider activities to HEIs. As I discuss more generally in section 2.1.2.1, making such offline associations between the HEIs direct activities and potentially related consumption expenditures is difficult and often subject to judgement. Kelly *et al* (2004) analyse records from the Residence and Catering services at the University of Strathclyde in order to estimate the number of

[19] In principle, for those students who would be retained within Scotland irrespective of the availability of higher education, one could explore the differences in their impacts as students or as recipients of unemployment benefits (as under IO-assumptions overall employment is unaffected by supply side conditions). However, at the margin, this would provide extra complexity with ambiguous benefits for the accuracy of the results.

visitors associated with the activities of the University of Strathclyde whose consumption expenditures can reasonably be argued to be additional to the host economy. A consistent database of visitor activities is not available for Scottish HEIs and would have to be constructed in order to estimate impacts of this type systematically for the HEIs sector in Scotland as a whole or a subset thereof. Therefore I follow the convention in the literature and estimate the direct impact of the HEIs and the associated exogenous consumption expenditures of their students. In any case other associated impacts are expected to be relatively small. For example Kelly *et al* (2004) estimate the impact of associated conference to represent approximately 3% of the total impacts of the University of Strathclyde upon Scotland.

Armstrong (1993) stresses the importance of estimating the direct expenditures of HEIs accurately as when spending leakages from the region are big these direct first round expenditures come to dominate the demand impact. The geographical scope affects the level of leakages and therefore the magnitude of the multiplier. In cases where the impact is estimated for a narrowly defined geographical area the multiplier values will, *ceteris paribus*, be lower than if the same study was conducted for a larger region. For example the multiplier impacts of the University of Strathclyde will be significantly lower when measured only in terms of Glasgow impacts rather as compared to its impact on Scotland as a whole. Generally the more narrow the definition of the study region, the higher the expenditure leakage and the smaller the multiplier values. Conversely, the bigger the region of study the greater share the final demand of the HEIs and their students that can be met 'locally' and hence the greater the knock on impacts. Similarly, the more diversified and developed the local economy the larger the multiplier is likely to be as more of the inputs can be obtained locally. However, the degree of additionality is greater for a smaller area. For example, increased Scottish Government spending on the University of Edinburgh would be additional spending to the City of Edinburgh, whilst at a Scottish level it would simply be a redistribution of Scottish Government spending, given that total government expenditure in Scotland is exogenously determined by the Barnett Formula[20]

2.1.2.1 Offline association of demand

A note of caution should be sounded about assigning causality between HEI spending and related activities. It is common practice, and a reasonable one (given previously mentioned qualifications about the additionality of student expenditure), to associate student spending to HEI spending. Extending this association however can be problematic. An example would be the expenditure of conference visitors. Their visits to Scotland are in some cases clearly due to academic events organised and initiated by Scottish HEIs. In other cases, however, conferences, possibly using the universities facilities, are not caused by the HEIs themselves. On balance it can be argued that off-model associations of this kind can be legitimate in principle however it is a difficult judgement to what extent associated activity of this sort is truly additional.

Another issue is that since public funding is only part of the HEIs income sometimes causality is assigned from income from recurring public funding to other forms of income for HEIs. This is sometimes done in HEI impact studies published by the institutions themselves, where the multiplier is amplified as each £1 of recurring public funding is assumed to draw in a given amount of matching funds from other sources[21]. There may be an element of truth in this. It is certainly the case for Scotland that the HEIs which receive the largest amount of Scottish Government funding also draw in the largest amount of funding from outwith Scotland. However, apart from such observations, there is not enough evidence to support this kind of linkage to justify its inclusion in economic impact studies of a rigorous academic standard.

2.1.3 HEI impacts at the national (UK) level

Even under the most restrictive assumptions demand side studies show HEIs as producing an unambiguously positive economic stimulus at the regional level.

---

[20] For a discussion of the Barnett formula see for example: Christie & Swales (2010), Ferguson *et al* (2007) and Ferguson *et al* (2003).

[21] See for example: National Assembly for Wales (2009).

HEIs bring in spending to the local economy, if not from incoming students then at least from central government. It has been argued, however, that at a national level (in this case the UK) their long run net demand side impact is precisely zero due to crowding out effects. This conclusion is based on economic models which maintain a fixed natural rate of employment. McGregor *et al* (2006) point out that while this limiting view can be challenged the broad consensus is that supply side restraints are significant for national economies. Whilst national IO tables may provide some useful descriptive analyses of linkages they are inappropriate to derive national impacts. For this an explicit account has to be taken of supply side constraints for example within a Computable General Equilibrium (CGE) framework.

Although it can be concluded that IO-modelling is inappropriate at the national level due to resource constraints (binding supply side), these constraints do not bind (at least not to the same degree) at the regional level. Therefore Input-Output models are a relevant tool for estimating impacts at the regional level given the assumptions of a passive supply-side underlying the Input-Output model. This might be appropriate in the short-run for an economy with unemployment problems or for a regional economy in the long-run where inter-regional migration and additional investment can relax labour market and capacity constraints[22]. This makes IO a relevant approach for analyses at the Scottish level, albeit limited as a CGE-model would be required to capture price, as well as quantity, responses, and how those adjustments evolve over time.

A similar point is sometimes raised that HEIs do not have a net impact at the national level (or at the regional level under devolved spending as in Scotland) as their funding stems from public sources and therefore could as well have been spent on some other public services in absence of the HEI (the expenditure is therefore non-additional). That argument only partially applies to HEIs, due to their diverse income sources. But it does apply to the public sector-supported element of their funding.

[22] For a further discussion of these points see Hermannsson *et al* (2010a).

Even if HEIs are often perceived as part of the public sector it should be noted that they are in fact classified as non-profit institutions serving households (NPISH). As is detailed in Table 2 below, the biggest share of income of Scottish HEIs, approximately 54% comes directly from the Scottish Government. Around 29% comes from export earnings, thereof 13% from the rest of the UK and 16% from overseas. This is in addition to export earnings from the consumption spending of incoming students. The remaining income is from various services rendered, including research, to both public and private parties. Therefore it is clear that in terms of the income structure, HEIs differ from the public sector.

Table 2 Scottish HEIs, Income by origin 2005/2006, £000's (the percentages are calculated as % of row totals). Own calculations based on source data from HESA (2007)

	Scottish Government		External income		Other income		Total	
Aberdeen	85,193	54%	45,487	29%	26,303	17%	156,983	100%
Abertay	22,870	70%	7,363	23%	2,222	7%	32,455	100%
Bell College	17,558	88%	1,564	8%	801	4%	19,924	100%
Dundee	83,218	51%	49,090	30%	31,664	19%	163,971	100%
ECA	10,272	70%	3,566	24%	869	6%	14,707	100%
Edinburgh	186,111	43%	162,550	37%	86,909	20%	435,569	100%
Caledonian	74,046	76%	15,609	16%	7,988	8%	97,644	100%
GSA	11,250	71%	3,580	23%	970	6%	15,799	100%
Glasgow	160,766	51%	84,297	27%	67,309	22%	312,372	100%
Heriot-Watt	46,403	47%	36,204	36%	16,937	17%	99,545	100%
Napier	58,978	72%	13,080	16%	9,293	11%	81,351	100%
Paisley	46,942	80%	6,346	11%	5,193	9%	58,481	100%
QMUC	19,199	70%	5,662	21%	2,709	10%	27,570	100%
Robert Gordon	50,072	67%	11,536	15%	13,475	18%	75,084	100%
RSAMD	6,812	66%	2,009	19%	1,557	15%	10,378	100%
St Andrews	40,200	37%	56,107	52%	12,456	11%	108,762	100%
SAC	22,349	51%	12,546	29%	8,763	20%	43,659	100%
Stirling	46,862	56%	24,194	29%	12,608	15%	83,663	100%
Strathclyde	110,682	58%	44,385	23%	35,987	19%	191,054	100%
UHI	25,017	71%	8,769	25%	1,579	4%	35,365	100%
Total	**1,124,802**	**54%**	**593,942**	**29%**	**345,592**	**17%**	**2,064,336**	**100%**

Furthermore, there is a slight difference between HEIs and other sectors strongly supported by public expenditure (Public Administration, Education, Health) in terms of the structure of expenditures. Both HEIs and public sectors tend to have bigger knock on impacts than most other sectors as a relatively large part of their direct spending is on wages, which reduces leakages. However, this pattern is even stronger within the HEIs sector. Hermannsson *et al* (2010b,c) find that in Scotland HEIs have a higher multiplier value than the public sector's on average due to their lower import propensity. Therefore if public expenditure were to be allocated solely on the basis of possible knock-on impacts, spending on HEIs would generally be more effective than spending on other publicly funded activity.

Table 3 Spending impact of Scottish HEIs and their students, net of Scottish Government funding, 2005/20006 (Type-II impacts with Scottish Government funding (HEIs and student support) returned and spent on other public services).

	Output £ m					GDP £ m					Employment FTE				
	HEI spending	Student impacts			Total	HEI spending	Student impacts			Total	HEI spending	Student impacts			Total
		SCO	RUK	ROW			SCO	RUK	ROW			SCO	RUK	ROW	
Aberdeen	127	17	10	16	169	74	3.8	2.3	3.5	84	1,816	100	59	93	2,069
Abertay	18	6	2	7	33	10	1.3	0.4	1.5	14	265	35	11	39	350
Bell College	4	7	0	0	11	3	1.5	0.0	0.0	4	69	40	1	0	110
Dundee	141	20	12	16	189	82	4.7	2.6	3.7	93	2,068	122	69	98	2,357
ECA	8	2	2	4	16	5	0.4	0.6	0.9	7	125	10	14	23	172
Edinburgh	456	21	46	33	556	249	4.7	10.5	7.5	272	5,755	123	275	196	6,349
Caledonian	42	27	4	9	82	25	6.1	0.9	2.1	34	594	161	24	55	835
GSA	9	2	3	3	16	5	0.4	0.6	0.6	7	133	10	16	15	175
Glasgow	257	31	15	19	322	150	7.0	3.4	4.3	164	3,320	185	90	112	3,707
Heriot-Watt	98	8	8	17	131	55	1.9	1.9	3.8	62	1,263	50	49	99	1,461
Napier	39	14	4	19	77	22	3.3	1.0	4.4	31	525	86	26	116	753
Paisley	20	15	1	6	41	11	3.4	0.2	1.3	16	279	90	4	35	408
QMUC	15	6	4	7	31	9	1.3	0.8	1.6	13	215	34	21	43	313
Robert Gordon	41	15	3	16	75	23	3.5	0.6	3.7	31	569	92	15	98	774
RSAMD	6	1	1	1	9	4	0.2	0.2	0.2	4	91	6	5	5	108
St Andrews	134	5	16	20	175	77	1.2	3.6	4.5	86	1,862	31	96	118	2,107
SAC	37	1	0	0	39	21	0.3	0.1	0.1	21	544	8	2	1	555
Stirling	66	12	6	7	92	38	2.6	1.5	1.6	44	971	69	39	42	1,121
Strathclyde	137	30	4	15	187	78	6.8	0.9	3.4	89	1,845	180	23	91	2,139
UHI	21	8	0	1	30	12	1.8	0.1	0.2	14	263	47	3	6	318
Total impact	**1,677**	**247**	**141**	**215**	**2,279**	**952**	**56**	**32**	**49**	**1,089**	**22,573**	**1,479**	**842**	**1,286**	**26,181**
% of SCO total GDP/employment	**0.94%**	**0.14%**	**0.08%**	**0.12%**	**1.28%**	**1.08%**	**0.06%**	**0.04%**	**0.06%**	**1.23%**	**1.13%**	**0.07%**	**0.04%**	**0.06%**	**1.31%**

Hermannsson *et al* (2010c) examine the expenditure impact of each of Scotland's HEIs and found their spending multipliers to be very similar. However, as shown in Table 2, the institutions differ significantly in terms of the source of their income – with export intensity varying from approximately 8% to 52% – suggesting that their effective impact net of Scottish Government funding may differ significantly from their gross impacts[23]. This aspect of expenditure impacts is explored in more detail in Chapter 5. there I introduce the notion of the "balanced expenditure multiplier", which is an explicit approach to acknowledge in impact studies the opportunity cost of public funds.

Table 4 shows the spending impact of Scottish HEIs and their students for the year 2006, allowing for the non-additionality of Scottish Government funding, both in terms of HEIs income and student consumptions driven by Government student support. The results are based on traditional IO-methodology in that they are the product of the final demand of Scottish HEIs and their Type-II multiplier, which incorporates indirect and induced (household consumption) knock-on effects. However, an important qualification is made in the analyses above in that the impact of the HEIs income from the Scottish Government is not included. The conventional regional multiplier analysis implicitly assumes that the financing of the HEI expenditures in Scotland comes from outwith the country (i.e. the Westminster Government), with no ramifications for other elements of government expenditure. The Scottish Government's income is restricted each year to the block grant it receives from Her Majesty's Treasury as it has limited means of collecting taxes independently. If the Scottish Government were to allocate additional funds to HEIs it would imply less would be allocated to other public expenditures. An impact study therefore cannot legitimately treat the Scottish Government's funding of HEIs as an exogenous stimulus to the regional economy (although that is the typical practice hitherto).

---

[23] This point is explored in detail for the HEI sector as a whole in Hermannsson *et al* (2010b) and for individual institutions in Hermannsson *et al* (2010c)

The impacts of students' consumption spending are reported separately for each student group. For Scottish students the impacts are net of Scottish Government-provided income support. The treatment of students' consumption expenditures is based on Hermannsson *et al* (2010b) where a novel approach is applied to identify the additional (exogenous) spending of the student population. This significantly curtails the impact of local students as so much of their income represents a transfer within the local economy (within household transfers, wage income, Scottish Government funded student support) rather than an addition to it. However, there are some elements of local students' incomes that are additional to the local economy. This includes student loans and new commercial credit that students take out to support their term time spending[24].

Based on this methodology, the net injection of consumption spending per student is estimated to be £1,204 for a Scottish student, £3,554 for an incoming student from the UK and £4,872 for an incoming student from further afield. This methodology implies that the spending impact per Scottish student is lower than for an incoming student. However, as local students are by far the most numerous at Scottish HEIs, in aggregate their impact is greater than for each of the two groups of incoming students. However, in aggregate incoming students contribute more to the Scottish economy in terms of expenditure impacts than do local students.

[24] For details of how students' incomes are determined see the Appendix in Hermannsson *et al* (2010b)

Table 4 Net injection of spending into the local economy per student, disaggregated by student origin. Based on Hermannsson *et al* (2010b).

Location of domicile		Scotland	Rest of the UK	Rest of the World
Gross average student spending £	+	6,230	7187	7187
Income from employment £	-	1,945	1,945	
Within household transfers £	-	453		
Other income £	-	570		
Dissaving £	-	1,073		
Student expenditure supported by Scottish Government funding	-	759		
Spending attributable to new commercial credit £	+	346		
Exogenous average per student spending	=	**1,776**	**5,242**	**7,187**
Direct imports £ (32%)	-	572	1,688	2,315
Net change in final demand per student £	=	**1,204**	**3,554**	**4,872**
Number of students FTE's	x	115,398	22,630	25,737
Estimated net contribution to final demand by student population £ m	=	**138.9**	**80.4**	**125.4**

Under these "balanced expenditure" assumptions, the spending of HEIs supports approximately 22,573 FTE jobs in Scotland or about 1.31% of total employment. Additionally, the consumption impact of students supports approximately 3,600 FTE jobs or about 0.2% of Scottish employment. Based on this the Scottish HEIs can be seen to support approximately 1.3% of regional economic activity, net of their activities funded from the Scottish Government.

2.1.4 **Main findings**

The spending impacts of HEIs have been widely studied, both in Scotland and elsewhere. I have reviewed the standard practice for estimating the impact of HEIs spending and the associated consumption spending of their students. Although estimating these impacts is a relatively straightforward exercise in principle, care must be taken to adapt credible assumptions and appropriate modelling approaches for the task at hand. In particular, I have emphasised how the geographical scope of studies affects the appropriateness of assumptions and approaches. At the local level it is easier to argue for additionality of spending than at a regional level, especially in the case of Scotland where public funding for HEIs is decided at a devolved level. At a national level (and to a generally lesser, but varying, extent at regional levels[25])

[25] Although supply-side rigidities are generally less binding the smaller the geographical unit under analysis, they do affect outcomes at the regional and sub-regional levels and can in some cases be very

there is the additional challenge of appropriate modelling approaches, since purely demand driven models cannot capture potential crowding out due to supply side rigidities.

HEIs constitute a significant sector in the Scottish economy, in terms of their direct spending impacts and subsequent knock-on impacts. However, when assessing the magnitude of that impact care must be taken in determining the additionality of various associated activities, as well as the additionality of their spending depending on the origin of their income. The Scottish Government's block grant imposes a binding budget constraint on government spending in Scotland and therefore changes in Scottish Government funding for Scottish HEIs implies redistribution within that budget constraint rather than an exogenous spending stimulus.

Acknowledging the budget constraint, Scottish HEIs still have a significant impact at the Scottish level as they draw in their income from a variety of sources. Therefore I conclude that at minimum (given the assumption of a passive supply-side) the spending of HEIs and their students supports about 1.3% of economic activity in Scotland.

This is of course, apart from potentially large supply-side benefits, accruing from increased skills in the labour force, knowledge exchange and other possible effects, which I now turn to consider.

2.2 Labour Market Impacts

This and following sections discuss the supply side impacts that occur as a result of the activities of HEIs. The term supply-side impact refers to effects that enhance the capacity of the economy to provide products and services, through augmenting technology and the factors of production[26]. The primary

---

dominant, such as in the case of peripheral or island economies. For example, in the case of Jersey, the institutional framework restricts migration so that the supply side could not legitimately be regarded as passive over any time interval. See Learmonth *et al* (2007).

[26] As discussed in 3.2.2 education not only affects production but also leisure. However, those effects will not be captured directly in output metrics (such as discussed in 5.1 and 5.3) but are registered only

focus is on the beneficial supply side impacts of education through augmenting the skills of the labour force (with an emphasis on higher education). As we will see in subsequent discussions skills in this context is a wide term, where education is not only seen as a source of practical skills but as a venue for socialisation and training of meta-skills. Other aspects of HEIs supply side benefits such as technological spillovers, innovation and spatial effects are discussed in Section 2.4 as most of the studies that can provide estimates of these are based on datasets at the local/regional level.

The focus of this section is a review of the numerous studies examining education wage premia and the monetary returns to education. I start by analysing the basic approach and examine how estimates of the graduate wage premia have evolved over time. In Section 2.2.1 I present a review of recent Scottish work. In subsequent sections I analyse how returns can vary over time (2.2.2), with the quality (2.2.3) and subject (2.2.4) of education and what recent trends can be observed in the returns to education. In section 2.2.5 I examine the long standing debates on the challenges involved in estimating the returns to education and how the results should be interpreted. I examine the topic of 'overeducation' in 2.2.6 before a brief overview of the expansive literature on labour market sorting, which I provide in 2.2.7.

An extensive micro literature documents the rates of return to education at various levels of schooling, in different countries at different times. Sometimes the results are further disaggregated by characteristics such as gender, discipline and social background. These studies reveal a clear correlation between education and income and provide rich information about the nature of this relationship. Due to an obvious inability to conduct controlled experiments in the field, verifying the causality between education and income has proven difficult. More recently a wealth of papers has been published utilising more

in as far as they contribute indirectly to production capacity. However, in principle, such effects can be valued in cost-benefit analyses (see 5.2).

advanced approaches, i.e. instrument variables, controlling for fixed effects (using samples of twins) and natural experiments, to clarify the issue.

As we will see the weight of empirical evidence leans towards education affecting income *per se* but not just being a proxy for unobserved ability. A closely related question, but motivated by theoretical work, is to what extent the income benefits of education reflect underlying productivity improvements. Human capital theory would suggest education enhances human capital which in turn improves productivity. However an alternative explanation is derived from theories on sorting in the labour market, either based on signalling or screening, which suggest increased income is driven by the labour market signal provided by holding a degree and does not necessarily reflect real productivity gains through enhanced human capital. In this genre of models it is assumed that employers have limited ability to estimate *a priori* (at least in the short run) the potential of their job candidates. Instead they rely on education credentials as a signal of these abilities they cannot measure directly. The 'value' of the signal, that is the wage premia gained by acquiring it, is then determined by the average job performance of those already employed with the same credentials.

As pointed out, even by advocates of signalling theory, there is a tendency to over interpret the implication of the theory by suggesting that under signalling education plays no role in raising an individual's productivity. "Such views are stereotypical and even the most vociferous proponents of sorting would concede the productivity-augmenting power of education", (Brown & Sessions, 2004, pp. 58). Recently, therefore, empirical efforts have been directed towards estimating the extent to which signalling determines income – suggesting a role for signalling, especially under shorter time horizons, but of a limited magnitude.

A further limitation of the graduate wage premia approach is that it captures only the private market (monetary) returns. This leaves out public (external) market impacts and private and public non-market (non-monetary) impacts, which have subsequent implications for the economy, environment, quality of life and development – although they are harder to quantify. For example, McMahon (2004) develops a taxonomy of 18 distinctive external impacts of education, which will be discussed in the section on wider impacts of HEIs.

In the remainder of this sub-section I review how the return to education is estimated and what insights are gained from examining the correlation between income and education. Furthermore I examine the long standing debate on the causal link between education and income and to what extent income can be expected to reflect true productivity.

Numerous reviews of the microeconomic literature on returns to education have been published. Recent examples include Checchi (2006), Blundell *et al* (2005), Psacharopoulos & Patrinos (2004, 2002), Harmon & Walker (2003) and Krueger & Lindahl (2001). From the outset the unconventional terminology of this literature should be noted: private returns are defined as the wage premia attributable to additional education over the private opportunity cost of that education; social returns constitute the direct private benefits as a return on both public and private costs, thereby ignoring any public benefits. By these measures social returns are always lower then private return. Psacharopoulos & Patrinos (2004) point out the historical reason for exclusion of social benefits as the lack of available data to quantify these. To clarify they suggest referring to social returns (as defined in the returns to education literature) as narrow social returns but as broad social returns when public benefits are included in the calculation.

Estimating the rate of return to education draws on the same principles as used for calculating the rate of return to any investment: a rate of discount (r) is found that equalises the present value of outlays to the present value of incomes. In all these cases the rate of return to education is the value of r for which:

Private returns: $$\sum_{t=1}^{42}\frac{(W_u - W_s)_t}{(1+r)^t} = \sum_{t=1}^{5}(W_s + C_{ud})_t(1+r)^t$$

Narrow social returns: $$\sum_{t=1}^{42}\frac{(W_u - W_s)_t}{(1+r)^t} = \sum_{t=1}^{5}(W_s + C_{ud} + C_{up})_t(1+r)^t$$

Broad social returns: $$\sum_{t=1}^{42}\frac{(W_u - W_s)_t + (E_u - E_s)_t}{(1+r)^t} = \sum_{t=1}^{5}(W_s + C_{ud} + C_{up})_t(1+r)^t$$

where W_u and W_s are the earnings of university and secondary school graduates and 42 the duration of working life after graduation, 5 is the length of the university cycle C_{ud} is the direct cost of attending university and C_{up} is the public cost of providing university education and E_u and E_s are the average external benefits of a university and secondary school graduate.

This discounting approach (often referred to as the elaborate method) requires detailed information about age-earnings profiles by education level, which is often not available (Psacharopoulos, 1981). In practice therefore, many researchers have resorted to a statistical approach, the fitting of Mincer earnings functions (Mincer, 1974). This is the dominant approach for UK studies, typically drawing on repeated cross-section data available in the Family Expenditure Survey, the General Household Survey and the Labour Force Survey (Blundell *et al*, 2005). An earnings function is estimated, whereby the logarithm of wages ($\ln W_i$) is explained by years of schooling (S_i), years of labour market experience (EX_i) and its square (EX_i^2):

$$\ln W_i = \alpha + \beta S_i + \gamma_i EX_i + \gamma_2 EX^2 + \varepsilon_i$$

This is referred to as a basic Mincerian earning function and it is often augmented with a variable for the amount of work supplied (Psacharopoulos, 2004). The coefficient on years of "schooling" can be interpreted as the average private rate of return to one additional year of schooling. As $\beta=(\delta \ln W/\delta S)$ it represents the average proportional increase in wages following one extra year of schooling. In the basic format the function does not distinguish between levels of schooling. To capture the effect of each education stage independently it can be extended with dummy variables for each education stage (Psacharopoulos, 2004).

Typically these micro studies find higher returns to education in lower income countries where education levels are generally lower. This is seen as consistent with the notion of diminishing returns to education, with the return to education falling as the average education levels rise. However as we note in section 2.2.2 the dynamism of these diminishing returns is more complex than a simple analysis of increasing supply within a comparative static framework might suggest. Perhaps most importantly rates of return to higher education in the UK have remained broadly stable for the last 15 years despite large increase in participation rates (Walker & Zhu, 2008) and have been increasing in the US over the last thirty years (McMahon, 2009).

2.2.1 Returns to education in Scotland

Recent comprehensive studies document the return to different levels of education in Scotland. For the United Kingdom as a whole there is further evidence on the returns to higher education by subject and on the robustness of returns estimates, based on examination of identical twin pairs. This sub-section is devoted to summarising the relatively rich evidence base on returns to education in Scotland and the UK.

Houston *et al* (2002) draw on a sample of 15,283 working age individuals in Scotland, from the 1999 and 2000 labour force surveys, to estimate the likelihood of employment and wages by education level. Firstly they use a multinomial logit model to estimate how qualifications impact the likelihood of being in employment. They found that higher education (HE) graduates have a higher probability of being in work than those holding further education (FE) qualifications. For FE diploma holders the evidence was ambiguous with men being less likely to be employed than their counterparts possessing Highers[27] only, whereas women were more likely to be employed. Completion of Highers however significantly increases the likelihood of employment. By fitting an earnings function to their data Houston *et al* (2002) estimate the wage premium of HE graduates over those with no qualifications at 51.33%, while the wage premium for Further Education and Highers was estimated at 17.68% and 15.25% respectively.

Table 5 Wage premia from Highest Qualification Models source: Houston *et al* (2002, p. 32).

	All	Next lower level	Males	Next lower level	Females	Next lower level
He Level	51.33%	33.65%	57.93%	41.76%	47.98%	29.78%
FE Level	17.68%	2.43%	16.17%	1.26%	18.20%	3.83%
Highers	15.25%	15.25%	14.91%	14.91%	14.37%	14.37%

Gasteen & Houston (2003) used an identical sample from the Labour Force Survey, as Houston *et al* (2002), to examine whether there was a wage differential among HE and FE graduates depending on their education route. Based on five levels of qualifications[28] they derived 32 ways in which an individual could combine these in education pathways. They reported that due to the high degree of variability within each pathway statistically significant results could not be obtained, suggesting that returns are driven by the individuals' own characteristics rather than different routes. However they conclude that: "While none of the pathways proved to be statistically different from the others, non-standard education routes to both HNC/Ds and degrees (i.e. those that lacked lower level, formal school qualifications) were generally found to appear towards the lower end of the wage premia distributions.

[27] The Higher grade is the traditional school-level qualification obtained by Scottish students wishing to enter higher education. In Scotland this is referred to as a "Higher" or "Highers", the plural form being adopted as usually a student completes a Higher grade in a number of subjects to prepare for university entry.
[28] 'O' Standard Grades, Highers, Other FE qualifications, HNC/HND FE qualifications and HE degree.

'Second chance' educational routes may therefore not yield equivalent returns to orthodox HNC/D or degree routes" (Gasteen & Houston, 2003, pp. 8).

Bell & Sarajevs (2004) use both the National Child Development Survey (NCDS) and the Labour Force Survey (LFS) to compare returns to education in Scotland and the rest of Great Britain (RGB). The NCDS is a longitudinal survey of a sample of Britons born in March 1958, which has been updated regularly and includes rich information about individual characteristics, which allows application of detailed controls. The LFS on the other hand contains less detail and is not longitudinal, but allows inference to be built on larger samples. Where comparable analyses could be performed on both datasets they produced broadly similar findings. The authors present 3 main findings from their results: Firstly, conditional on applied controls, the weekly wage of full time employees was not found to differ between those educated in Scotland and the Rest of Great Britain (RGB); those educated in Scotland who had obtained no formal qualifications were found to be worse off than their RGB counterparts and the marginal return to education was found to be lower in Scotland than the RGB. Furthermore they find that controls for both cognitive (e.g. literacy, numeracy) and non-cognitive skills (soft skill metrics) significantly impact labour market performance. The authors highlight this finding and argue, with reference to Heckman (2000) that since non-cognitive skills are more malleable than cognitive skills "policy interventions to influence these may yield a higher net social return than investment in formal education" (Bell & Sarajevs, 2004, p. 4)[29]. However they treat non-cognitive skills as exogenous to schooling, which is a rather extreme assumption. If non-cognitive skills are partially developed through socialisation in institutions of formal education using controls for non-cognitive skills can therefore pick up some of the benefits from schooling.

Walker & Zhu (2007a) pool ten years of data from the Labour Force Surveys in 1996-2005 to construct a large enough sample to estimate wage premia by qualification level at a regional level within Great Britain. Their broad findings

---

[29] See also discussion in Bell & Sarajevs (2004, p. 9, column 1)

are in line with other work in the field; qualifications increase the likelihood of employment and more qualified workers generally earn higher wages. For both men and women they find the value of qualifications broadly similar to that experienced across Great Britain.

Table 6 Hourly wage premium of vocational and academic qualifications in Scotland. Source: Walker & Zhu (2007b).

Vocational wage premium	Male	Male [cumulative]	Female	Female [Cumulative]
None	Base	Base	Base	Base
Level 1	9%	9%	11%	11%
Level 2	7%	16%	9%	20%
Level 3	19%	35%	9%	29%
Level 4	17%	52%	23%	52%
Above level 4	30%	82%	29%	81%

Academic wage premium	Male	Male [cumulative]	Female	Female [Cumulative]
None	Base	Base	Base	Base
Level 1	17%	17%	18%	18%
Level 2	12%	29%	12%	30%
Level 3	19%	48%	13%	43%
Level 4	31%	79%	34%	77%
Above level 4	12%	91%	13%	90%

Table 7 Examples of SVQ/NVQ Levels. Source: Walker & Zhu (2007b).

SVQ/NVQ level	Academic qualification	Vocations qualification
5	PhD, Masters degree	PGCE, Non-masters postgraduate quals
4	Undergraduate degree	HNC/HND
3	2+ A-levels/3+Highers	OND, ONC
2	5+ GCSEs at A-C, 'O' Grades, Credit Standard Grade	GSVQ/NVQ intermediate, RSA diploma
1	<5 GCSE, General Standard Grade	BTEC, SCOTVEC first or general cert

For vocational qualifications they use standard classification from 'Level 1' (lowest) to 'Above level 4' (highest) as found in the Scottish Vocational

Qualifications and National Vocational Qualifications (SVQ/NVQ). Although an official equivalent ranking does not exist for academic qualifications labour market researchers have established conventions as to equivalent ranking of academic qualifications.

As is evident from the tables below, Walker & Zhu (2007a, 2007b) find strong wage premia effects for both vocational and academic qualifications in the Scottish labour market. Overall the academic qualifications yield a higher wage premia but what is also noteworthy is how the structure of the wage premium by levels of qualification differs between vocational and academic qualifications. The marginal effect of low level vocational qualifications is modest vis-á-vis low level academic qualifications, whereas the additional wage premia gained by postgraduate study is modest. From a human capital perspective these findings may not be surprising if the amount of schooling behind these education levels is examined. For example a Level 4 undergraduate degree typically takes four academic years to complete, whereas a common duration for masters degrees in Scotland is 12 months[30] so the wage premia earned per effective duration of study (and therefore also the return to education) is broadly similar between Level 4 and Level 5.

In addition, Walker & Zhu (2007a, b) undertook further analysis to verify their findings. To test the possibility that the wage premia does not reflect education but simply unobserved attributes of the workers they draw on a natural experiment, the raising of the national school leaving age in the 1970's. Since these institutional changes added a year of schooling, which the individuals did not choose themselves, it can be used to estimate the causal effect of education upon earnings without picking up effects of individual characteristics[31]. Applying both an instrument variable model and a Heckmann two-step selection model, they conclude that estimates broadly confirm their OLS results for Scotland as well as England and Wales.

---

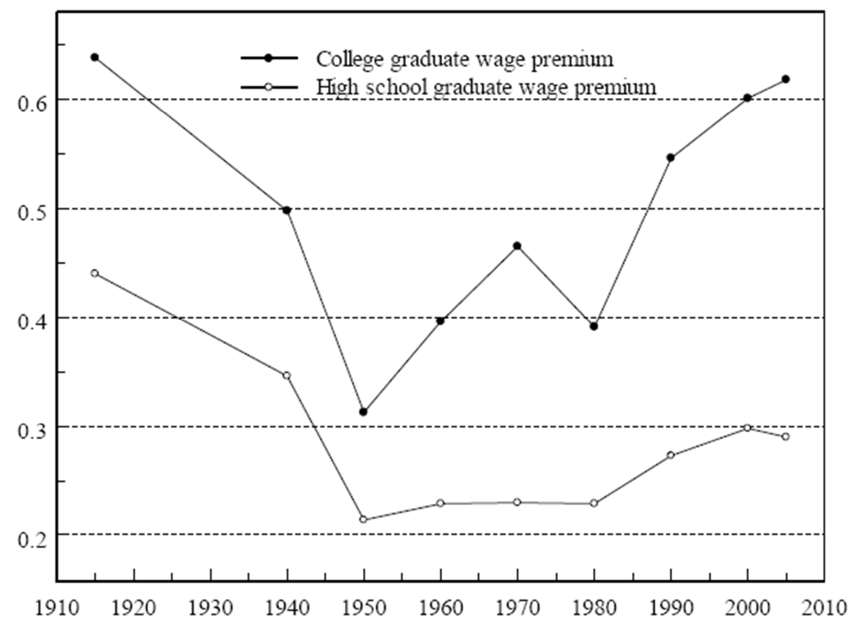
[30] Presumably respondendts with masters degrees dominate the sample as the PhD graduates are far less common.

[31] For details of methodology see Walker & Zhu, 2007a, pp 46-48.

2.2.2 **Skill biased technical change and the return to education over time**

In cross sectional comparisons institutional features of the labour market affect the wage premium. Over time, however, it is not only the relative supply of graduates that determines the wage premium but also demand. Demand for skilled labour has been gradually increasing – a fact typically attributed to technical change[32]. Goldin & Katz (2007) use estimates of supply and demand for graduate labour to investigate the level of the graduate wage premium in the US over the 90 year period from 1915 to 2005[33]. They find that the graduate wage premium (vis-á-vis high school dropouts) was at a very similar value, around 65% at the beginning of the period as the end, albeit with significant intermittent fluctuations. Two troughs can be identified, around 1950 when it fell close to 30% and again in 1980 when it fell slightly below 40%.

Figure 1 US College and High School graduate wage premiums 1915 to 2005. Source: Goldin & Katz (2007, Figure 1, p. 32).



[32] For a review see: Machin (2004) and Acemoglu (2002).
[33] For some metrics they examine an even longer period from 1890 to 2005.

Acemoglu (2002) reviews evidence and theoretical perspectives on the links between technical change and skills premia in the labour market. He draws on economic history to argue that technological change can be skill biased (increasing the need for skilled labour) but can also be skill replacing (decreasing the need for skills). Whereas evidence from the United States in the 20th century suggests that technological change has been skill biased, counterexamples are found in 19th century Britain where industrialization made highly skilled artisans redundant as they were substituted by low skill factory workers. He argues that this dual nature of technological change can be understood if it is recognised that the development and use of technology responds to profit incentives. In circumstances where it is profitable to develop and implement technologies which complement low skill workers technological change will tend to be skill replacing, however when technological advances requiring high skill operators are more profitable technological change will tend to be skill biased.

> I suggest that the early nineteenth century was characterized by skill-replacing developments because the increased supply of unskilled workers in the English cities (resulting from migration from rural areas and from Ireland) made the introduction of these technologies profitable. In contrast, the twentieth century has been characterized by skill-biased technical change because the rapid increase in the supply of skilled workers has induced the development of skill-complementary technologies (Acemoglu, 2002, pp. 9).

Furthermore, Acemoglu (2002) argues that the acceleration of skill biased technical change is likely to have been a response to the increased supply of skilled workers, which made skill-intensive production methods more competitive. However, that point does not have to imply that the overall rate of technical change has increased, but rather that the types of technologies being developed has shifted.

In addition to technical change, the graduate wage premium has been affected by other factors such as changes in labour market structure, i.e. union power, changes in firm organisation and increasing trade between high skill and low skill countries. McMahon (2009) points out that the rise in the graduate wage premium in the US since 1980 can partially be explained by negative real term growth in the wages of unskilled labour. He attributes this fact to a relative abundance of unskilled labour, in part due to an effective increase in the supply of unskilled labour through increased integration of developing countries in the World economy. Furthermore, he suggests that automation has replaced many low-skill jobs and therefore reduced the demand for uneducated workers. Acemoglu (2002) suggests that all of these factors have amplified the effect of technical change upon the graduate wage premia and are likely causes for the real wage decline of low skill workers observed in the US.

2.2.2.1 Recent trends in returns to education

Despite academic focus on the long run the persistence of the graduate wage premia and skill-biased technical change a question of some urgency is whether the recent increases in higher education attainment have led to a fall in the wage premium earned by graduates. In a UK or Scottish context studies addressing this issue are based on the labour force survey. Developments over time are based on different samples so that unless trends are quite distinct they are difficult to confirm statistically. Walker & Zhu (2008) point out that at a UK level, although the average return to higher education has remained stable the distribution has widened with increased participation, where higher ability people are earning further beyond the average and lower ability people are falling farther behind the average. They argue that this might be the joint effect of increasing demand for skilled workers and growing heterogeneity in the HEIs' student intake. They argue that strong candidates (high unobserved abilities) are earning a greater wage premium than people of similar abilities in previous generations. However, the number of graduates with relatively lesser abilities has increased and these individuals are earning a below average wage premia.

Some work in progress argues for falling wage premia. See for example McGuinness & Bennet (2005). However, these are subtle effects, which might be coincidental. Consistency over a longer term is needed to ascertain that there is in fact a trend of falling graduate wage premia.

2.2.2.2 Is Scotland reaching further and further into the ability barrel?

A common perception is that the democratisation of higher education has gone so far that a greater share of the population is now graduating from higher education than may be economically sensible. This has primarily two manifestations. That there is an oversupply of graduates leading to a scramble for the few graduate jobs available with subsequent unemployment and fall in wages. Secondly, that the increases in HE attainment has driven HEIs to accept candidates ever less capable of participating in higher education. In this subsection I will examine this popular perception in light of the evidence for labour market outcomes in Scotland, presented in the previous section.

What has been repeatedly confirmed in Scottish and UK studies is that, despite the increase in higher education attainment, the graduate wage premium has not changed significantly. Furthermore, anecdotal evidence on graduate unemployment (which typically follows cyclical downturns) is not backed up by the data as Scottish studies reveal that the likelihood of employment steadily rises with level of education attained. Even if there may be a portion of the graduate population that is employed in professions traditionally not regarded as graduate they are awarded for their education with a significant wage premia – albeit not of the same magnitude as traditional professional employment. Therefore the notion that graduate labour is in oversupply is not backed up by evidence. However, as we will see, evidence suggests the graduate labour market has been changing.

On the question of student and graduate quality, a university professor who does not wish for a more eager and hard-working student body is hard to find. In the labour market, graduates are on average as successful as they have ever been. However as the work of Walker & Zhu (2008) suggests, it may well be that the dispersion of graduate quality has increased. Based on the empirical evidence they hypothesise three developments have occurred simultaneously.

Graduate supply has increased, and at least partially, that increase has been met by an intake of less able students, while at the same time demand for graduate labour has increased. This manifests itself in a stable average wage premium but a wider dispersion. High quality graduates are now earning more than their counterparts of a previous generation. The average graduate is now of a slightly lesser quality than before, but due to increased demand maintains the same wage premium and the tail end of the distribution earns a positive wage premium but less than the average. In short, even if it may be the case that a proportion of HE graduates are of lesser quality than in previous generations it does not seem to be a serious problem in terms of labour market outcomes. Graduates still earn a substantial wage premium and are better off than they would have been with less education.

Whether education attainment should be increased and at what education levels is a complex matter, which is not the primary purpose of this dissertation to address. However, reviewing the existing evidence for Scotland and the worldwide literature provides some qualitative points. Perhaps most importantly, Scottish evidence suggests increasing attainment offers benefits at all levels[34]. Theory suggests marginal students can be either 'better' or 'worse' depending on whether ability bias or cost bias dominates. However, based on observations where policy interventions have increased the uptake of education by students from disadvantaged background, return to education has been found to be higher for students for those groups. For a discussion of this point see Krueger & Lindahl (2001, pp. 1106-1107).

Recently it has been argued that education policy needs to consider what might be seen as a Human Capital Supply Chain view. Heckman & Carneiro (2005) draw on pedagogic science and present an argument along two dimensions. Firstly that education and job market performance do not only depend on cognitive skills but also wide ranging non-cognitive skills (these constitute a

[34] Apart from individual benefits, it might be the case that social benefits are best served by increasing completion rates at the bottom end of the qualification scale.

wide range, from personality traits like conscientiousness to soft skills like social skills). Secondly (drawing on longitudinal data) they argue that ability begets ability over time. This is based on American observations where children who were found to be equally 'smart' based on test scores at early age diverged over time – with those from lesser social circumstances typically falling behind. As a policy conclusion they argue in order to increase university attainment earlier education levels need to be strengthened. This would result in more high ability individuals that would pursue higher education. Furthermore, they argue policy interventions should not necessarily be focussed on education institutions but may need to enter the realm of social and family policies to be effective.

The policy conclusion reached by Heckman & Carneiro (2005) is that in order to increase HE attainment, policies should not focus so much on enabling secondary school graduates to enrol in HEIs (as is arguably a mainstream view) but to address the conditions of lesser performers at early stages of schooling. In their view, as ability begets ability, intervening at pre-school and early primary levels could feed up the human capital supply chain with subsequent increases in higher education attainment as more high ability students come out of the school system. Furthermore, it could be added, the one should, if anything, expect the average quality of the HEIs potential intake to grow over time through intergenerational transmission of human capital, i.e. the next generation's parents will be more educated than the current generation's and so on. See for example Holmlund *et al* (2011), Oreopoulos & Page (2006).

In short based on labour market outcomes it cannot be concluded that higher education participation rates in Scotland are too high. Available observations of the graduate wage premium reveal it as being high and stable over time. Diminishing returns to education cannot be assumed by default, especially over longer time horizons, as the demand for skilled labour changes as well.

2.2.3 **Returns to education and quality**

The bulk of the literature examining education quality and graduate outcomes is US- based and has focused on links between measures of school quality and either test scores or labour market outcomes. A later development is a proliferation of studies examining the link between higher education quality and labour market outcomes – results of which will be summarised below. However the influential/mainstream US school quality literature inevitably forms a backdrop for any other application, to different geographies and different levels of the education. Therefore I shall very briefly summarise the broad results of that debate. If only to prevent confusion of these two closely related literatures.

A mainstream interpretation of much of the earlier literature was that a higher level of school resources, such as class sizes had little or very limited influence on academic achievement as measured by test scores. Card & Krueger (1996) refer to the conclusions of Hanushek (1986) as an example of an influential survey maintaining this.

> The results are startlingly consistent in finding no strong evidence that teacher-student ratios, teacher education, or teacher experience have an expected positive effect on student achievement. According to the available evidence, one cannot be confident that hiring more educated teachers or having smaller classes will improve student performance. Teacher experience appears only marginally stronger in this relationship (Hanushek, 1986, pp. 1162).

This view has come under scrutiny on methodological grounds, where it is argued that negative results have been over weighted. Hedges, Laine & Greenwald (1994) conduct a meta-analysis of the studies surveyed by Hanushek (1986) and find that "Re-analysis with more powerful analytic methods suggests strong support for at least some positive effects of resource inputs and little support for the existence of negative effects", (Hedges *et al*, 1994, p.15). Furthermore, studies that focus on the links between school resources and educational attainment and future earnings provide stronger results. However Card & Krueger (1996) conclude that it would be an over statement to say that the literature proved beyond a doubt that resources matter as the "available evidence is not unambiguous or ubiquitous, and it suffers from all the standard criticisms of drawing causal inferences from observational data" (Card & Krueger, 1996, p. 47).

A growing literature, hitherto primarily based on US data, examines the link between earnings and various proxies for university quality (e.g. Dale & Krueger 2002, Black & Smith 2004). As Hussein *et al* (2009) point out generally these studies find a positive effect of quality proxies on subsequent wages of graduates. However these studies are not unanimous and there are widely recognised methodological challenges, in particular how to proxy quality and how to control for unobserved ability of the graduates. More recently similar studies have been undertaken outside the US, including several based on UK data (Hussein *et al* 2009, Chevalier 2009, McGuinness 2003, Chevalier & Conlon 2003, Belfield & Fielding 2001).

Belfield & Fielding use a survey of the 1985 and 1990 graduate cohorts and find expenditure per student and the student staff ratio affect graduate wages. However, they conclude that resource effects are modest relative to individual effects, such that factors relating to each individual explain about 10 to 15 times more of the wage variation than do institutional resource effects. The upper bound of their estimate is that a £1,000 increase in expenditure per undergraduate student per annum can result in a 1.8% increase in wages after graduation (with average spending per undergraduate per annum in the study at £6,218)[35].

McGuinness (2005) uses a small sample of all Northern Ireland domiciled students who entered higher education in 1991-92 surveyed in 1999 (with

---

[35] Although the results appear quite modest they do suggest there might be a positive rate of return to quality, which could be a competive choice vis-á-vis other investment options. A back of an envelope calculation assuming a fixed age/earnings profile, 4 years of study, 40 years of labour market participation after graduation and a graduate wage of £20,000 p.a., yields a return of 7.6%. Furthermore, returns might vary among individuals, so that for some individuals paying more in tuition fees might make good business sense at the margin.

potential work experience of 2-4 years). Of an effective sample of 837 just over 60% studied at Northern-Irish institutions, while the majority of the rest opted for institutions in the rest of the UK. He finds that teaching assessments score has no effect on wages or overeducation[36]. However when using the Guardian research score as indicator of quality there is a positive impact on wages, but only for the students with the lowest grades.

Chevalier & Conlon (2003) use propensity score matching to control for individual ability effects based on three cohorts of graduates (1985, 1990 and 1995). They group the institutions by prestige into Russell Group, old universities and modern universities and find a 1% to 6% premium for attending a Russell Group institution over a modern university. They conclude that as the financial benefit of attending a Russell Group[37] university is neither dependent on previous academic achievement nor parental background these universities level the playing field internally among their students. However, they point out that heterogeneity among Russell Group institutions is large, with returns varying up to 10%.

Recent work in progress (Hussein *et al* 2009, Chevalier 2009) broadly corroborates the findings by Chevalier & Conlon (2003) with estimates of the wage premium attributable to institutional quality[38] ranging from approximately 2% to 6%. Based on findings using a subject level quality indicator Chevalier (2009) argues that the quality-wage effect is non-linear, with most of it occurring at the edges of the quality distribution. Most benefits are reaped from not going to an HEI at the very bottom of the quality ranking or going to those few institutions at the highest end.

---

[36] Overeducation in this study is defined as whether respondents held what is perceived to be a graduate-job or not. I discuss the overeducation literature further in Section 2.2.6.

[37] The Russell Group is a self-selected advocacy group of 20 universities, which are among the largest institutions in the UK in terms of research funding. The Russell Group is commonly seen as an indicator of prestige. For details see: http://www.russellgroup.ac.uk/

[38] Chvelaier (2009) uses the subject level quality indicator published annually by the Guardian newpspaper. The Guardian teaching quality score is an index containing six dimensions, i.e. teaching inspection, spending per student, staff/student ratio, job prospects, value added (link between entry score and graduation mark) and entry score.

2.2.4 **Returns to education by subject**

A perennial question is whether the returns to education differ between subjects. Strong views on this can be found in popular perception, but a rigorous quantitative confirmation of differing returns to subjects is harder to provide. The key limitation for statistical estimates is the size of the samples available. When searching for detailed patterns the precision of the statistical results is decreased. This is probably why no individual subject level results are found in Scottish studies because when region and subject specific effects are analysed simultaneously, the sample is too small to provide meaningful results. Blundell *et al* (2000) report some individual subject findings at the UK level based on the National Child Development Survey. For most subjects differences were found to be insignificant. For men a significant negative effect was found for biology, chemistry, environmental sciences and geography. However, for women the pattern is somewhat different, as they were found to earn higher returns in education, economics, accountancy and law, and an ‘other social sciences’ category. To control for the quality of the student intake into the subjects they included A-level results in their regressions. Inclusion of this variable did not alter the results qualitatively.

O’Leary & Sloan (2005) analyse returns to higher education degree subjects. To obtain a sufficiently large sample for this breakdown they pool observations from the Labour Force Survey from 1994 to 2002. Examining men, for undergraduate degrees they find the lowest wage premium accrues to holders of arts degrees, -2.5% vis-á-vis those who have completed two A-levels[39]. Based on an earnings index where earnings of Arts degree holders were fixed at 100 the highest wage premia accrue to accountancy, medicine, engineering and maths and computing (>130). Next in line (130>125) are law, business and finance and education, followed by geography and architecture (125>120). Lower wage premia (120>110) are earned in nursing, biology, psychology, other social sciences, English, history and languages. Interestingly no subject falls in the

[39] The negative wage premia for men‘s arts degrees is striking as it suggests these individuals might have been better off in monetary terms from entering the labour market after completing secondary shool. However, the converse applies to women with arts degrees who earn positive wage premia.

range between 100 and 110, implying there is a significant jump in wage premia from holding an arts degree to the next tier above.

Table 8 Index number of returns to narrow first degree subjects for men and women: Based on several waves of the Labour Force Survey (1994Q1-2002Q4). Source: O'Leary & Sloane (2005) Tables 7 & 8, pp. 82-83.

	Men				Women			
	n	index no	SE	rank	n	index no	SE	rank
Medicine and related	336	132.06+	0.0474	5	597	127.52+	0.0305	2
Nursing	25	114.39+	0.0358	20	220	113.93+	0.0301	9
Sciences	1327	125.22+	0.0335	12	696	106.13+	0.0261	17
Biology	130	115.87+	0.0482	18	188	101.6	0.0356	22
Psychology	125	118.66+	0.0454	17	303	101.98	0.0262	21
Geography	298	123.42+	0.0477	13	261	104.34	0.0398	19
Maths and computing	975	137.23+	0.031	3	346	118.10+	0.037	7
Engineering and technology	650	131.85+	0.0313	6	97	113.54+	0.0556	12
Civil engineering	411	129.25+	0.0325	7	24	113.7	0.095	11
Mechanical engineering	524	133.71+	0.0339	4	19	113.84+	0.0286	10
Electrical engineering	682	140.73+	0.0313	2	28	119.04+	0.0233	5
Architecture and related	410	120.97+	0.0288	15	83	118.70+	0.037	6
Social sciences	132	114.20+	0.0451	21	286	113.45+	0.0313	13
Sociology	126	110.83+	0.0394	24	269	106.50+	0.0292	16
Politics	118	115.70+	0.0477	19	72	99.09	0.0508	25
Law	315	128.04+	0.041	9	302	123.97+	0.0372	3
Business and financial studies	827	126.53+	0.0266	11	691	114.34+	0.0234	8
Economics	430	128.57+	0.0445	8	110	109.68++	0.0508	14
Accountancy	193	142.15+	0.047	1	95	137.12+	0.0504	1
Arts	804	100	n.a.	25	1091	100	n.a.	24
English	213	110.84+	0.0423	23	468	106.65+	0.0322	15
History	306	111.69+	0.041	22	318	110.95	0.0365	23
Languages	110	119.22+	0.054	16	291	103.3	0.0386	20
Education	490	126.73+	0.0316	10	1283	122.40+	0.0223	4
Combined	2529	122.41+	0.0241	14	3135	105.58+	0.0187	18

Notes: All returns are measured relative to an arts degree (base = 100); return to an arts degree relative to 2+ A-levels is -3.25% (men) and 19.29% (women); + (++) denotes a statistically significant difference in returns at the 95% (90%) confidence level; na denotes not applicable

A different pattern emerges for women. Compared to those who have completed two A-levels, women earn significant wage premia on arts degrees (19.29%). Again, based on an earnings index where holders of arts degrees are set at 100, fewer of the subjects were found to earn a statistically significant wage premia vis-á-vis an arts degree. Of statistically significant differences the biggest wage premium for women is earned in accountancy (137). The next tier

(130>120) is composed of medicine, law and education. Many subjects fall on the range between 120 and 110, including nursing, maths and computing, engineering, architecture and business and financial studies. In the range closest to arts (110>100) we find sciences, sociology, economics and English.

O'Leary & Sloan (2005) base the disaggregation of the subjects on what was feasible with the available data, with popular fields allowing more disaggregation due to larger samples. In their regressions they include a control for the quality of the student intake[40]. This affects the final ranking of the subjects; the wage premia is downwards suppressed if it has a relatively high quality student intake, but inflated (in relative terms) if the student intake is of a relatively low quality.

2.2.5 **Estimation bias in the returns to education**

An obvious weakness of the link drawn between education and earnings is that it cannot be verified by means of a controlled experiment, where randomly selected individuals would be given different education treatments and their labour market outcomes subsequently compared. Instead we have to rely on analyses of actual observations.

Various adjustments to the basic specification (presented at the beginning of the chapter) have been used in the literature to identify bias in estimates of the rates of return to education. These include adjustment for the anticipated growth in earnings, mortality, unemployment, taxes and innate ability. Authors of various recent surveys (Checchi 2006, Psacharopoulos 2004, Bonjour *et al* 2003, Krueger & Lindhahl 2001) have pointed out, following Card (1999), that application of various adjustments has led to the conclusion that the pluses and minuses effectively cancel so that the end result is a net benefit almost equal to the unadjusted one. Therefore the use of unadjusted returns has become prevalent. In the following paragraphs I examine the sources of these biases and how they can exert both a positive and negative bias on estimates of the

[40] Leslie's degree acceptance quality variable see: O'Leary & Sloan, 2005, p. 77.

returns to education. Furthermore, I briefly summarise a wave of recent papers applying novel approaches, which underpin the emerging consensus.

In his survey Checchi (2006) identifies three types of weaknesses of the estimated returns to education which could bias the results: omitted variables, measurement error and heterogeneity of returns in the population.

The case of omitted variables can apply when the researcher is unable to control for characteristics that might raise earnings independently of education, such as family background or individual ability. "A typical example is unobservable ability: more talented persons achieve more education because it is easier for them to do so, and at the same time they are more productive when working" (Checchi, 2006, p. 201). The sign of the bias is ambiguous. It could be positive since more intelligent and disciplined people also perform better as students, thus achieving longer schooling. However the bias could also be negative if better endowed individuals face a higher opportunity cost of schooling and may therefore leave education earlier. Further ambiguity stems from considering the fact that parents may take decisions on educational investment. On the one hand, they may do so on basis of efficiency where more is invested in abler individuals, which should produce a positive bias. On the other, they may be driven by equity considerations where more is invested in less able individuals to compensate for their shortcomings result in a negative bias.[41]

Measurement errors are a second source of bias. It has been observed that self reported schooling is not completely accurate and that the measurement errors do not cancel out as the least educated cannot underreport and the most educated cannot over report. "Research in the U.S. over the past three decades has concluded that the reliability of self reported schooling is 85-90 percent (Angrist and Krueger (1999, Table 9)), implying that the downward bias is on

[41] For details see Checchi (2006) pp. 201-202.

the order of 10-15 percent – enough to offset a modest upward ability bias“ (Card, 2001, p. 1135).

The third source of bias stems from the heterogeneity of the coefficient to be estimated in the population. Card (1995) points to two potential sources of the heterogeneity – ability bias and cost bias. The first is driven by the fact that differences in abilities result in difference in productivity so that more able individuals can expect a higher payback for any level of education achieved. The second originates from financial market imperfections, where people of different family backgrounds face different marginal cost in acquiring education, so that poor families face higher cost.

> The consequence of both distortions is that the subset of the population with low educational attainment will be composed of individuals with lower returns (less able) and by individuals facing higher costs (poorer backgrounds). Since the underlying model implies that each individual will optimally select the amount of education that will equate his/her expected returns to his/her marginal cost, the population estimate of the return on education will depend on sub-group composition. If the group of less able individuals prevails, I observe a positive correlation between education and error component ε in the wage function, and therefore the OLS estimate will be upwardly biased. Otherwise when the group of individuals from poorer families prevails, the opposite situation will occur, and I will observe a downward bias (Checchi, 2006, pp. 202-203).

2.2.5.1 Twin studies

Although the returns to education have been systematically studied for over 40 years, there have always been difficulties in determining to what extent the observed wage premia is reflecting the treatment effects of education and to what extent social circumstances and individual ability. More recent publications describe research where new approaches have been utilised, which support the notion, widely held by proponents of human capital theory, that there is indeed a treatment effect from schooling as such, even when individual abilities and circumstance have been controlled for. The most prominent of these utilise samples of identical twins. Because the twins share biological and social backgrounds analysing variation within twin-pairs controls for the fixed effects of genetics and the home, which is seen as (at least partial) controls for individual ability bias.

> There is wide agreement that identical twins studies offer probably the best basis for estimating the pure returns to education since they provide highly controlled conditions for the identical abilities and family backgrounds of monozygotic twins (McMahon, 2009, p. 332).

McMahon (2009) summarises US studies utilising within twin-pairs differences in earnings and education to estimate 'net-ability bias' in estimates of return to education. He points out these studies have found evidence of significant ability bias, but that these are partially offset by a downward biased measurement error. Early studies found a wide range of estimates for net ability bias but McMahon (2009) argues that in more recent studies, with larger samples and methodological advancement, estimates have converged on a more narrow range from 0.9% to 13.7%[42].

Perhaps the most prominent twin study based on data from UK twins is Bonjour *et al* (2003) who corroborate findings of previous authors that there is indeed an upwards ability bias in estimates for returns to education, but that this is offset by a downwards bias caused by measurement error. They conclude that these roughly cancel out.

2.2.6 **Overeducation**

Following the increase in the supply of educated workers in most OECD countries over recent decades, a concern, if not a perception, has arisen that the demand for graduate labour (the supply of graduate jobs) might not keep up

[42] These are percentage (not percentage point) deviations so that if a graduate wage premia of say 50% were to be revised downwards it would become 49.55% (50/1.009) or 43.97% (50/1.137) for the lower and upper bounds respectively.

with supply of graduates. The result would be overeducation in the labour market where ever more graduates have to take on jobs for which their skills exceed the skills required for the job. In this section I briefly summarise attempts to measure the extent of overeducation and assess what the economic implications of overeducation might be[43]. The broad finding advocated here is that studying changes in overeducation across cross sections or over time can be a useful tool for understanding the state and development of the labour market. However interpreting the level of overeducation metrics is problematic. This is due both to issues about the concept of overeducation and the way it is measured.

Critics have pointed out that even if graduates enter jobs which have traditionally been seen as non-graduate positions, employers may alter the way work is undertaken to utilise the increase in workers skills. A number of such examples are given in McMahon (2009).

> Janitors were normally illiterate early in the history of the United States and the European Union countries, and still are in the poor less developed countries. But in the United States now they are called building custodians, and most have high school and even college degrees. They can do many things in maintaining and protecting buildings that the illiterates before them could not do, can see what needs to be done and do it on their own, and have more responsibility and more equipment to operate and maintain. Hence, they are more productive (McMahon, 2009, p. 110).

As Battu *et al* (2000) point out this employer behaviour enhances productivity and goes against the notion that there is a set qualification level for doing a particular job.

Undoubtedly there are individuals in the labour market who are significantly over qualified for their work but providing a metric that can give a credible estimate of the level of overeducation is more difficult. There are broadly four

[43] For more detailed overview of the literature see recent surveys: Battu (2007), McGuinnes (2006).

approaches to measuring overeducation: two subjective and two objective. These are summarised in McGuinness (2006). The first of the subjective approaches asks respondents about the minimum qualification required for their job and then compares these with the acquired qualification of the respondent. The second approach is simply to ask workers whether they perceive themselves as overeducated or not. Harmon & Walker (2003) criticise these methods as suspect to measurement error. Furthermore they point out that educational requirements for new workers may exceed those of older workers to compensate for inexperience.

An alternative and more objective measure can be derived from comparing years of education of the worker with the average for the occupation category as a whole. Harmon & Walker (2003) point out that this approach is often criticized as the choice of classification for the occupation may mix workers in jobs requiring different levels of education depending on the level of detail in the industry classification. The second of the objective approaches is to compare observed qualifications with professional assessments of the required skill level of the occupation such as provided in the Standard Occupational Classifications in the UK or the Dictionary of Occupational Titles in the US (McGuinness, 2006).

A criticism of both of these objective measures is that the required level of education is typically the minimum required, which may not reflect the education level of those successful in the job (Harmon & Walker, 2003). Furthermore, Harmon & Walker (2003) are critical of the poor definition of overeducation in datasets used, which are often based on subjective responses of surveyed workers. They point out that in studies using more comprehensive definitions, such as applying job satisfaction as a proxy for goodness of match, the incidence of overeducation is much reduced and when controls for ability are included, overeducation loses its significance altogether.

Returns to education in excess of requirements are significant. A consistent finding in the literature is that overeducated individuals earn more than someone with appropriate qualifications doing the same job, but less than a similarly educated individual doing an appropriate job (McIntosh, 2005). Chevalier (2000) points out that the pay penalty for over education is typically found to increase the greater the extent of overeducation, i.e. the gap between education obtained and education required. Walker & Zhu (2005) estimate the college wage premium (relative to holding 2 A-levels) on recent graduates (25-29 years old) in two periods (1996-1999 and 2000-2003) using the Labour Force Survey. The college wage premium for those holding non-graduate jobs was found as ranging between 0% and 13%, whilst the range of estimates for those identified as holding graduate jobs was 29%-38%. Some authors have argued that the average masks a more polarised situation where a relatively small proportion of graduates pull the average down by achieving little or no wage premium (Chevalier, 2000).

How does overeducation affect labour market performance? Harmon & Walker (2003) conclude that where a more comprehensive definition is used (based on job satisfaction) and ability controls are included, the apparent negative effect of overeducation is eliminated. However, when overeducation appears to be genuine, the penalty may be much larger than was first thought.

> This has important implications for the variance in the quality of graduates produced by the higher education system. Firstly, a degree is not sufficient to ensure a graduate job — other complementary skills are expected by graduate employers. Secondly, since genuine overeducation can emerge it is clear that the labour market does not adjust fast enough. A degree of manpower planning may be required to ensure that particular types of graduate are not produced excessively (Harmon & Walker, 2003, pp. 149).

Unobserved heterogeneity further complicates overeducation studies. Battu *et al* (2000) point out that most studies implicitly assume individuals with a given qualification are of the same quality, whereas studies that do allow for heterogeneity have found differing results.

Chevalier (2000) examines the coincidence of overeducation, job satisfaction and returns to education. He argues that 'true', as opposed to 'perceived', overeducation should result in lower wages or lower job satisfaction than for those similarly qualified and appropriately placed in the job market. Furthermore, he suggests that graduates with similar qualifications are not homogeneous in their endowment of skills and that this variation of talent has led to the over-estimation of overeducation.

Chevalier (2000) draws on a sample of two cohorts of UK graduates, collected by a postal survey, conducted in 1996, of graduates from 30 HEIs covering the range of UK institutions. Firstly respondents were divided into well matched and overeducated based on a pre-selected classification of what constitutes a graduate job. The study further sub-divided those considered overeducated based on job classification into 'apparently' and 'genuinely' overeducated. This was done using reported job satisfaction as a proxy for matching – whereby it is implicitly assumed that those who are well matched (but 'apparently' overeducated) are satisfied in their jobs, while those who are 'genuinely' overeducated are less satisfied. He found that the apparently over-qualified group was paid nearly 6% less than well-matched graduates. However, this pay penalty disappears when a measure of ability is introduced. The 'genuinely' overqualified suffered from a pay penalty reaching as high as 33%. Based on this he concludes that 'genuine' over-education appears to be associated with a lack of skills that can explain 30% to 40% of the pay differential. According to this, much of the workers picked up in overeducation metrics are modestly affected by their status. However, within that group there is a sub-group which fares significantly worse in the labour market and drives the negative average of those perceived as overeducated based on job classification.

Reviewing the literature it is not entirely clear what overeducation means exactly and from the various different approaches applied a range of estimates can be arrived upon. It is worth asking therefore if it is a worthwhile exercise trying to obtain metrics for some sort of a technical fit between a worker's training and what is perceived to be the appropriate level of training for his job. The output of such an exercise is an intermediate metric, which has to be interpreted carefully in light of methodological challenges. Surely what matters in the end is the final labour market outcome, to what extent workers are being compensated for their training. We know that if the extent of overeducation were on the increase this should be reflected in the average return to education. However studies applying simultaneously measures of overeducation and the returns to education have found that the return to education in excess of the perceived required level of education for the particular job is positive but less than the return to education up to the required level. Still the approach can be valuable in cross-sectional comparisons. For example Battu & Sloane (2004) study the incidence of overeducation across ethnic groups in Britain. They find that incidence of overeducation is higher among non-white ethnic groups and that these groups receive a lower return to required education, although they do not attempt to explain the causes of the relatively weak labour market results for this group. Thus there is vindication for overeducation as a valuable and relevant metric when used for comparison, provided that the studies are based on clear methodology and results are carefully interpreted.

2.2.7 **Signalling and screening**

An often raised concern is that education may have a value in the labour market not because of the positive effects of formal education upon productivity but for spurious reasons. Particularly it is stressed that education may act as a signal of ability or other characteristics that employers value but cannot easily observe. In the extreme case, these abilities are unaffected by education altogether. That is to say, education signals, but does not contribute to, the workers' inherent productivity. As already stressed there is some tendency to over-state, or even dramatize, the role of signalling (see Brown & Sessions, 2004). However as noted by Harmon & Walker (2003) there is a fundamental difficulty in unravelling the extent to which education is a signal of existing productivity or truly enhances productivity. This is because both human capital and signalling theories suggest that there is a positive correlation between earnings and education, but for very different reasons. As we will see though, progress has been made on the empirical front. This indicates that there is a role for signalling in explaining the returns to education but it is of a modest magnitude. The idea that education is a purely non-productive signal is rejected but there remain indications that some of the value of education may be in overcoming information problems in the labour market by means of signalling.

Brown and Sessions (2004) refer to the theory which proclaims education 'signals' or 'screens' intrinsic productivity as the 'sorting' hypothesis. Signalling and screening refer to two related genres of models which describe this process from opposite starting points. Signalling models (Spence 1973, Arrow 1973) describe the process from the point of view of the employee obtaining a signal to enhance his labour market performance whilst screening models turn the game around to have employers screening the labour market by setting a required signal their applicants need to obtain (Stiglitz, 1975). The formal models[44] have their origins in well-known fields of economic theory on asymmetric information and market imperfections. Their elegance and pedigree undoubtedly enhances the standing of these literatures although empirical results are mixed.

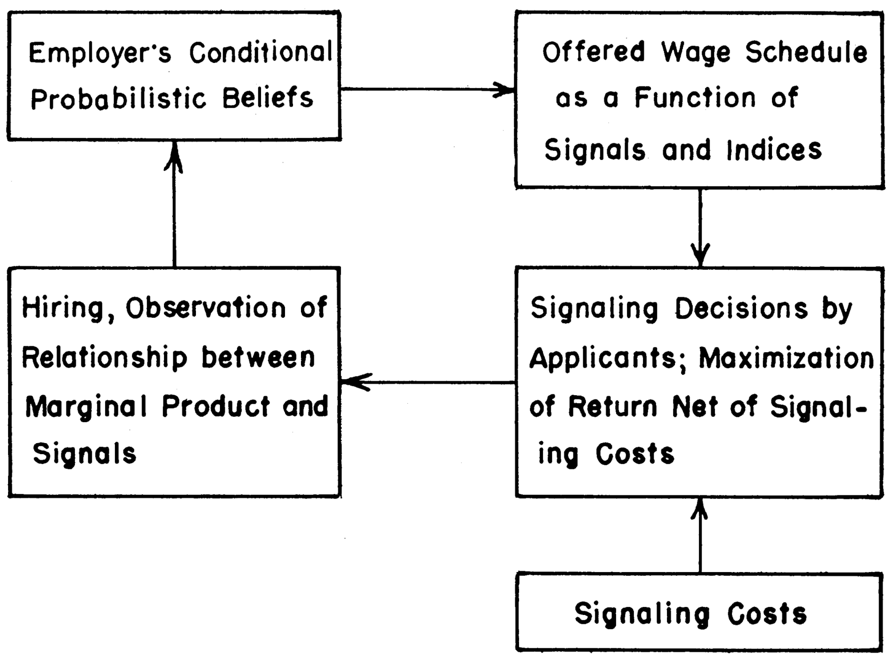
Signalling and screening models can explain the graduate wage premia at a theoretical level. However, even when adopting the extreme assumption that formal education neither enhances graduates cognitive nor non-cognitive skills, but merely acts as an elaborate sorting mechanism, the process can still be productive for the overall economy. If it is the case that formal education allows high ability individuals to move from low paying jobs requiring low skills

[44] I will not elaborate on the models here, but refer interestes readers to Brown & Sessions (2004) and Checchi (2006).

to high paying jobs requiring greater ability, then a signal that improves matching is in itself productive for the overall economy.

Much of the previous literature on asymmetric information, on which the education applications were based, built its examples on cases where a single transaction took place between the buyer and the seller and therefore asymmetric information could be used to the sellers advantage[45]. An employment relationship is continuous however and firms can revise their employment and wage decisions. Even if firms are paying their wages purely on the basis of credentials in the short run, over time they gather their own information about the employee and can change wages, through redundancy or promotion. Therefore under longer time horizons employers should correct for a potential initial effect of signalling. Arrow (1973) acknowledges the need to extend signalling and screening models to include employers learning[46].

Figure 2 Informational feedback in the job market (Spence, 1973, figure 1, pp. 359).



[45] See Akerlof (1970).

[46] Examples of signalling models with employer learning can be found in contemporary work, see for example Lange & Topel (2006). Furthermore, a review of empirical evidence, including studies allowing for learning, see Brown and Sessions (2004).

Spence (1973) gives a dynamic description of how signalling might work in that observed labour quality feeds into the value assigned to education signals in the labour market. See Figure 2. Over time therefore, the signal is not static but reflects recent observations of actual labour productivity by education level. A scenario where graduates are overpaid relative to their actual productivity can only occur under quite restrictive assumptions. The quality of new graduates entering the labour force has to be worse than in previous periods and the informational feedback sluggish enough not to adjust the wage premium assigned to a particular education level based on new observations of productivity. Needless to say, such overpayment relative to productivity cannot persist indefinitely. Sooner or later, market participants will discover that the quality of new graduate entrants is not the same as before and adjust the wage premia assigned to the education signal accordingly.

As summarised by Harmon & Walker (2003)[47] there are various ways of finessing the problem of estimating empirically the extent of signalling in the labour market. One of the ways suggested is to compare the wages of the employed and self-employed[48]. It is argued that education has no value as a signal for the self-employed as individuals know their own productivity and therefore do not need to signal it to themselves. Therefore the difference in returns to education of the self-employed and employees should reflect the value of education as a signal. They find, based on British Household Panel Survey data, that the rates of return to education are quite comparable between the two groups and this implies that the signalling component is quite small. They note a potential problem in that self-employment is not random and that individuals with specific and often unobservable characteristics choose to be self-employed. However their results are robust to estimation methods controlling for unobserved characteristics[49].

---

[47] For a further review of empirical evidence on sorting hypothese see Brown & Sessions (2004).

[48] Some studies compare returns to education in the public and private sectors but these have been found less credible. See Harmon & Walker (2003) p. 134.

[49] Harmon & Walker (2003) use a Heckmann two-step method to control for unobservable differences between the employed and self-employed. For this they draw on information on parents‘ self-

Another approach that has been used to distinguish between signalling and productivity is to directly include ability measures in the regressions. However a difficulty with this method is that the ability measures need to be 'uncontaminated' by the effects of education or they will pick its productivity enhancing effects. "Moreover, the ability measures need to indicate ability to make money rather than ability in an IQ sense. It seems unlikely that any ability measure would be able to satisfy both of these requirements exactly" (Harmon & Walker, 2003, p. 134).

Furthermore, Harmon & Walker (2003) test for signalling by using the longitudinal National Child Development Survey (NCDS), applying controls for ability obtained at ages 7, 11 and 16. They find, as expected, that using ability controls at later ages than 7 confounds the effects of education on ability scores, amplifying the apparent bias. Thus, they conclude that the results at age 7 are probably the most accurate estimates of the extent to which education picks up innate ability. At this age they observe a small difference whether ability controls are included or not, which they claim suggests little signalling value to education.

> It is possible that the return to education actually reflects the underlying ability that education signals — in other words education is a signal of inherent productivity of the individual rather than a means to enhance the productivity. Estimates presented here of the signalling component of the returns suggest that the effect is quite small. Based on datasets where direct measures of ability are available the inclusion of ability measures lowers the return to schooling by less than one percentage point. This can be higher where the ability measure is taken at an older age — this is likely to be because, at older ages, the ability measure is almost certainly contaminated by the effect of schooling (Harmon & Walker, 2003, pp. 149-150).

---

employment and household equity, "both of which are likely to be associated with self-employment but are not likely to be very correlated with current wages" p. 134.

Further evidence has been sought from the literature based on comparing the returns to education of twins. As twins share the same or similar hereditary traits, financial background, family and peer influence, etc, the comparison should circumvent unobserved variable bias (see 2.2.5.1.). Little work has been undertaken hitherto to address sorting issues using twin datasets. Brown & Sessions (2004, pp. 91-93) summarise the methodological challenges involved in testing sorting hypotheses using twin data and results so far. Their only reference is to Miller *et al* (2004) who test a sorting model of education for Australia.

Miller *et al* (2004) implement an argument set forth by Wise (1995) that if sorting holds the returns to education measured in terms of twin pairs (controlling for ability and social background) should fall over time relative to returns estimated using uncontrolled approaches. This is based on the notion that at time of labour market entry employers have little to judge candidates on and therefore use level of education as a proxy for other personal traits that may be desired in the workplace, i.e. conscientiousness, punctuality, etc. If it is the case that education mostly serves as a signal of innate abilities it should be a weaker explanatory variable for wages of older workers, for whom employers can base their remuneration decisions on more direct information relating to performance (track-record), rather than younger workers who have less of an employment history and therefore the education signal will have more weight in determining their wage.

Using samples of Australian twins that are split by age group they find results in support of signalling as the returns to education fall with age. However, their study has some methodological shortcomings and has hitherto not been repeated. Miller *et al* (2004) do not have direct observations of the earnings of the individuals in the sample and therefore have to assign each earnings according to the average of his occupation. Unfortunately they do not disclose how detailed their occupational classification is. Although earnings differences between occupations may be far greater than differences within occupations, this is particularly problematic for twin-samples, which due to self-selection, tend to be disproportionately middle-class. The variation within a pair may already be very limited. So if studying marginal differences in education levels driving earnings differentials, assigning occupational averages may significantly blunt the study. In the future this approach might prove beneficial in establishing a potential value for signalling however, as of yet these should be seen as tentative results.

Furthermore, even if it is established empirically that the relative strength of education diminishes with age, vis-á-vis other personal characteristics, an alternative explanation might simply be that the value of education as a direct driver of earnings is at its greatest shortly after graduation as then the skills picked up in formal training are 'fresh'. And over time, a wider range of attributes begins to weigh more heavily in determining labour market success, i.e. on job training, etc.

To conclude, as of yet there is not a widespread consensus on how best to reconcile Human Capital and Sorting theories as explanations of graduate wage premia. However, most well informed readers of both views will conclude that the perceived incompatibility of the two is hyperbole. Indeed, in the International Handbook on the Economics of Education, Brown & Sessions (2004) strongly refute what they see as the common misinterpretation that that sorting implies that education only signals productivity and therefore cannot cause it as such.

> But the pioneering theoretical work of Spence (1973), Arrow (1973) and Stiglitz (1975) only abstracted from an augmenting role for education to clarify their analysis. Indeed Arrow explicitly stated that he was merely applying Occam's Razor while, in his later work, Spence allowed for both a human capital and an informational role (see Spence 2002). (Brown & Sessions, 2004, p. 94).

Therefore, a pure signalling view indicating education as unproductive is completely rejected (see for example Brown & Sessions, 2004). As Arrow (1973) states he did not believe education was unproductive; rather, that this assumption was adopted as the extreme view made the modelling process easier.

In any case, as suggested from the outset in Spence (1973), if signals are not backed up by productivity on average this should feed back to the wage premium over time. The value of the signal is based on observed productivity in the labour market. If new graduate cohorts start entering the labour market that are revealed to perform worse than previous cohorts, observed productivity will be lower and therefore the value of the signal will be revised downwards. As the empirical evidence reveals returns to education in the UK have been found to be high and stable despite a large increase in higher education attainment. If this result is to be interpreted within a pure signalling view, either innate abilities of the population increased in line with increased attainment or the education signal was 'productive' in the sense that it allowed high-ability individuals to increase their productivity by entering graduate employment.

> Overall, I may conclude this section by stating that education may have a return in the labour market as a signal for unobservable components. However, the empirical evidence in support of this view is not entirely convincing, and I should limit ourselves to saying that educational credentials convey information to potential employers who do not have the time or ability to assess all self-declared competences." (Checchi, 2006, p. 185).

The current state of the academic debate about the value of education is not about either seeing education as productivity enhancing or just a signal, but to narrow the range for which education may have a true treatment effect on worker productivity as reflected in wages (apart from any wider impacts of course). The recent application of twin data sets is bringing that objective closer, so that a range for the returns to education can be established that is quite robust to ability bias or potential signalling effects.

2.2.8 **Main findings**

This subsection has surveyed the relatively rich microeconometric evidence there is on returns to higher education and graduate wage premia, with particular emphasis on Scotland. Furthermore, I have examined the international literatures, which seek to address the various issues that arise in terms of measuring the returns to education and how these estimates should be interpreted. Finally, I have attempted to reconcile the empirical findings with the literatures on labour market sorting and overeducation.

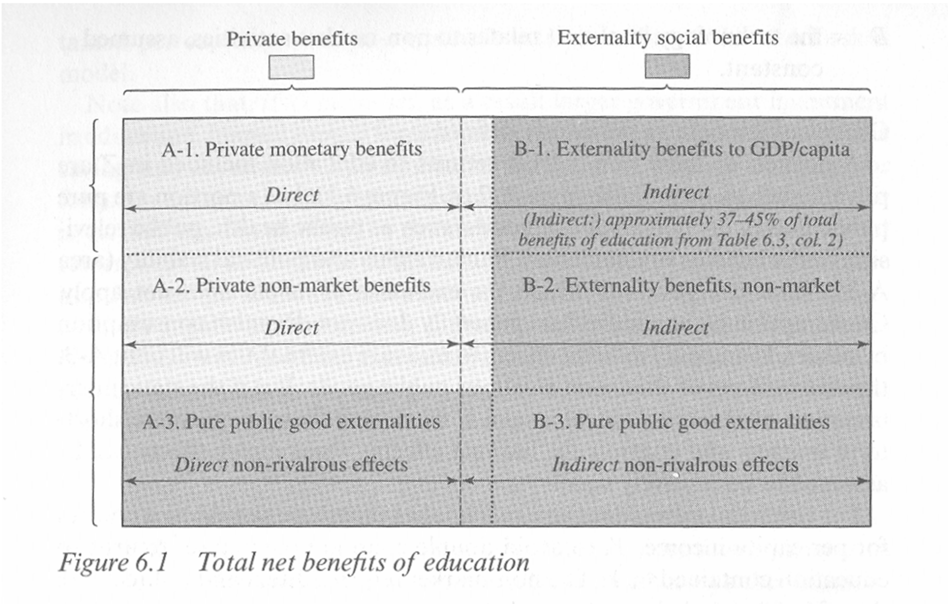
The empirical evidence suggests that there are high returns to education generally, but that these do vary across subjects and institutions to a lesser extent. There is no compelling evidence to suggest that Scotland's performance differs from the RUK (at least in the recent past). Similarly, there is no evidence that the return is falling or that marginal returns are less than average (over time). However, see 2.2.2.2 for a more detailed discussion. In section 2.5.3 I shall review how the microeconometric evidence can be used to simulate system-wide impacts using a Computable General Equilibrium (CGE) modelling approach. Furthermore, this is discussed in detail in the context of the CGE-analyses presented in Chapter 6.

2.3 Wider impacts of HEIs

Most of the academic effort hitherto has focused on the more direct impacts of education for the economy; in particular institutional demand-side impacts and private returns to education. However, these may only constitute a part of the overall impact of education for the economy. Additionally there is an assortment of potential benefits, which are captured under the heading of wider impacts of HEIs. These include for example productivity externalities (Heurman 2011, Moretti, 2004b, Battu *et al* 2003) impacts on public health (Feinstein *et al*, 2006), strengthening of civic institutions and social engagement (Campbell, 2006), lower crime rates (Machin *et al*, 2011) and environmental effects (Appiah & McMahon, 2002). McMahon (2004, 2009) argues that the economic contribution of these wider impacts can be significant but measurement problems make them difficult to pin down. Many of these impacts only reveal themselves with long time lags and there is an inherent difficulty in disentangling the impact of education per se from the impact of other developments. For example, education increases income and socioeconomic advancement, but rising income also has a beneficial impact on many socioeconomic metrics. Determining causation is therefore difficult, as is attributing outcomes to particular actions or developments. Many of these effects are particularly relevant for developing countries, i.e. birth rates, political stability, rule of law. But potentially very significant benefits can be reaped by developed economies as well, such as through i.e. through educations' impacts on health and crime rates.

In relation to the topics surveyed in the previous chapters, where much has been published over several decades, systematic analysis of the wider impacts of education is an emerging and relatively underdeveloped theme. Much of the analysis of the economic impact of wider effects of education hitherto is found in the work of McMahon (2004, 2009), which summarises and evaluates the relevant existing literature. I also refer to a recent review by Oreopolous & Salvanes (2011). McMahon (2004, 2009) provide a conceptual framework for the wider impacts of education, where impacts are classified using two dimensions, Public-Private and Monetary-Non-Monetary. Furthermore, McMahon (2004, 2009) summarises the literature attempting to estimate a potential value to the wide range of possible effects that it identifies. This taxonomy is adopted here to guide the review of the wider impacts of education. These benefits occur either as a direct consequence of education or indirectly. Indirect effects refer to any subsequent rounds of impact of the direct impacts. For example McMahon (2009) explains that education can improve someone's health (a direct effect) and subsequently improved health can increase that persons' income (indirect effect). An element of further complexity in the diagram is that some indirect benefits are private while most of them are expected to be social.

Figure 3 Total net benefits of education. Source McMahon (2004) Figure 6.1, p. 215.



Before examining valuation of these effects it is useful to take a look at the individual sectors of the model and what they capture.

- A-1. Private monetary benefits (direct): These are the impacts of higher earnings from education as described by the returns to education literature summarised in 2.2.1.
- A-2. Private non-market benefits (direct): These include various non-monetary benefits that accrue to the educated individual himself. Probably the most important of these is improved health, but a range of effects have been explored in the literature, i.e. more successful marriages and improved happiness. For an overview see Oreopoulos & Salvanes (2011). These effects are strongly correlated with income, which is typically controlled for.
- B-1. Externality benefits for GDP/capita (indirect): Externalities that feed back to economic growth, especially over longer time horizons, e.g. effects that arise via more investment in physical capital, more

investment in education, adoption of technology, improved R&D & innovation, slower population (particularly relevant for less developed economies).

- B-2. Externality benefits, non-market (indirect): These are non-monetary benefits that are captured at a social level as an indirect impact of the level of education in the community. These are distinct from B-1 in that they are not captured in measures of economic output but may improve other development indicators. This category would include education's contributions to various types of social advancement, such as the quality of culture or the rule of law, as reflected in quality of life metrics, for example happiness scales (independent of the effects of income on the same metrics to avoid double counting).
- A-3 & B-3. Pure public good externalities (direct and indirect non-rivalrous effects): A non-rivalrous externality is one whose value is not diminished the more people partake of it. An example would be an improvement in human rights. McMahon (2004) lists 13 examples of effects that contribute to non-market aspects of economic development and are non-rivalrous (see Table 6.1, pp. 218). These include improvements in public health, crime rates, civic institutions, environment, poverty reduction and less inequality. Many of these are seen as particularly relevant at earlier stages of economic development. As before the distinction between direct and indirect impacts is made in such a way that if education levels directly contribute to the externality it is considered a direct effects, whereas if some of the secondary impacts of education contribute to the externality then the linkage is considered indirect. For example a direct linkage is education↑→public health↑, whereas an indirect link would be education↑→ income↑→ public health↑.

To estimate the impact of wider benefits of education, cross-country macro regressions can be used (as described in 2.5.1). However, these are limited in that they include various controls for development indicators that are themselves influenced by education (i.e. political stability, fixed effect dummies) and therefore pick up some of the educational benefits. Furthermore if these include time dummies or are conducted over a short time horizon many of the effects will not be picked up as they occur with long time lags of at least 10-20 years. These highly controlled regressions therefore risk underestimating the wider impacts of education If these controls are relaxed researcher are faced with the problem of potentially overstating impacts, as education starts to pick up the beneficial impacts of other closely related socioeconomic developments. Researchers have attempted to engage with this problem by applying different specifications, in which each has its potential positive or negative biases. These recent studies have provided a range of results which give an indication of the plausible magnitude of the wider impacts of education.

McMahon (2004) combines a variety of estimates for the social rate of return to education as found in macroeconometric studies and broad findings for private rates of return to provide a possible range for the magnitude of the wider impacts of education. Based on recent literature he argues a plausible social rate of return of education may vary from approximately 10% to 30%. The lower bound implies the returns to education are almost solely based on private market returns with limited or no wider impacts. The result is based on tightly controlled static regressions, which McMahon (2004) argues fail to attribute wider impacts to education, and therefore understate education's impact. The upper bound is based on dynamic, more loosely controlled specifications, which he conversely argues is probably overstated as the lack of controls means that the education variable picks up effects from other economic developments. Drawing on a number of empirical studies and simulations he presents "educated guesses" by economic development and education level.

Figure 4 Estimates of social returns to education in the OECD countries. Source: McMahon (2004), Table 6.5, p. 244.

	Conventional monetary social rates of return (A1+B1)	Non-market private returns (A2+B2)	Non-market education externalities (B-3)	Total social rates of return (includes non-monetary)
Primary	8.5	6.8	2.5	**17.8**
Secondary	9.4	7.5	2.8	**19.7**
Higher	8.5	6.8	2.5	**17.8**

These estimates reveal that the typically un-measured impacts of education are at least as big as the frequently estimated private returns to education. However most of these wider impacts are in fact non-market benefits accruing to the educated individual himself. The externalities, although significant, are relatively small. As for education levels their economic impacts seem to be broadly of the same order of magnitude. Implying that expansion of education at any level will have a high social rate of return[50].

Although notionally high on the agenda, academic work establishing the economic value of wider impacts of higher education (and education in general) is at an early stage. There is a substantial literature analysing specific, often quite narrow, effects. However, this evidence base is fragmented and has yet to be comprehensively bridged. Pioneering work, such as McMahon (2004) and McMahon (2009) has indicated that potentially the wider supply side benefits of education are no less significant than the direct supply side effects. Verifying these micro-level effects with macroeconomic data has proven difficult (see 2.5.1) however a nascent development is to simulate the system wide effects of developments at the micro level using modelling techniques such as Computable General Equilibrium analysis (see 2.5.3). Therefore, in coming years a clearer picture should gradually emerge.

---

50 McMahon (2004) makes similar estimates for developing countries were social returns are sometimes twice as large, in particular for primary education.

2.4 Regional/Local supply side impacts

A range of effects of HEIs may be at play at the regional or local levels and only partially captured in micro/labour market estimates as summarised in Section 2.2 or macro/overall approaches as discussed in Section 2.5.1. Examples of these are spatial effects, where the presence of HEIs affects the location of R&D or highly skilled labour. These may not be captured at the macro level as they may simply be causing a re-arrangement of existing R&D capacity or the existing stock of highly skilled labour. On the other hand it is quite possible that such agglomerations can be powerful enough to exert their attractive powers over borders and in such a way have a positive national impact. Another example is from econometric studies of the effects of HEIs in improving regional productivity. As before these studies can, to an extent, be identifying a re-location of existing productive people/businesses, but there can also be a positive national benefit. Regardless of the potential national impacts of these effects the studies reviewed reveal important impacts of HEIs for the region where they are located. This section aims to straddle somewhat dispersed academic work in a relatively brief summary. Inevitably, breadth has come at the expense of detail. However, it is important to give a flavour of these works[51].

2.4.1 Spatial/Location effects on labour supply

The presence of HEIs has been shown to affect the location and migration choices of highly skilled labour at the regional and sub-regional levels. The broad findings suggest that an HEI's presence makes it more likely that a region will attract and retain highly skilled labour. In addition there are examples of graduates being retained in their region of study. Varga (1997) argues that proximity to HEIs may affect the locational behaviour of the highly skilled workforce but not workers associated with mass production. He points out that the hypothesis is reinforced by studies showing that the spatial distribution of the relative share of scientists and engineers in the workforce is governed by university proximity. Furthermore, Beeson & Montgomery (1993)

---

[51] For a further discussion of these topics see McLellan (2006) and Drucker & Goldstein (2007).

show that not only does university research affect location of the highly qualified workforce but that such workforce is also attracted by local university teaching activity as measured by the number of degrees awarded in the fields of science and engineering.

For migration behaviour of the highly educated workforce Herzog *et al* (1986) find that university availability at the current location does not affect the out-migration choice of scientists and engineers. However the presence of HEIs seems to be an important influence when deciding where to move to (Beeson & Montgomery 1993, Herzog *et al* 1986). As for the potential benefit of retaining graduates in the region, Florax (1992) points out that for the Netherlands alumni have tended to cluster around their institution of study. Groen (2004) in a study of US graduates finds a significant link between studying in a state and working in it, although the magnitude of the impact was quite modest with approximately 10 of every 100 students living in the state of study 10- 15 years after graduation. Bound *et al* (2004) point out that graduates are quite mobile and find that at a state level in the US there is only a modest link between production of graduates within a state and the build-up of a graduate work force. Venhorst *et al* (2011) examine the migratory behaviour of recent graduates in the Netherlands from 1997 to 2008 and find that graduate migration is primarily dependent on the spatial distribution of suitable jobs. Over the period examined they find that graduates are becoming less migratory, a result they attribute to increased spatial dispersion of graduate level opportunities over the period.

2.4.1.1 Findings on student and graduate migration in Scotland and the UK

Wright & Mosca (2011) use the Destination of Leavers Survey to examine the migratory behaviour of graduates within the UK. The survey draws on a sample of recent graduates and asks them about their employment status and whereabouts 6 months after graduation. A follow up survey, taken 42 months after graduation, is available for some cohorts. The tables below show some of the details of their findings.

Half a year after graduation approximately 86% of those who studied in Scotland were found to be living in Scotland. However, this cannot be interpreted as a net retention-rate as students studying elsewhere also migrate into Scotland from elsewhere. When findings from the survey are used to estimate the graduate flows in terms of headcounts (Table 9), we see that on average for the five cohorts from 2002/03 to 2006/07 of the approximately 29,000 who graduated in Scotland per annum, a little less than 25,000 are retained within the country 6 months after graduation. However, almost 2,000 graduates who studied elsewhere in the UK move to Scotland, indicating a net out-migration of approximately 3,000 thousand graduates. This implies a net retention rate of about 93% for Scotland.

Table 9: Place of employment 6 months after graduation (estimated headcount, % of row total). Source: Wright & Mosca (2011).

		England		Scotland		Wales		N-Ireland		Total	
Place of study	England	246,222	97.8%	1,768	0.7%	2,908	1.2%	912	0.4%	251,810	100%
	Scotland	3,429	12.0%	24,738	86.4%	79	0.3%	379	1.3%	28,626	100%
	Wales	6,160	35.8%	101	0.6%	10,896	63.3%	50	0.3%	17,207	100%
	N-Ireland	419	4.7%	93	1.0%	15	0.2%	8,456	94.1%	8,983	100%
	Total	256,230		26,700		13,898		9,798		306,626	

When the follow up study from the Destination of leavers survey is analysed it reveals a further out-migration of those who studied in Scotland. The gross retention ratio has fallen from 86.42% as revealed in Table 8 to 80.72% as reported in Table 9.

Table 10: Place of employment 42 months after graduation (Based on destination of leavers survey 2002/2003m cohort). Source: Wright & Mosca (2011).

		England	Scotland	Wales	N-Ireland
Place of study	**England**	97.50%	0.89%	1.29%	0.32%
	N-Ireland	9.38%	1.05%	0.76%	88.81%
	Scotland	16.56%	80.72%	0.85%	1.87%
	Wales	41.56%	0.77%	57.17%	0.50%

Wright & Mosca (2011) emphasise that counting heads only tells a part of the story. They argue that migration is a selective process and that the characteristics of 'stayers' and 'movers' can differ significantly. They run a logit regression to analyse what kind of graduates are likely to migrate for work. Of those who study in their country of domicile they find that those who are more likely to out-migrate tend to be male, have studied full-time, are disabled, hold a first-class undergraduate degree, attended a Russell-Group University, studied science and have already moved in order to attend university.

Furthermore, Wright & Mosca (2011) examine the graduates labour market outcomes in terms of whether they hold what is commonly perceived to be a graduate job or not. They find that for Scottish domiciled students that study in Scotland approximately 75% of students hold a 'graduate' job 6-months after graduation and that this rises to approximately 82% when examined 42 months after graduation. Scottish students studying locally appear to be slightly more successful at obtaining 'graduate' jobs than their counterparts from elsewhere in the UK, although the difference is modest.

Table 11 % in a 'graduate' job 6 and 42 months after graduation. Source: Wright & Mosca (2011).

	% in a graduate job after 6 months (pooled cohorts)	% in a graduate job after 42 months (2002/03 cohort only) - weighted
English-domiciled studying in England	72.51%	80.50%
Northern-Irish students studying in NI	74.12%	79.31%
Scottish-domiciled studying in Scotland	74.85%	81.89%
Welsh-domiciled studying in Wales	70.28%	79.00%

Furthermore, Wright & Mosca (2011) use logit regression to analyse the characteristics of those who obtain 'graduate' jobs and those who do not. They find that of those who studied in their own country of domicile those who move to take up employment are more likely to occupy what is perceived to be a 'graduate' job.

In absolute terms Scotland 'looses' graduates, even when inflow from other regions has been considered. Compared to the US labour market (for which most of internationally published findings focus on) where graduates are footloose the net out-migration of graduates from Scotland appears to be modest. However, as Wright & Mosca (2011) point out the headcounts only tell a part of the story as there may also be quality differences between the out-flow and in-flow. Indeed, their findings indicate that high-potential graduates are over-represented among the out-migrants.

A similar conclusion is reached by Faggian, McCann & Sheppard (2010) who analyse graduate retention rates at the level of NUTS-1 and NUTS-2 regions in the UK. They find that Scotland has the second highest graduate retention rate in the UK, only after London, and attribute this to differences in the education system between Scotland and the rest of the UK.

2.4.2 **HEI knowledge spillovers**

A phenomenon of much interest is knowledge transfer from HEIs to industry. This proposed external benefit of HEIs results in various impacts which can be said to be related and are sometimes referred to under the heading of knowledge effects (Varga, 1997). This includes effects on firm's location decisions, R&D activity and innovation rates as will be explored in the following subsections.

According to Parker & Zilberman (1993) technological transfer from HEIs is seen as any process where understanding, information and innovations move from an HEI to industry. This occurs through various channels from seminars and scholarly publications to spin-offs and scientific parks. Varga points out that cooperation in R&D, faculty consulting, journal publications and industrial associates programs channel knowledge regardless of distance, however several means of technological transfer are more dependent upon spatial proximity.

Fischer & Varga (2003) used a spatial econometric approach on Austrian data and found a geographically mediated university spillover to be present and subject to a distance decay pattern.

Varga (1997) cites several sources which highlight the importance of the graduate labour market as a source of technology transfer. Firstly access to graduate students, trained graduates and scientists is seen as major university industry linkage. Therefore the local labour market for graduate level personnel promotes technology transfer. For one, faculty scientists and engineers are more likely to move to nearby firms when changing jobs and in addition trained graduates may seek jobs in the area of their university. He further points out that knowledge transfer can occur through seminars, industrial incubators, industrial parks and spin offs. More informally, technology transfer can occur through local professional associations or even by getting together in a local pub or restaurant.

Faggian, McCann & Sheppard (2010) and Faggian & McCann (2006) point out that regional innovation in the UK is strongly linked to graduate migration flows and argue that a major channel for knowledge transfer is that embedded in human capital. They suggest that a cumulative causation mechanism is at work for high technology sectors (but not for manufacturing) where graduates migrate to regions with job opportunities, this inflow spurs innovation, which again reinforces job opportunities and human capital inflows.

> An endogenous process of feedback between inflows of graduate human capital and high technology innovation dynamism operates in all UK regions [...]. Relatively larger net inflows of human capital help foster high technology regional innovation, and high technology regional innovation further encourages such human capital inflows. A process of circular and cumulative causation appears to be operating in the case of high technology industries, but this is not [the] case for all manufacturing industries. For all manufacturing industries, inflows of human capital are still essential for innovation (Faggian, McCann & Sheppard, 2010, pp. 287-288).

Kitson *et al* (2009) argue that interactions between academia and industry are more frequent, heterogeneous and dispersed than previously thought. Furthermore, interactions are not only driven by STEM (Science, Technology, Engineering and Mathematics) subjects through licenses and spin-offs, but a wide range of subjects through various different channels, often informal.

2.4.3 **Innovation and patent activity**

At the national level HEIs role in contributing to innovation through the creation of new technologies or absorption of existing ones, and the contribution of these to productivity, is captured primarily in the growth theory literature summarised in 2.5.1. A review of the various potential mechanisms of knowledge exchange and innovation systems is beyond the scope of this study, however I refer to McLellan *et al* (2006) and Harris (2006) for recent summaries of the literature. For a recent overview of work applying knowledge production functions to estimate knowledge spillovers I refer to Acs (2010). Some of the best known studies providing quantitative evidence on innovation- and productivity links are based on observations at the local level. Therefore I shall focus on these here.

Jaffe (1989) found a positive link between university research and the level of innovation activity within US states. Using patent registrations as a proxy for innovation he found a statistically significant relationship showing a 1% increase in spending on university research resulting in a 0.1% increase in the number of patent registrations within the state. The strength of the effect varied between sectors and was found to be almost quadruple in the drugs and electronics sectors compared to the overall impact.

Anselin *et al* (1997) built on the same dataset as Jaffe, using number of registered patents as a proxy for innovative activity, but expanded it somewhat. They confirmed the positive link between university research and innovation activity both directly and indirectly through its effect on private R&D. At the MSA level their model for innovation activity used both university research and private R&D as explanatory variables. In addition the research employed spatial lags including university research within 50 miles radius outwith the MSA and private R&D within 75 miles out of the MSA. Furthermore they controlled for 3 local business characteristics: specialization in high tech industries, importance of business services and presence of large firms, in addition to the ranking of the university institution in question, which they considered a proxy for the institutions quality. University research up to 50 miles outwith the region was found to have a significant effect on innovation activity but the same did not hold for private R&D at up to 75 miles distance from the region. Furthermore, specialization in hi-tech industries and proliferation of business services were found to have a positive effect on innovation while large companies were found to have significant and negative effect on innovation activity. University ranking was found to be positively associated with innovation activity.

Anselin, Varga & Acs (2000) expand previous work in two directions. They examine whether innovation activity in US Metropolitan Statistical Areas (MSA's) is affected by proximity to other MSA's and if the drivers of innovation activity differ between sectors. In this case they used data for patent registration in the US for 1982 and examined four broad sectors regarded as high-technology: Drugs and Chemicals, Industrial Machinery, Electronics, and Instruments. The first extension is motivated by the idea that areas in proximity to each other may form a network within which knowledge externalities can operate. This is done by dividing the sample into connected and unconnected MSA's and testing for structural stability. Regional homogeneity was rejected in the cases of Industrial Machinery and Instruments but when examining Electronics and Drugs and Chemicals a significant difference was not found between the connected and unconnected samples.

When examining the drivers of innovation activity in the four broad sectors Anselin *et al* (2000) used a similar regression as before, including as explanatory variables Private R&D and University research in addition to controlling for the presence of high-tech firms, concentration of business services and large companies. The results differ between sectors. For some, most coefficients are significant while for others fewer are significant. As an example, for the Drugs and Chemicals sector the only significant coefficient is for industry R&D, indicating no knowledge spillovers for that sector, but for Electronics both university and industry research were found to have a significant and positive coefficient in addition to the variables representing a concentration of high tech companies and business services.

Anselin *et al* (2000) conclude that the findings have broadened the evidence for both sectoral and regional differences in the innovative process. As we have seen there is supportive evidence for a localised effect of HEIs where they seem to attract private R&D into its spatial proximity. Furthermore there is a link between research activity at HEIs and regional innovation activity measured as patent registrations.

2.4.3.1 Spatial/Location effects on innovation

Studies that have analysed R&D location in the US give strong evidence of localised impacts of HEIs, where private research and development tends to concentrate around places where universities are conducting research. Such impacts have been found at state, metropolitan and intra metropolitan levels.

Jaffe (1989) uses data on private R&D expenditures in 29 US states over 8 years and university research expenditures over the same period. This study found that after controlling for population and economic activity there is an association where increased university research seems to drive increased private R&D.

> Establishing causality with statistics is a tricky business, but it appears that university research causes industry R&D and not vice versa. Thus, a state that improves its university research system will increase local innovation both by attracting industrial R&D and augmenting its productivity (Jaffe, 1989, pp. 968).

More precisely his regressions showed that overall a 1% increase in university research spending should result in 0.7% increase in private R&D spending within the state. This association varied in magnitude and significance between sectors. Anselin, Varga & Acs (1997) extend the work of Jaffe by examining the relation between university and private R&D and innovation activity at a more localized level of a Metropolitan Statistical Area (MSA) in the United States. They confirmed the positive link between university research and private R&D.

2.4.4 **Spatial econometric estimates of HEIs local productivity impact: A Swedish natural experiment**

An interesting example of the regional effects of HEIs is that of Sweden, where a deliberate policy of spatial decentralization of higher education was undertaken, beginning in 1987 (Andersson, Quigley & Wilhelmsson, 2004). As late as 1977 11 established HEIs (universities and technical institutions) were operating in six Swedish cities in addition to 14 small colleges affiliated with universities. In 1977 11 new institutions were founded and status of the existing colleges raised, placing all 36 universities, institutes and colleges, which were located in 26 municipalities under one administration. In most cases the sites of new establishments were formerly occupied by teacher training schools or military training facilities (Andersson *et al*, 2004).

According to Andersson *et al* (2004) the new institutions developed relatively slowly until 1987 when a substantial expansion began, with student numbers growing faster than at the established institutions and an increase in resources. In 1998 84,000 students were enrolled at the new institutions, representing a third of the country's students of higher education. In addition two new colleges were formed and four of the former established colleges upgraded to university status. At the time of the study there were 13 universities and 23 colleges operating in Sweden

Andersson *et al* (2004) maintain that expansion of the regional colleges has generally been considered an important part of the government's regional policy. The policy can be seen simply as a fiscal policy where by expanding higher education the government brings a fiscal stimulus to the regions. However, a second effect is the possibility of supply-side benefits which would improve the regional business environment or induce innovation and increased regional activity, what the authors refer to as the Silicon Valley model. They point out that a policy of this sort is likely to have effects only after some lags, as it may take considerable time to build up a research environment and it will take 3-4 years to educate the students before they will be productive in employment post graduation. In addition they argue that the effects are most likely contingent upon the research and educational focus of the individual institutions, the existing economic activity in the region and the migratory response of the newly educated students.

Andersson *et al* (2004) used econometric methods to study the effects of this decentralisation upon regional labour productivity. They use the number of full time researchers as an indication of the institutions research activity and the number of full time students as a measure of their overall scale. As has been mentioned both the number of students and researchers increased greatly from the 1980's onwards. These exogenous changes in educational policy are related to productivity (output per worker) measured at the community level. This is possible since annual data are available on gross regional product for each of Sweden's 285 municipalities from 1985. Andersson *et al* (2004) conduct their regressions using panel data from 1985 to 1998, enabling them to control for fixed effects.

Their model implies that the level of HEI activity (measured in number of students or researchers) is related to the level of productivity per worker for that community and year. They found a statistically significant link between university activity and regional labour productivity. Interpreted literally, an increase of 100 students is associated with an increase in labour productivity amounting to 0.00098% per annum. Research activity however appears to be more important, as an increase of 100 researchers is associated with an additional annual improvement in regional productivity of 0.00774%[52]. Furthermore there is a statistically significant difference between the marginal effect of additional students or researchers in favour of the new institutions over the established ones, as the effect is roughly twice as large for students and eight times as large for researchers.

A weakness of the study is that it assumes the effect is isolated to the resident community of each institution and ignores spillovers between regions. Indeed Anderson *et al* (2004) could not reject the hypothesis of spatial dependence and resorted to augmenting their analyses by adding a gravity variable representing the distance of each community to all students and researchers based in other communities. The results for the explanatory variables confirmed earlier results and a significant gravity variable provided strong evidence of spillovers between regions. When spatial lags are included the result changes somewhat. The lags are highly significant as are the gravity variables suggesting that a region's productivity depends on that of its neighbouring regions. Using spatial autocorrelation models reduces the significance of the relationship between student numbers and productivity to the point that it is only significant at 0.2 levels. The association between number of researchers and regional productivity is still found to be significant and of similar magnitude.

They conclude that there is systematic evidence that the average productivity of labour is higher in regions that received larger university investment. As a possible explanation of why there is much stronger association between university researchers and productivity than the number of students Andersson *et al* (2004) argue this may arise for several reasons. Researchers are bound to the geographical area where they have tenure whereas the graduates are not. It takes at least 3-5 years until a student enters the workforce and many graduates are without technical expertise, whereas researchers are productive as soon as they are recruited. Furthermore as a possible explanation why investment in the

[52] On the face of it therefore a single researcher drives an 8-fold impact relative to a student. However, the average student to researcher ratio for the period was 17 implying that the aggregate impact of students is about double that of researchers.

new institutions returned more productivity gains than that of the established institutions they argue this could arise if the new institutions are more vocational and technical in nature. Of course, some of the new institutions are, in fact, upgrades of former technical colleges. So this may explain some of the differences. (Andersson *et al*, 2004, p. 386).

As noted before the productivity boost also extends to communities located near the HEIs. Andersson *et al* find that this effect is highly localised with more than half of the reported productivity gain occurring within 20 kilometres of the municipality containing the HEI and about 75% occurring within 100 kilometres of it.

2.4.5 **Impact of US HEIs on regional development**

Using data on all 312 US MSA's (Metropolitan Statistical Areas) from 1969 to 1998 Goldstein & Renault (2004) analyse the impact of HEIs on regional development (measured as change in average earnings) while controlling for regional factors such as size, location, industry structure, entrepreneurial activity and accessibility. For the first half of the period, from 1969 to 1986, their hypothesis that research universities contribute significantly to regional economic development is not supported. However, it was found to be a significant factor in the second period from 1986 to 1998.

Goldstein & Renault (2004) argue this is in line with the view that the role of the university has changed since the beginning of the 1980's in that it has taken on the additional task of facilitating economic development, what they refer to as the "entrepreneurial university period" (p. 741). In addition they argue that the economy was more knowledge intensive in the latter period. For the period from 1969 to 1986 they find that the variables that can explain variation in the MSA's development (change in average earnings) are location in the Midwest and West (negatively related), MSA size (positive) and a presence of large airport hub (positive). Therefore they conclude that the general regional macroeconomic conditions, agglomeration economies (significance of size) and industrial structure are most important for explaining regional economic development in the period.

For the latter period the results are quite different. Total university R&D activity has a significant and positive effect on the dependent variable (relative change in earnings per worker) while the total number of degrees awarded is significant but negative and university patent activity is insignificant. Location is significant and positive for the Northeast. As before size is significant and positive. University patent activity is insignificant however, which Goldstein & Renault view as an indication that "the mechanisms by which university R&D activity stimulates economic development are much broader and diverse than just patenting and licensing activity" (p. 744).

They conclude that the evidence points towards university research activity as the foremost source of positive externalities.

> That the presence of universities did not matter either way in 1969-86 supports the view that the teaching and milieu functions are not as important as the research and economic development functions of universities, since the former functions did not change appreciably over the full period, while research activity and economic development increased dramatically from the early to the later period (Goldstein & Renault, 2004, p. 744).

Furthermore the coefficient for teaching activity (number of degrees awarded) was significant and negative for the period 1986-1998, which Goldstein & Renault suggest could be interpreted as saturation of highly educated workers in the average regional labour market. Such interpretations should however be approached with caution as there is a clear risk of multicolinearity between the research and teaching output variables undermining the validity of the regression. Teaching output (measured in number of degrees awarded) is likely to be closely associated both with the scale of institutions and their research output and therefore the robustness of the results should be accepted with caution.

Goldstein & Renault (2004) address the question if agglomeration economies are more important for regional economic development than research universities and whether universities can act as substitutes for agglomeration economies. They conclude that the present evidence is mixed. MSA size was a positive and significant factor in affecting regional average earnings in both periods indicating that agglomeration economies matter irrespective of university activity. However when results on the impact of university R&D were disaggregated according to size of MSA it was only significant for small MSA's. This can be seen as an indication that HEIs can provide external benefits for small MSA that urban agglomeration generally provide (Goldstein & Renault, 2004). They conclude that even though university R&D was found to have a statistically significant effect on regional economic development the order of magnitude was small.

> Controlling for other factors, it would have taken an increase of US$10 million in research expenditure among universities in 'average' MSA to increase the index of average earnings per job by 0.36. To give these numbers some perspective the average MSA had US$30.7 million in R&D expenditures in 1986. If the universities in this hypothetical MSA had increased their R&D expenditures by US$10 million more (about a 33% increase), the MSA would have increased its index from 100.00 to only 100.36 (Goldstein & Renault, 2006, p. 744).

2.4.6 **Conclusion for local supply side impacts**

Scotland retains a large proportion of its graduates. This is a contrast to the US state level, for which most studies have been conducted – where graduates have been found to be footloose. However, ongoing work by Wright & Mosca (2011) on graduate mobility in Scotland warns that Scotland may lose in terms of the quality of the net-migration flows, as early findings indicate that graduates with good credentials are more likely to out-migrate[53].

---

[53] However, in-migrants tend to hold better than average credentials as well. Therefore we must await the release of more detailed analysis before reaching an unequivocal conclusion.

The literature documenting the spatial effects of HEIs upon research activity, innovation and skilled labour suggests that potentially strong and divergent local effects are masked within the national average impact of HEIs.

It is clear that HEIs can attract highly skilled labour, thus making the local labour market more attractive to employers. There is also supportive evidence for a localised effect of HEIs where they seem to attract private R&D into its spatial proximity. Furthermore there is a link between research activity at HEIs and regional innovation activity measured as patent registrations.

US studies have found statistical regularities indicating that HEI activity has beneficial impacts on innovation at the local level as measured by patent registration. The strength of this effect varies depending on sectors and local characteristics. Furthermore university research is found to be positively associated with private research at the state level.

There is evidence of distance decaying local knowledge spillover effects from HEIs. Sometimes this is associated with formal technical activities, but Kitson *et al* (2009) argue for a more pluralistic view, where HEI –industry interactions occur through a variety of sources, both informal and across a range of disciplines.

Availability of rich dataset enables evaluation of the economic impacts of the decentralisation of higher education in Sweden. Those findings indicate that increased HEI activity enhances local labour productivity and that these effects are contagious over space. Stronger impacts were derived from research intensive institutions and new institutions had stronger marginal impacts than established ones.

Study of cross sectional data for US MSA's gives mixed results. When the sample is split by periods significant results are found after 1986 but not between 1968 and 1986. Similarly when split by the size of the MSA, results indicate universities are more important for smaller region, than big ones, where it is hypothesised they act as a substitute for agglomeration economies, enjoyed by more populated regions.

2.5 Overall Impact Approaches

Previous sections have reviewed various approaches used to estimate partial economic impacts of education and in particular higher education. Section 2.1 covers demand-side or spending impacts of HEIs, whereas sections 2.2 to 2.4 summarise supply side benefits of HEIs and how HEIs affect the location of other activities and actors within a region or nation. In this section, however, I analyse methods that can potentially be used to derive the system-wide or overall economic impact of HEIs. A natural starting point is to review how HEI activity affects macroeconomic indicators identified in the literature on macroecononometric estimates of the determinants of economic growth. I also briefly examine cost-benefit analysis, which is an approach to enumerate in monetary terms the total social costs and benefits of an activity, often applied in public policy settings. Finally I consider the potential of Computable General Equilibrium (CGE) models for simulating the system-wide economic impact of HEIs.

2.5.1 Macro measures (GDP and growth)

This section briefly summarises the literature that applies econometric approaches to macro level data in order to estimate an empirical link between education and economic growth. The microeconometric work reviewed in Chapter 3 shows that at a pecuniary level, education enhances the productivity of individual workers. Furthermore there is evidence of productivity externalities, whereby the level of education positively affects the productivity of the non-educated. Furthermore, from the work on wider benefits, we know that education brings non-pecuniary private benefits, such as better individual health. Furthermore we know that the level of education can bring external benefits such as improved population health, greater democray and lower crime rates. A range of these external benefits may be particularly important at the early stages of economic development, such as its role in stabilizing population growth.

In theory, estimates of the magnitude of these effects at the micro-level could be added up to give an estimate of the overall impact of education, which could then be corroborated by comparison to similar estimates made at the macro level. By its very nature, using macroeconomic data should be better able to capture the wider economic impacts of education, whereas the micro measures are suited to assess individual impacts. Reconciling micro and macro measures of the impacts of education is seen as fundamental to the economics of education research agenda (Psacharapoulos, 2004). However, there are significant methodological difficulties in conducting macroeconometric studies of the growth impacts of education and in many ways this literature lags behind its microeconometric counterpart. But the macroeconomic approach has produced some valuable broad findings which partially reinforce or complement the understanding gained from the microeconometric literature.

The theoretical underpinning to empirical studies that link education and economic growth is provided by growth theory - a range of models that describe the output potential of economies in terms of their supply side[54]. These are taken to be appropriate tools for longer time horizons where economic management has countered shorter term demand disturbances so that the economy is at its full potential output.

Growth theory has two broad strands. The earlier ‘neo-classical’ models treat technological development as exogenous and emphasize factor accumulation as the path that policy makers can pursue in order to stimulate growth. The standard textbook example traces back to Solow (1956). A later development, usually labelled ‘new’ or ‘endogenous’ growth theory, models the level of technological advancement as a function of human capital therefore making technology an endogenous variable that can be affected by policy. This new

[54] Although export lead growth models still consider the role of demand.

theoretical outlook provides a much wider frame for the potential impact of human capital policies.

Under the neo-classical view human capital affects the level of output in the same way as any other factor input, i.e. physical capital or labour[55]. The more of it, the higher the maximum level of output attainable with a given state of technology. Endogenous growth theory, however, maintains that the accumulation of human capital not only raises the level of output, but also the speed of technological development, therefore enabling, in theory, a permanent increase in the rate of growth of economic output. To estimate empirically the validity of these theories there are broadly two approaches: growth accounting and regression using macroeconomic data. Both come with serious health warnings[56].

The first approach is essentially an accounting exercise, where the factor inputs that contribute to the level of economic output are counted and multiplied by the role of each input in generating output changes (marginal social product). The growth that can be explained or attributed to factor accumulation in this way is then compared to actual growth to reveal a residual, or unexplained growth, (total factor productivity), which is sometimes attributed to technological change. Methods for measuring inputs have been extended to allow for differing quality of inputs, which has led to factor accumulation being able to explain a larger part of economic growth, reducing the unexplained residual. The contribution of each input to growth is typically estimated based on the assumption that market prices accurately reflect marginal product.[57] Even if growth accounting is a reasonable way to get some quantitative feel for the role of each factor input, it is not an independent empirical verification as it rests on parameter assumptions which can be varied to produce a range of results.

---

[55] For examples of these extended ´Solow´ models see: Mankiw, Romer & Weil (2002).
[56] For overview see Siansei & Van Reenen (2003) and Krueger & Lindahl (2001).
[57] For a general discussion of growth accounting see: Barrro & Sala-Martin (2004, Ch. 10).

But the available statistical approaches are also not without faults, both in terms of the data and methods applied. Sianesi & Van Reenen (2003) survey over 20 macro growth regressions and argue that overall these provide valuable evidence on the link between education and economic output, especially in terms of qualitative findings, but in light of methodological complications they urge caution in using results to quantify the magnitude of such links. Sianesi & Van Reenen (2003) identify five types of methodological difficulties:

1. Data: There are various difficulties involved in defining and measuring human capital. The quality of the available data has been challenged. Furthermore the data needed come from a variety of sources that may not be internally consistent. This is in addition to difficulties caused by potential differences in data definitions and accuracy between countries.
2. Endogeneity bias: As education is potentially both a cause and effect of economic growth, regressions can be affected by simultaneity bias.
3. Parameter heterogeneity: Cross-country growth studies typically included countries at different levels of economic development and there are indications that the effect of inputs differ at different development stages. This can be solved by splitting the sample into groupings defined by the countries level of development. But this reduces sample size, leading to less accurate parameter estimates than could, in principle, be obtained by using the full sample.
4. Model uncertainty: Parameter significance and sign have been found to be precarious with regards to model specifications, i.e. the other regressors that are included.
5. Non-linearities: Typically a linear relationship is assumed between human-capital accumulation and growth. However, there is no strong a priori reason to assume a linear relationship (Sianesi & Van Reenen, 2003).

Taking the studies as a whole however, Sianesi & Van Reenen (2003, p. 159) argue that "there is compelling evidence that human capital increases productivity suggesting that education really is productivity-enhancing rather than just a device that individuals use to signal their level of ability to the employer". They find that the empirical literature is largely divided over whether the stock of education affects the long-run level (neo-classical approach) or long-run growth rate (new growth theories) of the economy.

> Increasing average education in the population by one year would raise the level of output per capita by between three and six percent according to the former approach, while it would lead to an over one percentage point faster growth according to the latter — an extraordinarily large effect. I think the effect is overstated due to methodological problems such as correlation with omitted variables and the imposition of restrictions that are rejected by the data. I conclude, therefore, that the evidence in favour of the new growth theories (especially for OECD countries) is quite weak due to a whole host of problems (Sianesi & Van Reenen, 2003, p. 159).

Sianesi & Van Reenen (2003) point out some broad qualitative implications supported by the macroeconometric literature. Confirming findings from the microeconometric literature the macroeconomic studies suggest that schooling returns are generally higher in less developed countries than for the OECD and that the quality of education matters for generating a positive impact on growth. Furthermore they argue that; the impact of increased education appears to greatly depend on the level of a country's development with tertiary education being the most relevant for OECD countries; education yields additional indirect benefits to growth, in particular, by stimulating physical capital investments, technological development and adoption; the efficiency with which resources are allocated to the different levels of education also matters considerably.

As for quantitative results, Sianesi & Van Reenen (2003) conduct simulations to give readers a feel for the potential magnitude of effects under both the exogenous and endogenous growth model approaches. Using a number of parameter estimates located within the range found in major studies, they simulate the impact on national output of increasing the human capital stock in an economy with basic features as the UK. For the exogenous growth approach Sianesi & Van Reenen (2003) draw on an augmented neoclassical growth model and estimates of production function parameters from Mankiw, Romer & Weil (1992). They estimate that a doubling of the level of human capital would lead to an increase in output per capita of one third. Furthermore, using different endogenous growth models, Sianesi & Van Reenen (2003) obtain a wide range of results depending on the modelling framework and the parameter values applied. Assuming a 1.5% increase in the human capital stock, with the adjustment occurring over a 40 year period, the outcome of their simulations range 76-fold (in present value terms) depending on the simulation setup[58]. The biggest difference lies in whether the models are set up in term of a level specification (where human capital affects output levels) or a growth specification (where human capital affects the rate of growth). They conclude that the growth specifications yield incredibly large impacts and that a levels specification is more credible for long run impacts, although both yield similar results under typical public policy planning horizons (approximately 4 years).

Some earlier macroeconometric studies have been cited as evidence for the irrelevance of human capital for economic growth. Krueger & Lindahl (2001) point to the studies by Benhabib & Spiegel (1994) and Barro & Sala-i-Martin (1995) as examples of this. Krueger & Lindhal (2001) argue that these negative findings were driven by measurement errors in education data. To illustrate this they replicate Benhabib & Spiegel (1994) and find that by adjusting for measurement error the impact of education is in fact bigger than that typically found in micro studies. They suggest that this result may either reflect significant external effects of education or be driven by omitted variables.

> Although the micro-econometric evidence in several countries suggests that within countries the causal effect of education on earnings can be estimated

[58] Taking the present value of simulated GDP changes over a 40 year period due to a 1.5% one-off increase in the human capital stock, Sinanesi and Van Reenen (2003) find impacts ranging from £bn 14.4 to £bn 1,061.2. For details see Sianesi & Van Reenen (2003, p. 186).

> reasonably well by taking education as exogenous, it does not follow that cross-country differences in education can be taken as a cause of income as opposed to a result of current income or anticipated income growth. Moreover, countries that improve their educational systems are likely to concurrently change other policies that enhance growth, possibly producing a different source of omitted-variable bias in cross-country analyses (Krueger & Lindhahl, 2001, p. 1131).

The literature on macroeconometric studies of the impacts of education and human capital upon output and growth rates is at an early stage of development. Although many interesting studies have been conducted the range of results is wide and there are significant methodological challenges to be overcome. As of yet there is not a widespread consensus on the most appropriate specifications or a plausible central range of results[59]. For a period of time sceptics argued that macroeconometric studies showed no impact of education and the studies referred to making this argument have become well known and widely cited. However, their conclusion has been refuted on methodological grounds. The current consensus is that macroeconometric work confirms the positive economic impact of education or at least cannot be used to refute it (Sianesi & Van Reenen 2003, Temple 2001, Krueger & Lindahl 2001).

2.5.2 **Cost-Benefit applications**

Cost-benefit analysis (CBA) is widely used to derive an estimate of the social net-benefit of public projects by enumerating and evaluating the total social costs and total social benefits. To this end a range of methods and rules are applied. Perhaps the most common use of CBA is for valuing public infrastructure projects, although in principle the technique can be applied to any investment or activity. Hitherto relatively little use has been made of CBA in estimating the impacts of HEIs. Undoubtedly this is due to perceived

[59] One could review existing studies and pass a judgement as to what methods and results are most credible, in order to establish a central range of results. Such an undertaking would be beyond the scope of this chapter but interested readers are referred to McMahon (2004) or the summary of his results in section 3.2.2.

difficulties valuing the non-market benefits of education in monetary terms. Recently however, work has been undertaken to systematically address the issue of identifying the outputs of HEIs and valuing them in monetary terms, see: Kelly *et al* (2005, 2008). Furthermore there are some examples of attempts to derive the social net-benefit of an HEI, e.g. Hill *et al* (2005), Hipple (2001), Feehan, (1995) and Psacharopoulos (1980).

CBA is a bottom up approach which includes identifying the relevant costs and benefits (including externalities), assigning each a monetary value and applying an appropriate discount rate to derive a present value of future cost and benefit streams. As with any method in applied economics (i.e. IO-impact studies or CGE-modelling) each of these steps requires careful consideration and should not be treated as a mechanical exercise. Costs and benefits have to be identified so that there is neither under- nor over attribution of costs or benefits to the activity being evaluated. Various techniques are used to assign prices depending on circumstance and available information and no single discount rate is universally appropriate or accepted. However, sensitivity analyses can be applied around critical parameters to produce a range of plausible outcomes. One of the benefits of CBA is that it is a well-established approach with well know qualities and limitations. If done in a transparent way users should be reasonably able to draw their own judgements as to the validity of assessment for the valuation of individual components and adjust their interpretation of conclusions accordingly.

CBA approaches are outlined in broad brush terms in the Green Book on Appraisal and Evaluation in Central Government (HM Treasury, 2003). Typically in practice public institutions, adopt a simplified "formula" for CBA which is deemed appropriate and useful within their field of work. However at a more general level the methods involved raise some significant theoretical and practical challenges[60].

[60] For an overview straddling both the applied and theoretical challenges of CBA see Layard & Glaister (1994).

In general it can be said that results on the cost side of HEIs are relatively straightforward to estimate on the basis of accounting data and the results of such exercises are widely accepted. The difficulties arise when assigning a monetary value to the benefits provided by HEIs[61].

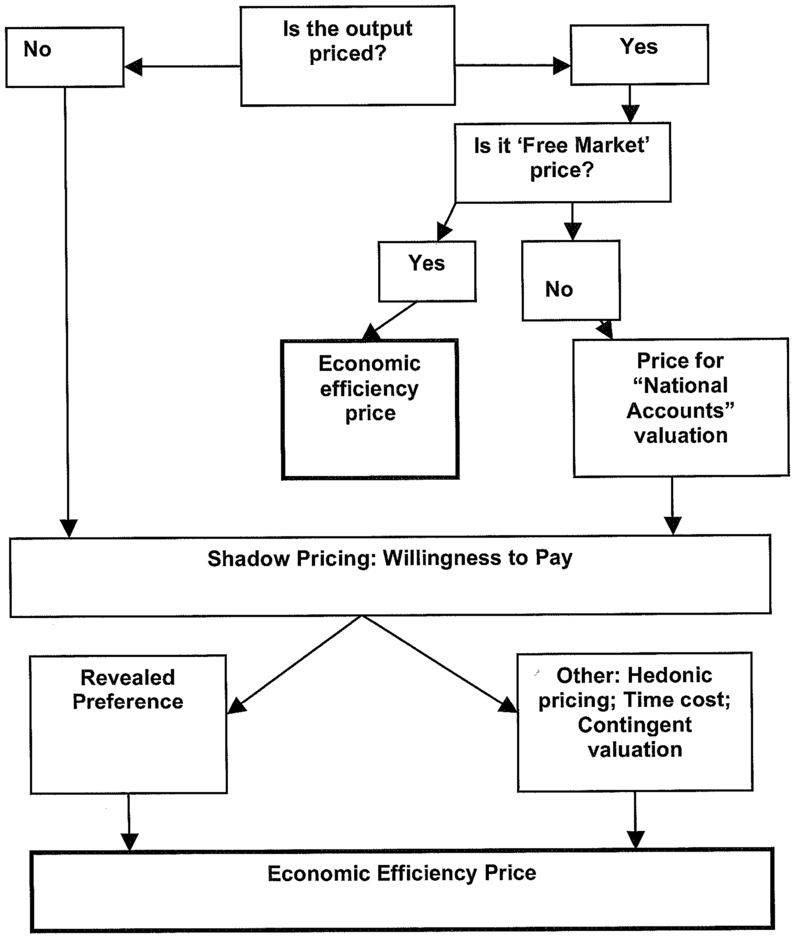
In their case study of the University of Strathclyde, Kelly *et al* (2008) identify over 220 separate outputs, which could subsequently be valued on CBA basis, as part of 6 broad activity categories undertaken at the university:

- Teaching
- Research
- Consultancy/Advisory work
- Cultural Outreach
- Community Outreach
- Other

Furthermore, they identified potential volume measures for these outputs. For pricing these outputs they suggests a schematic approach in line with recognised CBA approaches as summarised in Figure 5.

[61] These include all outputs of the university education.

Figure 5 Pricing outputs for CBA. Source: (Kelly *et al*, 2008, p. 14).



Kelly *et al* (2008) point out that the price applied in a CBA context is not necessarily equivalent to the income received by the HEI for undertaking the considered activity, as for many activities there isn't a specific remuneration or this does not reflect the economic value of the output. For example academic's testimonials to parliamentary committees are typically unfunded.

> With some outputs it is relatively straightforward to identify the 'free market rate'. With 'Teaching', for example, the current 'overseas' full fee rate is likely to be the most appropriate 'free market rate' for a year's tuition, given that this is an area where HEIs operate in an open and competitive national and international market place and tend to pitch their fee rates at 'what the market

will bear'. With government advisory work, an appropriate 'free market rate' could be the hourly consultancy rate charged by an equivalently qualified and experienced professional consultant. There are also a range of techniques such as 'willingness to pay' or 'willingness to spend time' which can be used to deduce prices where no 'free market rate' equivalent is easily identified (Kelly *et al*, 2008, pp. 13-14).

An interesting example of an HEI Cost-benefit analysis in practice is that of the Memorial University of Newfoundland (Feehan, 1995). The study identifies and values teaching and research as the main source of benefits from the universities activities. Although Feehan (1995) recognises and cites examples of externalities and public amenities provided by the university these are excluded from valuation in the study.

> There is considerable appeal to the notion that there are benefits to Memorial University research and teaching beyond what has already been attributed to them in this study. However, there is no accepted means of calculating the values of those externalities. Without such a methodology, any estimate could be criticized as highly speculative. Moreover, there is a severe credibility problem if one were to advocate expenditure on any activity on the basis of beneficial externalities when those externalities may be impossible to measure (Feehan, 1995, pp. 60-61).

Overall Feehan estimates that the present value of the university's benefits is equivalent to approximately 173% of total costs. The single biggest benefit, by far, is from education benefits (valued at 146% of total costs) and research (valued at 16% of total costs). The benefits of education provided by Memorial are estimated as the present value of the future wage premium of memorial graduates (based on historical observations of wage premiums for Canadian graduates, less a 30% allowance for ability bias in wage premiums).

To estimate the value of research Feehan (1995) draws on some previous work on the returns to basic research and assumes a (rather conservative) 7% return. Furthermore he makes the precautionary assumption that only 60% of research expenditures contribute to this return and that the remaining 40% contribute to duplication of existing research or educational benefits.

Feehan (1995) acknowledges the need to recognise the cost of obtaining the public funds, which finance 75% of the university's operations. Doing this is not straightforward (nor universal practice in CBA) due to both uncertainty about the level of the "excess burden of taxation" and how it is most appropriately treated. Feehan (1995) cites Musgrave *et al* (1987) who estimated that for Canada the "excess burden of taxation amounted to 33% of every dollar raised. Including this extra cost lowers the estimate of net benefits from approximately 73% of university expenditures to approximately 48%.

A limitation of CBA, as it is typically implemented, is that it is a partial equilibrium framework, i.e. it does not take into account the econmywide implications of the policy being analysed through impacts on prices and quantities and subsequent knock-on impacts. To capture these effects requires the use of general equilibrium models. Heckman, Lochner & Taber (1999ab) and Klaiber & Smith (2010) discuss the differences between partial- and general equilibrium policy analysis and how general equilibrium effects can best estimated using a dynamic overlapping generations model and a CGE model, respectively. The next section explores the application of CGE-models to simulate the economy-wide impacts of HEIs.

2.5.3 **Modelling work**

A recent development is the application of Computable General Equilibrium (CGE) models to simulate the potential economic impact of HE-policies. The use of such simulation models is particularly relevant where there are insufficient data to address a policy issue using statistical models or where the analytical potential of statistical observation has been exhausted. CGE models incorporate the supply and demand sides of the economy, with sectors and transactors linked together using well known micro- and macroeconomic principles to represent a stylised view of the circular flow of economic activity. The models are parameterised to recreate their base year values. They can then be subject to some exogenous disturbance that replicates the direct policy impact. The model then identifies the impact of subsequent interaction within the model on the endogenous economic variables (such as employment, GDP, etc.) The structure of these models and level of detail is typically determined by the application they are designed for. Common applications include development policies, regional policies, taxation and trade analyses. With existing levels of computing power these models are an efficient way to provide answers to "what if" questions. Typically modellers will run a wide range of potential scenarios representing different views and assumptions about the direct impacts of the policy and its transmission mechanism within the economy. These provide a range of outcomes from limiting cases to scenarios that are judged to be more plausible. Often these simulations provide results which, at least for particular subsets of inputs, run counter to what would be expected from partial equilibrium analyses. I shall discuss CGE-models in more detail in Chapter 6, where I calibrate a CGE-model of Glasgow and use it to simulate the economic impacts of HEIs.

The application of CGE models to HE policies is a nascent development. So far there is only one peer reviewed publication on the subject, which applies the Australian Monash model. However, further work is under way at the University of Stratchlyde applying the AMOS model to HE policies in the UK regions (see for example Hermannsson *et al,* 2010d, g).

2.5.3.1 Application of the MONASH model to HE in Tasmania

Giesecke & Madden (2006) employ a dynamic multiregional computable general equilibrium (CGE) model to analyse both demand- and supply side impacts of the University of Tasmania in Australia. Typically impact studies have focused on the demand side impact HEIs have on the regional economy. CGE allows the effects of both demand- and supply-side stimuli to be examined while the dynamic features of the model enable subsequent effects on a region's population and capital stock growth rates to be incorporated (Giesecke & Madden, 2006).

In their estimation of the supply side impacts of the University of Tasmania Giesecke and Madden (2006) leave aside various effects that might be considered to contribute to the local economy but are difficult to quantify. Instead they model two supply-side effects they identify as the major ones amenable to quantitative analysis: the productivity impact of R&D and the increase in the skill level of the Tasmanian labour force.

R&D is assumed to translate into a productivity shock through its addition to the national stock of knowledge, which is seen to be positively related to primary factor productivity. That relationship has been estimated for Australia using econometric methods. They base their calculation of the productivity impact of the University of Tasmania on Dixon & Madden (2003) who estimate the social rate of return on research funded by the Australian Research Council to be approximately 50%. In this case the social rate of return is defined as the increase in GDP as a percentage of the dollar cost of the investment that lead to the GDP increase.

Dixon & Madden (2003) base their calculation on an increase in GDP and cumulative research funding over a 10 year period. This is interpreted by Giesecke & Madden as meaning that 50% rate of return is on the stock of knowledge, which they point out is consistent with econometric work. They assume Tasmanians capture 25% of the benefits directly and the rest is enjoyed equally by all Australians. Hence by virtue of their population fraction Tasmanians should enjoy roughly 2% of those benefits. In a nutshell they calculate the rate of return from the stock of knowledge (which is measured as cumulative research funding, less 10% annual depreciation) and find the Tasmanian fraction of that based on the aforementioned assumptions. Change in total factor productivity is then found as the change necessary to bring about the estimated social benefit.

For the second productivity shock of increased skill level of the regional workforce they approach the issue in two steps, first by estimating the number of additional graduates living in the region as a result of the presence of University of Tasmania and then estimate what impact higher education has on the productivity of each worker. The latter is derived from the graduate wage premia. Citing Borland *et al* (2000) they claim the standard assumption is that 80% of the wage difference is due to higher education and 20% to innate abilities. Therefore returns to higher education are calculated as 80% of the difference between the graduate and non-graduate wage (Giesecke & Madden, 2005).

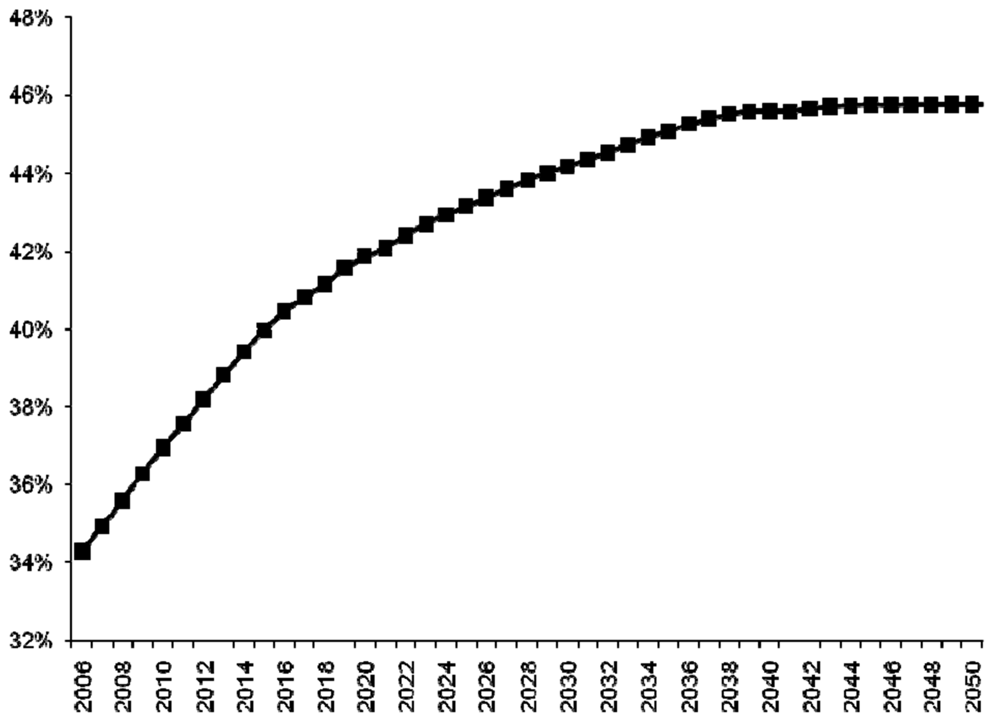
They note that the supply side effect tends to be cumulative as R&D outcomes add to the stock of knowledge (as long as successful R&D outcomes exceed knowledge turning obsolete) and retention of students adds to the number of university graduates working in Tasmania. Based on their simulation of both supply- and demand-side effects they conclude that the macroeconomic impact of 100 EFTSU (equivalent full time student units) equals between 1.6 $m and 2.1 $m. Overall they conclude that demand side impacts dominate over the supply side impact.

2.5.3.2 Scottish HEI applications using the AMOS model

Hermannsson *et al* (2010d) relate improvements in the skill base of the workforce to improvements in GDP using a similar approach to that adopted in Giesecke & Madden (2005). That is, the graduate wage premium is used to derive estimates of improvements in labour productivity due to a higher average skill level of the labour force. The economic impact of the potential increase in average skills in the labour market is simulated under the assumption that the number of graduates from Scottish HEIs after the 2006/07 academic year changes proportionately to the number of people aged 20-25 and that the retention rate of graduates within the regional labour force remains constant. The long-run implications of a higher participation rates since the late 1990's is a gradual increase in the share of graduates in the labour force as illustrated in Figure 6 below.

A range of sensitivity analyses are conducted around the scale of the labour productivity improvement brought about by increasing skills. These relate to the magnitude to the graduate wage premium and the extent to which the wage premium captures a true treatment effect of education in terms of productivity improvement and to what extent it may be reflecting other factors such as innate ability (signalling). As is evident from Chapter 2.2 these issues represent a theoretical and empirical challenge and are difficult to pin down exactly. Therefore an appropriate response for policy simulations is to explore the implications of the range of these potential outcomes identified in the literature.

Figure 6 Share of graduates in the Scottish labour force (Hermannsson *et al,* 2010d, p. 17).



The results suggest that the long term improvement in GDP due to the gradual accumulation of skills in the labour market (based on the current scale of the HEIs sector) range from 2.3% to 5.9% based on various assumptions relating to the scale of the productivity impact. A further range of sensitivities comes from various economic viewpoints and assumptions regarding the setup of the model, such as labour market structure, regional migration, and Scotland's integration into UK and World product markets. I discuss the approach of Hermannsson *et al* (2010d) further in Chapter 6, where I apply it to simulate the economic impact of increasing the share of graduates in the Glasgow working age population.

2.6 What we know from existing evidence

The aim of this chapter was to summarise and bridge the disparate literatures on the economic impacts of HEIs. The end of each section has presented relatively detailed findings for the fields being summarised. Therefore the emphasis here will be on providing broad conclusions.

Available evidence supports the view that higher education provides positive economic impacts. Demand-side impacts can be significant and positive, although some qualifications have to be made when accounting for the impact of HEIs' spending of public funds (subject to a binding budget constraint). The most important benefits of higher education are probably its supply side impacts.

Reviewing the academic literature, it is clear that as of yet the understanding of the economic impacts of education leaves a lot to be desired. This is a difficult agenda to advance as the work cuts across many disciplines, the possibilities of using controlled experiments is limited and primary data collection is both very expensive and potentially very time consuming (as in the case of longitudinal data). A retrospective view of the longest established strands of these literatures (such as the econometric work on wage premia surveyed in Chapter 3) suggests that developments have occurred in small increments with significant repetitions of previous work. Furthermore, limitations of available data have undermined the robustness of findings and generated prolonged periods of ambiguity.

For conventional demand-side work, some estimates revealing very high multiplier impacts of HEIs spending are probably based on overly optimistic methodology. However, claims that HEIs have no net-spending impact at the regional level are equally unrealistic.

I argue that even if public spending as a whole (the Scottish block grant) is additional to the Scottish economy it is not appropriate to claim an 'impact' for the particular institution spending that money. Public expenditures in a devolved region like Scotland face a binding budget constraint and if the money had not been spent on HEIs it could have been spent on some other beneficial public service. However, HEIs are only partially funded from the Scottish Government and they bring in funding that is additional to the Scottish economy. Furthermore they provide the regional economy with the consumption spending of incoming students.

Theoretical and empirical studies suggest that increasing graduate supply can, in principle, both work to increase, as well as decrease, the rates of return to education (in terms of individuals' wages). This depends on whether the existing supply of graduates is primarily restricted due to academic ability or availability of finance. A long-run static view would suggest that returns to education would eventually diminish if the supply of graduates continued to rise over time. However, the world is not static and, as empirical evidence reveals, demand for education has grown together with supply, sustaining high returns to education for over a century in the USA (where the longest time series data are available).

The progress towards an empirical consensus on graduate wage premia has not been smooth. At each successive stage the notion that education as such improves labour market performance has been robustly criticised. This debate has been prolonged by a lack of datasets that would allow sufficiently robust analyses. However a number of studies drawing on natural experiments and twin datasets have underpinned the consensus view that education as such does independently improve skills important in the labour market. Conversely, if taken out of the context of the overall literature provided by more than 30 years of academic debate, individual published papers can be extracted to refute economic benefits of education in the labour market.

In models of sorting in the labour market, students are thought to signal their ability, or firms screen job applicants, using academic qualifications. These models are theoretically elegant and boast a pedigree of some major names in economics (Arrow, Stiglitz). They offer a plausible explanation of the labour market in the short run. However their implications have been over-interpreted to mean the demise of human capital theory and the productivity of education. Such a result requires a careful misunderstanding of the literature and a selective look at empirical evidence. However, this dismal interpretation of sorting hypotheses seems to attract a lot of attention.

In addition to the direct supply-side impacts of HEIs, there are wider benefits and longer term socioeconomic feedbacks, which are potentially much bigger than the impacts traditionally quantified hitherto. However, enumerating the value of these effects is an elusive task. In particular it is doubtful to what extent they can be disentangled from other socio-economic advancements and to what extent they can be attributed solely to the direct effects of higher education.

At the regional and sub-regional levels, the impacts of HEIs are potentially much larger than at national levels. A significant body of academic research suggests HEIs exert gravity on people, knowledge and knowledge related activities, such as R&D, which can affect the spatial distribution of productive capacity within the national economy. This does not necessarily affect national output, but may have strong impacts locally. However in principle, there is nothing to preclude such effects from working over national borders. Indeed, with increasing economic integration it is highly likely that the national value of such HEI-associated pull effects will, if anything, increase.

Work on aggregate econometric estimates of the economy-wide impacts of HEIs (and education in general) has yet to resolve significant challenges regarding the precision and robustness of such analyses. This is in addition to classical concerns about inferring causality from observational statistics. Figuratively speaking, this field is likely to be the 'battleground' over the true economic impact of education for the coming decades.

Existing evidence suggests the overall economic benefits of education are potentially very large and certainly large enough to disregard pessimism about the returns to education. However, there is still much work to be done to establish definite answers from the point of view of public expenditure decisions. Firstly we need to ascertain whether more investment in education at the margin will justify the marginal cost of public funds and secondly how the substitution of education compares up with other public expenditure and investment opportunities.

A synthesis of different views can be advanced using simulation models. The policy simulation approach is agnostic in that it can accommodate different theoretical views and assumptions to address 'what if' questions. It offers a way of estimating the potential impacts of HEIs, whilst acknowledging the multitude of uncertainties and different views present under the current state of the art.

Existing challenges are unlikely to be fully resolved through theoretical or empirical means in the near future. Therefore it can be useful to take an agnostic stance and estimate the impacts of HEIs by asking a number of "what if" questions, reflecting the range of assumptions that can be reasonably motivated under the current state of knowledge.

3 Construction of Input-Output databases

3.1 Introduction

In this chapter I construct the Input-Output (IO) database that forms the basis of my analysis. This is put to direct use in Chapter 5 where I analyse the expenditure impacts of HEIs and their students. Furthermore, in Chapter 6 I draw on the IO databases to construct a Social Accounting Matrix (SAM) for Glasgow. The SAM is required to calibrate a CGE-model, which I then use to analyse the supply-side impacts of HEIs. The construction of the IO database proceeds in two steps. First I disaggregate the education sector in the Scottish IO tables to obtain a separate sector for each of the 20 HEIs in Scotland. Once the HEI-disaggregated Input-Output table of Scotland is complete I proceed to disaggregate it by regions to obtain a 3-region HEI-disaggregated Input-Output table for Glasgow, the Rest of the Strathclyde area and the rest of Scotland.

3.2 HEI disaggregated Input-Output table for Scotland

In this section I build on the official Input-Output tables for Scotland to construct an HEI-disaggregated Input-Output table for Scotland. Within this table each Higher Education Institution (HEI) in Scotland is represented as a separate sector with its own row, detailing its income structure, and its own column for its expenditures.

The HEI-disaggregated Input-Output table was constructed in tandem with the Overall Impact of Higher Education Institutions on Regions project (Hermannsson *et al*, 2010a) and has been used as the basis for a number of recently published analyses (Hermannsson *et al*, 2010b, c, d). Furthermore, the same method has been used to construct HEI-disaggregated Input-Output tables for other UK regions (Hermannsson *et al*, 2010e, f). The tables have several applications. They provide a useful descriptive snapshot of the Scottish economy and the role of HEIs within it for a particular year, 2006. The table can also be used to calibrate a conventional input-output model that enables the derivation of, for example, output, value-added and employment multipliers for each higher education institution, as well as for the HEI sector as a whole.

Furthermore, the table facilitates a wide range of additional Input-Output based "impact" studies, and may also be used in attribution analyses. The Input Output table is, in addition, an essential component of databases used to calibrate other multi-sectoral, HEI-disaggregated models of regional economies, including Social Accounting Matrix (SAM) and computable general equilibrium (CGE) models.

To my knowledge this is the first example of an Input-Output table that treats each Scottish HEI as a separate sector in a single unified framework. In the construction process I do not apply universal assumptions to all HEIs, but rather seek to determine incomes and expenditures individually for each in a coherent and transparent manner. This enables the first consistent comparison of the expenditure effects of individual HEIs in Scotland. To a significant degree I can determine the income and expenditure structure of each HEI from accounting data relating to each institution, by drawing on databases provided by the Higher Education Statistics Agency (HESA). In addition I employ survey data and purchasing data from the Joint Consultative and Advisory Committee on Purchasing (JCAPC), the purchasing consortium of HEIs in Scotland and Northern-Ireland. Nevertheless, I have to make some general assumptions in respect of a number of elements of incomes and expenditures. While these impact on a relatively small part of the relevant totals, I endeavour to be as transparent as possible, so that other researchers may scrutinise our assumptions, and perhaps choose to modify them, in future expenditure analyses of Scottish HEIs.

The chosen reference year is 2005/2006 since this is the latest year for which the necessary data were available, when this work commenced. The procedure used to derive the HEI disaggregated IO-table can be divided into two steps. First I "rolled forward" the 2004 Scottish IO table to reflect changes in Gross

Value Added (GVA) from 2004 to 2006. I then create an individual row and column for each institution.

3.2.1 **Rolling forward the 2004 IO table**

Since the academic year 2005/2006 has been chosen as the reference year of the study, the official Scottish analytical I-O Table for 2004 (Scottish Government, 2007) had to be rolled forward to reflect the output level and prices in the year 2006. This is done using Gross Value Added (GVA) as a benchmark. Between 2004 and 2006 GVA increased by 10.28% from £82,538 million to £91,024 million. All of the figures in the official 2004 table are uniformly adjusted upwards by a factor of 1.1028. Comparisons of surveyed IO tables have shown that changes in the technical structure of an economy occur slowly so that limited change can be expected over the short run (Miller & Blair, 2009). Accordingly, extrapolating the table to reflect price and volume changes over a two-year period is unlikely to result in significant errors. Furthermore, the analysis can be updated in due course to assess the impact of this assumption.

3.2.2 **Disaggregation of the Education Sector**

The next step is to separate out the HEIs' sector from the education sector as a whole, which corresponds to IO sector code 116 in the official Scottish IO accounts. The additional data required are sourced from HESA (2007a), which gives information on output totals and expenditure on wages. In addition, data on income by source can be used to estimate exports for each institution. By combining income and expenditure totals from HESA with accounting and survey data on HEIs' expenditures I am able to construct a separate row and column for each institution. Finally, the individual HEI rows and columns are summed and then deducted from the education sector in the IO table to form an Education sector that excludes HEIs.

3.2.2.1 Creating separate columns for each HEI

A column in an IO table reveals the total expenditure of a sector and how it is divided between intermediate inputs, imports and valued added. The following is a description of the steps taken in creating a separate column for each HEI.

The first issue is the estimation of imports for each institution. I have data on the amount of interregional and international imports from JCAPC, the purchasing consortium for Scottish and Northern Irish HEIs. These data reveal aggregate expenditures by Scottish HEIs broken down by category and geographic location of suppliers (Scottish, rest of UK (RUK), overseas). Imports were 12.9% of total output in 2005/2006. Ninety eight per cent of total imports come from RUK and only 2% are international imports, so that the interregional links predominate. The data do not reveal purchases of individual HEIs so the proportions are applied uniformly to all of them. This import propensity differs from ones assumed in previous impact studies. For example (Kelly 2004) assume 25% while (Harris 1997) calculates imports to be 22% based on the narrow geographic definition of Portsmouth. Input-Output tables for Scotland record imports to the education sector at 11% of the value of total output.

Table 12 Summary of HEI columns.

Column Component	Level of detail	Data source
Total expenditure	Individually determined for each HEI	HESA accounting data
Imports	Determined in a uniform manner for all HEIs	JCAPC data on aggregate purchases of Scottish and N-Irish HEIs
Compensation of employees	Individually determined for each HEI	HESA accounting data
Taxes on expenditure	Proxied by assuming ratios for the education sector as whole hold for HEIs	Scottish Input-Output tables
Other Value added	Proxied by assuming ratios for the education sector as whole hold for HEIs	Scottish Input-Output tables
Intermediate expenditures	Total intermediate expenditures determined as a residual item. Distributed uniformly across all HEIs based on an expenditure survey	Expenditure survey obtained from previous work done by Kelly *et al* (1997).

From HESA publications I have data on employment costs (compensation of employees) and total output (income) by source. The remaining elements of each IO column I need to derive are: the intermediate purchases, net taxes and gross operating surplus. Net taxes and gross operating surplus were determined for each HEI as the same proportion of overall expenditure as in the education sector as a whole (IO116) in the 2004 tables. These represent a small fraction of overall expenditure: 2.8% for net taxes and 3.1% for gross operating surplus.

Having identified all of the other cost elements the residual is the amount of intermediate purchases from Scottish industries. The sectoral distribution of this expenditure was governed by the coefficients used by Kelly *et al* (2004). These coefficients of intermediate expenditures are based on a survey of UK HEIs described in Kelly *et al* (1997). Production technology in IO tables has been found to change only very gradually (Miller & Blair, 2009). It is likely therefore that new survey-based information would have a modest impact, since it would only alter the composition of intermediate inputs and since expenditures on intermediate inputs are less than a quarter of the total output of HEIs (23% on average). In any case there was no funding available for new survey work on HEIs in the current project, but this could easily be revisited in future.

3.2.2.2 Creating separate rows for each HEI

A row in an IO table reveals the total income of a sector and the various components of income, including intermediate sales to other production sectors and sales to final demand sectors such as households, government and exports. Table 13 summarises the methods and sources I used to identify individual HEI's revenues.

Table 13 Summary of HEI rows.

Row Component	Level of detail	Data source
Income from exports	Individually determined for each HEI	Accounting data from HESA
Income from Scottish Government	Individually determined for each HEI	Accounting data from HESA
Income from other final demand categories and intermediate demand	Income apart from exports and Scottish Government funding is uniformly distributed along the row based on proportions of the overall education sector	Scottish Input Output table

Drawing on HESA data allows us to construct IO rows that reflect the particular structure of each HEI's income. HEI incomes from Exports and the Scottish Government amount to 29% and 54% respectively of HEIs' income on average. These two categories alone represent 83% of the HEI sector's total income and are determined separately for each HEI based on HESA accounting data. This is a key feature of the HEI-disaggregated IO table, which enables an accurate account of the heterogeneity of HEIs' income structures. The residual obtained by deducting the sum of export and government income from total income is then distributed along the row (other final demand categories and intermediate demand) in the same proportions as in the overall education sector (IO 116) of the Scottish Input-Output tables.

Table 14 Attribution of HESA income sources in IO table to origin – Scottish Government, rest of the UK (RUK), rest of the World (ROW) and other demand.

Income category	Attribution	Total
Funding Council grants		
Recurrent grants (Teaching)	Scottish Government	28%
Recurrent grants (Research)		9%
Recurrent grants (other)		3%
Release of deferred capital grants		1%
FE provision		0%
Tuition fees & education grants & contracts		
Standard rates	Attributed to ScotGov and RUK demand based on student numbers	8%
Non-standard rates		2%
Part-time HE fees		1%
Non-EU domicile	ROW	7%
Non-credit bearing course fees	Other (local demand)	1%
Other fees & support grants		1%
Research grants & contracts		
OSI Research Councils	RUK	7%
UK based charities	Indirectly attributed	4%
UK central government/local authorities, health & hospital authorities		3%
UK industry, commerce & public corporations		2%
Other sources	Other	0%
Other overseas sources	ROW	1%
EU sources		2%
Other income - other services rendered		
UK central government/local authorities, health and hospital authorities, EU government bodies	Indirectly attributed	2%
Other		3%
Other income - other		
Grants from local authorities	Scot Gov	0%
Release of deferred capital grants	Indirectly attributed	1%
Income from health & hospital authorities (excluding teaching contracts for teaching provision)		1%
Income from intellectual property rights		0%
Residences & catering operations (including conferences)	Student numbers	6%
Other operating income	ROW	5%
Endowment & investment income	Other	2%
		100%

HESA classifies HEIs' income into broad categories and a number of subcategories. I allocate these incomes to four distinct categories depending on whether they come from the Scottish Government and whether they originate within or outwith the Scottish economy. From the definitions of these sub-categories, 84% of HEIs income can be attributed directly either to local demand (Scottish Government or other demand) or export demand (RUK, ROW). The remaining 16% of HEIs income categories constitute income originating from some combination of either local, RUK or ROW sources, for which the exact proportions are unknown. In these cases income is attributed indirectly based on the weights revealed by income sources with a known and unambiguous origin. The details of how each of these accounting categories is treated are provided in Table 14 above.

In the remainder of this section I discuss the treatment of income sources and the assumptions required to allow us to attribute all of HEIs' income to IO demand categories. I begin by considering those income categories that have a clear origin, and then discuss our treatment of those that are more ambiguous.

3.2.2.2.1 Funding Council grants

The whole of the category 'Funding Council Grants' reports funding provided by the Scottish Funding Council (SFC). This is ultimately drawn from the Scottish block grant and hence attributed to the Scottish Government.

3.2.2.2.2 Tuition fees & education grants & contracts

In the HESA dataset tuition fees are pooled for Scottish, RUK and REU students. Student numbers by origin are used to disaggregate these into Scottish, RUK and REU tuition fees. The Scottish Funding Council pays for Scottish students. I treat the tuition fees of REU students as Scottish Government demand under the assumption they are all Erasmus exchange students, whom the Scottish Funding Council pays for as well. RUK tuition income is treated as RUK exports. Tuition fees of students from outwith the EU are treated as ROW exports. *Non-credit bearing course fees* and *Other fees & support grants* represents courses that the HEIs charge for and are therefore attributed to *Other demand*. HESA (2007a) does not explicitly define the category *Other fees & support grants*. This is assumed to be income from *Other* local demand.

3.2.2.2.3 Research grants & contracts

Research income from the OSI research councils[62] is treated as RUK exports as these are funded by the central government of the UK. *Other overseas sources* and *EU sources* are classed as ROW exports. *Other sources* are, for simplicity, assumed to come from other demand[63] Other sub-categories under this heading are indirectly attributed (see discussion below).

3.2.2.2.4 Other income – other services rendered

These income streams are for various services rendered, including consultancy to external bodies both public and private, UK and foreign. These are attributed indirectly (see further discussion below)

3.2.2.2.5 Other income – other

The category *Other income – other* is treated in three different ways depending on the sub-category. *Grants from local authorities* are attributed to the Scottish Government. This is a simplifying assumption as only a part of Scottish local Government's incomes are derived from the Scottish Government and the Scottish block grant. *Residence & catering operations* mainly comprises student residences and on-campus catering services consumed by students. Therefore I use student numbers by origin to attribute this income to local demand and exports. Some of these services are consumed by conference attendees. I assume that the ability of the university to attract conference guests is proxied by the student population. *Other operating income* is treated as ROW exports since, according to HESA definitions, this mostly comprises European funding sources. *Income from intellectual property rights* is for simplicity assumed to stem

[62] The category "OSI Research Councils" refers to funding from the various UK research councils: http://www.rcuk.ac.uk/

[63] This only contributes 0.34% of HEIs income and so is not a material concern.

from other local demands[64]. The remaining sub-categories are attributed indirectly.

3.2.2.2.6 Indirectly attributed incomes

Seven HESA accounting categories, 16% of the total of HEIs' income, have an ambiguous spatial origin. Although I cannot directly determine the origin of the various incomes that have to be attributed indirectly, the definitions of the HESA accounting categories give some indication of their nature. I try to capture this by devising an attribution mechanism that is consistent with the nature of the income category. The application of these is summarised in Table 15 and described for each case below.

3.2.2.2.7 Research grants & contracts

Income from 'UK based charities' is from charities in either Scotland or other UK regions. I expect the HEIs to draw mostly on local charities, so I attribute this income category to O*ther local demands*. However, I allow for some export income from RUK in the same proportion as the RUK export intensity of research income.

Income from *UK central government/local authorities, health & hospital authorities* will by definition either originate from central government funding at the UK level, in which case it will be counted as RUK-exports, or from funding sources that can ultimately be traced back to the Scottish block grant and hence will be attributed to the Scottish Government. To determine the relative weight of each I use non-student incomes as revealed by directly allocated income as a basis for distribution to final demand.

UK industry, commerce & public corporations is assumed to originate from other regions of the UK, in which case it is counted as exports, or Scottish non-government sources (intermediate demand) in which case it is attributed to other local demands. To determine the proportion that is attributed to RUK-

[64] The category only comprises 0.24% ofScottish HEIs income.

exports I use the RUK export intensity of research incomes with known spatial origin (30%). I assume that the HEIs predominantly interact with local producers and hence allocate the remainder of this income to other local demands.

3.2.2.2.8 Other income – other services rendered

UK central government/local authorities, health and hospital authorities, EU government bodies can in principle originate from both local and external, and public and other bodies (e.g. the Scottish Government, Scottish production sectors, UK-consumers, EU-funding, etc,). I use non-student income as revealed by directly attributed income sources as a basis for distribution among final demand categories. This income category includes income from non-departmental public bodies and because of its services-rendered nature it is reasonable to assume some of this is intermediate demand from Scottish production sectors (other local demands), rather than attributing it solely to Scottish Government demand and exports.

Income classed as 'Other' is assumed to originate either from intermediate demand or exports. Again, I assume this income is primarily raised locally except for RUK income, based on the RUK export intensity as revealed by directly attributed income sources.

Table 15 Indirect attribution of incomes.

	% of total income	Attributed to: Scot Gov	RUK	ROW	Other
Research grants & contracts					
UK based charities	4%		●		●
UK central government/local authorities, health & hospital authorities	3%	●	●		
UK industry, commerce & public corporations	2%		●		●
Other income - other services rendered					
UK central government/local authorities, health and hospital authorities, EU government bodies	2%	●	●	●	●
Other	3%		●		●
Other income - other					
Release of deferred capital grants	1%		●		●
Income from health & hospital authorities (excluding teaching contracts for teaching provision)	1%	●	●		
	16%				

3.2.2.2.9 Other income – other

Release of deferred capital grants comprises capital grants from sources other than the higher education funding councils. I assume this can involve local non-government sources as well as sources in RUK and ROW (perhaps EU). I assume the pattern of this income source follows that of the HEIs research income in general and use the previously revealed origins of research income as a basis for distributing these grants between other demands and RUK and ROW exports.

Income from health & hospital authorities (excluding teaching contracts for teaching provision) can in principle derive from health and hospital authorities either within Scotland (in which case they are ultimately derived from the Scottish block grant) or the other regions of the UK (in which case it will be treated as RUK exports). To determine the relative weight of each I use non-student incomes as revealed by directly allocated income as a basis for distribution to final demand.

Table 16 Income of Scottish HEIs by origin, £m %.

	Devolved Government		RUK Exports		ROW exports		Other		Total	
Aberdeen	85,018	54%	20,262	13%	25,324	16%	26,379	17%	156,983	100%
Abertay	22,826	70%	1,530	5%	5,884	18%	2,215	7%	32,455	100%
Bell College	17,551	88%	59	0%	1,513	8%	801	4%	19,924	100%
Dundee	83,380	51%	24,109	15%	24,848	15%	31,635	19%	163,971	100%
ECA	10,222	70%	858	6%	2,757	19%	869	6%	14,707	100%
Edinburgh	186,796	43%	86,442	20%	73,802	17%	88,528	20%	435,569	100%
Caledonian	73,925	76%	2,681	3%	13,064	13%	7,974	8%	97,644	100%
GSA	11,238	71%	1,018	6%	2,570	16%	973	6%	15,799	100%
Glasgow	160,862	51%	41,771	13%	41,943	13%	67,796	22%	312,372	100%
Heriot-Watt	46,119	46%	14,068	14%	23,188	23%	16,169	16%	99,545	100%
Napier	58,953	72%	2,680	3%	10,278	13%	9,440	12%	81,351	100%
Paisley	46,910	80%	378	1%	5,980	10%	5,212	9%	58,481	100%
QMUC	19,199	70%	1,706	6%	3,836	14%	2,830	10%	27,570	100%
R. Gordon	50,008	67%	1,837	2%	9,844	13%	13,395	18%	75,084	100%
RSAMD	6,801	66%	407	4%	1,613	16%	1,556	15%	10,378	100%
St Andrews	40,216	37%	27,613	25%	28,342	26%	12,592	12%	108,762	100%
SAC	22,360	51%	5,196	12%	7,341	17%	8,762	20%	43,659	100%
Stirling	46,867	56%	7,928	9%	16,115	19%	12,754	15%	83,663	100%
Strathclyde	110,508	58%	16,223	8%	28,351	15%	35,972	19%	191,054	100%
UHI	25,026	71%	5,540	16%	3,220	9%	1,579	4%	35,365	100%
Total Scotland	**1,124,784**	**54%**	**262,306**	**13%**	**329,813**	**16%**	**347,433**	**17%**	**2,064,336**	**100%**

The calculated exports and Scottish Government incomes directly enter the rows as final demand categories. To complete the row I use coefficients of the Education sector from the existing IO table to distribute other income between other categories of final demand and intermediate income from other sectors for each institution. This concludes the procedure of estimating the IO rows for each institution.

Having derived columns and rows for each HEI I next incorporate them into the existing (rolled forward) Input-Output table. The estimated rows and columns are subtracted from the existing "Education" sector. The resultant IO table has 148 sectors of which 20 represent the higher education institutions themselves.

3.2.3 **Sectoral employment**

Sectoral full-time-equivalent (FTE) employment figures are based on those published in the 2004 Scottish IO tables. Since the base year is 2006 these had to be updated. For this I use head count data from the Annual Business Inquiry, which reports full time and part time employment by region. Following convention, part time employment was divided by 3 to approximate full time equivalence. Comparing headcount figures for 2004 and 2006 reveals an employment growth of 1.4%, which was used to update the FTE employment level. Employment in the HEIs is reported in Table 25 of HESA (2007), which reveals FTE employment of all staff of each HEI for the academic year 2005/2006.

3.2.4 **Student numbers**

Student numbers are used to disaggregate UK tuition fees by their origin from within Scotland or from other UK regions (RUK). Furthermore, in subsequent applications of the IO-tables, for calculating the economic impact of HEIs, student numbers are used to inform the estimation of students' consumption impact. The published student numbers in HESA (2007b) do not provide sufficient detail on the spatial origin of the students. Therefore I commissioned a custom query from HESA into their student records database, which provided me with FTE student numbers disaggregated by origin from each of the UK regions (England, N-Ireland, Scotland and Wales), the EU, the rest of Europe and the rest of the World. For the purpose of constructing the IO-table the student population of each institution is aggregated into three groups, Scottish students (SCO), students from the rest of the UK (RUK) and students from the rest of the World (ROW). A summary of these is provided below.

Table 17 Student numbers by origin at Scottish HEIs (FTEs, %).

	SCO		RUK		ROW		Total	
Aberdeen	7,749	70%	1,557	14%	1,774	16%	**11,079**	**100%**
Abertay	2,704	72%	278	7%	749	20%	**3,731**	**100%**
Bell College	3,067	99%	19	1%	4	0%	**3,091**	**100%**
Dundee	9,462	72%	1,810	14%	1,868	14%	**13,140**	**100%**
ECA	799	49%	379	23%	442	27%	**1,620**	**100%**
Edinburgh	9,495	46%	7,201	35%	3,745	18%	**20,440**	**100%**
Caledonian	12,466	88%	629	4%	1,054	7%	**14,149**	**100%**
GSA	789	53%	423	28%	289	19%	**1,501**	**100%**
Glasgow	14,267	76%	2,360	13%	2,145	11%	**18,773**	**100%**
Heriot-Watt	3,859	55%	1,276	18%	1,892	27%	**7,027**	**100%**
Napier	6,627	70%	675	7%	2,220	23%	**9,522**	**100%**
Paisley	6,940	90%	114	1%	661	9%	**7,716**	**100%**
QMUC	2,648	66%	549	14%	817	20%	**4,013**	**100%**
Robert Gordon	7,121	76%	395	4%	1,867	20%	**9,383**	**100%**
RSAMD	439	65%	135	20%	105	15%	**678**	**100%**
St Andrews	2,370	33%	2,512	35%	2,245	31%	**7,128**	**100%**
SAC	603	89%	46	7%	26	4%	**675**	**100%**
Stirling	5,344	75%	1,011	14%	811	11%	**7,165**	**100%**
Strathclyde	13,913	86%	611	4%	1,729	11%	**16,253**	**100%**
UHI	3,599	95%	72	2%	114	3%	**3,785**	**100%**
Total	**114,262**	**71%**	**22,052**	**14%**	**24,555**	**15%**	**160,870**	**100%**

3.2.5 **The Scottish HEIs sector and the Scottish economy**

In this section I draw on the HEI-disaggregated Input-Output table and some of the data sources used in its construction to describe the characteristics of the HEIs sector within the context of the Scottish economy. Although the table was constructed at a 148 sector level of aggregation it is presented in a condensed 12-sector format below to simplify the presentation.

Based on the HEI disaggregated IO-table I can obtain the broad characteristics of Scottish HEIs. Their relatively small type I multipliers reflect the fact that HEIs do not source much intermediate inputs locally, or indeed elsewhere as their import propensity is also low (12.9%). Of the 12 sectors shown in the table below HEIs exhibit the highest Type II multiplier indicating that local wages form a bigger share of expenditure than in other sectors. This is evident from Figure 7 below, while Figure 8 illustrates the income structure of each of the 12 production sectors.

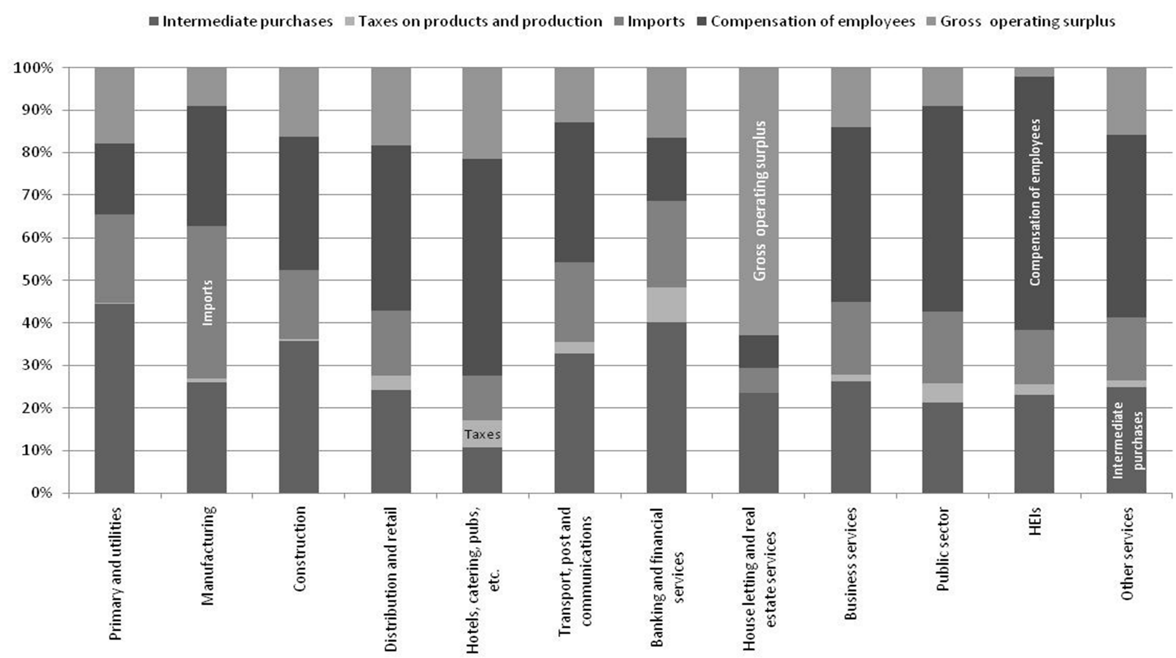
Table 18: Output multipliers of IO sectors.

Sector	Type I	Type II
Primary and utilities	1.72	2.10
Manufacturing	1.39	1.83
Construction	1.53	2.07
Distribution and retail	1.35	1.90
Hotels, catering, pubs, etc.	1.16	1.80
Transport, post and communications	1.48	2.03
Banking and financial services	1.59	1.96
House letting and real estate services	1.34	1.55
Business services	1.37	1.99
Public sector	1.30	1.97
HEIs	1.33	2.12
Other services	1.35	1.98

Table 19: 2006 HEI-disaggregated Input-Output for Scotland, industry by industry, 12-sector, £m.

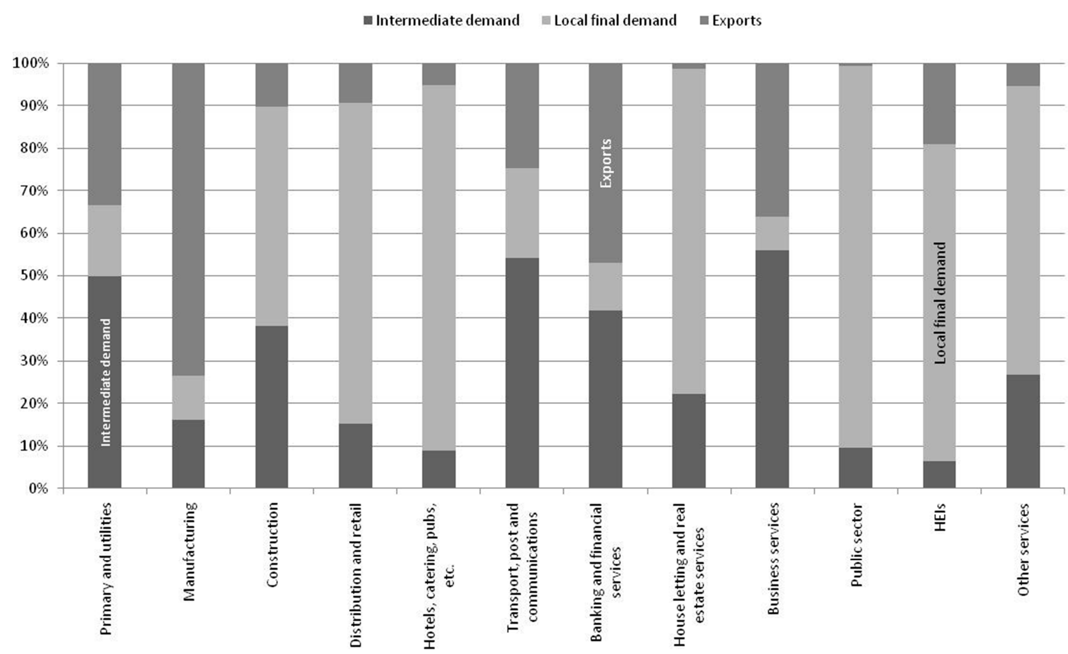
2006 Scottish IO 12-sector IxI, £m	Primary and utilities	Manufacturing	Construction	Distribution and retail	Hotels, catering, pubs, etc.	Transport, post and communications	Banking and financial services	House letting and real estate services	Business services	Public sector	HEIs	Other services	**Total Intermediate Demand**	**Local**	**Government**	**Capital**	**External**	**Total final demand**	**Total Demand for Products**
Primary and utilities	3,572	2,191	148	135	42	55	66	10	85	227	21	32	**6,583**	2,085	2	104	4,416	6,607	**13,190**
Manufacturing	207	2,660	526	411	99	229	180	23	311	527	155	61	**5,389**	2,428	0	906	24,608	27,941	**33,330**
Construction	193	103	2,333	92	11	54	322	979	44	489	74	35	**4,731**	288	0	6,070	1,260	7,618	**12,349**
Distribution and retail	235	1,158	195	188	39	146	166	26	156	149	11	34	**2,501**	11,669	3	315	1,858	13,846	**16,347**
Hotels, catering, pubs, etc.	12	9	0	121	9	22	54	3	20	129	5	8	**393**	2,748	0	0	1,227	3,975	**4,368**
Transport, post and communications	267	610	91	1,006	57	2,571	1,495	101	427	737	22	81	**7,464**	2,652	0	143	3,523	6,319	**13,782**
Banking and financial services	567	1,000	394	493	63	482	2,233	471	595	1,164	15	160	**7,636**	2,007	0	18	8,612	10,637	**18,273**
House letting and real estate services	69	87	215	821	27	148	494	115	62	202	53	31	**2,325**	7,716	0	232	177	8,125	**10,450**
Business services	670	614	464	629	85	609	1,861	349	1,854	1,066	53	386	**8,640**	378	13	799	5,606	6,796	**15,436**
Public sector	58	131	26	32	11	89	211	342	268	1,889	45	51	**3,153**	2,908	25,916	95	103	29,022	**32,175**
HEIs	1	4	1	1	0	4	19	2	19	28	20	3	**104**	240	1,125	1	595	1,961	**2,064**
Other services	26	77	8	32	29	107	258	29	212	222	2	749	**1,751**	3,354	708	237	522	4,822	**6,574**
Total domestic consumption	**5,876**	**8,645**	**4,401**	**3,961**	**472**	**4,517**	**7,359**	**2,451**	**4,054**	**6,828**	**475**	**1,632**	50,670	**38,474**	**27,768**	**8,921**	**52,507**	**127,669**	178,339
					472														
Imports	2,708	11,979	1,994	2,505	460	2,567	3,698	632	2,638	5,453	267	970	**35,871**	20,213	0	5,034	1,118	26,366	**62,237**
Net product & production taxes	37	315	65	557	270	378	1,488	1	239	1,461	53	112	**4,976**	6,547	-9	1,432	1,656	9,626	**14,602**
Compensation of employees	2,199	9,353	3,882	6,326	2,230	4,555	2,713	790	6,328	15,489	1,229	2,818	**57,912**						**57,912**
Gross operating surplus	2,370	3,039	2,007	2,998	936	1,766	3,014	6,577	2,176	2,945	41	1,041	**28,910**						**28,910**
Total primary inputs	**7,314**	**24,685**	**7,948**	**12,386**	**3,896**	**9,266**	**10,914**	**7,999**	**11,382**	**25,348**	**1,589**	**4,941**	**127,669**	**26,761**	**-9**	**6,465**	**2,775**	**35,992**	**163,661**
Output at basic prices	**13,190**	**33,330**	**12,349**	**16,347**	**4,368**	**13,782**	**18,273**	**10,450**	**15,436**	**32,175**	**2,064**	**6,574**	**178,339**	**65,234**	**27,759**	**15,386**	**55,282**	**163,661**	**342,000**
FTE employment (thousands)	*60,593*	*230,001*	*123,655*	*287,612*	*124,603*	*119,718*	*103,133*	*27,346*	*247,176*	*539,924*	*34,011*	*99,614*	*1,997,386*						
FTE employment-output coefficients	*0.22*	*0.14*	*0.10*	*0.06*	*0.04*	*0.12*	*0.18*	*0.38*	*0.06*	*0.06*	*0.06*	*0.07*	*0.09*						
Income-output coefficients	*0.167*	*0.281*	*0.314*	*0.387*	*0.511*	*0.330*	*0.148*	*0.076*	*0.410*	*0.481*	*0.595*	*0.429*	*0.325*						
GDP-output coefficients	*0.346*	*0.372*	*0.477*	*0.570*	*0.725*	*0.459*	*0.313*	*0.705*	*0.551*	*0.573*	*0.615*	*0.587*	*0.487*						
Import propensity	*0.205*	*0.359*	*0.161*	*0.153*	*0.105*	*0.186*	*0.202*	*0.060*	*0.171*	*0.169*	*0.129*	*0.148*	*0.201*						

Figure 7: Expenditure structure of Scottish IO sectors.



HEIs' income is primarily driven by local final demand but just under a quarter of their income is from exports. These characteristics set HEIs apart from the 'public sector' which receives negligible income from exports.

Figure 8: Income structure of Scottish IO sectors.



3.3 Spatial disaggregation of the Scottish IO-table

In this section I conduct a spatial disaggregation of the Scottish Input-Output table, presented in the last section, in order to obtain an interregional IO-table consisting of 3 economically interdependent sub-regions; Glasgow (GLA), the rest of the Strathclyde area (RST); and the rest of Scotland (ROS). These Input-Output accounts are subsequently used, in Chapter 5 to determine the sub-regional and interregional demand impacts of Glasgow HEIs.

In the early stages of the PhD work I constructed a single-region IO-table for the Glasgow City Council Area. However, it became clear that this approach suffered from significant shortcomings. In particular, although the Glasgow City Council area is a separate political unit and there is significant demand for economic policy analysis based solely on Glasgow[65] it is not a separate economic entity in functional terms. As we will see it is highly interdependent with other sub-regions in Scotland, in particular the surrounding council areas in the Strathclyde region, which, via commuting, provide approximately half of the labour force employed in Glasgow[66]. Therefore significant wage payments from employers in Glasgow flow to these suburban communities. A subsequent counter flow occurs as suburban households bring their consumption spending to Glasgow. As we shall see it is clear that Glasgow and the Rest of Strathclyde (RST) form a single metropolitan area with strong sub-regional interdependencies. From Strathclyde (including Glasgow) there are links to the Rest of Scotland, both through commuting and intermediate purchases, but these are much smaller than those occurring internally within the Strathclyde region.

As I illustrate further in Chapter 4 the city of Glasgow is Scotland's main concentration of higher education activities, closely followed by Edinburgh. Each of these represents an interesting case to analyse. Glasgow's HEIs are

[65] For example Glasgow City Council and Scottish Enterprise have joined forces in the Glasgow Economic Commission, specifically charged with developing an economic strategy for the City: http://www.glasgoweconomicfacts.com/Dept.aspx?dept_id=191

[66] These circumstances are not unique to Glasgow however, for a discussion of interdependencies between an urban centre and its hinterland see for example Hewings & Parr (2007), Hewings *et al* (2001), Voith (1998) and Downs (1996).

slightly more student intensive, they tend to draw their intake more from Scotland, particularly from the surrounding Strathclyde area and, perhaps unsurprisingly therefore, graduates tend to remain in Glasgow City post-graduation. Conversely Edinburgh HEIs tend to be slightly more research intensive, they draw more of their students from further afield, from the rest of the UK or the Rest of the World, and the city retains less of its students as graduates than does Glasgow. Apart from some data benefits that I enjoy from working at the University of Strathclyde, Glasgow has two particularly attractive features to study as a city of HEIs. Firstly, it is a relatively large metropolitan area in the European context and well suited to demonstrate core-periphery interdependencies in a metropolitan economy and the potential tension that arise when administrate boundaries divide functional areas. Secondly, it contains institutions across the range of HEIs, from old research universities to art institutes, which compete internationally but draw most of their intake locally and retain a significant share of graduates within the local economy. Therefore it serves as an excellent example of the flow of students, graduates, incomes and expenditures between the core and periphery within a large metropolitan area. Results from the Glasgow case are likely to be generalizable for other medium to large monocentric metropolitan areas exhibiting typical core-periphery relationships, such as Manchester or Copenhagen. An additional feature of Glasgow, for which results can be generalised, is how it illustrates potential tensions between administrative and functional regions. Previously, this has for example been explored for the Chicago metropolitan area (Hewings & Parr, 2007). The case of Glasgow is likely to be less generalizable to significantly different metropolitan areas such as polycentric areas (e.g. the Randstad area in the Netherlands, or the German Ruhr area) and smaller 'university-town' cities, such as Durham or York in the UK or Lund in Sweden.

In the next section I define the spatial demarcation of the three sub-regions GLA, RST and ROS. Then I review the use of non-survey techniques for estimating interregional IO-tables, in particular the use of Location Quotients (LQs). In the third section I explain the details of the disaggregation process and finally in section 4 I briefly discuss the resulting table and explore its sensitivity to the selection of LQ-technique.

3.3.1 **Delimitation of spatial boundaries – why GLA-RST-ROS?**

Table 20 Demarcation of spatial zones in the GLA-RST-ROS IO-tables.

IO region		NUTS 2 Region	NUTS 3 Region
SCO	GLA	South Western Scotland	Glasgow
SCO	RST	South Western Scotland	East Dunbartonshire, West Dunbartonshire, and Helensburgh and Lomond
SCO	RST	South Western Scotland	East and North Ayrshire mainland
SCO	RST	South Western Scotland	Inverclyde, East Renfrewshire, and Renfrewshire
SCO	RST	South Western Scotland	North Lanarkshire
SCO	RST	South Western Scotland	South Ayrshire
SCO	RST	South Western Scotland	South Lanarkshire
SCO	ROS	South Western Scotland	Dumfries and Galloway
SCO	ROS	Eastern Scotland	Angus and Dundee
SCO	ROS	Eastern Scotland	Clackmannanshire and Fife
SCO	ROS	Eastern Scotland	East Lothian and Midlothian
SCO	ROS	Eastern Scotland	Scottish Borders
SCO	ROS	Eastern Scotland	Edinburgh
SCO	ROS	Eastern Scotland	Falkirk
SCO	ROS	Eastern Scotland	Perth and Kinross, and Stirling
SCO	ROS	Eastern Scotland	West Lothian
SCO	ROS	North Eastern Scotland	Aberdeen and Aberdeenshire
SCO	ROS	Higlands and Islands	Caithness and Sutherland, and Ross and Cromarty
SCO	ROS	Higlands and Islands	Inverness, Nairn, Moray, and Badenoch and Strathspey
SCO	ROS	Higlands and Islands	Lochaber, Skye and Lochalsh, Arran and Cumbrae, and Argyll and Bute*
SCO	ROS	Higlands and Islands	Eilean Siar (Western Isles)
SCO	ROS	Higlands and Islands	Orkney Islands
SCO	ROS	Higlands and Islands	Shetland Islands

Table 20 lays out the demarcation of the IO-regions in terms of NUTS 2 and NUTS 3 regions. Furthermore, key economic and social indicators for these areas are given in Table 21. The main focus of my analysis is on the Glasgow City Council jurisdiction, which spans an area of 175 km^2 and included 581 thousand inhabitants in 2006. Roughly 313 thousand full time equivalent jobs are found in Glasgow, which is approximately 17% of total employment in Scotland. This is a much larger share of Scotland wide employment than Glasgow's population share would suggest – to the extent that (as we will see in section 3.3.3.3) approximately every second job in the City is taken by in-commuters, primarily originating from other parts of the Strathclyde region.

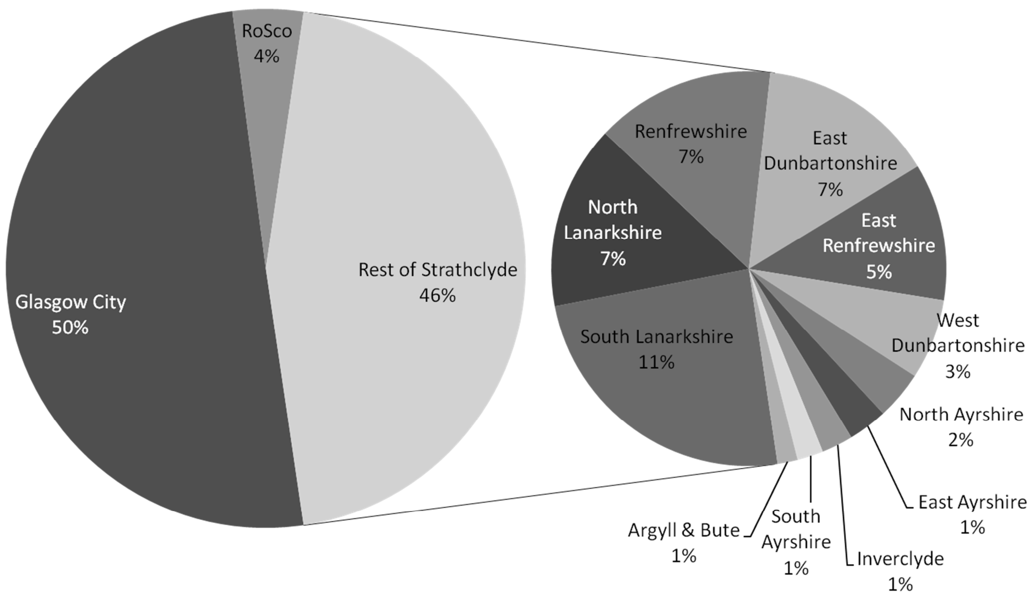
The boundaries of the Strathclyde region as depicted in this study conform to those of the Strathclyde Regional Council (SRC). The SRC was one of nine regional councils created by the Local Government (Scotland) Act 1973 and came into operation in May 1975. It was responsible for various public services, including education, social work, police, fire services, water sewage and transport. Regional Councils were abolished in 1996 but many public services in the area are still provided by entities operating at the Strathclyde level, such as Strathclyde Police, Strathclyde Fire and Rescue Service, and the Strathclyde Partnership for Transport, which runs public transport in the region.

Table 21 Key social and economic indicators for each IO-region in 2006.

		GLA	RST	ROS	SCO
Population	**000's**	580,690	1,555,374	2,980,836	5,116,900
	% of total	11%	30%	58%	100%
Employment (IO-based)	**FTEs**	313,535	448,296	1,089,529	1,851,360
	% of total	17%	24%	59%	100%
Gross Domestic Household Income Per Head	**£**	11,968	12,975	13,319	13,071
	% of average	92%	99%	102%	100%

The rest of the Strathclyde region (RST) has somewhat different economic characteristics than Glasgow (GLA). In terms of population it is approximately 3 times the size of Glasgow. However, there are only 1.4 times as many jobs in RST as there are in GLA. As we shall see the lower job density in the RST region is explained by significant out-commuting to seek employment in Glasgow (46% of all those working in Glasgow come from the rest of the Strathclyde region, see Figure 9). Furthermore, as we will see (in section 3.3.3.4.1) households in RST bring significant amounts of consumer spending to GLA. On balance therefore, it is clear that there are strong links within the Strathclyde region, between RST and GLA, through economic activity, transport and governance.

Figure 9 Sub-regional origin of workers in Glasgow based on the 2008 Annual Population Survey (APS). Source: ONS, (n.d. a).



The third region of the Rest of Scotland (ROS) is determined as a residual that allows the interregional table to conform to the HEI-disaggregated Scottish IO table for control totals. This approach of identifying the two regions of main interest for analysis and treating the rest of the country as a residual is similar to that used by Akita & Kataoka (2002) for Japan and Eskelin (1983) for the study of Finland. Furthermore, the approach adopted here, in particular the identification of interregional commuting and household consumptions flows, can arguably be categorised under the broad heading of metropolitan IO-models[67].

3.3.2 **Nonsurvey techniques and Location quotients**

When conducting economic analysis based on input-output accounts the methodologically preferred option is to work with accounts generated using survey data such as those constructed regularly for Scotland. These are, however, rarely available for sub-regional economies, such as the city of Glasgow or the Strathclyde area, and resource constraints typically make constructing such survey-based tables infeasible. A commonly used alternative is to apply non-survey methods to estimate Input-Output accounts. This is typically the least expensive option, but also the least accurate. In response to criticism of non-survey methods, a number of hybrid, or partial survey, methods have been proposed[68]. Here available data are used to augment a non-survey approach thereby improving the accuracy of the IO-accounts. These hybrid options can potentially offer an attractive cost/accuracy trade-off.

Non-survey and partial survey methods for construction of IO-accounts are reviewed comprehensively in Miller & Blair (2009, Ch. 7-8, pp. 303-392). For an overview of earlier literature see Round (1983) and Richardson (1985). For the interregional IO-accounts constructed here I apply the more affordable alternative of using a published (surveyed) regional table as a starting point for deriving a sub-regional table using non-survey and partial survey methods. For this I will use location quotients (LQ's)[69], but incorporate sub-region specific data where available. In brief a sub-regional LQ table can be thought of as a sub-section of the original table where available data on local characteristics are used to scale the regional table to an output level and structure compatible with local benchmarks.

---

[67] For a discussion of IO-models applied within an urban context see Jun (2004). Notable examples include Jun (1999), Hewings et al (2001), Madden (1985) and MacGill (1977).

[68] See Lahr (1993) for a review of hybrid methods.

[69] The approach taken here is on the spectrum moving from a simple non-survey approach to a hybrid table. It uses available regional economic statistics and commuting data to address the flow of wages and consumption expenditures over sub-regional boundaries, particularly between Glasgow and the Rest of Strathclyde. Furthermore, sub-regional economic data are used as control totals for final demands. However, a weakness of the table is that it relies on non-survey methods to estimate interregional trade.

3.3.2.1 Non-survey versus hybrid methods in IO-construction

As previously noted the Input-Output table presented here is not a typical non-survey construct, but offers novel features by drawing on secondary data such as commuter flows and spatial distribution of public expenditures to improve the table's accuracy over a strict location quotient approach. Still, it is not a hybrid table in the commonly used meaning of the term, i.e. additional data has not been used to improve the accuracy of the intermediate transactions matrix (Z-Matrix). This begs the question why in this case the Z-matrix is determined using mechanical locations quotients but not hybrid approaches. The short answer is that there were no secondary data available to aid the accuracy of the intermediate transactions matrix and primary data collection was beyond the means of the project. However, this is a very interesting question from the point of view of future refinements over the current approach and hence worth considering in slightly more detail before moving on.

There are a number of partial survey approaches available for estimating Input-Output tables (see Chapter 7 in Miller & Blair (2009) for an overview). The broad idea in all of these is that you can improve the accuracy of the estimates over purely mechanical approaches by drawing on actual observations to constrain the results. These approaches typically proceed in several steps (Lahr, 1993, p. 278). For example, we could start out with a location quotient based Z-matrix for a local economy. Then to improve the accuracy of the estimates within reasonable means, it would be possible to survey or conduct case studies of companies in the most important sectors to determine the total of intermediate sales (row sum) and purchaes (column sum). Numerical approaches could then be applied to adjust the original matrix to conform to these more accurate control totals. Or as put more generally by Snickars & Weibull (1977) information about macro states can be used to inform estimates of micro states. As summarised by Lahr & de Mesnard (2004) there are a range of techniques available for reconciling partial observations with estimates. Within the context of Input-Output tables the RAS Technique is probably the most well-known of these (see Section 7.4 in Miller & Blair (2009)). As Lahr & de Mesnard (2004) point out these adjustment algorithms fall into broadly two categories: Scaling algorithms, of which RAS is one, and maximizing algorithms. Prominent examples of the latter are entropy maximisation principles (Wilson 1970) or Efficient Information Adding. Snickars & Weibull (1977) discuss the general principle and demonstrate its application to several spatial-economic problems. The approach is discussed further in the context of estimating interregional IO-tables by Batten (1982) and Snickars (1979) demonstrates its application to estimating interregional trade within Sweden.

On balance these hybrid adjustment techniques are attractive to use because of the relative ease with which they can be applied and the proven ability of hybrid techniques to improve the accuracy of estimates (Harris & Liu, 1998). However, the bottleneck is obtaining actual firm or sector level estimates of intermediate sales and/or purchases. For the case of Glasgow it is evidence that the most important sectors to gauge accurately, due to their share of total economic activity, would be service sectors (business services and the public sector account for 47% of total employment). In principle it should be relatively straightforward to obtain some better information about these sectors through consulting experts, conducting plant level case studies or surveying businesses in particular sectors. However, such an undertaking would inevitably require some resources and would ideally need to be backed up by an influential organisation such as the city council or the local chamber of commerce, in order to gain access and encourage responses from the business community. However, this is certainly feasible, and one can imagine, with for example repeated consultancy work on Glasgow sectors, accuracy could be gradually improved through obtaining of better information about more sectors. Even if better information is only obtained for a subset of the sectors, due to the accounting constraints of the Input-Output system that would make residual estimates less inaccurate.

3.3.2.2 Location Quotients

Various LQ methods have been suggested in the literature. These are summarised in Miller & Blair (2009, pp. 349-360). In general LQ approaches adjust the national technical coefficient to take account of the potential for satisfying input needs locally. A regional Input-Output coefficient is a function of the location quotient and the national Input Output coefficient:

$$a_{ij}^{RR} = a_{ij}^{RR}\left(LQ_i^R, a_{ij}^N\right)$$

Where a_{ij}^{RR} is the regional IO technical coefficient, LQ_i^R is the location quotient and a_{ij}^N is the national technical coefficient[70].

3.3.2.2.1 Simple location quotient (SLQ)

The simple location quotient for sector i in region R is defined (Miller & Blair, 1985) as:

$$SLQ_i^R = \left[\frac{E_i^R / E^R}{E_i^N / E^N}\right]$$

Where E_i^R and E^R are employment in sector i in region R and total employment in region R respectively and E_i^N and E^N are employment in sector *i* and total employment in the nation as a whole.

When the SLQ_i is greater than one (less than one), it can be inferred that sector *i* is more (less) concentrated in region R than in the nation as a whole. Where the location quotient is less than one the region is perceived to be less able to satisfy regional demand for its output, and the national coefficients are adjusted downwards by multiplying them by the location quotient for sector *i* in region R. Where the sector is more concentrated in the region than the nation at large

[70] Which shows the required input of commody i per unit of output of commodity j.

(LQ_i>1), it is assumed that the regional sector has the same coefficients as the nation as a whole. Therefore for row *i* of the regional table:

$$a_{ij}^{RR} = \begin{matrix} a_{ij}^{N} SLQ_i^R & \quad if \quad SLQ_i^R < 1 \\ a_{ij}^{N} & \quad if \quad SLQ_i^R \geq 1 \end{matrix}$$

3.3.2.2.2 Cross industry location quotient

A criticism of the simple location quotient is that it does not take into account the relative size of the sectors engaged in intermediate transactions. The argument goes that if a sector which is relatively small locally is supplying a sector which is relatively big, this should imply a need for imports to satisfy intermediate demand, and vice versa. This is addressed with cross industry location quotients (CILC). The CILQ for sectors *i* and *j* can be defined as:

$$CILQ_{ij}^{R} = \frac{SLQ_i^R}{SLQ_i^R}\left[\frac{E_i^R / E_i^N}{E_j^R / E_j^N}\right]$$

Where sector *i* is assumed to be supplying inputs to sector *j*. As with the SLQ national coefficients are not adjusted if $CILQ_{ij}^{R} \geq 1$ as it is assumed that intermediate demand can be met within the economy.

3.3.2.2.3 Round's semi-logarithmic Location Quotient (RLQ)

Round (1978, p. 181) surmises that "following the basic notion of the location quotient, one could reasonably conjecture that the size of trading coefficient may be ascertained by some function of the relative size of the supplying sector, the relative size of the purchasing sector, and the overall size of the region relative to the nation as a whole".

As Miller & Blair (2009, p.354) point out, if we rewrite the simple location quotient (LQ) as $\left(E_i^R / E_i^N\right) / \left(E^R / E^N\right)$ it is clear that the LQ adjusts for the relative size of the selling sector and the relative size of the region, but ignores the relative size of the buying sector.

The Cross Industry Location Quotient (CILQ, however, includes relative sizes of both selling $\left(E_i^R / E_i^N\right)$ and buying $\left(E_j^R / E_j^N\right)$ sectors, but contains no term for relative size of the region, such as $\left(E^R / E^N\right)$. In order to incorporate all three of these measures in a location quotient, Round (1978) suggested a semilogarithmic quotient, which he defined as

$$RLQ_{ij}^R = SLQ_i^R / \log_2\left(1 + SLQ_j^R\right)$$

Round (1978) does not discuss the rationale for this approach in detail but notes that it was devised "simply to account for all three ratios in a way which maintains the basic properties of both LQ and CI[L]Q methods" (Round, 1978, p. 182). On the selection of the functional form he notes that "the semilogarithmic form is arbitrary, but is among the simplest functions which maintains basic properties of the α values [the technical coefficients in the A-matrix] without further parametrization" (Round, p. 182, Footnote 4).

As Miller & Blair (2009, p. 354) further point out $\log_2\left(1 + SLQ_j^R\right) = 1$ when $SLQ_j^R = 1$ and therefore $RLQ_{ij}^R = SLQ_i^R$. When $SLQ_j^R > 1$, $\log_2\left(1 + SLQ_j^R\right) > 1$ and therefore $RLQ_{ij}^R < SLQ_i^R$ and the reverse is the case when $SLQ_j^R < 1$.

Despite its potential to capture the relative size of the supplying sector *i*, the relative size of the purchasing sector *j* and the relative size of the region in its adjustment of national coefficients the RLQ proved unsatisfactory: "perhaps surprisingly, applications using this [R]LQ generally failed to demonstrate any particular improvement over simpler measures like LQ and CI[L]Q. This spurred attempts to include these three factors in a measure that might perform better" (Miller & Blair, 2009, p. 354).

3.3.2.2.4 Flegg, Webber and Elliot's Location Quotient (FLQ)

Flegg, Webber and Elliot introduce the FLQ approach (Flegg *et al*, 1995), which is subsequently developed in Flegg *et al* (1997) and Flegg *et al* (2000). In this approach they modify the CILQ to incorporate a measure of the relative size of the region such that $FLQ_{ij}^{R}=(\lambda)CILQ_{ij}^{R}$, where $\lambda = \{\log_2[1 + (E^R/E^N)]\}^{\delta}$, where $0 \leq \delta \leq 1$. Then

$$a_{ij}^{rr} = \begin{matrix} FLQ_{ij}^{R}a_{ij}^{N} & if\ FLQ_{ij}^{R} > 1 \\ a_{ij}^{N} & if\ FLQ_{ij}^{R} < 1 \end{matrix}$$

The broad idea behind this formula is to reduce national coefficients more for smaller regions, under the general expectation that smaller regions are more import intensive[71].

The problem with this method however, is that it requires an ad hoc assumption about the parameter δ. Flegg & Webber (1997) propose that an approximate value for δ=0.3 "would seem reasonable" (p. 798).

Given that repeated empirical testing has shown existing LQ methods to overstate multipliers by a significant margin, it is an intuitively appealing approach to devise a mechanism for revising these downward. Unfortunately it seems that Flegg *et al* (2005) was a somewhat rushed job (see for example criticism from Brand (1997)). This led to the revised version of the FLQ formula, which is the one presented here and originally published in Flegg & Webber (1997)[72].

To avoid confusion it should be noted that the empirical testing of the FLQ formula reported in section 3.3.2.4 is based on an earlier version of the formula presented in Flegg *et al* (1995), where: $FLQ_{ij}^{r}=CILQ_{ij}^{r} * \lambda^{\beta}$ and $\lambda = (E^r/E^N)/\{\log_2[1 + (E^r/E^N)]\}$. Flegg & Webber (1997) argue that λ is better behaved in

[71] This logic has been questioned by Brand (1997) and McCann & Dewhurst (1998). For responses see Flegg & Webber (1997) and Flegg & Webber (2000) respectively.
[72] Miller & Blair (2009) present the Flegg & Webber (1997) version and ignore Flegg *et al* (1995).

the 1997 specification than the earlier one. However, parameter values are not directly comparable between the two specifications. Flegg & Webber (1997) suggest that for the 1997 specification a parameter value of δ=0.3 would seem reasonable, based on their experience.

Figure 10 The behaviour of the λ function under the 1995 specification (left) and 1997 specification (right). Source: Flegg & Webber (1997, p. 798).

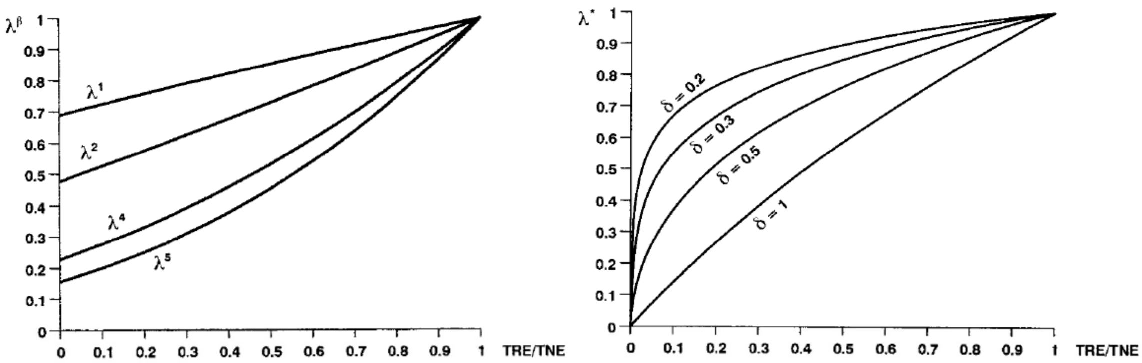


Fig. 1. The original function, λ^{β} *Fig. 2. The new function,* $\lambda^{\star}$

In Figure 10 I reproduce two diagrams from Flegg & Webber (1997), which illustrate the behaviour of the scalar λ for different parameter values for each FLQ formula specification. The original 1995 version is illustrated in the left hand panel and the 1997 specification used here is illustrated in the right hand panel. In both cases the y-axes reveal the degree to which the CILQ is revised downwards to produce the FLQ. The x-axes show the relative size of the local sector measured in terms of regional employment in the sector (TRE) divided by the employment in that sector at the national level (TNE). The different curves reveal outcomes under different values of the ad-hoc parameter called β in the earlier specification but δ in subsequent versions: “As before, this formula generates a family of curves linking the regional scalar to TRE/ TNE, each curve corresponding to a specific value of δ . What is different, however, is that these curves pass through the origin rather than having a positive intercept of $(0.693\ ...)^{\beta}$. Furthermore, they are convex from above rather than concave. These two characteristics could both be held to be improvements. The smaller the assumed value of δ, the greater the degree of convexity and the larger is λ^* for any given TRE/TNE. $\delta = 0$ represents a special case where $\lambda^*=1$ and the CILQ and FLQ coincide" (Flegg & Webber, 1997, p. 798).

3.3.2.3 Limitations of the LQ approach

As noted earlier the widespread use of the LQ approach in constructing regional Input-Output tables is primarily driven by pragmatic concerns as detailed data are seldom available at the regional level to implement more accurate methods and collecting the primary data needed is typically beyond the means of the IO-users. Given this predicament a typical way out (and indeed one that is applied in this dissertation) is to draw on a published input output table pertaining to a larger geography and use employment based location quotients to estimate a local sub-section of that table. Implicitly by going down that route the researcher is accepting some rather bold assumptions. For these Harris & Liu (1998) refer to Norcliffe (1983, pp. 162-163), which identifies the main assumptions underlying the use of location quotients to identify the export base in export base models[73].

It is clear that for employment to be used as a proxy for output there must be identical productivity per employee in each region in each industry so that a region's share of national employment accurately represents its share of national production. Furthermore, for similar reasons, there must be identical consumption per employee. Perhaps most importantly however, so as not to underestimate interregional trade, there must be no cross-hauling between regions of products belonging to the same industrial category.

Given that these assumptions rarely hold, a number of authors have attempted firstly to estimate empirically the extent to which the breakdown of these assumptions will influence estimates for IO-accounts and secondly to come up with modifications of the LQ-approaches that might counter some of the inherent biases. I have already introduced the most well-known location quotients in section 3.3.2.2 and will now proceed to discuss the empirical testing of these methods.

---

[73] Norcliee identifies 4 main assumptions. However, his fourth assumption is not relevant in the context of IO-accounts, as it is for estimating export base models, and is hence omitted here.

3.3.2.4 Empirical testing of alternative LQ methods

A number of studies have been undertaken to test the accuracy of various hybrid and non-survey methods including location quotients. See for example: Schaffer & Chu (1969); Smith & Morrison (1974); Round (1978); Harrigan *et al* (1981b); Willis (1987); Harris & Liu (1998); Tohmo (2004); and Stoeckl (2010). These studies have found that IO-tables constructed using location quotients produce multipliers that are systematically biased upwards. These tables tend to underestimate the openness of the sub-regional economy, i.e. they underestimate imports and exports and overestimate local intermediate transactions. This is primarily due to their failure to acknowledge cross-hauling (Harris & Liu, 1998). Secondly, when Type-II multipliers are being used, an accurate identification of household consumption and labour income is critical for accurate multipliers (Lahr 1993, Richardson 1985).

Tohmo (2004) summarises the findings of five studies comparing multipliers derived from location quotients to survey based multipliers. These are Smith & Morrison (1974), Harrigan *et al* (1980b), Flegg & Webber (1996) and Harris & Liu (1997) in addition to his own comparison in Tohmo (2004). The results of this comparison are presented in Table 22 below.

Table 22 Comparison of survey and LQ-based regional multipliers (average % difference). Based on Tohmo (2004, Table 6, p. 51).

Comparison / study	Smith & Morrison (1974)	Harrigan *et al* (1980b)	Flegg & Webber (1996)	Harris & Liu (1997)	Tohmo (2004)
	Avon 1968	Scotland 1973	Scotland 1989	Scotland 1989	Keski-Pohjanmaa (Finland) 1995
SLQ v survey	17.2%	25.0%		14.5%	15.1%
CILC v survey	24.9%	20.0%	11.7%		13.1%
RLQ v Survey	23.2%	22.5%			
Hybrid v survey				0.0%	
FLQ v survey			0.5%		-0.3%

As the comparison in Table 22 reveals, several tests of the accuracy of LQ-techniques have found them consistently to overstate multipliers on average, when compared to a surveyed table. It does not seem to make much difference whether the SLQ, CILC or the RLQ formulas are used. These methods seem to produce multipliers that are on average biased upwards by 12 to 25%. An exception to this is the FLQ formula, which is able to recreate on average[74] the multipliers found based on a surveyed Input-Output table. However, this depends on identifying the right adjustment parameter, which is not known *ex ante* but has to be deduced from comparison with surveyed tables *ex post*. Indeed Flegg *et al* (2006a) systematically try a range of parameter values and then identify at what approximate value the best fit can be obtained. Tohmo (2004) points out that the problem with the FLQ method is specifying a value of the exponent β (or δ in the Flegg & Webber (1997) specification). Based on three studies he indicates a range of approximately 1 to 4.5. For the case of the English sub-region of Avon Flegg *et al* (1995, p. 557) find 4.5 to be an appropriate value, but for Scotland Flegg *et al* (2006a) use the value 2. The lowest parameter value (β=1) is found in the study of the Keski-Pohjanmaa (K-P) region in Finland (Tohmo, 2004). Despite this parameter selection problem, the FLQ formula can be a useful addition, as if a 'reasonable' range of parameter values can be identified, these can be used to conduct sensitivity analysis to simulate a range of IO-parameters for which it is likely that realistic values are contained.

The upward bias to multipliers derived from LQ-based IO-tables does not seem to be uniform across regions or sectors. For example Harris & Liu (1998) point out that this bias is more acute for traded sectors such as manufacturing than for services. Furthermore, Flegg *et al* (1995, p. 555) argue that the error increases inversely with the size of the region being examined.

The academic debate on formulating appropriate location quotients is mostly concerned with finding the most appropriate method to counter the bias of overestimating regional multipliers (and underestimating trade) (Flegg *et al*, 1995, Flegg & Webber, 1997, 2000, Brand 1997). However, McCann & Dewhurst (1998) point out that in some cases, particularly where strong

---

[74] Flegg *et al* (1995, p.548) indeed point out that even if the systematic errors are removed, inaccuracies in individual coefficients are bound to remain.

regional specialization occurs, traditional LQ-approaches can actually underestimate local multipliers by over-estimating interregional trade. Flegg & Webber (2000) acknowledge this point in principle but argue that based on empirical testing this does not seem to be a significant concern in practice.

In light of the evidence it has to be accepted that in the GLA-RST-SCO IO model, home region multipliers may be overestimated, possibly by an order of magnitude of up to 25% on average. Within the interregional framework this can lead to an overstatement of impacts upon the HEIs host sub-region and a parallel understatement of knock-on impacts upon other regions. However, when added up to a Scotland-wide impact, these attribution errors will cancel out and conform to estimates from parallel work on Scotland-wide impacts based on the fully surveyed official Scottish IO table (Hermannsson *et al,* 2010c)[75]. As Round (1983) points out, from a purely informational point of view the potential misattribution is a problem whether in a stand-alone or interregional framework. However, in the context of an impact study, the problem is less serious as the overestimation of intraregional multipliers is compensated for by an underestimation of interregional multipliers.

However the bias may not be as problematic as suggested by average estimates as the spending of HEIs and their students is more concentrated on service sectors, which tend to be less sensitive to the overestimation biases of un-augmented LQ approaches. This is because of less cross hauling of the outputs of service sectors, as compared to manufacturing sectors (Harris & Liu, 1998).

3.3.3 **Disaggregation process**

The starting point for deriving the 3 region Interregional Glasgow-Rest of Strathclyde-Rest of Scotland (GLA-RST-ROS) Input-Output accounts is the single region IO-table for Scotland. This is presented in a schematic form on

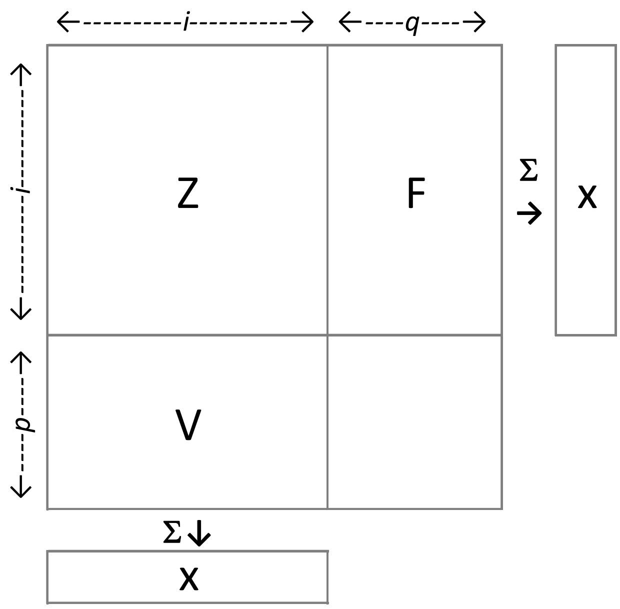
---

[75] The total impact of HEIs has been estimated for Scotland based on a surveyed (unbiased) IO table. Subtracting from this the impact upon the Glasgow City Council Area gives the impact for RST and ROS. Therefore any overestimation of impacts upon the GLA-region does not result in an overestimation of the impact of HEIs but a misattribution of that impact upon Glasgow at the expense of the impact attributed to the Rest of Strathclyde and the Rest of Scotland.

the next page[76]. The IO-table has *i* intermediate sectors, *q* final demand sectors and *p* primary (i.e. value added categories) sectors. The matrix notation and dimensions is as follows (small bold cases for vectors and capital bold cases for matrices):

x = i-vector of outputs
Z = i x i - matrix-of intermediate demand
F = i x q - matrix-of final demand
V = p x i – matrix of primary costs

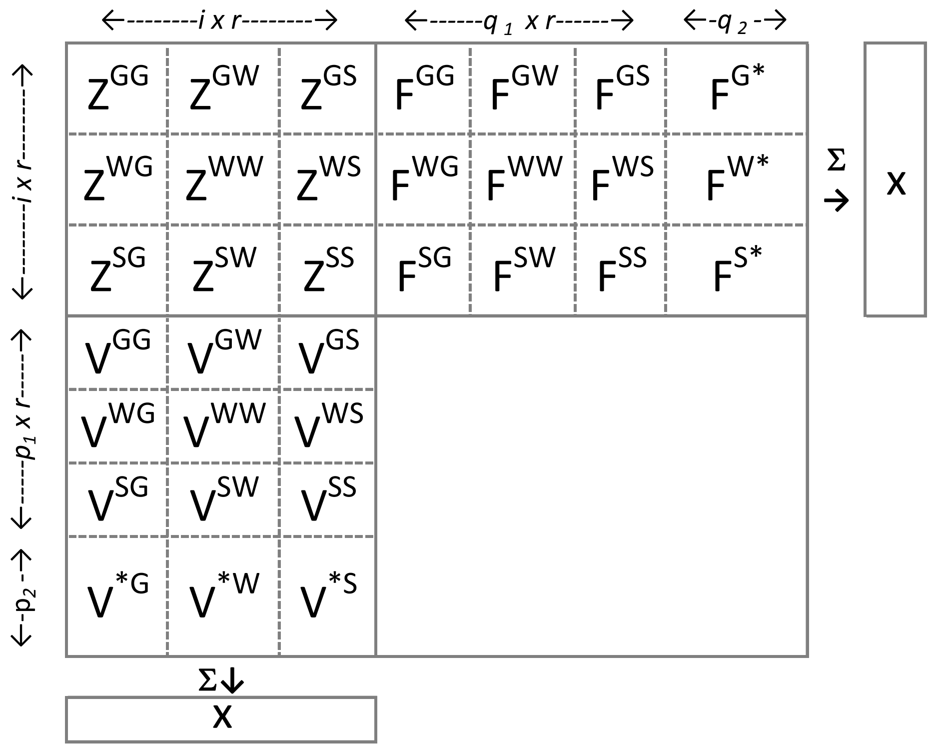
Figure 11: Single region IO-table for Scotland



The aim of this section is to disaggregate the table above into 3 regions as presented schematically in the figure below.

[76] The schematics and notation used are based on Oosterhaven & Stelder (2007).

Figure 12: Interregional Input-Output table for three regions (r = 3)



The superscripts indicate the spatial origin and destination of the matrix elements, with G representing Glasgow, W the rest of the Strathclyde region and S the rest of Scotland. The order follows the familiar row/column convention for matrix elements, for example the matrix $\mathbf{Z}^{WG}$ contains the elements for the intermediate demand rows of the rest of Strathclyde region (W) and the intermediate expenditure column of Glasgow (G).

For final demand and primary inputs the table is more complicated. The household consumption category of final demand has a region of origin and a region of destination. This q_1 category is represented by the interregional matrices $\mathbf{F}^{GG}$, $\mathbf{F}^{GW}$, $\mathbf{F}^{GS}$, $\mathbf{F}^{WG}$, $\mathbf{F}^{WW}$, $\mathbf{F}^{WS}$, $\mathbf{F}^{SG}$, $\mathbf{F}^{SW}$ and $\mathbf{F}^{SS}$. The q_2 final demand categories are not assigned a spatial origin (from within the interregional IO-accounts), e.g. government and capital formation (and export) final demand. These matrices are denoted as $\mathbf{F}^{G*}$, $\mathbf{F}^{W*}$, $\mathbf{F}^{S*}$.

The disaggregation process relies heavily on employment as an indicator of sub-regional economic structure and activity levels. This is because employment is the only indicator available consistently at sufficiently detailed levels of sectoral and spatial disaggregation. Data on employment by sector and NUTS 3 region is obtained from the 2006 Annual Business Inquiry (ABI) using the NOMIS data portal (formerly known as the National Online Manpower Information System). The ABS provides headcount numbers of full time and part time workers. To obtain estimates of full time equivalent (FTE) employment, I follow convention and consider part time workers to be holding on average one third of a full time equivalent job.

The IO sectors in the Scottish IO-table refer to specific Standard Industrial Classification (SIC) categories and therefore employment levels from the ABS can be matched to each IO-sector. However the IO-sectors refer to SIC categories at different levels of aggregation with some referring to a single 2 digit SIC category while others may be a combination of 3 or 4 digit categories. Therefore to match employment by SIC-sectors to IO-sectors I started out with employment data from NOMIS split into 2 digit categories and proceeded stepwise disaggregating relevant sectors according to 3 digit and 4 digit classifications until they matched the IO categories.

A four step process was used to estimate an 18-sector interregional IO-table for Glasgow, the Rest of Strathclyde and the Rest of Scotland:

1. Estimate sector gross output totals
2. Estimate technical coefficients (A-matrices) and intermediate transactions (Z-matrices)
3. Estimate primary inputs
4. Estimate final demands and balance table

3.3.3.1 Step 1: Sector gross output totals for GLA-RST-ROS

To derive gross output totals by industrial sector and sub-region I use employment to disaggregate output levels from the Scottish HEI-disaggregated input output table:

$$x_i^R = x_i^N \left[\frac{E_i^R}{E_i^N} \right]$$

Where x_i^R refers to output of sector *i* in region *R* and x_i^N refers to output of sector *i* in Scotland. Similarly, E_i^R and E_i^N denote employment in sector *i* in region *r* and Scotland, respectively. Following this method, if for instance 20% of Scottish wide employment in a particular sector is located in Glasgow, then Glasgow's gross output total is 20% of the Scottish gross output total for that sector.

Table 23 summarises employment and estimated gross output for each sector in each sub-region.

Table 23: Employment and gross output by sector (*i*) and region (*R*)

	IO-Sector	Employment (FTEs by sector and region)				Estimated Gross Output (£m, % of total by sector and region)							
		GLA	RST	ROS	SCO	GLA		RST		ROS		SCO	
						£m	%	£m	%	£m	%	£m	%
1	Primary and utilities	7,945	15,113	64,899	87,957	1,191	9%	2,266	17%	9,732	74%	13,190	100%
2	Manufacturing	22,512	63,214	129,143	214,869	3,492	10%	9,806	29%	20,033	60%	33,330	100%
3	Construction	16,740	37,791	78,043	132,574	1,559	13%	3,520	29%	7,269	59%	12,349	100%
4	Distribution and retail	38,065	65,142	154,216	257,423	2,417	15%	4,137	25%	9,793	60%	16,347	100%
5	Hotels, catering, pubs, etc.	17,528	23,148	69,581	110,257	694	16%	917	21%	2,757	63%	4,368	100%
6	Transport, post and communications	18,764	31,723	58,013	108,500	2,384	17%	4,030	29%	7,369	53%	13,782	100%
7	Banking and financial services	21,018	11,861	45,976	78,855	4,871	27%	2,748	15%	10,654	58%	18,273	100%
8	House letting and real estate services	7,204	8,296	15,765	31,265	2,408	23%	2,773	27%	5,269	50%	10,450	100%
9	Business services	59,332	52,469	145,249	257,049	3,563	23%	3,151	20%	8,723	57%	15,436	100%
10	Public sector	96,561	130,887	308,830	536,278	5,793	18%	7,853	24%	18,529	58%	32,175	100%
11	Other services	12,921	18,480	49,254	80,654	1,053	16%	1,506	23%	4,014	61%	6,574	100%
12	HEIs in RoSco	0	0	21,358	21,358	0	0%	0	0%	1,359	100%	1,359	100%
13	HEIs in RoStrath	0	1,418	0	1,418	0	0%	78	100%	0	0%	78	100%
14	Caledonian	1,613	0	0	1,613	98	100%	0	0%	0	0%	98	100%
15	GSA	255	0	0	255	16	100%	0	0%	0	0%	16	100%
16	Glasgow	4,820	0	0	4,820	312	100%	0	0%	0	0%	312	100%
17	RSAMD	145	0	0	145	10	100%	0	0%	0	0%	10	100%
18	Strathclyde	2,973	0	0	2,973	191	100%	0	0%	0	0%	191	100%
	Total	**328,395**	**459,539**	**1,140,328**	**1,928,262**	**30,053**	**17%**	**42,785**	**24%**	**105,502**	**59%**	**178,339**	**100%**

3.3.3.2 Step 2: Technical coefficients (A-Matrices) and intermediate transactions (Z-Matrices)

First of all, I assume for each sub-regional production sector that its structure of intermediate purchases is the same as for the sector as a whole in Scotland. This assumption is necessary as purchasing information is not available at the sub-regional level. The next step is to determine to what extent intermediate inputs are sourced locally and to what extent these are imported from the other regions within Scotland, using LQ's.

For this I estimate the share of intermediate inputs sourced locally as: $a_{ij}^{RR} = a_{ij}^{RR}\left(LQ_i^R, a_{ij}^N\right)$, such that $a_{ij}^{RR} = \begin{matrix} a_{ij}^{RR} LQ_i^R & if \;\; LQ_i^R < 1 \\ a_{ij}^N & if \;\; LQ_i^R \geq 1 \end{matrix}$

Using this method I can estimate the elements in the diagonal technical coefficient matrices $\mathbf{A^{RR}}$ or more specifically: $\mathbf{A^{GG}}$, $\mathbf{A^{WW}}$, $\mathbf{A^{SS}}$.

This leaves the issues of estimating the off-diagonal matrices of technical coefficients $\mathbf{A^{SR}}$. In a two region setting this would be straightforward as $a_{ij}^{SR} = a_{ij}^N - LQ_i^R\left(a_{ij}^N\right) = a_{ij}^N - a_{ij}^{RR}$.

In a three region setting, however, the residual between the technical requirements of a sector *i,* denoted by the national technical coefficient a_{ij}^N, and what it sources of it locally a_{ij}^{RR} has to be divided up between the two other regions 1 and 2, so that: $a_{ij}^N - a_{ij}^{RR} = \sum_{S=1}^{2} a_{ij}^{SR}$. To disaggregate $\sum_{S=1}^{2} a_{ij}^{SR}$ I adopt the simple assumption that this residual is divided pro-rata among the two *s* regions based on sectoral employment shares of sector *i* in each of the regions so that for each region *S*

$$a_{ij}^{SR} = \left(\frac{E_i^S}{\sum_{S=1}^{2} E_i^S} \right) \sum_{s=1}^{2} a_{ij}^{SR} = \left(\frac{E_i^S}{\sum_{S=1}^{2} E_i^S} \right) \left(a_{ij}^{N} - a_{ij}^{RR} \right)$$

Another possibility for disaggregating intermediate imports is to make strict assumptions about the spatial direction of intermediate flows between sub-regions based on the role of each sub-region in a regional hierarchy (see Robison 1997, Robison & Miller 1991,1988). This approach is quite appropriate when analysing interdependencies between relatively simple economies, for which we know the broad supply chain relationship. For example Robison & Miller (1991) apply this approach to the case of rural lumber and sawmill economies, for which supply chain relationships are quite transparent and the industrial structure is dominated by few industries. However, when observing GLA-RST-ROS an obvious trade hierarchy does not emerge. Therefore in the absence of better information a simple and transparent attribution rule is preferred.

Once all the technical coefficient matrices have been derived they can be multiplied with the sectoral gross outputs estimated in section 3.3.3.1 to obtain the $\mathbf{Z}^{rr}$ matrices of interregional intermediate transactions:

$$\begin{vmatrix} Z^{GG} & Z^{GW} & Z^{GS} \\ Z^{WG} & Z^{WW} & Z^{WS} \\ Z^{SG} & Z^{SW} & Z^{SS} \end{vmatrix}$$

3.3.3.3 Step 3: Sector primary inputs for GLA-RST-ROS

For estimating the primary inputs of industrial sectors in Glasgow (GLA), the Rest of Strathclyde (RST) and the Rest of Scotland (ROS) I adopt the assumption that firms in the sub-regions have the same needs for inputs as

Scottish firms in general. Therefore if 10% of the inputs to a particular sector at a Scottish level were imports from the Rest of UK (RUK) then this is assumed to hold for GLA-RST-SCO as well.

The primary inputs estimated in this way are: Imports from Rest of UK, Imports from Rest of World, Taxes on products, and Taxes less subsidies on production and Gross operating surplus. More formally this can be written as:

$$P_{ji}^{R} = P_{ji}^{N}\left[\frac{E_i^R}{E_i^N}\right]$$

Where P stands for primary input of source *j* (imports, other valued added, etc.) into sector *i*, in region *R* and in Scotland (*N*) and *E* stands for employment in sector *i* in in region *R* and Scotland (*N*). By applying this method directly I can estimate the elements for the primary input matrices $\mathbf{V}^{*G}$, $\mathbf{V}^{*W}$ and $\mathbf{V}^{*S}$ containing the primary inputs which are not accounted for as an internal flow within the GLA-RST-ROS Input-Output system.

A slight modification of this approach is used to estimate the elements of the primary input matrices, for which the inputs are attributed a definite spatial origin within the GLA-STR-ROS Input-Output system, i.e.:

$$\begin{array}{|c|c|c|} \hline V^{GG} & V^{GW} & V^{GS} \\ \hline V^{WG} & V^{WW} & V^{WS} \\ \hline V^{SG} & V^{SW} & V^{SS} \\ \hline \end{array}$$

This spatial disaggregation is only applied to one category of primary inputs, the compensation of labour. This is important as we know that the sub-regions are characterised by interregional commuter flows, in particular between GLA and RST. As before I maintain the assumption that the technical need for labour inputs in the sub-regions is the same as in Scotland as a whole.

However, the commuting statistics are used to disaggregate spatially where compensation of employees flows to.

Commuter flows been GLA-RST-ROS are based on findings from the 2001 census published in Fleming (2006). Table 16A in Fleming (2006) reveals the origins and destinations of people who travel between Scottish addresses for work or study by local authority area. The table reveals the absolute number at each origin and a percentage breakdown across destinations. Using this information I can derive the number of commuters from each origin to each destination, thereby creating an origin-destination table for those travelling for work/study in Scotland. This matrix is then aggregated to conform to the GLA-RST-ROS sub-regional demarcation, as revealed in Table 24.

Table 24 Origins and destinations of people who travel between Scottish addresses for work/study (headcount/column %). Own calculations, based on Fleming (2006, Table 16A, pp. 64-65).

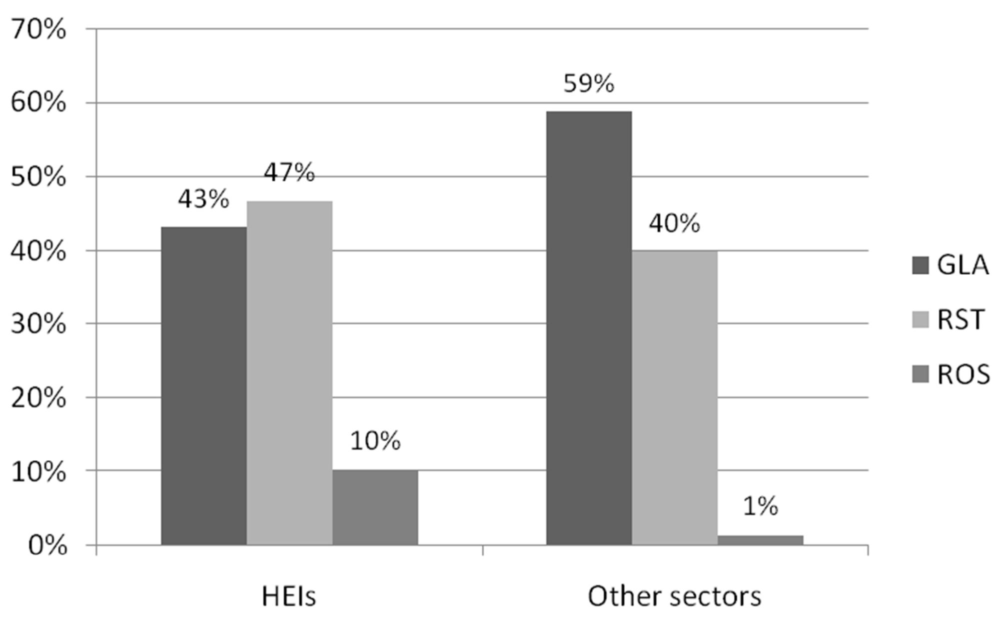
		Place of work							
		GLA		RST		ROS		SCO	
Residence	GLA	246,938	59%	46,677	6%	4,743	0%	**298,360**	**11%**
	RST	167,322	40%	727,112	93%	16,258	1%	**910,694**	**32%**
	ROS	5,961	1%	6,335	1%	1,613,211	99%	**1,625,507**	**57%**
		420,221	**100%**	**780,125**	**100%**	**1,634,212**	**100%**	**2,834,560**	**100%**

By using these data I am implicitly assuming that commuter flows do not differ significantly for students and those in employment, as wage flows should be primarily associated with the latter group. A further simplifying assumption that I make is that commuters are spread equally across sectors. Hence the column percentages from Table 24 were used to allocate compensation of employees originating in each region across the destination regions.

An exception to this approach is made for the HEIs in Glasgow. From the University of Strathclyde I have data on wage payments by postcode (see

Section 4.2.1). I assume this spatial structure of wage payments holds for other HEIs in Glasgow and apply this structure to their compensation of employees. As is illustrated in Figure 13, based on these data the HEIs in Glasgow employ more staff working outside the Glasgow City Council area than is predicted by the commuting data and assumptions applied to other data. In particular it is noteworthy how many more HEIs employees reside in the ROS than the general commuting pattern would imply. Presumably this is explained by the relatively flexible working environment offered by HEIs.

Figure 13 Spatial origin of workers in HEIs and other sectors in Glasgow.



3.3.3.4 Step 4: Final demand totals and balancing

To estimate final demand for the outputs of industries *j* in regions *r* I apply a mixed approach. Wherever possible I draw on published data to identify the level of a particular final demand category in each region. Where this is not possible I resort to attributing final demand at a Scottish level to each sub-region on a *pro rata* basis in line with the respective region's share of overall employment for the sector in question. Finally I determine the spatial allocation of exports to the Rest of the UK (RUK) and the Rest of the World (ROW) as a residual item that also balances the input-output table. A summary of these methods is provided in the table below. It reveals that 50% of overall final demand in the IO-tables is determined based on published data, 10% are determined indirectly based on employment shares and 40% are treated as a residual. A detailed description of the treatment of each item is presented in the subsequent sections.

Table 25 Overview of disaggregation approaches by final demand category.

	Total value £m	% of total final demand	Disaggregation method	Data source
Final consumption expenditure				
Households	36,002	28.2%	Direct data	ONS GDHI
NPISHs	2,472	1.9%	Pro rata	Based on employment share from ABI
Tourist Exp	1,816	1.4%		
Central Government	17,106	13.4%	Direct data	Regional Government Accounts Hillis (1998)
Local Government	10,662	8.4%		
Gross capital formation				
GFCF	8,701	6.8%	Pro rata	Based on employment share from ABI
Valuables	36	0.0%		
Change in Inventories	184	0.1%		
Exports				
RUK	33,297	26.1%	Residual	Control total from Scottish IO but spatial dispersion determined as a balancing item
RoW	17,394	13.6%		
	127,669	**100%**		

3.3.3.4.1 Household demand

For household consumption I assume that the households in the sub-region exhibit the same consumption pattern as households in Scotland as a whole. The complication that arises from working within an interregional framework is in determining not only the level of household demand, but also its spatial origins and destinations. To achieve this I use two different data sources to spatially disaggregate total household demand in Scotland. These two estimates for sub-regional household final demand, which I refer to as HFD(a) and HFD(b), can be interpreted as total household demand originating from a sub-region (approach b) and the total household demand spent in a sub-region (approach a) and hence the difference between these two is the net-inflow/outflow of household demand into/out of the sub-region. Finally a balancing procedure is undertaken where household demand for each sector is attributed to a spatial origin in order to satisfy previously estimated row and column control totals. The rest of this sub-section describes the process in detail.

The first step is to use employment shares to spatially disaggregate household demand in Scotland, such that:

$$HFD(a)_i^R = HFD_i^N \left[\frac{E_i^R}{E_i^N} \right]$$

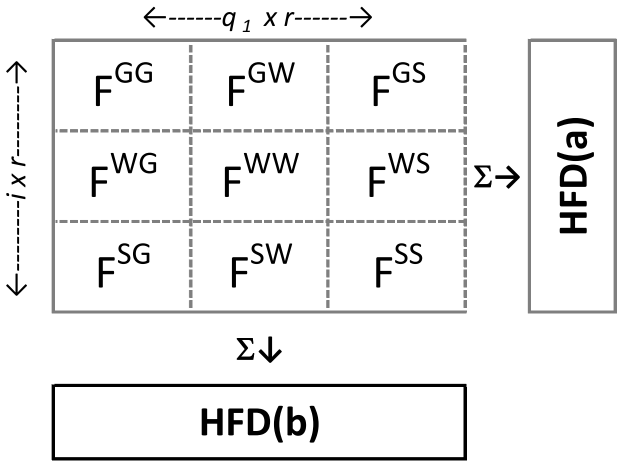
where $HFD(a)_i^R$ is Household Final Demand (estimated using approach a) for sector i in region R, HFD_i^N is the Household Final Demand for sector i in Scotland as a whole (N), E_i^R is the FTE employment in sector i in region R and E_i^N is the FTE employment in sector i in Scotland as a whole (N).

Then I again disaggregate household final demand in Scotland, this time using data on Gross Domestic Household Income (GDHI) by NUTS3 sub-regions published by the ONS (ONS, n.d. b):

$$HFD(b)_i^R = HFD_i^N \left[\frac{GDHI^R}{GDHI^N} \right]$$

where $HFD(b)_i^R$ represents Household Final Demand (estimated using approach b) for sector i in region R and HFD_i^N is the Household Final Demand in Scotland as a whole (N). $GDHI^R$ and $GDHI^N$ represent GDHI in region R and in Scotland as a whole (N). This can be interpreted as an estimate of the total household final demand originating from within a particular sub-region.

If I was assuming that there simply would not be any interregional flow of household demand, I could simply have used either of the disaggregation approaches introduced above directly. Under such an approach only the matrices on the diagonal would be used for household demand, i.e. $\mathbf{F}^{GG}$, $\mathbf{F}^{WW}$ and $\mathbf{F}^{SS}$. However, I want to estimate to what extent this household demand flows between the sub-regions and hence I use these two estimates (HFD(a) and HFD(b)) as control totals for the matrix of interregional household final demand. More specifically the sum of each column $\mathbf{F}^{*R}$ equals the sum of HFD(b) for each sector *i* of a particular sub-region and the sum of each row $\mathbf{F}^{R*}$ equals the sum of HFD(a) for each sector *i* in sub-region *r*.



Having determined the control totals for each row and column, the next step is to arrange the elements in the interregional household final demand matrix so as to conform to these control totals.

To determine the amount of interregional flow of household demand for each sector *i* in each region *R* I subtract HFD(b) from HFD(a):

$$IHFD_i^R = HFD(a)_i^R - HFD(b)_i^R$$

Table 26 shows this calculation for each region on aggregate. This reveals that Glasgow is a net-exporter of goods and services that satisfy household final demand in the rest of the Strathclyde region and Scotland.

Table 26 Percentage breakdown of household demand in Scotland by sub-region and interregional flow of household demand.

	HHD estimated from GDHI data (HFD(b))	HHD estimated from employment share (HFD(a))	HHD from (to) other regions (IHFD)
GLA	10%	17%	7%
RST	30%	25%	-6%
ROS	59%	58%	-1%
	100%	**100%**	**0%**

Determining the interregional flow of household demand between the three regions for each sector is relatively straightforward, as there are either two regions of origin but only one destination or only one origin and two destinations. Take for example the Primary and Utilities sector. For both GLA and RST HFD(a)<HFD(b), i.e. local household final demand is greater than the local sector can supply. Hence households in GLA and RST have to import from the Primary and Utilities sector in ROS where HFD(a)>HFD(b), i.e. the sector produces more than local demand can absorb. For both GLA and RST I assume households have preference for the local sector (no cross hauling) and hence they purchase as much of the outputs of the Primary and Utilities sector in their home region as the sector can supply (HFD(A)), in this case the excess demand from each sub-region (IHFD) has to be imported from ROS.

Conversely, there are sectors for which two regions have more capacity for meeting household consumption than is needed by local households but only one region where there's more demand for household consumption then can be met internally. For example this applies to the Hotels, Catering & Pubs sector, where GLA and ROS have excess capacity (HFD(a)>HFD(b)) but RST has excess demand (HFD(a)<HFD(b)). For the exporting sectors in GLA and ROS I assume local household demand (HFD(b)) is met locally, what is in this case exports (IHFD) have to be soaked up by demand from RST. Similarly for RST I

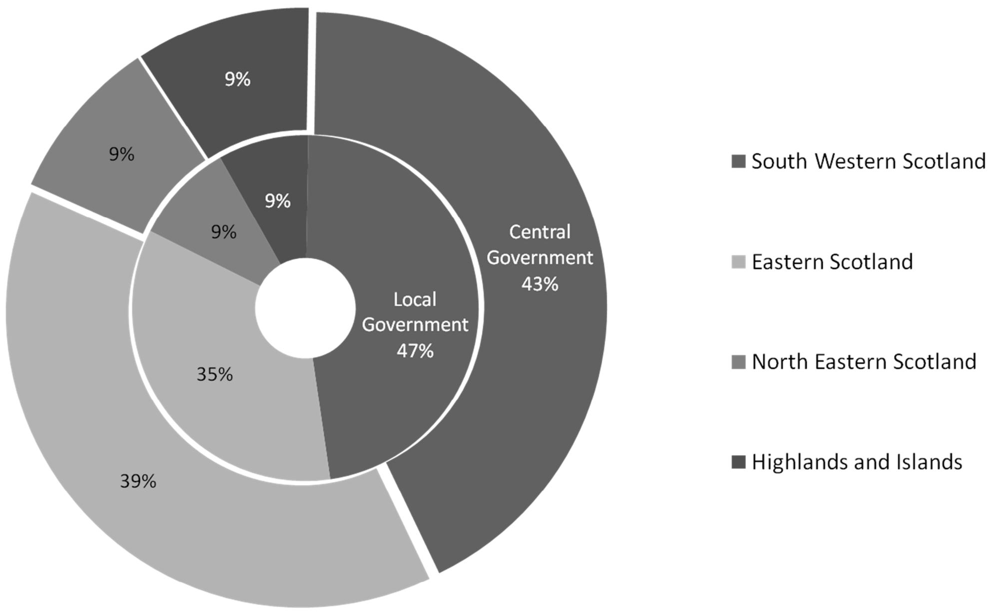
assume that local capacity (HFD(a)) goes to meet local demand (HFD(b)). The difference (IHFD) has to be satisfied with imports from GLA and ROS. By following this procedure stepwise for each sector the interregional household final demand matrices are estimated to satisfy row and column control totals.

Effectively this approach estimates the net-flow of household consumption between regions. As I do not have information about cross-hauling of household consumption Type-II multipliers are likely to be somewhat overstated. However, accounting for the net-flows is a significant improvement over not assuming any interregional consumption flows. The implications of this point for the output multipliers are demonstrated in a sensitivity analysis in Section 3.3.3.6.2.

3.3.3.4.2 Government demand

To disaggregate government final demand by sub-region I draw on regional government accounts (Hillis, 1998) and public sector employment by sub-region to construct weights, which in turn are used to disaggregate the local and central government final demand columns from the Scottish HEI-disaggregated IO-table.

Figure 14 Regional breakdown of central- and local government expenditure in Scotland in 1998. Source: Hillis (1998).



The latest year the regional government accounts (Hillis, 1998) refer to is 1998. This was a one-off publication. Therefore I have to assume that the spatial distribution of government activities within Scotland has not changed significantly since then. These accounts reveal central and local government expenditures at NUTS2 level, as depicted in Figure 14. As is illustrated in section 3.3.1. the NUTS2 area South West Scotland includes Glasgow and what is designated as the Rest of Strathclyde (RST) in this IO-table – in addition to the relatively small NUTS3 area of Dumfries & Galloway, which I attribute to the Rest of Scotland. Therefore I have to disaggregate government expenditures in the NUTS 2 region SW-Scotland into expenditures in GLA, RST and ROS. This is done using public sector employment in the NUTS 2 area South Western Scotland, broken down by each IO region. Government expenditures in the other three NUTS 2 regions (North Eastern Scotland, Eastern Scotland and Highlands and Islands) are attributed directly to ROS.

Table 27 Public sector employment in the NUTS 2 region South West Scotland, broken down by IO sub-region

	FTEs	%
GLA	96,561	40%
RST	130,887	55%
ROS (Dumfries & Galloway)	12,646	5%
South West Scotland (total)	**240,094**	**100%**

As Table 27 reveals, 40% of public sector final demand in the NUTS 2 region South West Scotland will be attributed to Glasgow, 55% to the rest of the Strathclyde region and 5% to the rest of Scotland.

Table 28 Breakdown of central- and local government expenditures by IO region.

(Sub-) region	Central	Local
GLA	17.1%	19.1%
RST	23.2%	25.9%
ROS	59.7%	55.1%
SCO (total)	100.0%	100.0%

Table 28 reveals the breakdown of central- and local government expenditures in each of the 3 IO-regions. As the table reveals local government expenditures are relatively larger in GLA and RST, whereas the converse holds for ROS where central government expenditures are a relatively larger share.

3.3.3.4.3 NPISHs, Tourist Demand and Gross Capital Formation

For the disaggregation of NPISHs (Non Profit Institutions Serving Households), Tourist Demand and the Gross Capital Formation final demand categories a simple approach is used. I assume that demand for each sector is proportional to the share of Scotland-wide employment in that sector found in Glasgow, such that:

$$F_i^R = F_i^N \left[\frac{E_i^R}{E_i^N} \right]$$

where F_i^R is a final demand (of an unspecified category) for sector *i* in region *r*, F_i^N is the final demand (of the same category) for sector *i* in Scotland as a whiole (*N*), E_i^R is the FTE employment in sector *i* in region *R* and E_i^N is the FTE employment in sector *i* in Scotland as a whole (*N*).

3.3.3.4.4 Exports and balancing

Having estimated the Z-matrices of intermediate transactions and most final demand categories using the best available information, what remains is to estimate exports and balance the table. As the 3-region table is a disaggregation of the balanced HEI disaggregated Scottish IO-table it should by definition balance if constrained to each sector's row and column total. Therefore there is no need to apply an adjustment procedure such as RAS, as the IO-table conforms to the accounting identity of single entry bookkeeping that column sum must equal row sums. As there is least information available for spatial distribution of RUK and ROW exports I choose this as a balancing row. As all the other demand categories are constrained to the control totals from the Scottish IO-table, the balancing entries will automatically conform to the control totals of total exports in the Scottish table.

The starting point in this process is determining the shares of total exports of a sector that go to the RUK and ROW. For this I assume that the RUK/ROW breakdown of exports at the Scottish level hold at the sub-regional level. Then the total exports of sector *i* in region *r* is determined as that sector's estimated gross output, less intermediate demand and less all the final demands estimated so far (i.e. everything but exports). This estimate for total exports is then attributed to RUK and ROW exports using the previously determined weights for RUK and ROW exports for sector *i*. This concludes the disaggregation process.

3.3.3.5 GLA-RST-ROS IO

In the table below I present the interregional Type-I and Type-II multipliers for the GLA-RST-ROS IO-table. The multipliers are shown in a disaggregated format, revealing the direct effect upon the host region and the knock on effects for each of the 3-regions of the model. Finally total Scotland-wide impact (the sum of the direct and knock-on impacts across the rub-regions) is presented in the most rightward column, for each of the Type-I and Type-II multipliers. For example, for the Type-II multiplier for the University of Strathclyde, we can see that the total Scotland-wide output multiplier for Strathclyde is 2.10. This is composed of the direct effect upon the host region GLA (1) in addition to knock impacts upon GLA (0.58), RST (0.33) and ROS (0.19).

Summarising the broad qualitative findings revealed by the multipliers, it is clear that the role of interregional intermediate trade (indirect effects as gauged by the Type-I multiplier) is rather limited. This is not a surprising result for an interregional IO-table, particularly given the construction method as discussed in Section 3.3.2. A graphical exposition of this point is provided in Figure 15, which reveals the percentage of type-I knock-on impacts, by sector and region, that materialise as spill-over effects outside the sector's host region. As the diagram reveals the strongest Type-I interregional effect is provided by the 'Primary and utilities' sector. However, the extent of this effect differs between regions and is most distinct for the 'Primary and utilities' sector based in GLA (dark grey bars) where 28% of the knock-on impacts materialise outside the host region in RST and ROS. The share of knock-on impacts that spill-over to nearby regions is slightly less for the 'Primary and utilities' sector' in RST at 22% but is only 2% for the sector in ROS. This pattern holds for the Type-I impacts of other sectors in ROS, which are mostly felt within their host-region. From the point of view of intermediate transactions it is clear therefore that the ROS is the least open of the 3 sub-regions.

Table 29: Type-I and Type-II interregional multipliers in the interregional GLA-RST-ROS Input-Output table

	Sector	Type-I multiplier					Type-II multiplier				
		Direct effect	Knock on effects				Direct effect	Knock on effects			
			GLA	RST	ROS	SCO		GLA	RST	ROS	SCO
GLA	Primary and utilities	1	0.44	0.07	0.21	**1.72**	1	0.61	0.19	0.29	**2.09**
	Manufacturing	1	0.27	0.04	0.09	**1.39**	1	0.48	0.19	0.14	**1.81**
	Construction	1	0.39	0.05	0.09	**1.53**	1	0.65	0.24	0.15	**2.04**
	Distribution and retail	1	0.31	0.01	0.02	**1.35**	1	0.59	0.20	0.08	**1.87**
	Hotels, catering, pubs, etc	1	0.13	0.01	0.02	**1.16**	1	0.45	0.23	0.08	**1.76**
	Transport, post and communications	1	0.45	0.01	0.02	**1.48**	1	0.73	0.20	0.07	**2.00**
	Banking and financial services	1	0.55	0.01	0.02	**1.59**	1	0.74	0.14	0.06	**1.94**
	House letting and real estate services	1	0.29	0.02	0.03	**1.34**	1	0.39	0.09	0.06	**1.54**
	Business services	1	0.34	0.01	0.02	**1.37**	1	0.66	0.22	0.08	**1.96**
	Public sector	1	0.27	0.01	0.02	**1.30**	1	0.61	0.24	0.08	**1.93**
	Other services	1	0.32	0.01	0.02	**1.35**	1	0.64	0.23	0.08	**1.95**
	Caledonian	1	0.19	0.02	0.04	**1.26**	1	0.54	0.34	0.18	**2.05**
	GSA	1	0.19	0.02	0.04	**1.25**	1	0.53	0.34	0.18	**2.05**
	Glasgow	1	0.22	0.03	0.04	**1.29**	1	0.56	0.33	0.18	**2.07**
	RSAMD	1	0.23	0.03	0.05	**1.30**	1	0.56	0.33	0.18	**2.08**
	Strathclyde	1	0.25	0.03	0.05	**1.33**	1	0.58	0.33	0.19	**2.10**
RST	Primary and utilities	1	0.03	0.50	0.18	**1.72**	1	0.11	0.74	0.26	**2.10**
	Manufacturing	1	0.01	0.31	0.06	**1.39**	1	0.10	0.61	0.12	**1.83**
	Construction	1	0.01	0.48	0.04	**1.53**	1	0.13	0.84	0.10	**2.07**
	Distribution and retail	1	0.01	0.30	0.03	**1.35**	1	0.13	0.68	0.10	**1.90**
	Hotels, catering, pubs, etc	1	0.01	0.13	0.02	**1.16**	1	0.14	0.57	0.09	**1.80**
	Transport, post and communications	1	0.01	0.43	0.04	**1.48**	1	0.13	0.80	0.10	**2.03**
	Banking and financial services	1	0.04	0.47	0.08	**1.59**	1	0.11	0.71	0.14	**1.96**
	House letting and real estate services	1	0.01	0.30	0.03	**1.34**	1	0.06	0.44	0.06	**1.55**
	Business services	1	0.02	0.31	0.05	**1.37**	1	0.15	0.72	0.12	**1.99**
	Public sector	1	0.01	0.26	0.03	**1.30**	1	0.15	0.71	0.11	**1.97**
	Other services	1	0.01	0.30	0.03	**1.35**	1	0.14	0.73	0.11	**1.98**
	HEIs in RST	1	0.01	0.26	0.02	**1.29**	1	0.17	0.82	0.11	**2.10**
ROS	Primary and utilities	1	0.01	0.01	0.70	**1.72**	1	0.03	0.02	1.05	**2.11**
	Manufacturing	1	0.00	0.01	0.38	**1.39**	1	0.03	0.02	0.79	**1.84**
	Construction	1	0.01	0.01	0.52	**1.53**	1	0.04	0.02	1.02	**2.08**
	Distribution and retail	1	0.01	0.01	0.32	**1.35**	1	0.05	0.03	0.83	**1.91**
	Hotels, catering, pubs, etc	1	0.00	0.00	0.15	**1.16**	1	0.04	0.02	0.74	**1.81**
	Transport, post and communications	1	0.02	0.02	0.44	**1.48**	1	0.05	0.05	0.94	**2.04**
	Banking and financial services	1	0.02	0.02	0.55	**1.59**	1	0.04	0.04	0.89	**1.96**
	House letting and real estate services	1	0.01	0.01	0.33	**1.34**	1	0.02	0.01	0.52	**1.56**
	Business services	1	0.01	0.01	0.35	**1.37**	1	0.05	0.03	0.92	**2.00**
	Public sector	1	0.01	0.01	0.29	**1.30**	1	0.05	0.03	0.91	**1.98**
	Other services	1	0.01	0.01	0.33	**1.35**	1	0.04	0.02	0.93	**1.99**
	HEIs in ROS	1	0.01	0.01	0.33	**1.34**	1	0.05	0.03	1.06	**2.14**

When we incorporate induced effects, using the Type-II multipliers, a greater degree of interregional interdependency is revealed. This is evident both from looking at individual multipliers in the table and the percentage of Type-II knock-on effects, by sector and host-region, that spill over to other regions, presented in Figure 16. This diagram is identical to Figure 15 and drawn in the same scale, allowing comparison that clearly reveals the increase in interregional spill-overs of knock-on effects, once induced effects are accounted for in addition to indirect effects.

Figure 15 % of Type-I knock-on effects that spill over to other regions by sector and host-region.

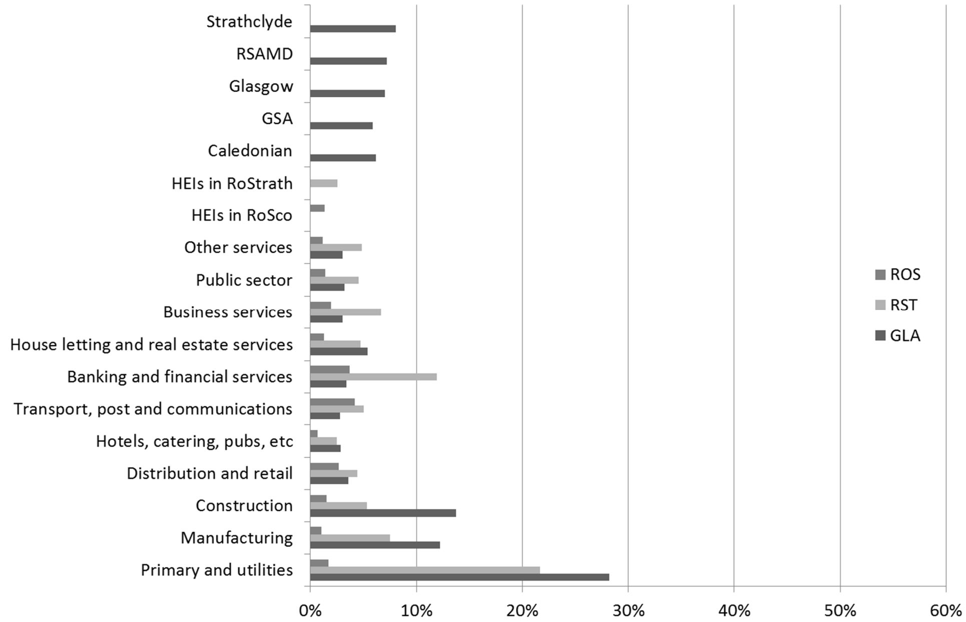
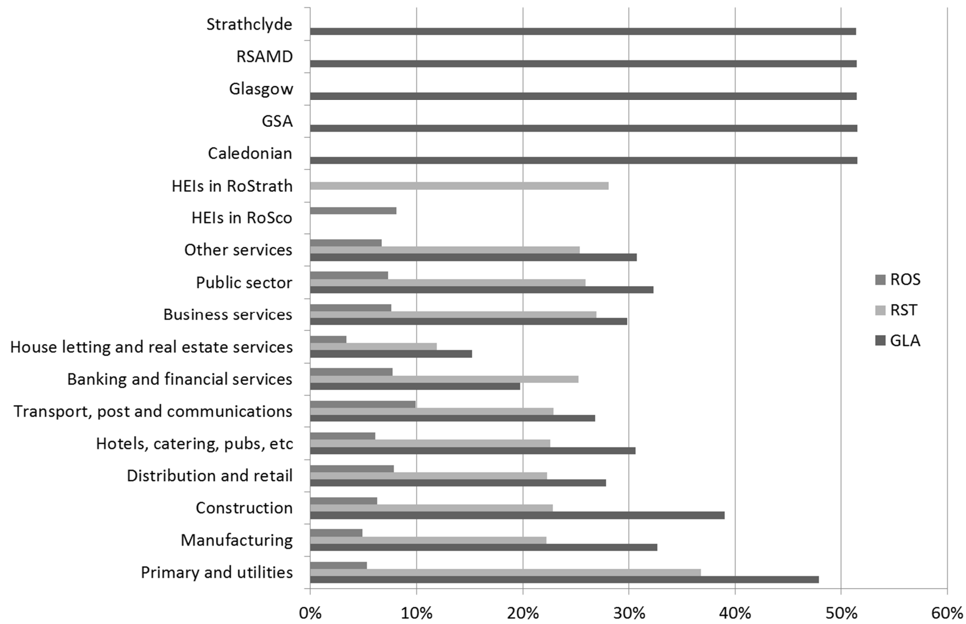


Figure 16 % of Type-II knock-on effects that spill over to other regions by sector and host-region.



Again, the individual sub-regions differ in the extent to which a host-region demand stimuli spills over to the other regions. In this regards GLA is clearly the most open of the sub-regions (dark-grey bars in the diagram), driven by interregional flows of wages and household consumption. A similar, but slightly more subdued pattern of interregional spillovers of Type-II knock-on impacts is evident for RST. However, by comparison, expenditure impacts in ROS are mostly captured within the host region.

If we compare, for example, the construction sectors in GLA and ROS we see that both of them have very similar Scotland-wide Type-II multipliers, 2.04 in GLA and 2.08 in the ROS. However, of this the interregional effect is only 0.06 for ROS, whereas in GLA it is 0.39 or approximately two fifths of the total knock-on effect. This is even more distinct for the HEIs. For example Caledonian has a Scotland wide Type-II multiplier of 2.05, of which 0.52 is an impact felt in RST and ROS. More specifically, every £1 of final demand for Caledonian translates into an output impact of £2.06 in Scotland as a whole. Of these, £1 would be felt as a direct impact in Glasgow, whereas for knock-on impacts 54p would be felt in GLA, 34p in RST and 18p in ROS.

Simply by observing the multipliers it is clear that allowing for commuting by identifying interregional flows of wages and consumption can make a critical difference to the results of impact studies at the sub-regional level, in particular within metropolitan areas, such as the Strathclyde region. I further explore the importance of identifying the interregional flow of wages and consumption in the sensitivity analyses in the next section. These I compare the multipliers presented above with ones estimated from a table that ignores commuter flows and interregional flows of consumption expenditures. The IO-table is fully utilised to analyse the expenditure impacts of HEIs in Glasgow and Scotland in Chapter 5.

3.3.3.5.1 Aggregation bias

Before moving on to analyses based on the 3-region interregional IO-tables in the next chapter, a note should be made on the comparability of results between the 3-region IO-table and its single region predecessor. Because of the spatial-disaggregation the multipliers for individual institutions derived from the 3-region table will differ from those derived from the single region table. It is well known that any changes to the structure of an IO-table will cause slight changes in individual multipliers[77]. This, however, is not as consequential as might seem at first. Due to the accounting constraints of an IO-table these errors have to balance out across sectors as the aggregate final demands and gross outputs of the economy described by the table are unchanged. That is, some multipliers will see a slight increase while others are slightly decreased as changes are made to the structure of the IO-table. Furthermore, these differences are not so big as to shift the qualitative implications of the analysis.

Table 30 Comparison of Type-II multipliers from a single region IO-table of Scotland and a weighted average of the multipliers from the spatially disaggregated GLA-RST-ROS table.

	Weighted average Type-II multipliers from interregional table	Type-II multipliers from single region SCO table	Disaggregation bias	Error as % of single region multiplier
	(A)	(B)	(A-B)	(A-B/B)
Primary and utilities	2.11	2.10	0.00	0.13%
Manufacturing	1.83	1.83	0.00	0.10%
Construction	2.07	2.07	0.00	0.07%
Distribution and retail	1.90	1.90	0.00	0.03%
Hotels, catering, pubs, etc	1.80	1.80	0.00	0.04%
Transport, post and communications	2.03	2.03	0.00	-0.04%
Banking and financial services	1.96	1.96	0.00	-0.11%
House letting and real estate services	1.55	1.55	0.00	-0.05%
Business services	1.99	1.99	0.00	-0.12%
Public sector	1.97	1.97	0.00	-0.03%
Other services	1.98	1.98	0.00	0.02%
HEIs in RST	2.14	2.13	0.01	0.57%
HEIs in ROS	2.10	2.10	0.00	0.00%
Caledonian	2.06	2.09	-0.03	-1.50%
GSA	2.05	2.08	-0.03	-1.51%
Glasgow	2.08	2.11	-0.03	-1.45%
RSAMD	2.08	2.11	-0.03	-1.45%
Strathclyde	2.10	2.13	-0.03	-1.41%

[77] For an overview see Miller & Blair (2009, Ch. 4.9.2., pp. 65-65).

The aggregation bias driven by the disaggregation of the single region Scottish IO-table into 3-regions is illustrated in Table 30 above. Type-II output multipliers are compared against the weighted (by gross output) average of each sector across the three regions. As is revealed by the third column of the table, the difference between the output multipliers derived from the two versions of the IO-table is quite small. This is further detailed in the fourth column of the table, which expresses the aggregation bias of Type-II output multipliers of sectors in the 3-region IO-table as a percentage of Type-II multipliers in the single region IO-table. Of the non-HEI sectors the largest bias is found in the Type-II multiplier of the banking and financial services sector, which are understated relative to the original single region table by 0.11%. The HEI sectors are more strongly impacted by the disaggregation with the Glasgow HEIs' multipliers understated by 1.4%-1.51% of the multipliers in the original single region version. However, the multiplier for the HEIs in ROS sector is 57% larger than in the single-region case.

3.3.3.6 Sensitivity analysis

To test the sensitivity of the multipliers (applied in Chapter 5) to the assumptions applied in constructing the 3-region interregional IO-table I conduct sensitivity analysis around two major components of the table: intermediate transactions and household incomes/expenditures.

The intermediate transactions are estimated using Location Quotients. As we have seen a substantial literature analyses and criticises the ability of LQ-based approaches to accurately estimate intermediate transactions in IO-tables. An obvious response to this literature is to adjust the chosen LQ-approach by the degree to which it is expected to overestimate intermediate transactions. I undertake such an exercise in order to test to what extent a potential LQ-induced bias can affect the multipliers derived from the table.

A more novel feature is to test how alternative assumptions about the interregional flow of household's wage income (compensation of employees) and household expenditures affect estimated multipliers. The induced knock-on effects where wage income drives household expenditures is the additional knock-on effect included in the Type-II multiplier (over the Type-I multiplier) and is often a substantial part of overall knock-on impacts. The accuracy of the components of the IO-table that the induced impacts are based on has not received much attention hitherto. However, as the following analysis suggests this can have a significant impact on the extent to which impacts are attributed to the host region or to interregional spillovers.

3.3.3.6.1 Intermediate transactions

In order to assess the sensitivity of the multipliers derived from the IO-table to the LQ formulas used to estimate intermediate transactions I estimate the IO-table using alternative LQs. In this case I use the FLQ formula under a range of δ parameters and compare to the original version of the IO-table estimated using SLQs. I choose three parameter values: δ=0.3 is my central value for δ as this is recommended by Flegg & Webber (1997). Furthermore, testing by Flegg & Tohmo (2010) and Bonfiglio (2009) find the best results for intermediate transactions tend to be based on δ values clustered within an interval of 0.2-.03 and 0.25-.0.35, respectively. In addition to this I choose δ=0.5 as the upper bound for δ and δ=0.1 as a lower bound. Overall the SLQ and the FLQ, with δ=0.5 can be seen as representing the upper bound and lower bound, respectively, for local multipliers.

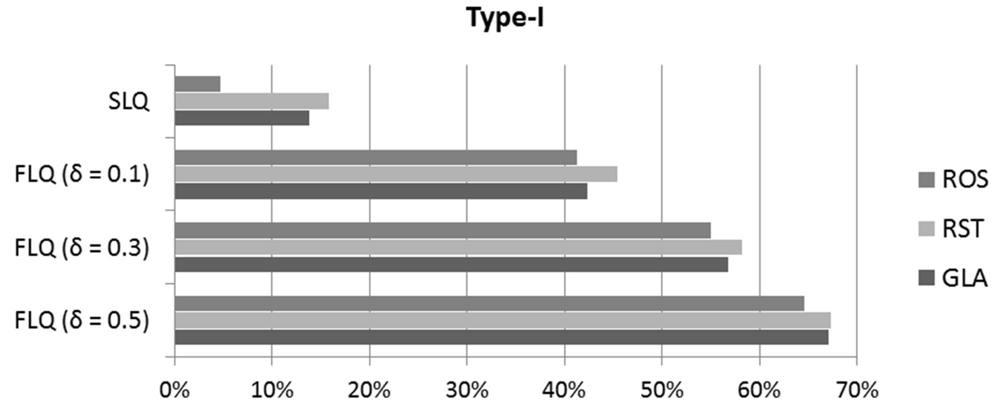
To simplify the presentation of results I aggregate the industrial sectors into 1 sector for each region. The multipliers presented in Table 31 below can therefore be interpreted as the weighted average output multipliers for each sub-region. The table below shows these aggregate multipliers broken down into their constituent components: direct effect, local knock-on effect and interregional knock-on effect. For each region the Type-I and Type-II multipliers are calculated based on Input-Output tables for which intermediate transactions are estimated using the FLQ formula under the three parameter values δ=0.1, δ=0.3 and δ=0.1 or the SLQ.

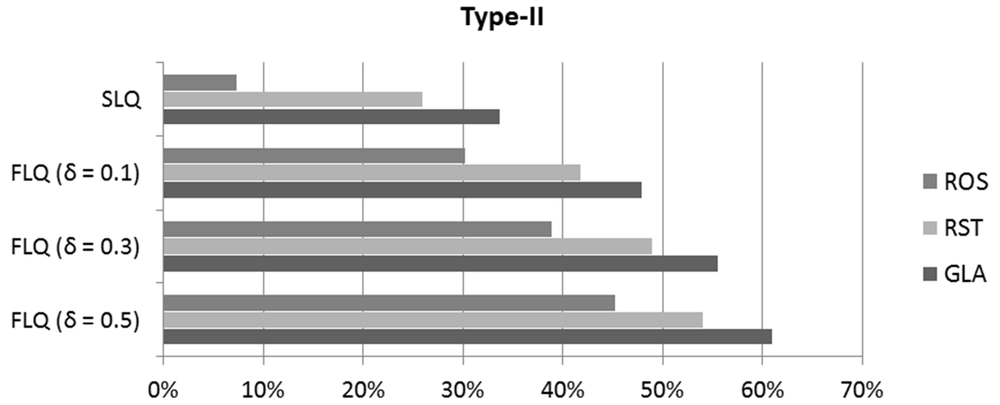
Table 31 Spatial decomposition of aggregate multipliers by sub-region

	Type I			Type II		
GLA	**Direct**	**Local**	**Int.**	**Direct**	**Local**	**Int.**
SLQ	1.0	0.32	0.05	1.0	0.61	0.31
FLQ (δ = 0.1)	1.0	0.21	0.16	1.0	0.48	0.44
FLQ (δ = 0.3)	1.0	0.16	0.21	1.0	0.41	0.51
FLQ (δ = 0.5)	1.0	0.12	0.25	1.0	0.36	0.56
RST	**Direct**	**Local**	**Int.**	**Direct**	**Local**	**Int.**
SLQ	1.0	0.32	0.06	1.0	0.70	0.24
FLQ (δ = 0.1)	1.0	0.20	0.17	1.0	0.55	0.39
FLQ (δ = 0.3)	1.0	0.16	0.22	1.0	0.48	0.46
FLQ (δ = 0.5)	1.0	0.12	0.25	1.0	0.43	0.51
ROS	**Direct**	**Local**	**Int.**	**Direct**	**Local**	**Int.**
SLQ	1.0	0.36	0.02	1.0	0.89	0.07
FLQ (δ = 0.1)	1.0	0.22	0.16	1.0	0.67	0.29
FLQ (δ = 0.3)	1.0	0.17	0.21	1.0	0.58	0.37
FLQ (δ = 0.5)	1.0	0.13	0.25	1.0	0.52	0.43

Furthermore, a graphical summary of these results is presented in Figure 17 below. The horizontal bars reveal the percentage of knock-on impacts of the aggregate sector in each region that would materialise as an interregional spill-over, based on estimates using alternative LQ specifications. The upper half shows Type-I multipliers, whereas Type-II multipliers are presented in the lower half. For example, looking at the uppermost cluster of bars in the upper half, the diagram reveals that when using simple location quotients (SLQ) to estimate Type-I multipliers for the aggregate sector in each region GLA, RST and ROS only 14%, 16% and 5% of the knock-on impacts would be felt outwith the host region.

Figure 17 Percentage of knock-on impacts that spills over to other regions under alternative LQ-formulas.





As the table and the diagrams reveal, the Type-I multipliers are very sensitive to the specification of the LQ formula used to estimate intermediate transactions. Under the SLQ formula 15% of the knock-on effects are realised outside GLA (16% for RST and 5% for ROS). However, a much stronger interregional effect is realised under the FLQ formula and results are similar for each sub-region. The share of interregional spillover under the FLQ range from approximately 40% (δ=0.1) to almost 70% (δ=0.5). For the FLQ formula using the base case parameter (δ=0.3), which based on existing literature can be seen *a priori* as the most favourable alternative to the SLQ, approximately 60% of the knock-on effects will be realised outside the host region. This is a very significant increase in interregional interdependency for indirect (Type-I) knock-on impacts.

The lower part of the diagram, which presents results for Type-II multipliers, reveals a slightly different picture. There are two main qualitative differences between the Type-I and Type II results:

- Based on Type-II analysis, the multipliers, although sensitive to the formula used to estimate intermediate transactions, are far less sensitive than indicated by the Type-I multipliers
- Whereas there is little difference between outcomes by sub-regions looking at Type-I multiplier, when looking at Type-II multipliers, sub-regional heterogeneity begins to emerge, in the sense that the degree of interregional interdependency starts to vary between the individual regions.

It is clear that in terms of the interregional spill-over of knock-on impacts as estimated by Type-II multipliers Glasgow is the most open of these sub-regional economies and the rest of Scotland least so. This is not surprising given that GLA is the smallest region being modelled and the ROS the biggest. Furthermore, Glasgow experiences the most significant commuter flows relative to its local economy. Based on Type-II multipliers the interregional share of knock-on impacts for GLA ranges from just under 40% to slightly more than 60%. Comparing the SLQ and the base case FLQ (δ=0.3) the interregional effect is about 50% larger under the latter one. This suggests that when using Type-II multipliers, particularly when working within a metropolitan setting, an accurate identification of interregional flows of wages and household consumption becomes relatively more important as including induced effects dampens the variation generated through intermediate transactions. Although significant steps have been taken in the construction of this IO-table to accurately identify interregional wage and consumptions flows, the assumptions adopted are still likely to overstate the local aspect of Type-II knock on impacts and understate the interregional spillovers. Unfortunately a further exploration or remedy of these issue is beyond the scope of this text, so it will have to be left for future work. However, the findings so far suggest that the priority for future enhancements of this table should not focus exclusively on intermediate transactions, as some of the literature might suggest (eg. Harris & Liu, 1997) but also emphasise accurate identification of the spatial origin of household income and the spatial destination of household consumption.

3.3.3.6.2 Household incomes and expenditures

As is detailed in section 3.3.3.3 and 3.3.3.4.1 more elaborate methods for the estimation of compensation of employees and household consumptions expenditures were used in the construction of the 3-region interregional IO-table than is common for LQ-based tables. In this process commuter flows were used to determine the interregional flow of compensation of employees and regional household accounts were used to estimate the (net) flow of household expenditures between the three regions. Although the literature on the use of non-survey techniques to estimate Input-Output tables primarily emphasis the accurate identification of intermediate transactions, anecdotal evidence would suggest that for the case of sub-regional economies like Glasgow (GLA) and the Rest of Strathclyde (RST) household transactions are important and occur across boundaries. This is why I am motivated to widen the focus beyond intermediate transactions and test additionally the sensitivity of results to the assumptions on the parts of the IO-table that determine the magnitude of induced effects.

The treatment of compensation of employees and household consumption expenditures in this IO-table is as accurate as the data currently available to me permit. However, this still leaves something to be desired, in particular sector specific data on commuter flows (and hence wage flows) and more detailed household expenditure data that would allow identification of cross-hauling of household consumption expenditures between the sub-regions. In this case aggregate data has only allowed me to identify the net-interregional flow of household consumption expenditures. However, I have argued that these additional features are a considerable improvement over simply assuming that compensation of employees stays within the sub-region of employment and using sector employment shares for each region to estimate household expenditures. To verify these claims I compare the multipliers obtained from the 3-region interregional HEI-disaggregated IO-table to those from a simpler version of the table where the aforementioned basic approach to identifying the spatial attribution of household wage income and consumption expenditures is applied. The results of this comparison are presented below.

Figure 18 Comparison of the percentage-share of host-region knock-on impacts of Glasgow sectors, based on a 'standard' treatment of household incomes/expenditures and a more elaborate treatment household incomes/expenditures acknowledging interregional commuter and consumption flows.

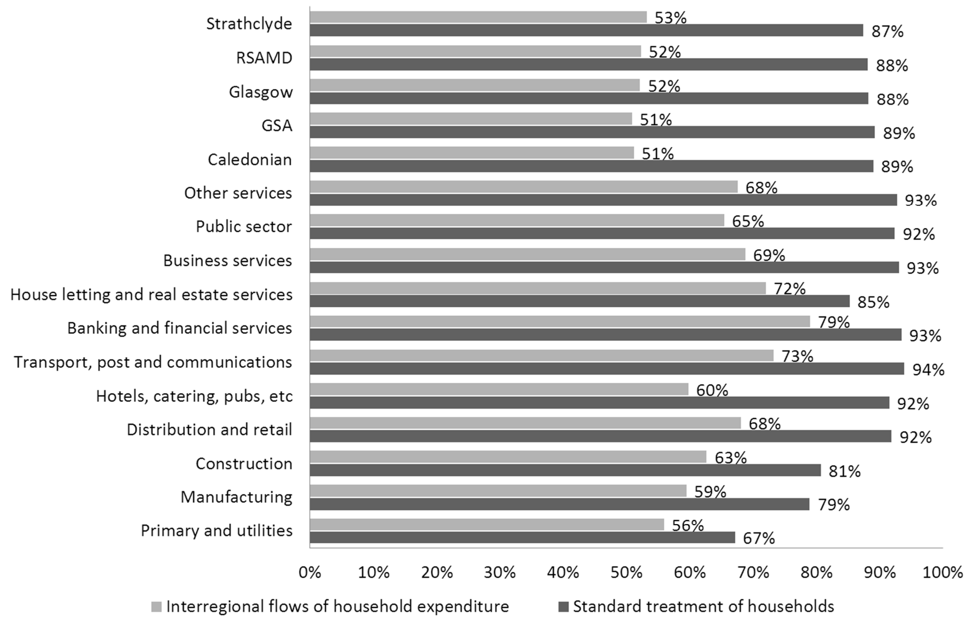
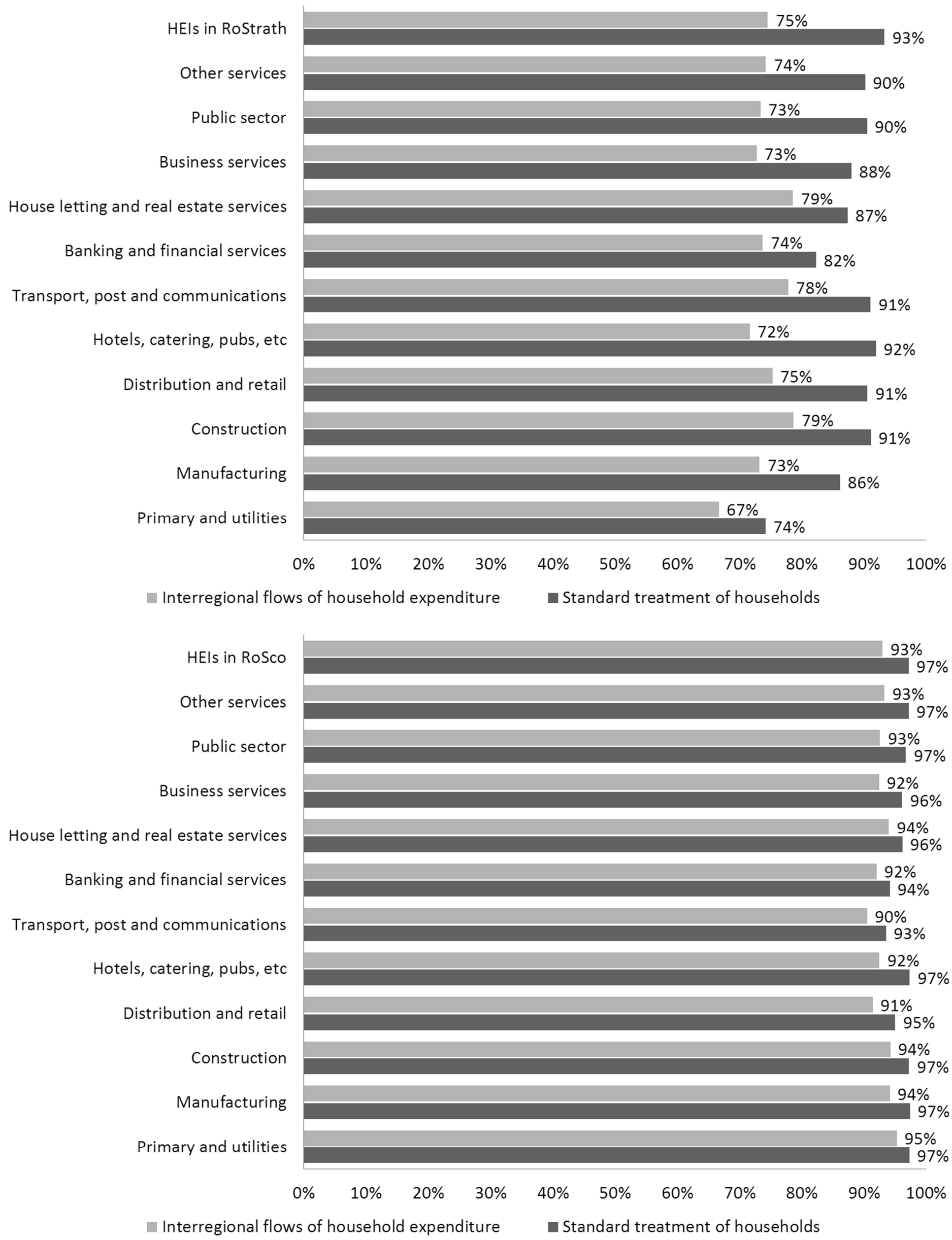


Figure 18 above compares the extent to which Type-II multipliers for Glasgow sectors reveal their knock-on impacts to be concentrated within the host region based on alternative treatments of household incomes and expenditures. Taking the example of the University of Strathclyde the diagram reveals that using the approach of the 3-region interregional HEI-disaggregated IO-table, where commuter- and consumption flows are explicitly recognised (lighter bars) 53% of the knock-on impacts of the University of Strathclyde manifest themselves within the host region Glasgow – the corollary being that 47% of the knock-on impacts of Strathclyde spill-over to the other two sub-regions RST and ROS. Conversely under the simpler 'standard' treatment of induced impacts (darker bars) 87% of the knock-on impacts are materialised within the host-region (GLA) while only 13% spill-over to the other regions (RST and ROS).

From Figure 18 it is clear that the discrepancy between the two approaches is most distinct for the case of the HEIs. This is not surprising, given the construction of the HEI sectors benefitted from the availability of direct data on the location of HEI-staff, which revealed them to be significantly more commute-intensive than Glasgow sectors on average. Furthermore, this discrepancy is greater for sectors for which expenditures are more heavily concentrated on wages such as 'Hotels, catering, pubs, etc' than those where intermediates feature more prominently in expenditures, such as 'Primary and utilities'.

Identical diagrams are presented below for the cases of the rest of the Strathclyde region (RST) and the rest of Scotland (ROS). Unsurprisingly the difference between the two methods is most marked for Glasgow, the region that is the most 'open' in terms of commuter flows and household consumption expenditures. The effect of the different treatments of household incomes and expenditures is still significant for the case of RST, whereas for the largest region, ROS, the treatment of household incomes and expenditures has negligible impact on multiplier values. As ROS is the largest region and commuter flows vis-á-vis GLA and RST are small relative to its overall economic activity it effectively 'internalises' the interregional spillovers that are so evident between GLA and RST.

Figure 19 Comparison between the percentage-share of host-region knock on impacts of RST sectors (upper half) and ROS sectors (lower half) based on a 'standard' treatment of household incomes-expenditures and a more elaborate treatment household incomes/expenditures acknowledging interregional commuter and consumption flows.



4 Glasgow HEIs: a descriptive overview

In this Chapter I provide a descriptive overview of Glasgow's HEIs within the context of the overall Scottish HEI sector. The purpose is to provide a factual backdrop to the subsequent analysis of the economic impact of Glasgow HEIs. The chapter draws mostly on data from the Higher Education Statistics Agency (HESA), which are available for all HEIs in Scotland (and indeed the UK). However, I also introduce some previously unpublished data obtained from the University of Strathclyde, which allow a more detailed understanding of the sub-regional impacts of HEIs. In addition I draw on data specifically sourced from HESA databases to shed light on the characteristics of the Glasgow student population, its origins and the destinations of the graduates.

In the first two sections I identify the income and expenditures of Glasgow HEIs, their composition in the study year of 2006 and how these compare to the corresponding data for Scotland as a whole. In the third section I focus on the student population of Glasgow HEIs. This is important both in terms of expenditure impacts (the consumption of students) and potentially the supply-side impacts of graduates in the labour market. I analyse the composition of students in terms of their geographical origin and the courses they attend – both in terms of the level and subject of study. In addition, I present more detailed information about students at Glasgow HEIs, which is indicative of their demand and supply impacts, such as their term time accommodation. Finally, to inform subsequent analysis of supply side impacts I examine the destination of students at Glasgow HEIs once they graduate.

4.1 Income of Glasgow HEIs

As Figure 20 reveals the HEIs in Glasgow represent a significant proportion of the overall HEIs sector in Scotland. Gauged in terms of income the five Glasgow HEIs receive 31% of the overall income of HEIs in Scotland[78].

---

[78] Interestingly the four HEIs in Edinburgh (Edinburgh, Heriot-Watt, Napier and the Edinburgh College of Arts (ECA)) attract 30% of the income of all HEIs in Scotland, only marginally less than their counterparts in Glasgow. Traditionally, QMUC is seen as an Edinburgh based institute. However, they recently relocated to Musselburgh in East Lothian, which is not part of Edinburgh City Council, although close by.

Figure 20 Income of individual HEIs in Scotland as % of the income of the sector as a whole, 2005/06 (Source: HESA 2007, own calculations).

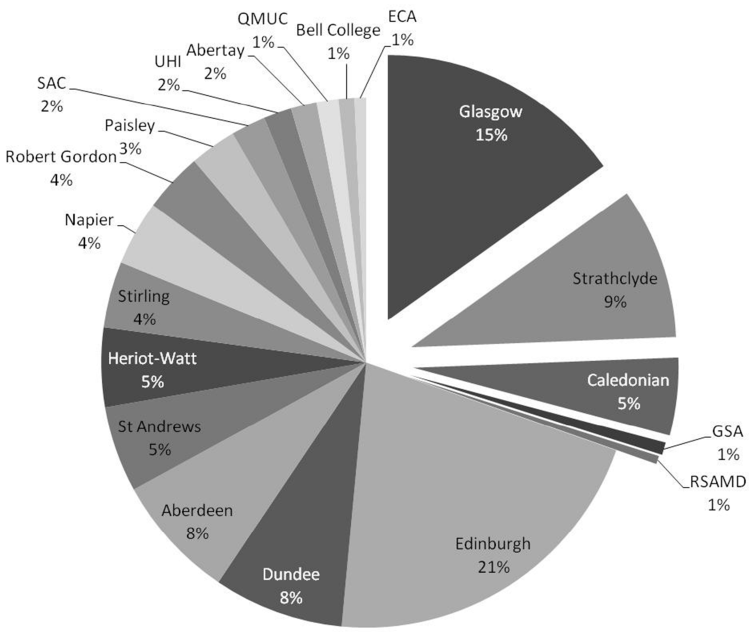
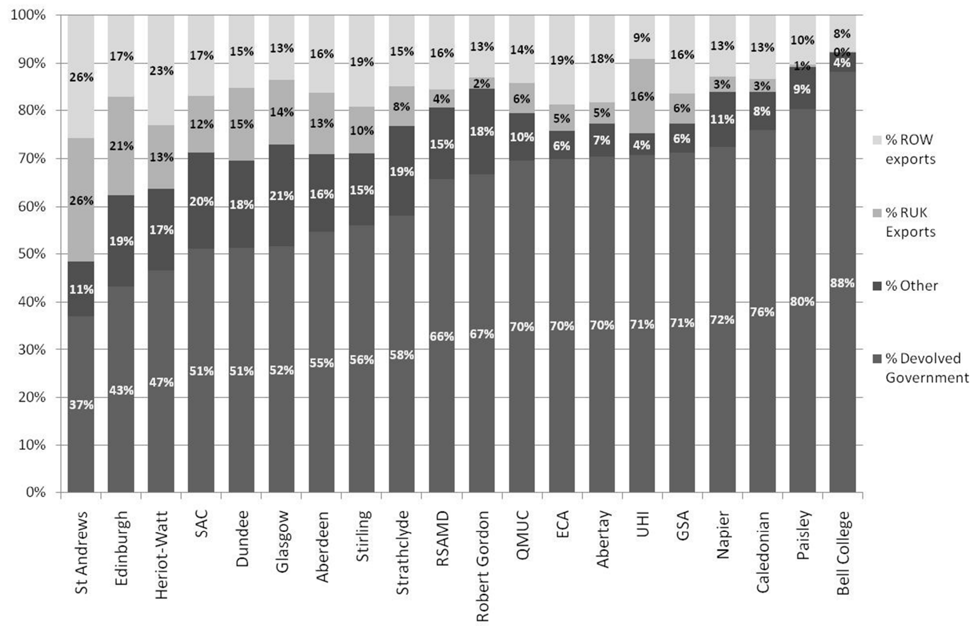


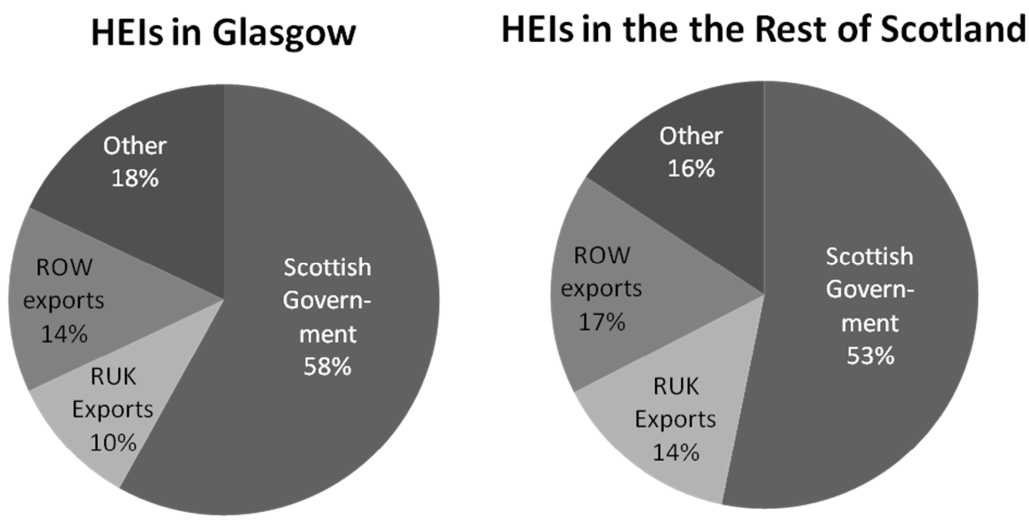
Figure 21 presents the income of each Scottish HEI disaggregated by source (as was derived in section 3.2.2.2). It reveals that the extent to which individual HEIs are dependent on funding from the Scottish Government (and conversely the extent to which they are able to draw on alternative sources of income) varies significantly, with St Andrews receiving only 37% of its income from the Scottish Government, while Bell College receives 88% of its income from the Scottish Government. The Glasgow institutions are spread around the median value of 66.5, with two falling below (Glasgow 52%, Strathclyde 58%), two above (GSA 71%, Caledonian 76%) and one at the median (RSAMD 66%). As we will see in Chapter 5 the source of HEIs income is a critical input in determining their 'balanced expenditure' impacts (Hermannsson *et al* 2010b, 2010c)

Figure 21 Income sources of Scottish HEIs 2005/2006 %, ranked by dependency on Scottish Government funding (own calculations based on HESA data).



A comparison between the aggregates of HEIs in Glasgow and the Rest of Scotland, as in Figure 22, reveals Glasgow HEIs as a whole to be slightly more dependent on funding from the Scottish Government and weaker at earning export income (from the Rest of the World (ROW) and the Rest of the UK (RUK)) than HEIs in the Rest of Scotland.

Figure 22 Income by source of HEIs in Glasgow and the Rest of Scotland, 2005/2006 % (own calculations (see Section 3.2.2.2) based on HESA data).



4.2 Expenditure of Glasgow HEIs

Before deriving the expenditure impacts of the Glasgow HEIs it is beneficial to examine their expenditure pattern and see if this differs markedly from other HEIs in Scotland. Hermannsson *et al* (2010c) report a striking degree of homogeneity in the multipliers of Scottish HEIs and major differences are not expected.

Based on data from HESA (2007) it is possible to break down the HEIs expenditures by accounting category. As we see in Figure 23 this reveals a slight difference between the HEIs in Glasgow and the Rest of Scotland in aggregate, with the former devoting a slightly larger portion of their expenditures on 'Academic Departments', while the latter spend a slightly larger portion on 'Research Grants' and the 'Other' category.

Figure 24 further reveals a similar pattern based on each of the 20 individual HEIs in Scotland. These diagrams do not indicate much heterogeneity between the institutions, although to a small degree they seem to suggest some differences in the way funds are allocated within institutions.

Figure 23 Expenditure of HEIs in Glasgow and the Rest of Scotland by type 2005/2006 % (based on HESA 2007, Table 2a).

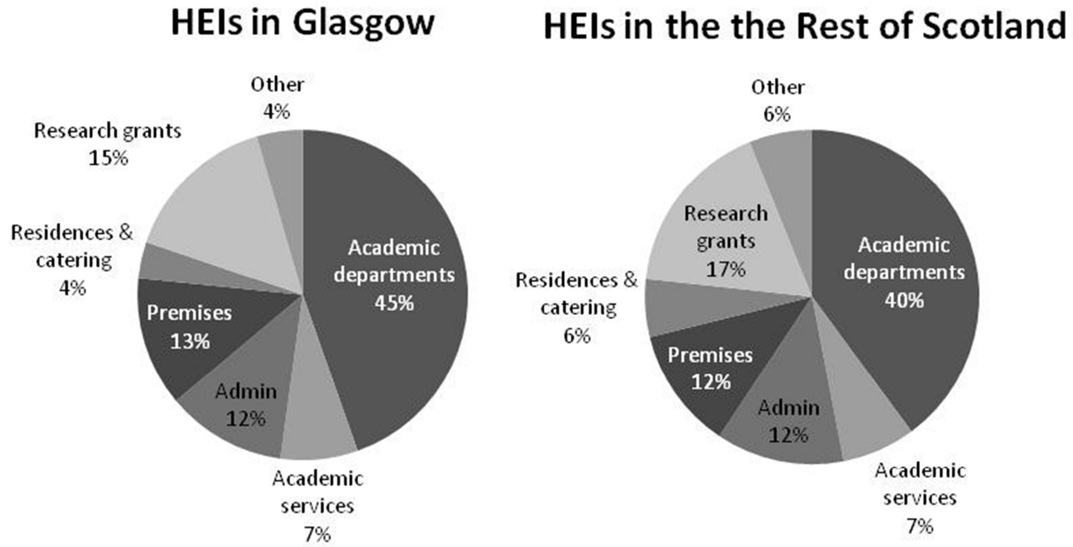
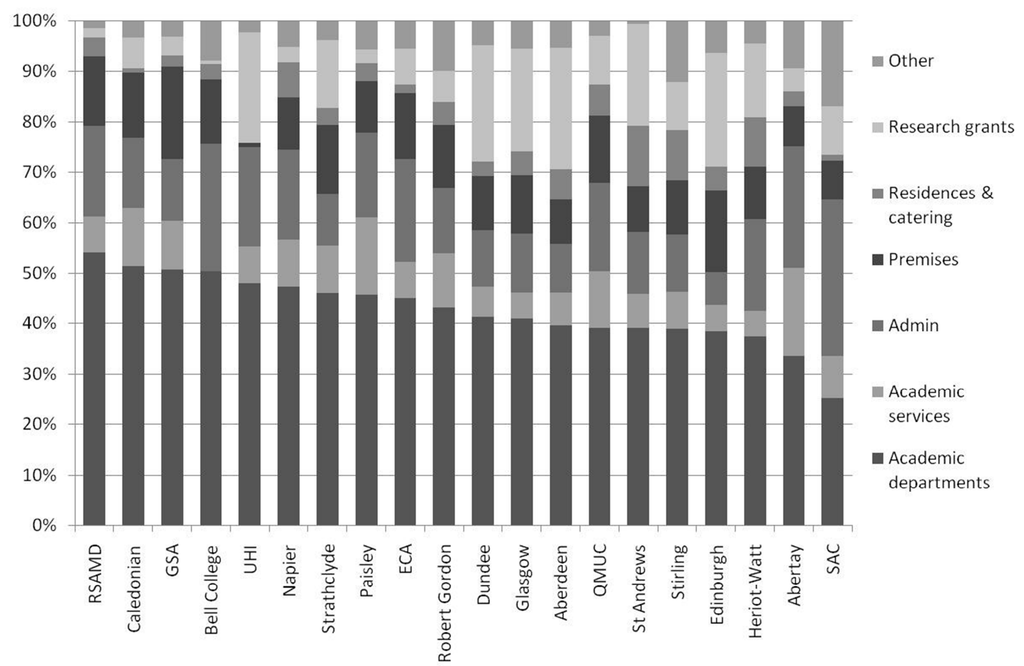


Figure 24 Expenditure of individual HEIS in Scotland by broad HESA accounting categories 2005/2006, %, ranked by relative share of expenditures on academic departments (based on HESA 2007, Table 2a).



Referring back to the HEI disaggregated Scottish Input-Output table constructed in Chapter 3, Figure 25 presents the expenditure structure for HEIs in Glasgow and the Rest of Scotland on aggregate. On the whole differences are minor, with Glasgow HEIs being slightly more employment intensive than in the Rest of Scotland. In Figure 26 we see the Input-Output expenditure structure for each individual HEI, which reveals minor variations in the composition of wages and intermediate expenditures for the HEIs.

Figure 25 Expenditure of HEIS in Glasgow and the Rest of Scotland by Input-Output category 2005/2006 % (own calculations (see Section 3.2.2.2)).

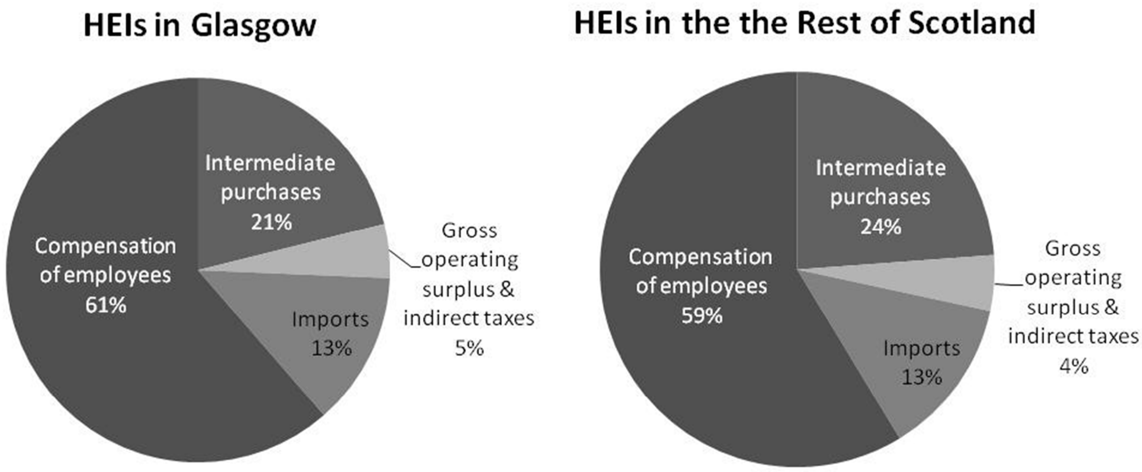
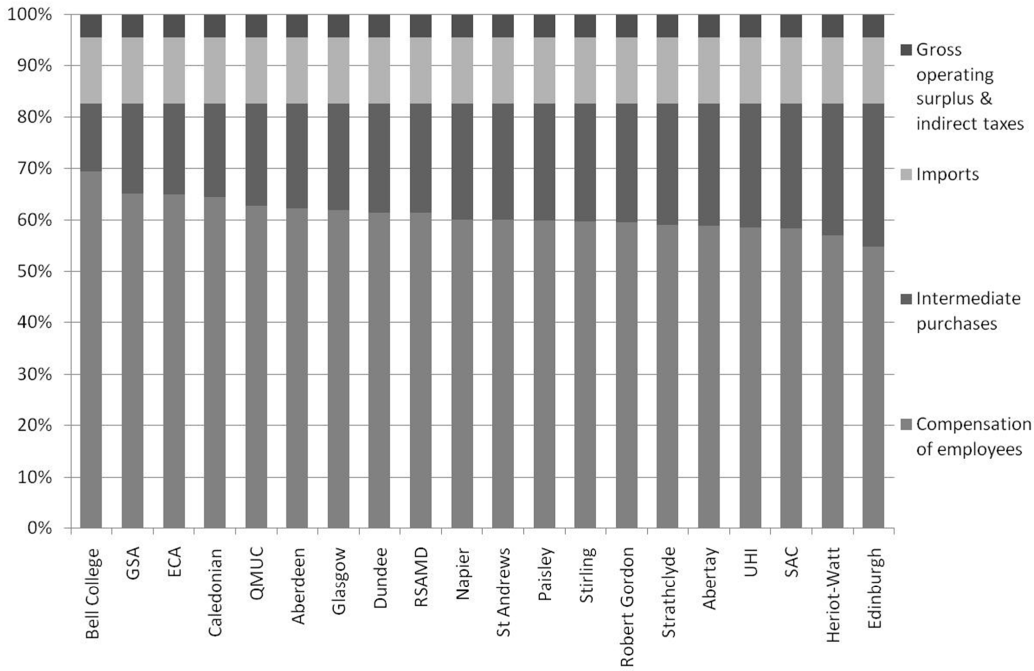


Figure 26 Expenditure of individual HEIS in Scotland by Input-Output category 2005/2006 %, ranked by relative share of compensation of employees (own calculations (see Section 3.2.2.2) based on HESA data)[79].



In Figure 27 I compare the composition of staff between the HEIs in Glasgow and the Rest of Scotland on aggregate. As the two pie charts reveal the structure of HEIs in the two sub-regions is practically identical in terms of the composition of staff by function. More variation is observed when we take a look at individual institutions. To an extent this may reflect differences in tenure policies between the institutions, with some institutions meeting most of the academic workload with staff holding academic positions, whereas in others the use of contract staff may be more prevalent.

[79] The IO-table was constructed using available accounting data for each institution, but some expenditure categories had to be imposed uniformly across the HEIs (see Section 3.2.2.2 for details), as is evident from looking at the 'Gross operating surplus & indirect taxes' and 'imports' categories in the diagram.

Figure 27 Staff composition of HEIs in Glasgow and the Rest of Scotland in 2005/2006 (Source: HESA, 2007, Table 25).

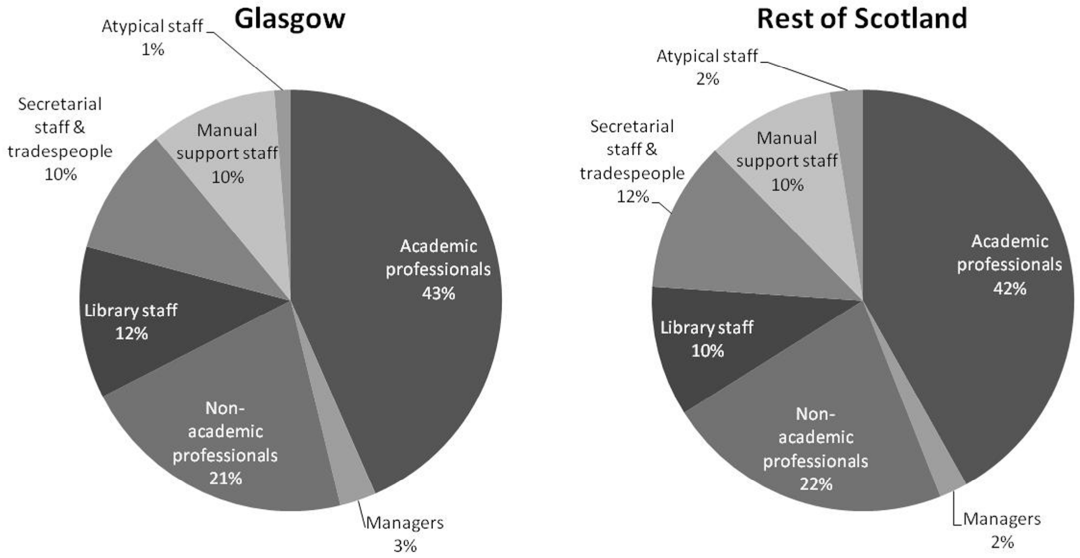
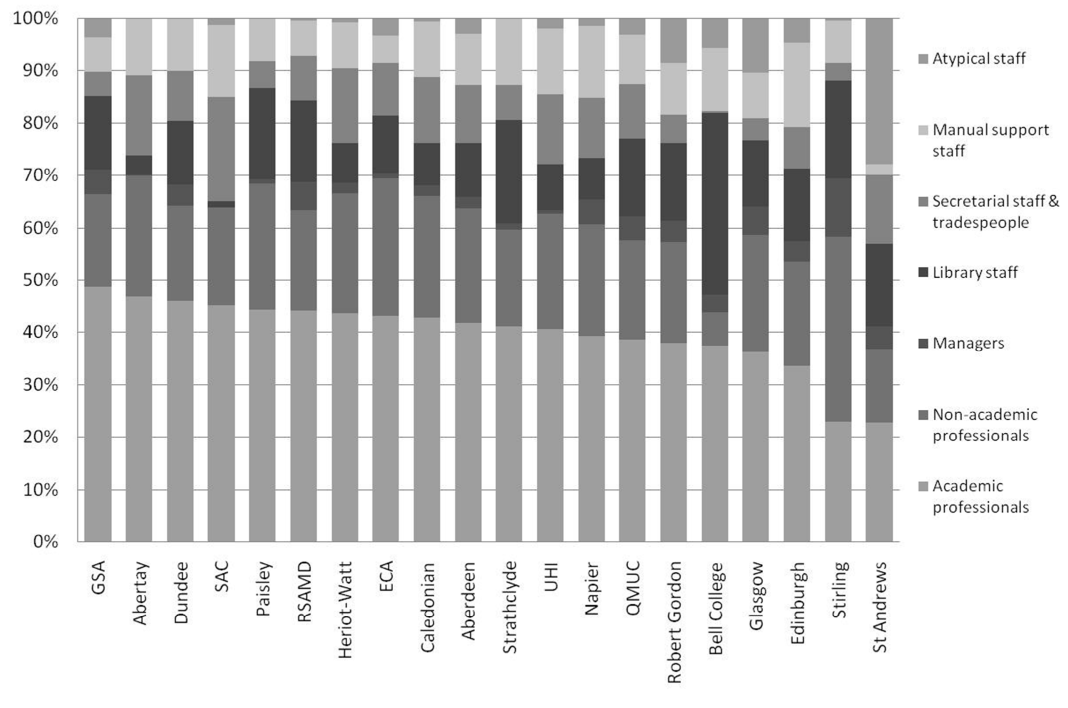


Figure 28 Staff composition of individual HEIs in Scotland in 2005/2006, ranked by proportion of academic professionals. (Source: HESA, 2007, Table 25).



4.2.1 Geographic dispersion of staff and suppliers of the University of Strathclyde

Only a part of the direct spending of the HEIs occurs within the limits of Glasgow City Council Area. No published data are available that detail this. However, the purchasing department at the University of Strathclyde has provided data on non-staff purchasing expenditures, which reveal commodity type and supplier location. This allows a further degree of accuracy as it is possible to determine the distribution of direct spending within and outwith the geographic boundaries of the impact assessment. In addition to this the University of Strathclyde has provided data on wage payments to staff by postcode so I was able to spatially disaggregate the University's staff expenditures.

As can be seen from Figure 29 approximately 84% of all salaries paid by the University of Strathclyde are received within the Strathclyde area. Significant amounts are paid to staff residing in the Central and Lothian areas, which are perceived to be within a commuting distance of Glasgow. A small fraction of staff reside further afield in Scotland and about 3% in the Rest of the UK. Another 3% could not be identified at a post code level. For the University of Strathclyde 60% of expenditures is on wages (61-65% for other Glasgow HEIs). Based on the salaries data alone it can therefore be deduced that at least 50% (0.84 x 0.6 = 0.5) of the first round expenditure impact of the University of Strathclyde is felt within the Glasgow City Council Area and the surrounding Strathclyde area. There is no apparent reason to expect this pattern to be significantly different for other HEIs in the city, in particular, as expenditure data reveal a significant degree of homogeneity among the Glasgow HEIs (and indeed Scottish HEIs). Furthermore, the main campuses[80] of all five of Glasgow's HEIs are co-located within a range of approximately 2 mile diameter and therefore should, at least in geographical terms, have access to the same labour markets.

[80] In addition the University of Glasgow operates a campus in Dumfries. Both the University of Glasgow and the University of Strathclyde operate additional campuses within the Glasgow City Council Area.

Figure 29 Geographical dispersion of wage payments at the University of Strathclyde in fiscal year 2007 (own calculations).

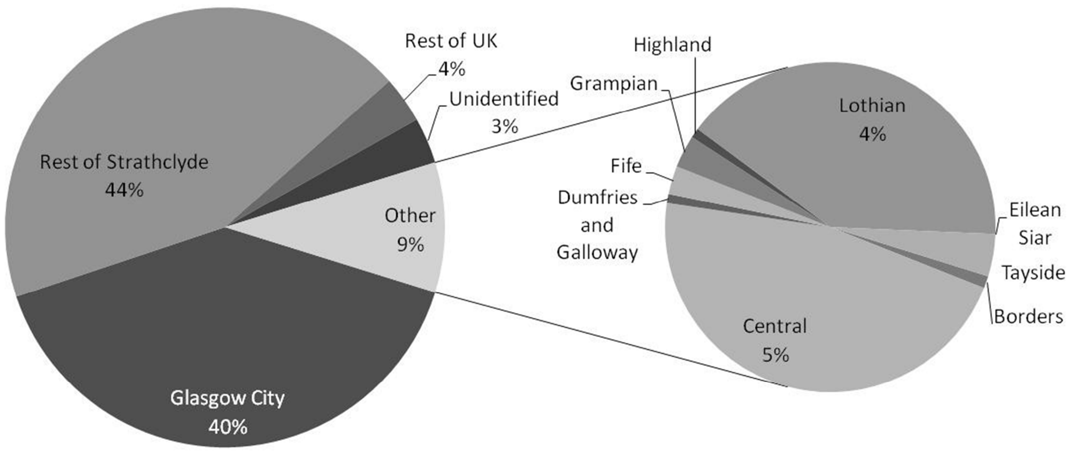
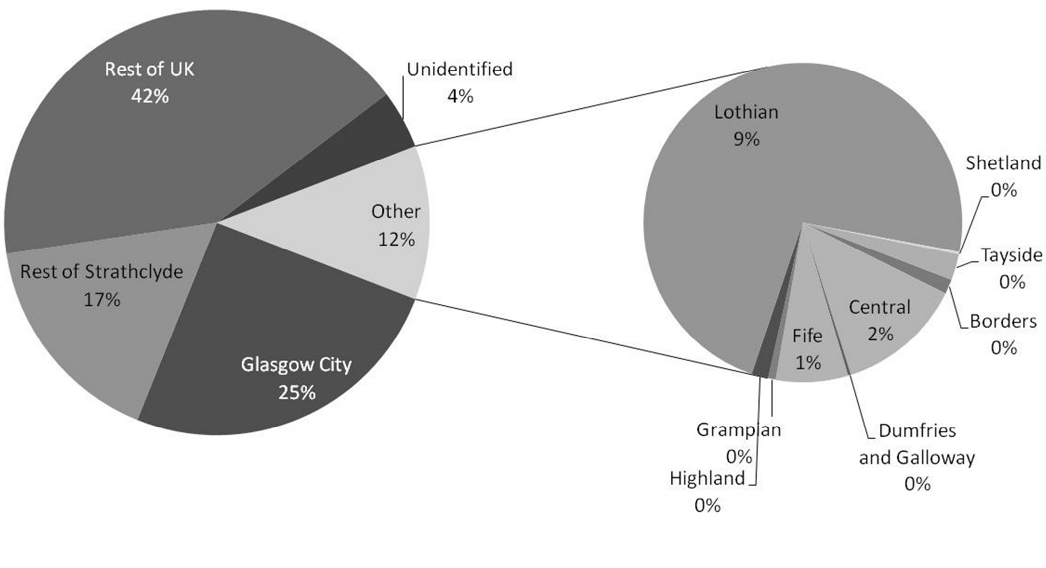


Figure 30 presents the geographical distribution of purchases made by the University of Strathclyde in 2007. The University's spending is concentrated on suppliers within the Strathclyde area, with 25% of the purchases being from suppliers within Glasgow City and 17% within the rest of Strathclyde. 11% of purchases are from Scottish suppliers outside Strathclyde, mostly in the greater Edinburgh (Lothian area). The 'Unidentified' category includes purchases from suppliers outside the United Kingdom as these are not assigned a UK postcode.

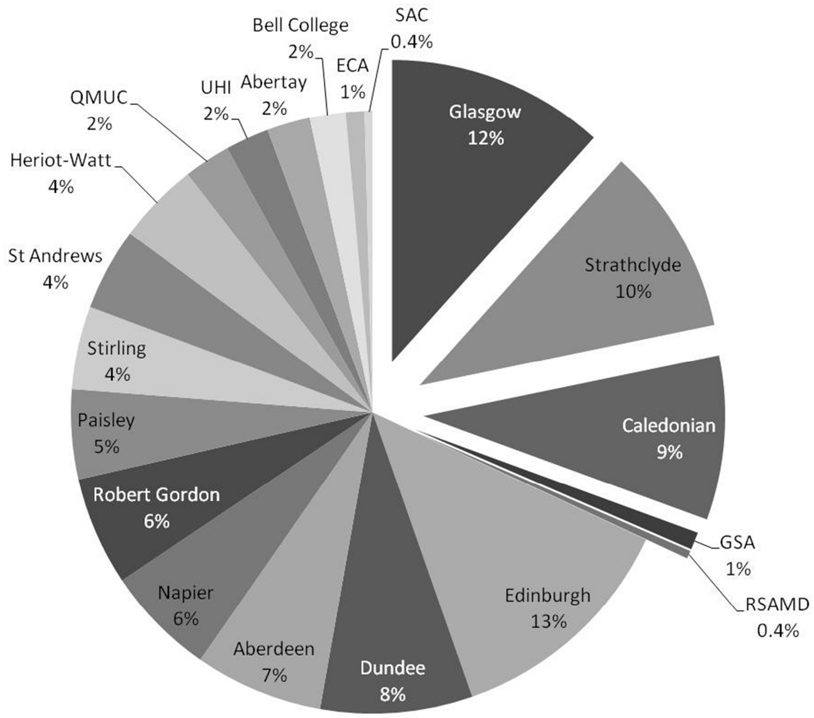
Figure 30 Geographical dispersion of purchases of the University of Strathclyde in fiscal year 2007, % of total value (own calculations based on accounting data).



4.3 Students at Glasgow HEIs

The composition of the student population is important for assessing the economic impact of Glasgow HEIs both for demand- and supply-side impacts. For demand-side impacts the composition influences the associated income of the institutions (e.g. Scottish Government funding, export earnings from tuition fees), the amount of consumption expenditures by the students and the degree to which these expenditures are exogenous to the local economy. For supply-side impacts, such as labour supply, the degree to which the HEIs draw in students from other regions/countries can be seen as an early indicator of contribution to the graduate labour market[81].

Figure 31 Breakdown of the HE student population in Scotland across individual HEIs in 2005/2006, % of FTEs (based on data obtained from HESA)



---

[81] Although in such cases it is important to consider graduates and how they are retained, as well as the net-retention rate, i.e. allowing for graduates drawn in from further afield (see sections 2.4.1.1 and 6.1). As indicated by the evidence reviewed in section 2.4.1 the presence of HEIs facilitates the retention and attraction of high-skill labour, making it easier for employers in the host economy to hire and retain high skill individuals.

As can be seen from Figure 31 Glasgow hosts approximately a third of the population of students studying at Scottish HEIs[82]. By comparison the four Edinburgh HEIs host approximately a quarter of Scotland's student population. However, as Figure 32 reveals, the composition of the student population in Glasgow differs from that in the rest of Scotland, with Glasgow maintaining a significantly lower share of incoming students (18%) than the rest of Scotland (34%). Looking at individual institutions in Figure 33 this structural difference is highlighted in the student populations of the University of Edinburgh and the University of Glasgow, which are the largest and second largest HEIs in Scotland as measured by income, and both enjoy Russell Group status[83]. However, whereas Edinburgh draws in more than half of its students from further afield (54% from the RUK and ROW), just under a quarter of Glasgow's students come from outside Scotland (24% from the RUK and ROW). Furthermore, as indicated by Figure 33 HEIs in Scotland vary significantly in terms of the geographical origins of their student populations.

As we will see in Chapters 5 and 6 he composition of the student population, in terms of its geographical origin, has different implications depending on the type of economic impact under consideration. For demand-side considerations incoming students tend to have a bigger impact as their consumptions expenditures, and in some cases tuition fees, are exogenous to the economy under consideration. For supply side impacts, the implications are more ambiguous. For human capital impacts via regional labour supply local students tend to be more important as they are more likely to be retained within the host region as graduates (and typically make up the largest share of each graduate cohort). However, as we saw in Section 2.4 evidence suggests HEIs exert some gravity over space on high-skill labour, innovation and knowledge intensive activities in industry. If the ability to attract students is associated with HEIs abilities to drive other spatial impacts, student composition could potentially be an indicator of other local economic benefits. In any case the ability to attract

---

[82] In addition to this a significant number of Scots are students of the Open University (need to find numbers compatible to the FTEs already presented. http://www3.open.ac.uk/near-you/scotland/)

[83] The Russell Group is an advocacy group of 20 of the most research instensive universities in the UK. It is generally perceived as an indicator of prestige to belong to this group.

students is to some extent indicative of the prestige of the institutions, at least as perceived by students in the Rest of the World and the Rest of the UK.

Figure 32 Composition of student population in Glasgow and the Rest of Scotland in 2005/2006, % of HEIs (based on data from

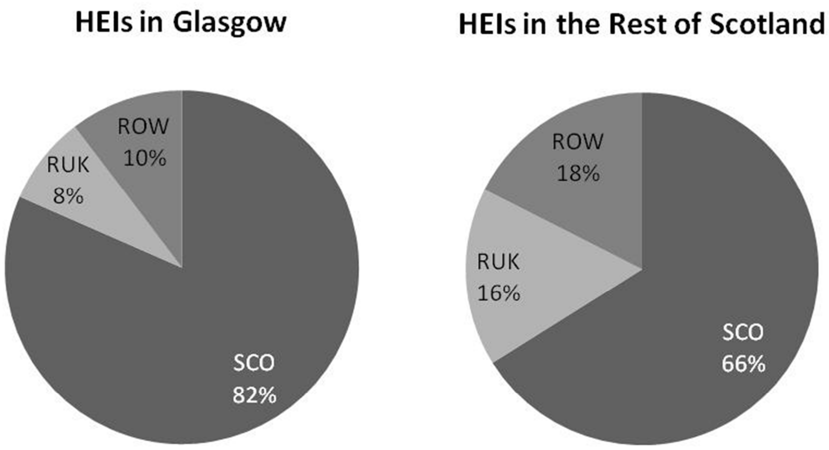
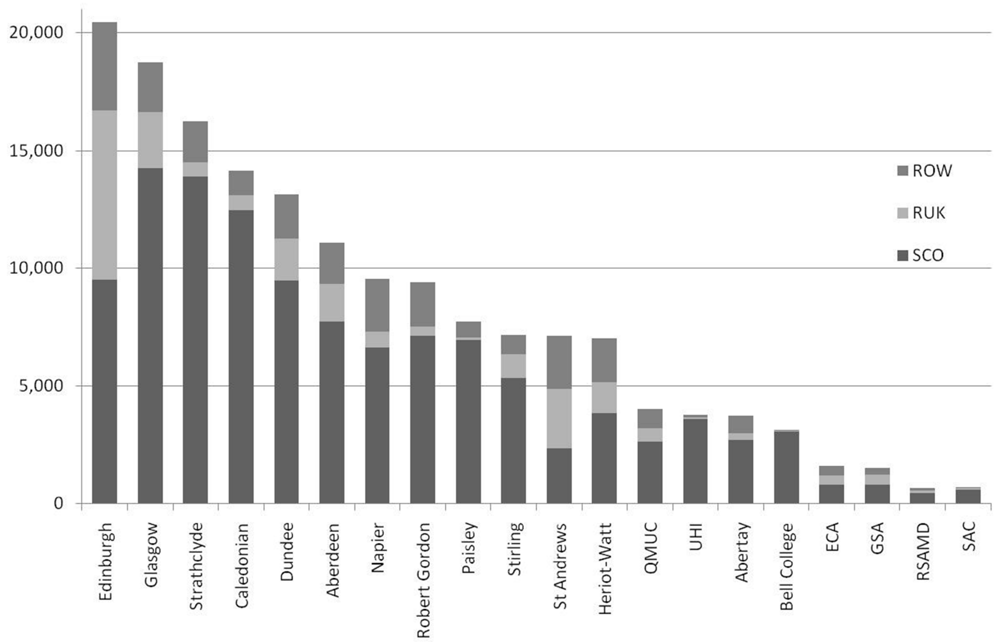


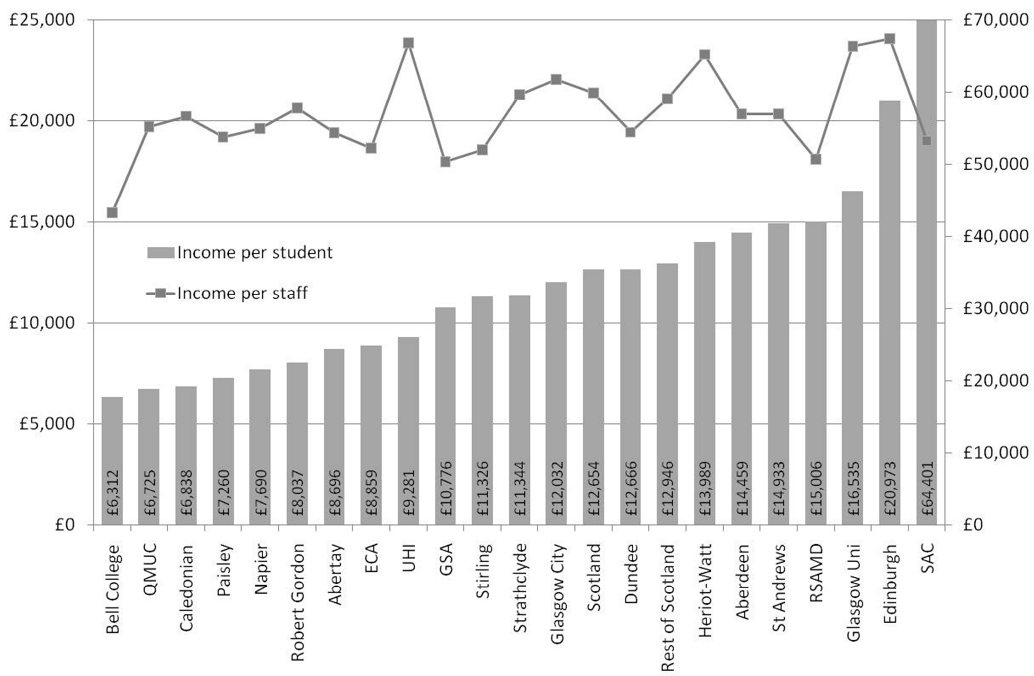
Figure 33 Students at Scottish HEIs, broken down by geographical origin (FTEs, ranked by size of student population)



In Figure 34

Figure 34I compare income per student and income per member of staff for each of the 20 Scottish HEIs, in addition to aggregates for Scotland as a whole, the 5 Glasgow HEIs and the 15 HEIs in the Rest of Scotland. As the diagram reveals, Scottish HEIs are heterogeneous as gauged by income per student. At Bell College, which receives the lowest income per student, it is just under one tenth of the Scottish Agricultural College (SAC), which earns the highest income per student. Broadly this difference reflects the research intensity of the institutions. However, the SAC is a real outlier, an institution with few students and much income from research and services rendered. The second highest income per student is for the University of Edinburgh (3.3 times higher than Bell College) and then for the University of Glasgow (2.6 times higher than for Bell College). Income per student for Glasgow HEIs is only slightly less than for institutions in the Rest of Scotland. Comparing income per staff, however, reveals a slightly more homogenous picture. The highest expenditure per member of staff is at the University of Edinburgh, which receives £67,399. This is 1.6 times the income per staff of Bell College (£43,249), where it is lowest among the 20 HEIs. Comparing these two outliers reveals a striking difference. Most of the HEIs however, fall within a relatively narrow range for their income per staff, around £57,000 or approximately 1.3 times that of Bell College and about four fifths that of the University of Edinburgh. Indeed 14 of the 20 HEIs fall within a range between £52,000 and £62,000 (the median value is £56,692 for Caledonian).

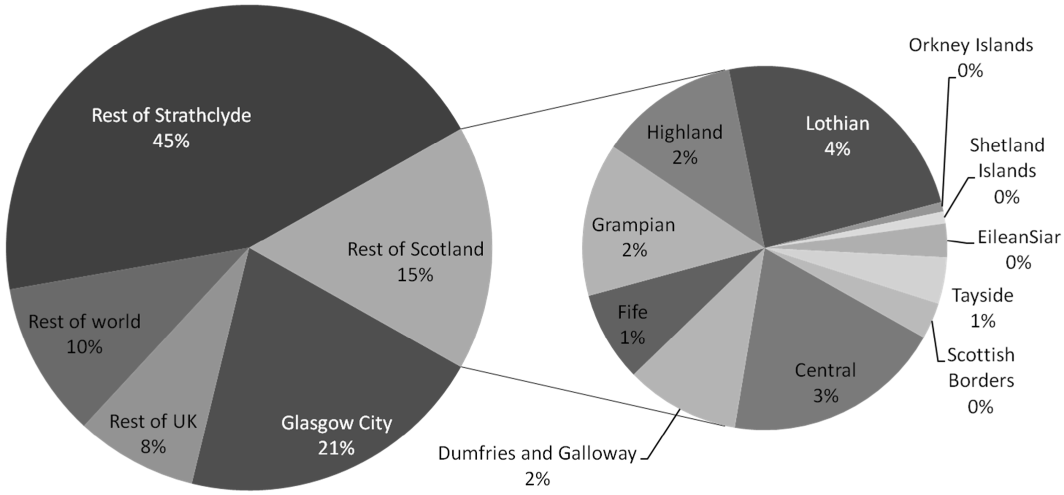
Figure 34 Income per student (left axis) and income per member of staff (right axis) for Scottish HEIs and selected regional aggregates 2005/2006, £ (Source: HESA 2007).



4.3.1 Geographical origin of students

Information on the origin of students was compiled using data from HESA's Students in Higher Education database. Home address post codes of all full time, part time and sandwich students were used to obtain headcount figures for the number of students at each HEI disaggregated by detailed spatial origin. As these headcount numbers are not directly comparable to the FTE student numbers used in the remainder of the dissertation (introduced in Section 3.2.4) they were instead applied as weights to disaggregate the FTE student population in Glasgow by local authority origin.

Figure 35 Breakdown of the aggregate student population of Glasgow HEIs 2005/06 by geographic origin.



As figure 25 reveals, Glasgow HEIs recruit approximately two in three students from Glasgow City and the rest of the Strathclyde area. Approximately 15% come from the Rest of Scotland. If we take a closer look at the geographical breakdown of the ROS students, of the 15%, 4% come from the Lothian (Greater Edinburgh) and Central (Stirling, Falkirk) areas. It can be concluded therefore, that almost 3 in 4 (73%) students are recruited from within a commuting range of Glasgow City. However, 18% of students are drawn in from outwith Scotland, 8% from the RUK and 10% from the ROW.

Dependence on students from local communities and nearby areas suggests the treatment of local student's consumption expenditure impacts is important for accurately determining the demand-side impact of these institutions. Apart from expenditure impacts, the prevalence of local candidates could suggest that these HEIs serve their local communities well in providing skills for local residents. Alternatively, the predominance of local students could be interpreted as suggesting a lack of prestige, which might possibly affect other supply side impacts, such as spatial pull effects.

Table 32: Percentage breakdown of students at HEIs in Glasgow by domicile 2005/2006.

Origin	Caledonian	GSA	RSAMD	Glasgow	Strathclyde	All HEIs
Glasgow City	**21%**	**13%**	**12%**	**20%**	**21%**	**21%**
Rest of Scotland	**67%**	**39%**	**53%**	**56%**	**64%**	**61%**
Scottish Borders	0%	1%	0%	1%	0%	1%
Central	3%	2%	3%	3%	3%	3%
Dumfries and Galloway	1%	1%	1%	2%	1%	2%
Fife	1%	1%	3%	2%	1%	1%
Grampian	2%	3%	4%	3%	2%	2%
Highland	2%	1%	3%	2%	2%	2%
Lothian	3%	6%	8%	5%	3%	4%
Orkney Islands	0%	0%	0%	0%	0%	0%
Shetland Islands	0%	0%	0%	0%	0%	0%
Rest of Strathclyde	53%	23%	25%	37%	49%	45%
Eilean Siar	1%	0%	1%	0%	1%	0%
Tayside	0%	0%	3%	1%	1%	1%
Rest of UK	**4%**	**28%**	**20%**	**13%**	**4%**	**8%**
Channel Islands	0%	0%	0%	0%	0%	0%
England	2%	24%	16%	8%	2%	5%
Isle of Man	0%	0%	0%	0%	0%	0%
N-Ireland	2%	4%	3%	4%	1%	3%
Wales	0%	0%	1%	0%	0%	0%
Rest of world	**7%**	**19%**	**15%**	**11%**	**11%**	**10%**
Total	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**

Looking at Table 32 reveals a more detailed view of the composition of students at Glasgow HEIs by institution and origin. The two art institutions the GSA and the RSAMD stand out in terms of their student composition as they attract a far larger share from the RUK and ROW than the traditional universities (47% for the GSA, 35% for the RSAMD). However, these institutions are small so their effect on Glasgow's overall student population is limited. Of the more traditional universities the University of Glasgow draws in the largest share of students from the RUK and ROW, with almost 1 in 4 students coming from outwith Scotland (24%). Another point worth highlighting is the relatively large share of students from N-Ireland among incoming students from the Rest of the UK. More than a third of these come from N-Ireland, while most of the remainder come from England, a country with a population almost 30 times that of N-Ireland[84].

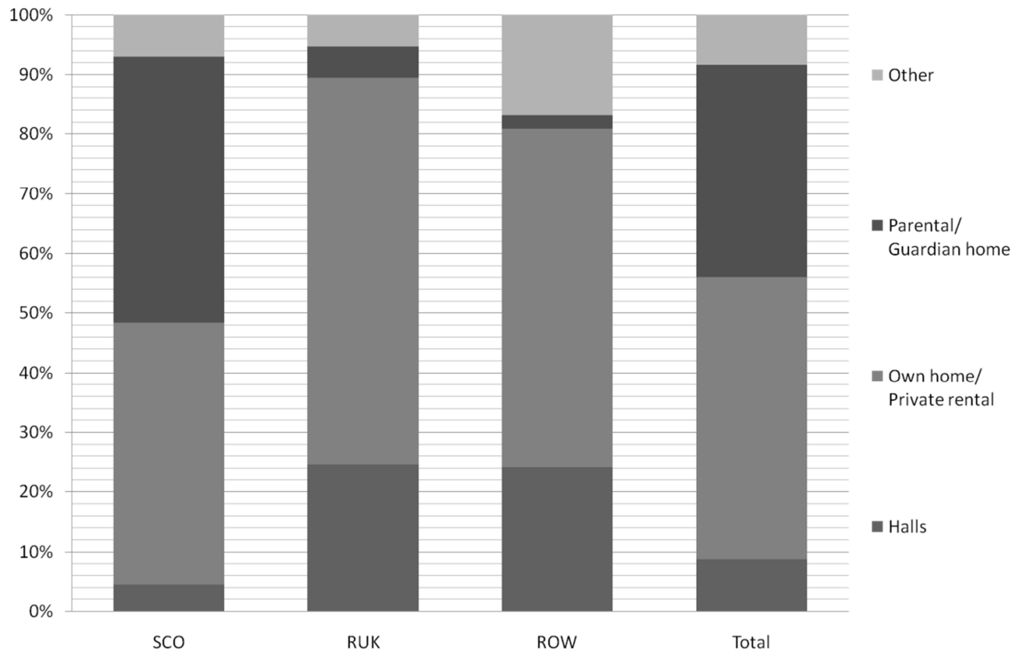
4.3.2 **Student term time accommodation**

Drawing on HESA's Students in Higher Education Database it is possible to obtain information about the housing arrangements of students at Glasgow HEIs. This data does not allow a tracking of where students stay during their period of study. However, it is possible to see in what type of accommodation they live. In Chapter 5 I use expenditure surveys to construct a profile of student's as consumers in the local economy. The information on student's term time housing complements those findings. In particular it emphasises the qualitative difference between the consumption patterns of incoming and local students, where the latter often reside at the parental home and therefore do not purchase housing services in the host economy.

As could be expected, Figure 36 shows that habitation patterns differ among students from Scotland and those from further afield. While almost half of Scottish students live with parents/guardians, the same only holds for 5% of students from the RUK and 2% of ROW students. As is evident from the far right column, results for the aggregate student population are dominated by Scottish students and hence about 36% of the overall HE student population in Glasgow resides with parents/guardians.

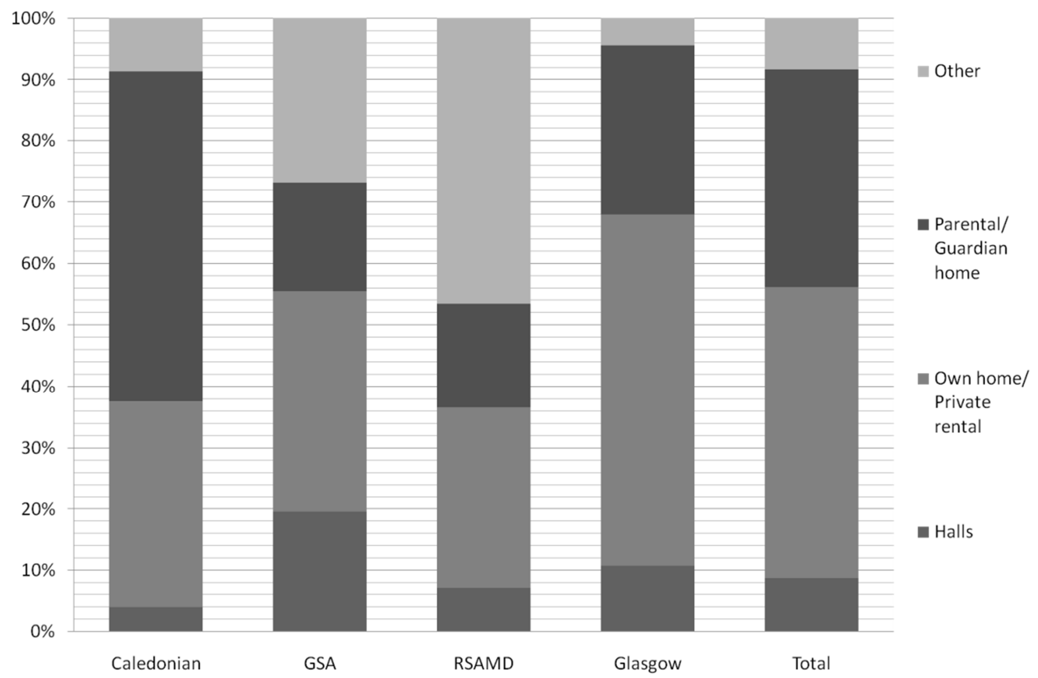
[84] The Office for National Statistics (ONS) estimates the 2009 mid year population of England at 51.8 m, while the same figure for N-Ireland is 1.8 m. See: http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/2009/index.html

Figure 36 Term time accommodation at Glasgow HEIs, broken down by student origin



In Figure 37 I examine the term time accommodation type of students in Glasgow by institution. Unfortunately for this comparison detailed data was missing for the University of Strathclyde in the HESA dataset. Looking at the more traditional universities, about twice as many students at Glasgow Caledonian University reside with parents/guardians than do students the University of Glasgow. A different pattern emerges for the two art institutions (GSA and RSAMD), where 27% and 47%, respectively, of students report residing in 'Other' type of accommodation. For the RSAMD this is outcome is not driven by an anomaly in the dataset, but the fact that students there are offered accommodation that can be seen as falling outwith the traditional categories. The RSAMD refers its students to Liberty Living, a private company that offers rooms to let specifically aimed at students. However, the spaces in halls offered by the GSA are of the traditional university-run type, so it is not clear if the 'Other category' is so large because of data entry issues or if students at the GSA genuinely seek out unconventional accommodation options.

Figure 37 Term time accommodation of students at individual Glasgow HEIs

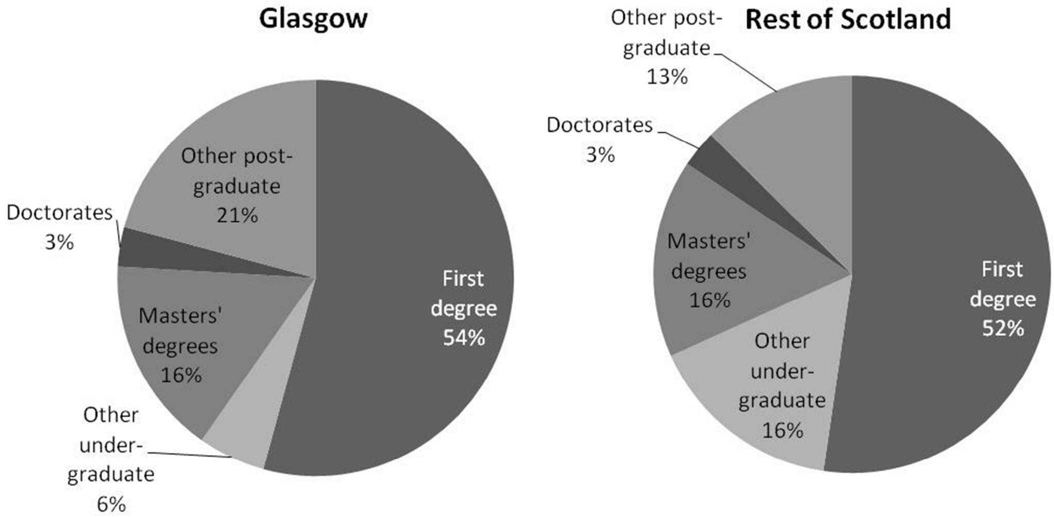


4.3.3 **Qualifications awarded**

In this section I present a brief summary of the nature of the degrees awarded at Glasgow HEIs. In this I follow two dimensions, the level of the degree and its subject. As we saw in Section 2.2.1 a higher level of degree commands a higher wage premium and generally, as we will see in Chapter 6 the higher the wage premium, the greater the beneficial supply side impact.

From Figure 38 it is clear that, on aggregate, HEIs in Glasgow and the Rest of Scotland award a similar percentage of undergraduate and postgraduate degrees. However, the two sub-regions differ in that HEIs in Glasgow seem to award relatively more postgraduate qualifications at a sub-degree level and relatively fewer undergraduate qualifications not leading to a degree than HEIs in the Rest of Scotland. What drives this difference is not clear.

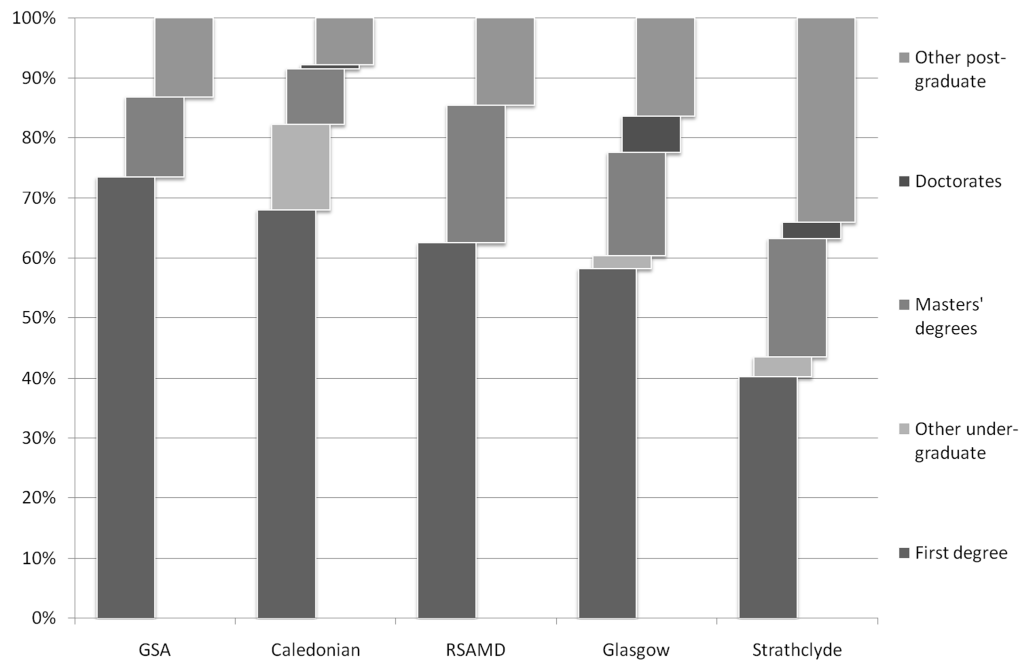
Figure 38 Distribution of degrees awarded by level in Glasgow and the rest of Scotland 2005/06 (Source HESA, 2007, Table 12a)



Examining these data for individual HEIs in Glasgow, as in Figure 39, it is clear that the composition of degree type differs between institutions. The GSA stands out with more than two thirds of its qualifications awarded as first degrees. Caledonian similarly awards a large share of first degrees but stands out among Glasgow HEIs with 14% of its degrees awarded as sub-degree level undergraduate qualifications. The RSAMD awards proportionately most postgraduate degrees (23%) and the University of Glasgow awards the most doctorates (6%). However, the University of Strathclyde stands out as being the Glasgow HEI that awards relatively the most sub-degree level postgraduate qualifications (34%). This is largely driven by the course structure at Strathclyde as more than half of these (54%) are Post Graduate Certificates of Education (PGCE)[85].

[85] This characteristic of Stathclyde is also evdient in the composition of the absolute numbers of graduates as it awards more than twice as many sub-degree postgraduaet qualifications as Glasgow, which is next in line.

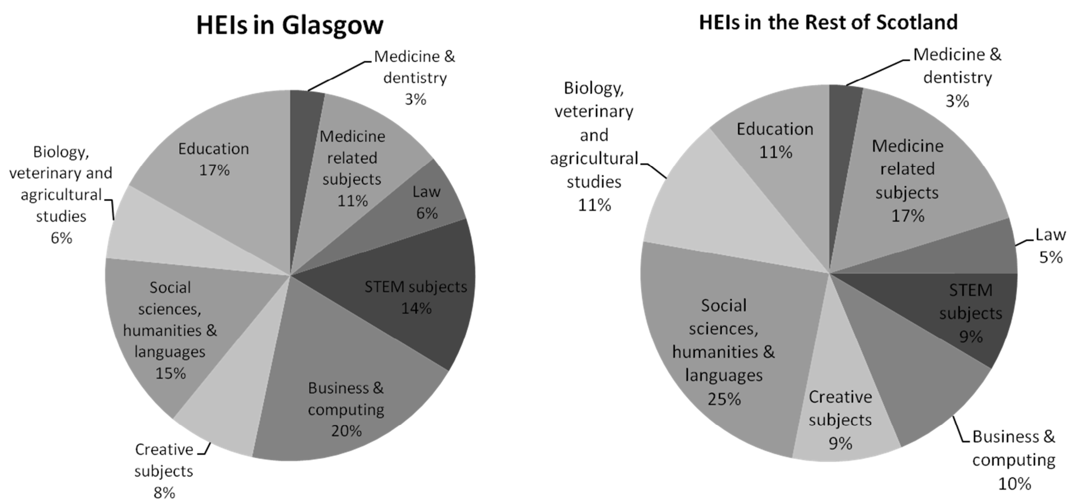
Figure 39 Distribution of degrees awarded by level at individual HEIs in Glasgow 2005/06 (Source HESA, 2007, Table 12a).



Another aspect of impact, which as of yet has not been researched much, is the way in which different subjects affect the economic impact of higher education. There seem to be strong public perceptions about the benefits of different degrees. Subjects such as medicine, law, teaching, business and engineering are often seen as 'good for a job', whereas arts, humanities and social sciences are generally perceived to offer more uncertain returns. The limited formal evidence on this is reviewed in Section 2.2.4 and although it reveals differences in labour market outcomes depending on subject the hierarchy of outcomes is not as clear cut as popular perception has it. Indeed there are outliers, which offer the best returns (medicine, economics, and accountancy) and the worst (art degrees for men). However, there is a relatively tight range in the middle, where some social science subjects seem to outperform some science subjects.

Recently the Confederation for Business and Industry (CBI) has emphasised the need to raise the number of STEM subject (Science, Technology, Engineering and Mathematics) graduates in the UK (CBI, 2009). Although they do not make the rationale for this clear (and a relative lack of these graduates is not reflected in relative wage premia) it seems to be a strongly held view in industry that the economy needs more STEM graduates to prosper. Perhaps this reflects some external benefits of these degrees not picked up in labour market statistics but observed by managers of business. However, as we saw in section 2.4.2 recent large scale survey of employers and academics (Kitson *et al,* 2009) reject the conventional wisdom that knowledge exchange activities are dominated by STEM subjects. On balance therefore, there are ample grounds to question the confidence with which the CBI makes its assertions about the economically feasible future direction of public policy in education.

Figure 40 Distribution of qualifications awarded by subject in Glasgow and the Rest of Scotland in 2005/2006 (Sources HESA, 2007, Table 15e).



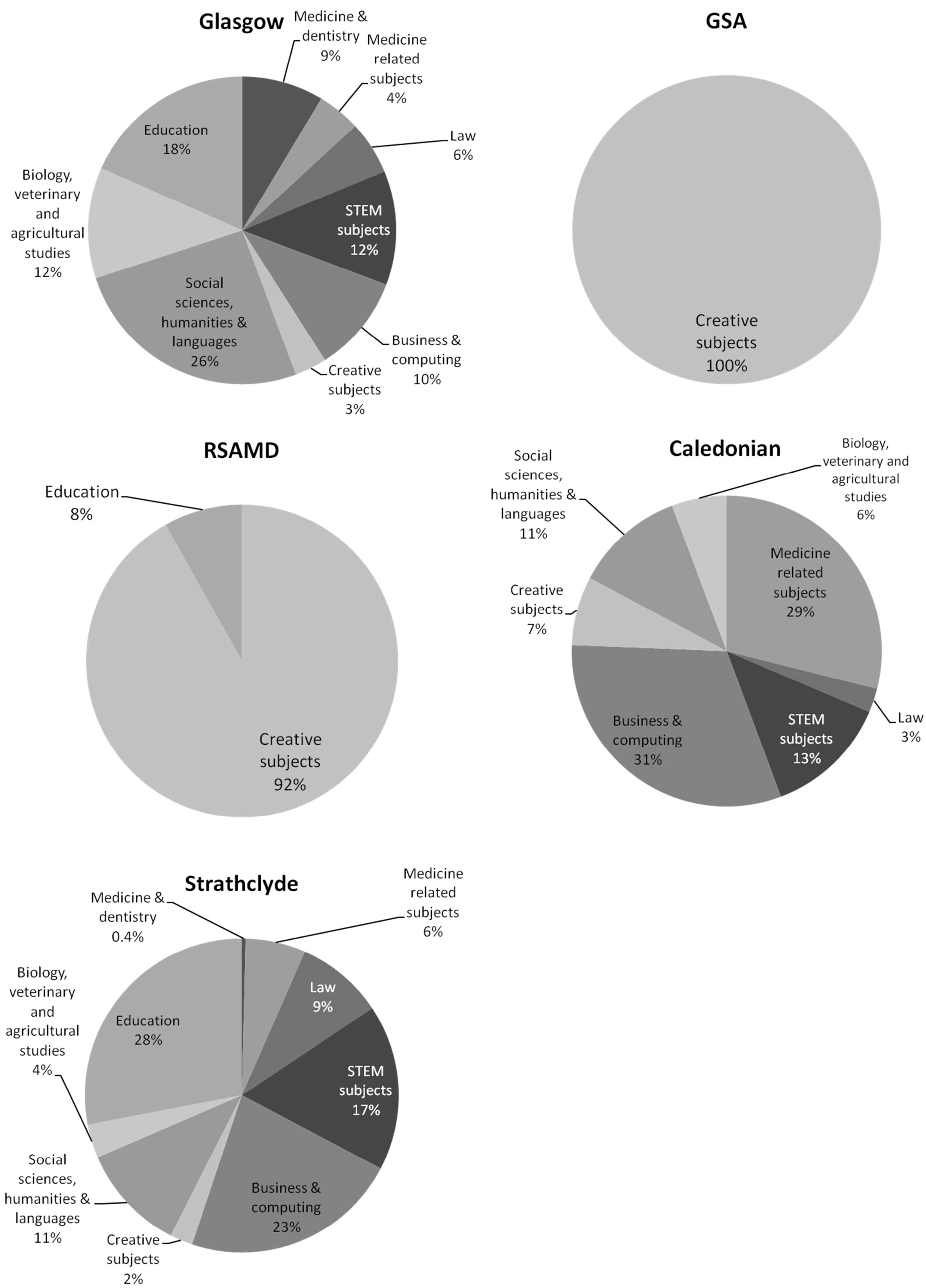
As Figure 40 reveals there are some differences in the subject composition of degrees awarded by HEIs in Glasgow and degrees awarded by HEIs in the Rest of Scotland. Some subjects are clearly relatively over-represented in Glasgow. In particular 'Business & Computing' (20% v 10%), 'Education' (17% v 11%), 'STEM subjects' (14% v 9%) and 'Law' (6% v 5%). Conversely, the subjects underrepresented in Glasgow vis-á-vis the Rest of Scotland are 'Social sciences, humanities & languages' (15% v 25%), 'Medicine related subjects' (11% v 17%), 'Biology, veterinary and agricultural studies' (6% v 11%) and 'Creative subjects'

(8% v 9%). 'Medicine & dentistry' represents 3% of degrees awarded, both in Glasgow and the Rest of Scotland.

The subject composition varies significantly between institutions, as can be seen in Figure 41 the GSA and RSAMD are clear outliers, focussing almost entirely on 'Creative subjects'. Among the more traditional universities the University of Glasgow appears to be the most 'universal', with some representation in all the subjects, while specialisation is more pronounced at the other two.

Glasgow Caledonian University awards 60% of its qualifications in two fields; 'Business & computing' and 'Medicine related subjects'. Similarly, 'Business & computing' represents a large part of qualifications awarded at the University of Strathclyde (23%). However, the subject for which Strathclyde awards most of its qualifications is 'Education' (28%). Notably, of the Glasgow HEIs Strathclyde is the one where 'STEM subjects' are most prevalent among the qualifications awarded (17%). However, these also represent a significant part of the qualifications awarded at Caledonian and Glasgow, 13% and 12%, respectively.

Figure 41 Distribution of qualifications awarded by subject for individual Glasgow HEIs in 2005/2006. (Sources HESA, 2007, Table 15e).



4.3.4 **Destination of graduates**

The retention of graduates is important for the supply-side impact of HEIs that occurs through the accumulation of human capital. In Section 2.4.1.1 I review evidence for the graduate retention for Scotland as a whole. To examine graduates in terms of institutional and spatial disaggregation I draw on HESAs Destination of Leavers dataset, which provides information on the whereabouts and employment status of graduates of EU origin six months after leaving their institutions of study. Results for the Glasgow HEIs, for the year 2005-2006 give an indication of where the graduates go upon completing their degrees. Although it is not possible to see what happens subsequently in their carriers, 93% of new graduates are retained within Scotland and 73% within the Strathclyde area in the months immediately following graduation.

As can be seen from Figure 42 the geographic dispersion of graduates is quite different for the Glasgow HEIs than it is for HEIs in the Rest of Scotland on aggregate. The degree to which graduates are retained within Glasgow and the Strathclyde area are striking. Perhaps, this is not so surprising though as such a large proportion of the Glasgow HE students are recruited from Glasgow and the rest of the Strathclyde area. However, comparing retention outcomes of HEIs in Glasgow with that of all the HEIs dispersed across the Rest of Scotland may not be a like for like comparison. A more appropriate comparison may be between HEIs in the two cities. Therefore, in Figure 42, the destination of leavers is explored for the HEIs in the City of Edinburgh. Although a large proportion (50%) of Edinburgh students are retained in the 6 months after graduation, this is significantly less than for Glasgow HEIs. Many more graduates from Edinburgh HEIs migrate out of Scotland after graduation. However, this is not surprising, as the Edinburgh HEIs draw in significantly more incoming students than do the Glasgow HEIs.

Figure 42 Destination of leavers 2005/06 6 months after graduation for HEIs in Glasgow and HEIs in the Rest of Scotland on aggregate (own calculations, based on data from HESA).

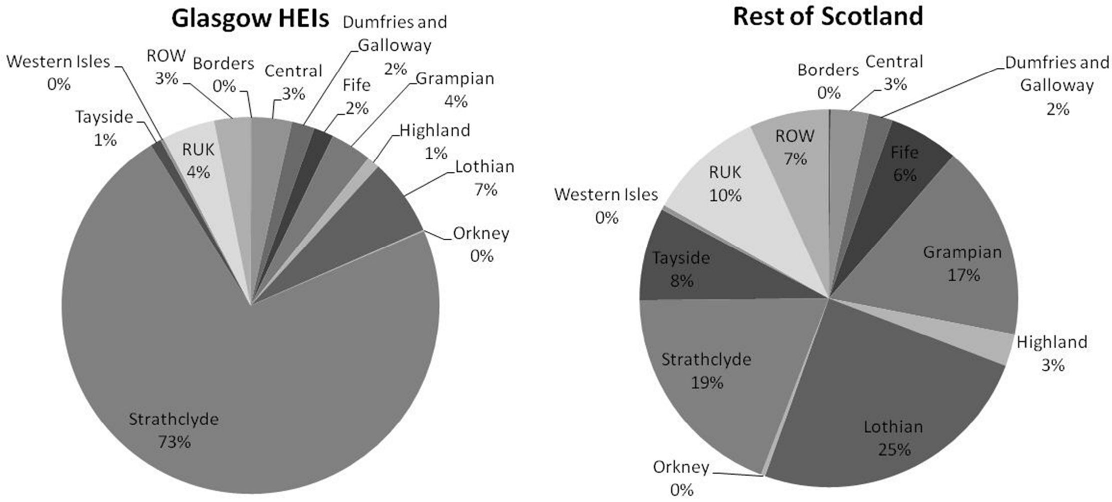


Figure 43 Destination of leavers 2005/06 6 months after graduation for HEIs in Edinburgh (own calculations, based on data from HESA).

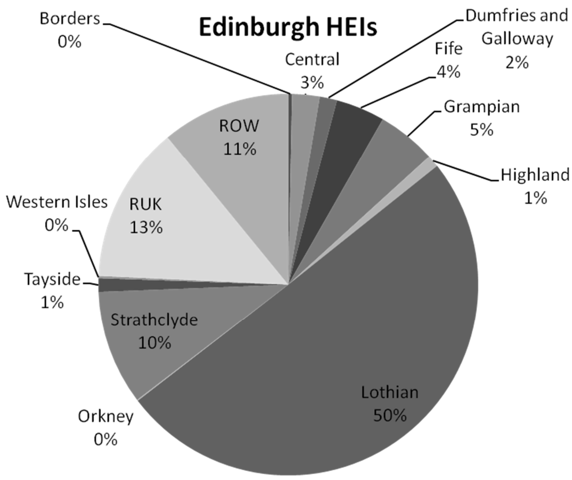


Table 33: Destination of leavers 6 months after graduation

	Caledonian	Glasgow	GSA	Strathclyde	RSAMD	Total
Glasgow City	**49.8%**	**42.3%**	**49.6%**	**36.1%**	**44.8%**	**41.7%**
Rest of Scotland	**44.7%**	**50.1%**	**39.3%**	**55.2%**	**47.1%**	**50.7%**
Borders	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
Central	3.2%	3.2%	0.0%	3.7%	0.0%	3.3%
Dumfries and Galloway	0.9%	2.8%	3.0%	1.7%	4.6%	1.9%
Fife	1.9%	1.9%	3.0%	1.3%	1.1%	1.7%
Grampian	2.8%	5.1%	0.0%	4.0%	1.1%	3.9%
Highland	1.0%	1.5%	0.0%	0.9%	0.0%	1.1%
Lothian	5.3%	6.4%	4.4%	7.2%	3.4%	6.4%
Orkney	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
Strathclyde (Rest of)	27.2%	28.3%	15.6%	30.4%	16.1%	28.6%
Tayside	0.5%	0.6%	0.7%	1.3%	2.3%	0.9%
Western Isles	0.2%	0.2%	0.0%	0.4%	0.0%	0.3%
Scotland, undisclosed	1.5%	0.0%	12.6%	4.0%	18.4%	2.5%
RUK	**3.8%**	**3.8%**	**6.7%**	**5.3%**	**3.4%**	**4.5%**
Channel Islands (The)	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
England	3.6%	3.5%	5.2%	5.1%	3.4%	4.2%
Northern Ireland	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Wales	0.0%	0.3%	1.5%	0.1%	0.0%	0.2%
ROW	**1.7%**	**3.8%**	**4.4%**	**3.4%**	**4.6%**	**3.1%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

4.4 Conclusions

In this chapter I provide a descriptive analysis of the characteristics of Glasgow HEIs within the context of the overall Scottish HEIs sector. For this I have used: publicly available data on the resources of HEIs from HESA (2007); specially commissioned data from HESA on the breakdown of the student population by broad origin; queries from HESA's Students in Higher Education and Destination of Leavers databases to provide additional detail; and previously unpublished data from the University of Strathclyde on the spatial distribution of wage payments and purchases. This should give a broad overview of the characteristics of Glasgow HEIs, that are relevant for assessing their overall economic impact, without undertaking a collection of new data, which is beyond the scope of this dissertation.

The analysis raises a number of relevant points for Glasgow HEIs:

- Glasgow's HEIs represent the largest geographical cluster of HEIs in Scotland as gauged by income. Earning 31% of the income of the overall income of the HEIs sector in Scotland, Glasgow's HEIs are closely followed by those of Edinburgh, which earn 30% of the income of the overall sector. Given that Edinburgh is a smaller city it is clear that Edinburgh's HEIs are a relatively more predominant feature of their local host economy than are Glasgow's.
- HEIs in Glasgow are slightly less export intensive (24% v 31%) and slightly more dependent on Scottish Government funding (58% v 53%) than HEIs in the Rest of Scotland.
- The expenditure pattern of HEIs in Glasgow on aggregate is similar to that of HEIs in the Rest of Scotland. More heterogeneity is observable when individual institutions are compared. HEIs in Glasgow are slightly more employment intensive than HEIs in the Rest of Scotland (61% v 59%).
- Detailed examination of payroll information from the University of Strathclyde reveals that 84% of wage payments are received by individuals within Glasgow City and the Glasgow Metropolitan Area (Glasgow 40%, rest of Strathclyde 44%). Furthermore, 9% accrue to nearby Central & Lothian areas.
- Similar analysis of purchasing data reveal that just over half of purchases are made from suppliers in Glasgow and surrounding areas (25% Glasgow, 17% rest of Strathclyde, 9% Lothian).
- Glasgow hosts the largest HE student community in Scotland, with the 5 Glasgow HEIs serving 32% of all students at HEIs in Scotland. Edinburgh is next in line with 25% of all students studying at HEIs in Scotland.
- The composition of the student population in Glasgow differs significantly from that at HEIs in the Rest of Scotland. Scottish students form a larger share of students at Glasgow HEIs (82% v 66%) and

conversely there are proportionately fewer incoming students (18% v 34%).

- Income per student is slightly lower for HEIs in Glasgow than for HEIs in the Rest of Scotland (£12,032 v £12,946). However, expenditure per member of staff is slightly higher at HEIs in Glasgow than in the Rest of Scotland (£61,777 v £59,051).
- 73% of students at Glasgow HEIs are recruited from Glasgow City and surrounding areas (Glasgow 21%, rest of Strathclyde 45%, Lothian & Central 7%).
- More than a third (37%) of students at Glasgow HEIs do not participate in the housing market but stay with parents/guardians. Focusing only of Scottish students at Glasgow HEIs, nearly half of them (44.6%) stay with parents/guardians.
- HEIs in Glasgow and the rest of Scotland award a similar set of qualifications, as gauged by level (composition of first degrees, masters degrees and doctorates.
- The subject composition of degrees awarded at Glasgow HEIs differs from that of the Rest of Scotland in that Glasgow HEIs award disproportionately many qualifications in Education, STEM subjects, Business & computing and Law. Conversely HEIs in the Rest of Scotland produce disproportionately many qualifications in Social sciences, medicine related subjects, creative subjects and Biology, Veterinary and agricultural studies. Medicine and dentistry are equally represented between Glasgow and the Rest of Scotland.
- The subject composition varies significantly among individual HEIs.
- Nearly three quarters (73%) of graduates from Glasgow HEIs remained within the Strathclyde area 6 months after graduation. 93% remain within Scotland. This is in contrast with for example HEIs in Edinburgh, which see a much wider dispersion of their graduates, with 50% staying within the Lothian area 6 months after graduation. 76% remain within Scotland and 13% leave for the UK and 11% for the Rest of the World.

5 Sub-regional and inter-regional expenditure impacts of HEIs and their students

In this chapter I use the 3 region HEI-disaggregated inter-regional Input-Output database developed in Chapter 3.3 to examine the expenditure impacts of HEIs and their students upon their host sub-regional economies. Furthermore, I show how HEI impacts are not constrained to an institution's host region, but also affect other parts of the Scottish economy. These demand spillovers occur through two distinct channels. Firstly, they arise through direct impacts, such as a transfer from a parent household in region A to a student who resides in region B. Secondly, the direct injection of expenditures from HEIs and students triggers knock-on effects that are incurred not only in the HEIs' host regions but also in other sub-regions. In short, it is clear that expenditure effects have a spatial dimension. Both because direct impacts in one region offset direct impacts in other regions through displacement of expenditures, but also because subsequent knock-on impacts of these direct injections are transmitted across regional boundaries. This is how expenditure in one region affects output in all 3 regions and how expenditure diverted from one region has corresponding negative effects.

In the next section I explore the interregional implications of the direct and knock-on impacts for HEIs and students in turn. In the subsequent section I introduce an additional layer of complexity as I draw on Hermannsson *et al* (2010b, 2010c) to examine the "balanced expenditure" impacts of HEIs within the interregional framework. That is, I examine the sub-regional and interregional expenditure impacts of HEIs once the displacement of Scottish Government expenditure has been taken into account. This displacement is caused by the binding budget constraint implied by the Barnett formula, which is used to determine devolved expenditures in the UK. As we shall see, applying the balanced expenditure multiplier in an interregional setting raises an additional problem: how do we determine the spatial attribution of the displaced Scottish Government funding? For this I apply two approaches. Firstly, I assume that total Scottish Government expenditures are fixed within each sub-region, so that Scottish Government funding for HEIs displaces funding for other Barnett-funded activities within their host region. This is "as if" they had devolved finances in their own right. Secondly, I redo this analysis under the assumption that Scottish Government funding is displaced equiproportionately in each sub-region, reflecting the initial spatial distribution of public spending in the IO-tables.

In this study the University of the West of Scotland (UWS) is not identified as part of the Glasgow HEIs but enters as the only HEI based in the rest of the Strathclyde area. Traditionally UWS would not be seen as part of the Glasgow HEIs, as its campuses are outside the Glasgow City Council Area. However, the Glasgow HEIs and the UWS are all part of the Glasgow metropolitan (Strathclyde) area. The value added gained from identifying the rest of the Strathclyde area as distinct from Glasgow, and hence UWS as distinct from the five Glasgow HEIs, is that this allows an examination of the interplay between the economic impacts of HEIs and core periphery dynamics within a metropolitan area. The Glasgow HEIs are all based in the core, whereas UWS is the only one based in the periphery. A simpler alternative would have been to model the whole of the Strathclyde area as one spatial unit including six HEIs, five in Glasgow and one in the rest of the Strathclyde area. This would have been a more economical approach in modelling terms and would have given the same end results as aggregating GLA and ROS impacts. However, such results would only be totals for the whole metropolitan area and would not offer a more localised identification of the impacts or spillovers across the core-periphery boundaries.

Before proceeding with the analysis a note on terminology is in order. Often in the context of UK regional studies, region refers to the 12 UK NUTS 1 regions[86]. My analysis, however, is restricted to events within Scotland, a single UK region. That is, I analyse impacts upon Scotland as a whole and the 3 sub-regions that have been identified in this analysis. Therefore 'interregional' in the

[86] These are: North West England, North East England, Yorkshire and the Humber, East Midlands, West Midlands, East of England, London, South East, South West, Wales, Scotland and Northern Ireland.

context of the analyses that follow refers to interactions among these 3 sub-regions in Scotland.

5.1 Sub-regional and interregional expenditure impacts

5.1.1 The multiplier concept

Before turning our attention to the derivation of specific results it is useful to review the assumptions underlying Input-Output modelling and how the multipliers are derived from the IO-tables[87]. Input-Output tables provide a snapshot of production in an economy for a given year. They reveal the activities of industries that both produce goods (outputs) and consume goods from other industries (inputs). The Input-Output tables are put to a wide range of uses[88] but are most frequently employed in various multiplier or "impact" analyses. Input-output models are calibrated using IO tables.

In the next two sub-sections I shall first review the assumptions of Input-Output modelling and then proceed to formally derive the IO-multipliers.

5.1.1.1 Assumptions of Input-Output modelling

Demand-driven multipliers[89] identify the impact of a sector as a purchaser of inputs. When a sector expands, it requires more inputs of intermediate goods and services and increases its employment and wage payments. This generates positive knock-on effects in sectors supplying the increased demand for intermediate and consumption goods. The expansion in these sectors will produce further increases in intermediate and consumption demands, the process continuing through successive rounds of the multiplier process, with the additional impact in each successive round becoming smaller and smaller. I-O analysis has a technique for capturing all these effects, as long as a number of assumptions hold.

---

[87] This section draws heavily on Appendix 1 in Hermannsson *et al* (2010a), Seafish (2007) and Miller and Blair (2009).
[88] For details of Input-Output applications and methodology see Miller & Blair (2009).
[89] Two broad generic types of multiplier are identified in the I-O literature. These are known variously as; backward, demand-driven, Leontief, or upstream multipliers; and forward, supply-driven, Ghoshian, or downstream multipliers. However, the notion of multipliers could have a wider application. In this dissertation I only utilise demand driven multipliers, but for wider discussions of different multiplier effects see Miller and Blair (2009).

IO-models (and indeed most regional demand-driven models, e.g. Export base, Keynesian multiplier). make a crucial distinction between exogenous and endogenous expenditures. Exogenous expenditures in these models are taken to be independent of the level of activity of the relevant economy; endogenous variables are primarily driven by the overall level of income or activity within the economy. Specifically, demand for intermediate inputs and often consumption demand are taken to be endogenous. Other elements of final demand (exports, government expenditure, investment) are taken to be exogenous. There is then a clear causal pathway from exogenous to endogenous expenditure.

When consumption expenditure is taken to be exogenous, the multiplier simply identifies the change in activity generated in the economy by changes in intermediate demand for goods and services. This multiplier is a Type I multiplier. It consists of the direct effects of the initial change in exogenous demand plus the indirect effects of the additional expenditure on intermediate goods and services. Where consumption demand is endogenous, and made to vary proportionately with wage income, the effects of induced consumption expenditure on activity is also included in the multiplier effect. This is a Type II multiplier. It covers the direct and indirect impacts that are quantified in the Type I multiplier but adds the induced effect of additional consumption.

In using I-O analysis to calculate demand multipliers, the following assumptions are made: constant-returns to scale; fixed coefficient production technology; constant coefficients in consumption (where Type II multipliers are calculated) and no supply constraints: I consider each of these assumptions in turn.

Constant-returns to scale, fixed coefficient production technology: In calculating the Leontief multipliers, we assume that all inputs into production in a particular sector change in strict proportion to the change in the output of that sector. Therefore, if output increases by 10%, all inputs similarly increase by 10%. This implies constant returns to scale in production. It also implies that there is no substitution between inputs as output changes. This assumption is usually interpreted as implying that production is characterised by a fixed-coefficients technology. However, an alternative is that substitution is possible but input prices do not change, so that the cost minimising choice of technique does not vary as output varies (McGregor, Swales & Yin, 1996).

Constant coefficients in consumption: Where induced consumption is incorporated into the multiplier values, in conventional models the consumption of all commodities changes in line with changes in wage income.

No supply constraints: This is the key assumption underlying the use of I-O demand multipliers. There must be available labour and productive capacity to meet any increase in demand in any sector. Similarly, there must be no key fixed natural resources that are fully utilised. Supply must therefore react passively to demand so that there is no crowding out of some demands by others and no changes in production techniques to economise on scarce resources or commodities. A corollary of this position is that as exogenous demand falls, I-O analysis assumes that there is no supply mechanism to redeploy the released resources.

Essentially a Type II demand-driven I-O multiplier is a sophisticated Keynesian multiplier. It operates in a conceptually similar way, but provides greater sectoral disaggregation and models imports and intermediate demands in a more accurate manner. It shares with the Keynesian multiplier the requirement that the supply-side of the economy plays a completely passive role. This might be appropriate in the short run for an economy with significant involuntary unemployment and excess capacity or for a regional economy in the long run where inter-regional migration and additional investment can relax labour market and capacity constraints. Clearly, the application to the UK national economy should be treated with some care, as the notion that the UK economy has no supply constraints in either the short or long run is less easy to maintain (McGregor *et al*, 1999).

5.1.1.2 Multipliers

In order to define the multipliers precisely, and to derive them, it is convenient to use a little matrix algebra. In matrix notation, a simplified standard I-O transaction matrix for an economy with n production sectors, and a vector of value added values and a final demand vector has the following form:

$$\begin{bmatrix} X & f & q \\ y^T & 0 & 0 \\ q^T & 0 & 0 \end{bmatrix}$$

Where X is the n × n matrix of intermediate sales and purchases with elements $x_{i,j}$ as the sales of sector i to sector j, f is the n × 1 final demand vector, q is the n × 1 gross output vector, and y^T is the 1 × n vector of value added inputs.

All of these are conventionally expressed in value terms, and the following accounting identities hold.

$$Xi + f = q \tag{5.1}$$

$$i^T X + y^T = q^T \tag{5.2}$$

Where i is an n × 1 vector of ones. If the elements x_{ij} of equation (5.1) are replaced by $a_{ij}q_j$, where q_j is the output of industry j and the technical coefficient a_{ij} is defined as $a_{ij} = \frac{x_{ij}}{q_j}$, the accounting identity (5.1) can be replaced by:

$$Aq + f = q \tag{5.3}$$

where A is an n × n matrix whose elements are the technical coefficients a_{ij}. If Aq is subtracted from both sides of equation (5.3), this produces:

$$f = q - Aq = (I - A)q \tag{5.3b}$$

where I is the n × n identity matrix.

Post-multiplying both sides of equation (5.3b) by the inverse of the (*I-A*) matrix gives:

$$(I - A)^{-1} f = q \qquad (5.4)$$

The matrix $(I\text{-}A)^{-1}$ is the Leontief inverse. This is used to calculate the vector of gross outputs, *q*, from the vector of final demands, *f*. Each element of the Leontief inverse, α_{ij}, measures the direct, indirect (and where appropriate induced) impact on sector i of a unit increase in the final demand for sector j. These are effectively sector-to-sector multipliers. The value of m_j the output multiplier for sector j is found as the sum of the elements of the jth column of the Leontief inverse. This is a sector-to-economy multiplier, that relates final demand in sector j to economy-wide output.

$$m_j = \sum_{i=1}^{n} \alpha_{ij} \qquad (5.5)$$

This basic approach can easily be augmented to link the exogenous elements of demand to a variety of activity metrics such as GDP, household income or employment. For example, employment multipliers for an industry can be produced by multiplying a row vector of direct employment multipliers (employment/output ratios) by the appropriate column vector in the inverse matrix. For industry j this can be stated as:

$$m_j^e = \sum_{i=1}^{n} (e_i/q_i)\alpha_{ij} \qquad (5.5b)$$

where m_j^e is the employment multiplier for sector j, e_i is the employment in sector i and q_i is the gross output of sector i. This is the direct, indirect (and induced) employment per £1m of final demand in sector j. Furthermore, Type-II multipliers can easily be derived by incorporating household expenditures and wage income into the A-matrix and deriving a Leontief inverse analogously to the Type-I case presented above[90].

As demonstrated in Chapter 3.3 the Input-Output system can be extended to more than one region, thereby incorporating both intraregional and interregional transactions. Based on the 3-region HEI-disaggregated Input-Output table for Scotland I have information on the intraregional and interregional transactions between and within the three regions, which can be used to obtain a 3-region 3n × 3n A-matrix of technical coefficients, consisting of nine sub-matrices.

$$A = \begin{bmatrix} A^{GG} & A^{GW} & A^{GS} \\ A^{WG} & A^{WW} & A^{WS} \\ A^{SG} & A^{SW} & A^{SW} \end{bmatrix} \quad (5.6)$$

Similarly, the 3n × 1 vectors of gross output and final demand, and the 3n × 3n unit matrix are all defined in 3-region terms as:

$$x = \begin{bmatrix} q^{G} \\ q^{W} \\ q^{S} \end{bmatrix} \quad (5.7)$$

$$f = \begin{bmatrix} f^{G} \\ f^{W} \\ f^{S} \end{bmatrix} \quad (5.8)$$

$$I = \begin{bmatrix} I & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & I \end{bmatrix} \quad (5.9)$$

so that the model (5.3) can be expressed as:

$$\begin{bmatrix} A^{GG} & A^{GW} & A^{GS} \\ A^{WG} & A^{WW} & A^{WS} \\ A^{SG} & A^{SW} & A^{SW} \end{bmatrix} \begin{bmatrix} q^{G} \\ q^{W} \\ q^{S} \end{bmatrix} + \begin{bmatrix} f^{G} \\ f^{W} \\ f^{S} \end{bmatrix} = \begin{bmatrix} q^{G} \\ q^{W} \\ q^{S} \end{bmatrix} \quad (5.10)$$

[90] For details about how to endogenise households in IO-models see Section 2.5 pp. 34-41 in Miller & Blair (2009).

and the leontief inverse (5.5) derived as:

$$\left\{\begin{bmatrix} I & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & I \end{bmatrix} - \begin{bmatrix} A^{GG} & A^{GW} & A^{GS} \\ A^{WG} & A^{WW} & A^{WS} \\ A^{SG} & A^{SW} & A^{SS} \end{bmatrix}\right\}^{-1} \begin{bmatrix} f^{G} \\ f^{W} \\ f^{S} \end{bmatrix} = \begin{bmatrix} q^{G} \\ q^{W} \\ q^{S} \end{bmatrix} \quad (5.11)$$

As in the single-region case the columns in the interregional Leontief inverse can be summed to obtain the convenient multipliers for individual sectors. Furthermore, in this case, the inverse can be partitioned so as to obtain not only a multiplier pertaining to the Scotland-wide impact of a particular sector, but to decompose the multiplier effect by the region of impact.

$$\left\{\begin{bmatrix} I & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & I \end{bmatrix} - \begin{bmatrix} A^{GG} & A^{GW} & A^{GS} \\ A^{WG} & A^{WW} & A^{WS} \\ A^{SG} & A^{SW} & A^{SS} \end{bmatrix}\right\}^{-1} = \begin{bmatrix} a^{GG} & a^{GW} & a^{GS} \\ a^{WG} & a^{WW} & a^{WS} \\ a^{SG} & a^{SW} & a^{SS} \end{bmatrix} \quad (5.11b)$$

In this this case the Leontief inverse is partitioned into sub-matrices containing the elements α_{ij}^{RS}, the inter-industry multiplier. As before these matrix elements describe the impact of a change in the final demand for sector j upon sector i, but in the interregional variant sector j is located in region S and sector i in region R. If region R is the same as S, such as in the matrices on the diagonal a^{GG}, a^{GG} and a^{SS}, we have an intra-regional effect, where as in the cases where R and S are not the same the multipliers describe interregional effects. For example the sector by sector multipliers contained in the sub-matrix a^{GS} describe the impact of sector j in the rest of Scotland upon sector i in Glasgow. As before the columns in these sub-matrices can be summed up to derive output multipliers for the impact of sector j in region S upon all sectors in region R

$$m_j^{RS} = \sum_{i=1}^{n} \alpha_{ij}^{RS} \quad (5.5c)$$

For practical purposes, deriving the output multiplier of a particular sector from the Leontief inverse allows the convenience of expressing output impacts as the product of the sector's final demand and its multiplier, so that:

$$Q_j = f_j m_j$$

Where Q_j is the economy-wide output attributable to sector j (or the total value of production in all sectors of the economy that is necessary to satisfy the final demand for sector j's output), f_j is is the final demand for sector j's output and m_j is the output multiplier for sector j.

However, if we want to apply this convenient approach of multiplier analyses to a 3-region interregional case, some matrix algebra is needed. For the three region case, the calculations should result in a vector of the total output in each region attributable to sector j in the particular region being examined.

This takes us back to the regionally partitioned Leontief inverse from (5.11b), presented here as:

$$\begin{bmatrix} a^{GG} & a^{GW} & a^{GS} \\ a^{WG} & a^{WW} & a^{WS} \\ a^{SG} & a^{SW} & a^{SS} \end{bmatrix} \qquad (5.11c)$$

Each sub-matrix a^{RS} of the Leontief inverse contains interindustry multipliers, originating in region S and destined for region R, for each sector j affecting each sector i. These sub-matrix elements are noted as α_{ij}^{RS}. In our three region case the interregional output multiplier for sector j combines the column sum of three sub-matrices of the interregional Leontief inverse, depicting the impact of sector j upon all sectors i in its host region as well as the two other regions of the three region model.

For example, looking at the case of Glasgow (G) the host region output impact of sector j becomes:

$$m_j^{GG} = \sum_{i=1}^{n} \alpha_{ij}^{GG} \tag{5.5d}$$

And the impact of sector j in Glasgow (G) upon all sectors in RST (W) and ROS (S), respectively, becomes

$$m_j^{WG} = \sum_{i=1}^{n} \alpha_{ij}^{WG} \tag{5.5e}$$

and

$$m_j^{SG} = \sum_{i=1}^{n} \alpha_{ij}^{SG} \tag{5.5f}$$

Therefore, the interregional output multiplier of sector j in GLA is a vector composed of the three output multipliers m_j^{GG}, m_j^{WG} and m_j^{SG}, so that:

$$\boldsymbol{m_j^G} = \begin{bmatrix} m_j^{GG} \\ m_j^{WG} \\ m_j^{RG} \end{bmatrix} \tag{5.11}$$

Similarly, for RST and ROS we can write the interregional output multipliers of sector j in those regions as:

$$\boldsymbol{m_j^W} = \begin{bmatrix} m_j^{GW} \\ m_j^{WW} \\ m_j^{RW} \end{bmatrix} \tag{5.11b}$$

$$\boldsymbol{m_j^S} = \begin{bmatrix} m_j^{GS} \\ m_j^{WS} \\ m_j^{RS} \end{bmatrix} \tag{5.11c}$$

Based on this, the output impact of sector j, located in say Glasgow (G), across the three regions can be found by post-multiplying its final demand with the vector of interregional output multipliers. This gives a vector of outputs in the 3 regions:

$$\boldsymbol{Q_j^G} = f_j^G \boldsymbol{m_j^G} = \begin{bmatrix} m_j^{GG} \\ m_j^{WG} \\ m_j^{RG} \end{bmatrix} f_j^G \qquad (5.12)$$

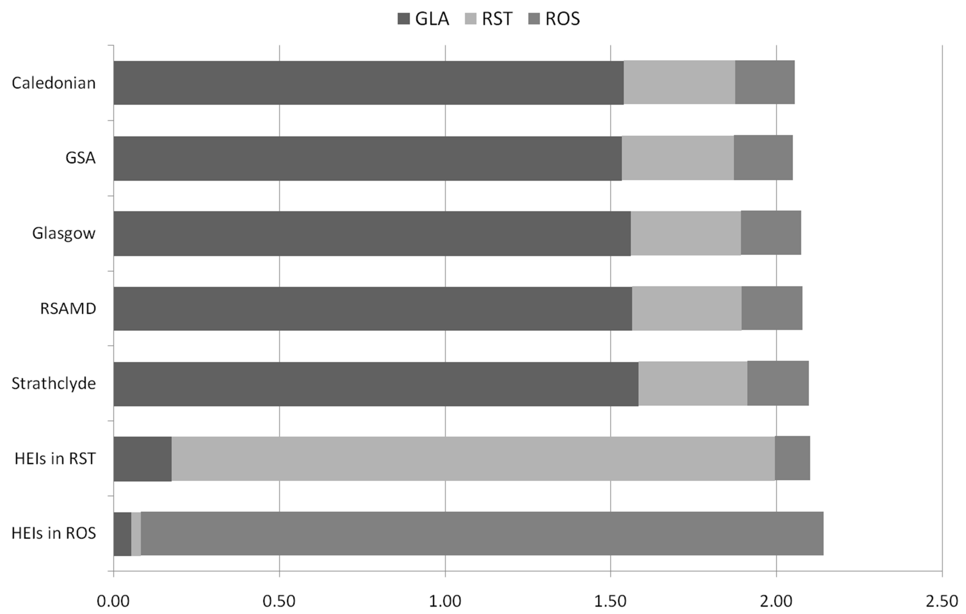
The Scotland-wide multiplier for any sector j located in any sub-region R can simply be expressed as a scalar. Similarly, as we've seen, a multiplier in a scalar format can be derived for any sector of the sub-matrices of the Leontief inverse, i.e. a multiplier for the impact of any sector j in any region S upon all sectors i in all regions R. However, there is some computational convenience in using vectors of sub-regional multipliers (as in 5.12 above) in that it allows the derivation of a Scotland-wide impact that is decomposed into separate impacts upon each sub-region, all in just one calculation. In the remainder of this chapter the terminology interregional multiplier refers to a vector of sub-regional multipliers, which permits the calculation of the output impact of sector j in host region S upon all sectors i, separately in each of the regions GLA, RST and ROS.

5.1.2 **Institutions**

Determining the sub-regional and interregional expenditure impacts of the HEIs themselves is a relatively straightforward matter, given the Input-Output database, which identifies each HEI as a separate sector (see section 3.2) and furthermore identifies the spatial distribution of their expenditures (see Section 3.3). The figure below reveals the interregional Type-II output multipliers for the Glasgow HEIs (Caledonian, GSA, Glasgow, RSAMD and Strathclyde) and two aggregate sectors comprising the HEIs in RST and ROS, respectively.

The output multipliers show how £1 of final demand translates into an output impact and how it is distributed spatially across Scotland. For example, imagine that the University of Strathclyde were to receive an exogenous injection of £100m, say in the form of increased fees from overseas students, we can infer from the interregional Type-II output multiplier that this would result in a Scotland-wide output impact of approximately £210m. Output in Glasgow would be stimulated by approximately £160m, while output in the rest of the Strathclyde region and the rest of Scotland would be boosted by approximately £30m and £20m, respectively.

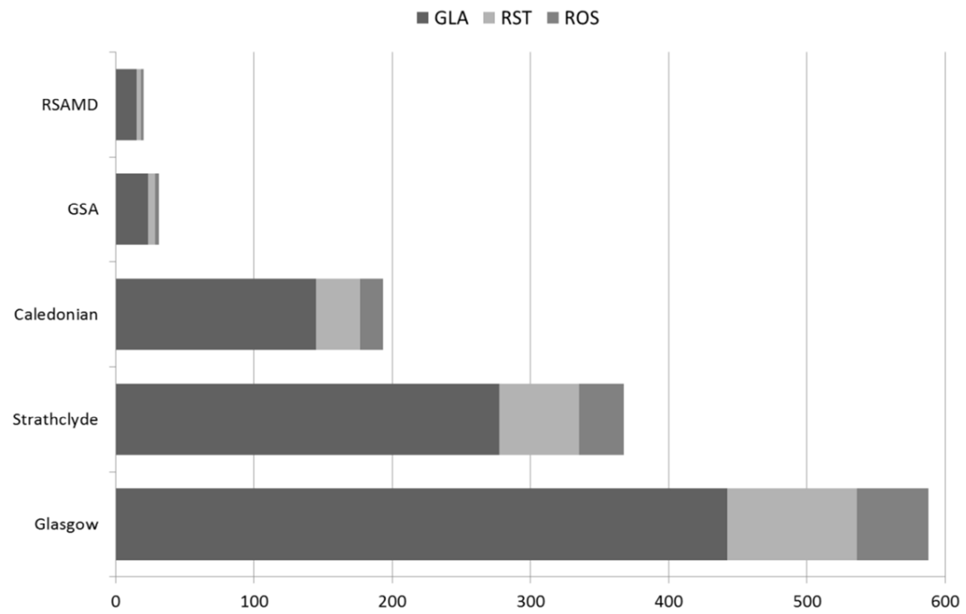
Figure 44 Interregional Type-II output multiplier of the HEI sectors identified in the 3-region GLA-RST-ROS HEI disaggregated IO-table.



As the diagram reveals, most of the knock-on impacts are incurred within the HEIs' host regions, most markedly for the aggregated impacts of universities located in the larger regions RST and ROS. Glasgow is the most open region with significant knock-on impacts occurring in the other two regions, particularly in RST.

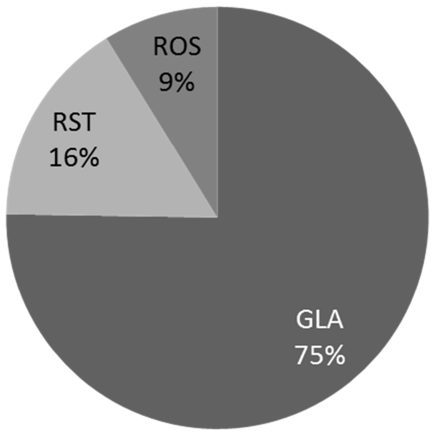
Figure 45 reveals the absolute output impact of individual universities located in Glasgow on the Glasgow, RST and ROS economies. Overall the Glasgow HEIs drive a Scotland-wide output impact of £1.2 bn. This amounts to approximately 0.7% of total output in Scotland. As the output impact is the product of the institutions' final demand and its output multiplier, scale is a significant driver of impact. In this regard the University of Glasgow is the biggest institution, generating approximately half of the total impact of all five Glasgow HEIs.

Figure 45 Interregional Type-II output impacts of HEIs in Glasgow. Horizontal bars represent absolute impact (£ millions), disaggregated by sub-region of impact.



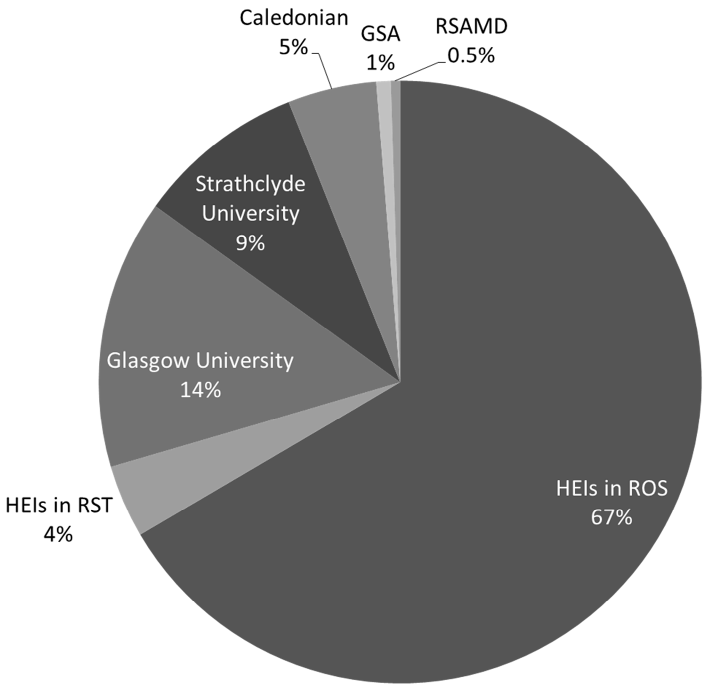
As Figure 45 reveals these impacts are not confined solely to the institutions' host regions, but are distributed through knock-on effects to other sub-regions. Figure 46 gives the spatial breakdown of the aggregate Glasgow HEI impact.

Figure 46 Regional breakdown of the aggregate output impact of the 5 Glasgow HEIs in percentages.



The output multipliers are a scale-independent measure of the HEIs' expenditure impacts. However, Figure 47 serves as a reminder that the institutions vary greatly in scale, which, given the similarity of Scotland-wide multipliers (Hermannsson *et al,* 2010c) is a key driver of total expenditure impacts.

Figure 47 Percentage-breakdown of the Type-II output impact of HEIs in Scotland



In this case the HEIs in ROS sector is composed of 13 HEIs in the ROS and the HEIs in RST is a composite of the two institutions in the Strathclyde region, Bell College and the University of Paisley, which in fact have now merged to form the University of the West of Scotland. The five Glasgow HEIs therefore represent approximately 30% of the total expenditure impacts of the sector in Scotland.

5.1.2.1 Interregional distribution of HEI activities and impacts within Scotland

Table 34 reveals where the stimuli of the HEI-sector originate and how they spread across Scotland through knock-on impacts. The rows indicate the origin of the stimulus while the columns reveal the location of impact. For example, looking at the top row, this depicts the impact of HEIs in Glasgow and how these are spread across Scotland. Reading across we can see that Glasgow HEIs exert an impact of £904m upon Glasgow itself, drives £192m of output in the rest of the Strathclyde region and £106 in the rest of Scotland. The rightmost value sums this up to reveal a Scotland-wide impact of HEIs in Glasgow of £1,201m. If we work our way down the GLA column in the table we see what impacts the HEIs in different parts of Scotland exert upon Glasgow. The local HEIs cause an impact of £904m upon their host city while HEIs in the rest of the Strathclyde region have an impact upon Glasgow to the tune of £13m and the HEIs in the rest of Scotland drive an output impact of £67m in the city. The sum of the column reveals that all HEIs in Scotland drive £984m of output within the City of Glasgow. Generally, for the HEIs in each sub-region, most of the impacts are felt within their host region, although significant impacts spills over to other regions. For example the HEIs in the rest of Scotland (RST) generate a Scotland-wide output impact of £159m. Of this, £138m or 87% occur within the host region while £13m are felt in GLA and £8m in the ROS.

Table 34 spatially disaggregated Type-II output impact of HEIs in Scotland. Rows indicate location of HEIs and columns reveal location of impact (£m).

		Location of impact			
		GLA	**RST**	**ROS**	**SCO total**
Location of HEI	**GLA**	904	192	106	**1,201**
	RST	13	138	8	**159**
	ROS	67	35	2,604	**2,706**
	SCO total	**984**	**365**	**2,717**	**4,066**
	– % of SCO total	*24%*	*9%*	*67%*	*100%*

As we saw in Section 4.1 the HEIs in Glasgow receive approximately 31% of the income of the HEIs sector in Scotland. A noteworthy feature of these results, however, is that Glasgow only reaps 24% of the output impacts of the overall HEIs sector in Scotland. If we take a look at GLA and RST in conjunction (the whole of the Strathclyde region) we saw in Section 4.1 that HEIs in this area receive approximately 34% of the income of the overall sector in Scotland. However, the region receives approximately 33% of the output impact of the HEIs sector in Scotland. Thereby it is evident that a significant share of the spillovers from Glasgow are captured in the RST. On balance, however, it is clear that due to interregional linkages, the Strathclyde region captures less of the output impact of the HEIs sector in Scotland (33%) than the scale of the HEIs in Strathclyde (34% of the income of the Scotland-wide sector) would suggest. From the point of view of policy discourse in Scotland, this is of further interest as Glasgow and the Strathclyde region are perceived to host a relatively large share of the HEIs sector vis-á-vis the rest of Scotland, or at least command a respectable share of the sector given the relative scale of the area.

Table 35 Share of population, HEIs sector and output impacts of HEIs by region in Scotland.

	GLA	RST	ROS	Scotland (GLA+RST+ROS)	Strathclyde area (RST + GLA)
Population 2006 (headcount)	580,700	1,443,900	3,092,300	5,116,900	2,024,600
% of row total	*11%*	*28%*	*60%*	*100%*	*40%*
Income of HEIs (£ millions)	627	78	1,359	2,065	*706*
% of row total	*30%*	*4%*	*66%*	*100%*	34%
Output impact of HEIs (£ millions)	984	365	2,717	4,066	1,349
% of row total	*24%*	*9%*	*67%*	*100%*	*33%*

As we see from Table 35, this perception holds from the narrow perspective of HEIs in Glasgow as part of Glasgow city. For the narrow city council area the HEIs are certainly over-represented relative to the city's share of overall population in Scotland[91]. However, as I argue in Chapter 3, Glasgow and the rest of the Strathclyde region are economically very interdependent and can be treated as a single functional entity. Looking at the Strathclyde region as a whole HEI capacity is relatively under-provided vis-á-vis the rest of Scotland. Due to the interregional economic structure of Scotland this imbalance is

[91] Universities are central place phenomena and therefore it may not be surprising that Glasgow, as Scotland's largest city, benefits from their presence. A further interesting aspect is to what extent Edinburgh benefits from the presence of HEIs. In population terms Edinburgh is about 80% of the size of Glasgow, but maintains an HEI sector that in income terms is approximately 101% of the size of the Glasgow sector. Furthermore it is an interesting question, but one that has to be left aside for future work, why such a large HEI sector evolved in Edinburgh? This can certainly not be explained by the size of the immediate catchment area, as when we compare metropolitan areas, in terms of population, the Lothian area is equivalent to only about 40% of the Strathclyde area.

further exacerbated as the Strathclyde region as a whole enjoys less of the output impact of HEIs than the scale of the area's HEIs sector would suggest.

Does this result imply that the HEIs sector is not equitably spread across space in Scotland, with the rest of Scotland being favoured at the expense of the Strathclyde area? As we know, just over one half of the sector's funding comes from the Scottish Government, so perhaps the question should be raised if spatial distribution of HEIs' income in Scotland reflects a relative underperformance of the HEIs in the Strathclyde area when it comes to competing for income from students' fees and research grants? As we know from Chapter 4.1 HEIs in Glasgow and the rest of the Strathclyde area tend to be more dependent upon funding from the devolved government than HEIs in the rest of Scotland. To address this I turn to Table 36, which shows the income by source for the aggregate HEI-sectors in each of the three regions.

Table 36 Income of HEIs in GLA, RST and ROS disaggregated by source (Scottish Government and other funding) for 2006.

	GLA	RST	ROS	Scotland (GLA+RST+ROS)	Strathclyde area (RST + GLA)
Scottish government funding (£ millions)	364	65	700	1,129	429
% of row total	*32%*	*6%*	*62%*	*100%*	*38%*
Other income of HEIs (£ millions)	263	14	659	936	*277*
% of row total	*28%*	*1%*	*70%*	*100%*	*30%*
Total income of HEIs (£ millions)	627	78	1,359	2,065	706
% of row total	*30%*	*4%*	*66%*	*100%*	*34%*

Looking at the HEIs in the Strathclyde area as a whole they receive 38% of all Scottish Government funding for HEIs. This is still slightly less than the area's population share would imply. However, when we look at the other sources of funding it is the extent to which the Strathclyde area is at a disadvantage vis-à-vis the rest of Scotland that is striking. Only 30% of the other income of HEIs in Scotland can be attributed to the HEIs in the Strathclyde area, where 40% of the population reside, whereas the remaining 70% can be attributed to the HEIs in the rest of Scotland, where 60% of the population reside. What drives this relative underperformance of the HEIs sector in the Strathclyde area is beyond the capacity of this analysis to answer. However, as a large share of the other funding category is external to the Scottish economy (UK-wide and international research funding and tuition fees) it is clear that a considerable boost to the Scottish economy could be obtained by raising the share of exogenous income of the Strathclyde HEIs to the same level as for those institutions in the rest of Scotland.

Looking at the HEIs in Strathclyde in aggregate 61% of their income comes from the Scottish Government while 39% comes from other sources. The same ratios for the HEIs in the rest of Scotland are 52% and 48%. If Scottish Government funding were held constant but the HEIs in Strathclyde could raise their share of other income to 48%, this would mean additional income for the Strathclyde HEIs sector to the tune of £119 m ((429/0.52)-706=119). This amounts to just under 17% of the aggregated income of HEIs in GLA and RST. Whether this is possible seems to be granted by the performance of HEIs in ROS. Whether this is feasible is an altogether more complicated matter. For example, would additional efforts at drawing in external funding and students substitute or complement efforts to train the indigenous population? If research grants and external students are complementary to efforts at training graduates for the local labour market then the outcome is all-round positive. However, if these income earning activities are at the detriment of efforts geared towards the host economy than these goals are conflicting and it cannot be determined *a priori* if boosting the Strathclyde HEIs' share of other funding is ultimately beneficial to the Scottish economy. We will get a clearer picture of how HEIs benefit the economy in distinctly different ways through the demand-side and the supply-side, when we have examined the impacts of increasing the skills of graduates retained in the local labour market in Chapter 6. However, for the remainder of this chapter I shall continue to focus on the expenditure impacts of HEI and their students.

5.1.3 **Students**

In addition to the impact of the institutions' own expenditures a further impact that needs to be accounted for is the exogenous component of HEIs' students' consumption expenditure that occurs within the local economy. In practice this involves: determining the level of student spending; judging the extent to which this is additional to the regional economy being analysed and identifying how student expenditures are distributed among sectors. Furthermore, I need to determine the pattern of how student expenditure is distributed across sub-regions. This is simultaneously challenging and interesting as students are mobile between sub-regions and may act to transfer income and expenditure from their sub-region of domicile to the sub-region they are studying in. Such interregional flows would represent endogenous transactions in the study of impacts at the Scottish level and would therefore net-out in a study of Scotland-wide impacts. However from the point of view of individual sub-regions these expenditures become exogenous.

There have been two alternative treatments of student expenditures in past impact studies: one incorporates only the expenditures of in-coming students (e.g. Kelly et al, 2004); the other includes all student expenditures, irrespective of their origin (e.g. Harris, 1996). Following Hermannsson *et al* (2010b) I argue that each of these past treatments of student expenditure impacts represents an approximation to an Input-Output accounting approach in which the crucial distinction is that between the exogenous and endogenous components of student expenditures. While it is true that the whole of external students' expenditures can be regarded as exogenous to the host region, home students' expenditures cannot legitimately be treated as either wholly endogenous, which is what would be required to validate the first approach, nor wholly exogenous, which would be required to validate the second.

To determine the sub-regional and interregional impacts of students I proceed in four stages. First I identify the level of endogenous and exogenous expenditures of students at the Scottish level. Then I proceed to disentangle the endogenous components of students' consumption expenditures into an injection of expenditures and a displacement of expenditures and identify to what extent these two occur between regions. Next based on the number of students in each sub-region and their origin, I determine how the total direct impacts of expenditure and displacement are attributed to each sub-region. Finally, I use the 3-region HEI-disaggregated IO-model to determine the knock-on impacts of students' consumption expenditures.

5.1.3.1 Students' Scotland-wide consumption expenditures

When determining students' exogenous consumption expenditures the case of external (non-Scottish) students is straightforward: their expenditures are unambiguously exogenous, as their incomes are derived from an external location. The treatment of their expenditure is similar to that of tourists. For local students, the distinction between their endogenous and exogenous consumption is less clear cut. To a large extent their income, and hence consumption, is endogenous to the local economy in that it comes from wages earned from local industries and transfers from within local households. That is, under standard IO-assumptions expenditures driven by these endogenous income sources are non-additional to the economy. For local students simplifying assumptions are adopted in line with the typical IO-notion of exogeneity. The exogenous components of local students' consumption expenditures are assumed to be expenditures financed from commercial credit taken out during their years of study, student loans and education-related grants and bursaries.

For details of Scottish students' income and expenditures I follow Hermannsson *et al* (2010b) and draw on a comprehensive survey by Warhurst *et al* (2009), who build on and expand work by Callander *et al* (2005). Warhurst *et al* (2009) conduct a large scale survey complemented with face to face interviews. They interviewed 1,000 Scottish domiciled undergraduate students at Scottish institutions and estimated their average term time expenditure at £6,404 in the academic year 2007/2008. However, these results only refer to one section of the student population at Scottish HEIs as 33% come from outwith Scotland[92] and 19%[93] are postgraduates. Surveys have not been carried out relating to the expenditure of students of RUK and ROW origin, nor for

---

[92] See Section 3.2.4 for details.
[93] See HESA (2007) Students in Higher Education, Table 0b

Scottish domiciled postgraduate students. These students' expenditures are expected to be greater as Warhurst *et al* (2009) found that the expenditures of undergraduate students increase with age and the year of study[94]. Furthermore, the incoming students are, by definition, staying away from home and so must pay for accommodation in full.

According to Warhurst *et al* (2009) Scottish-domiciled undergraduates living independently spent on average £7,187 in 2007/2008 while those living with parents spent £5,317. The expenditure level of Scottish students who are living independently is used as a proxy for expenditures of incoming students. However it is reasonable to expect incoming students to have to incur more costs than locals if only due to unfamiliarity with local conditions and an inability to draw on a social network, in contrast to local students. A higher estimate for living costs is, for example, suggested by the Icelandic Student Loan fund, which estimates student expenditures (apart from tuition fees) for an academic year in Scotland at £8,520[95]. Here the rather conservative approach is adopted that the average for Scottish domiciled undergraduates is applied to all Scottish domiciled HE students and the average expenditures of Scottish domiciled undergraduates living independently is applied to all incoming students.

A number of adjustments have to be applied to the 'gross' student spending as reported by Warhurst *et al* (2009) to conform with IO assumption. In particular care must be taken to deduct non-additional ('endogenous') spending components to avoid double counting. For Scottish domiciled students this means that the components of consumption that are treated as additional (exogenous) are those that are attributable to student loans, commercial credit

---

94 The youngest age group (16-20) was found to spend on average £5,587 per term, whereas those aged 21-24 spent £6,725 and those 25 and over spent £10,039 – nearly twice as much as the youngest age group. The difference is more subdued for expenditures by year of study. Students in their 1st year were found to spend £5,961 on average, whereas 2nd year students spent £6,373, 3rd year students spent £6,916 and those in their 4th year spent £6,953, or approximately 16% more than 1st year students. For details see Warhurst et al (2009, Tables 3.6 & 3.27, pp. 59 & 79).

95 For the academic year 2008/2009 the Icleandic Student Loan Fund (LÍN) estimates the cost of subsistance for obtaining a single ECTS credit in Scotland is £142, where a full academic year will consist of 60 credits, amounting to anticipated costs of £8,520. See: http://www.lin.is/Namslan/utlan/framfaerslutafla.html

students take out to support themselves and student support and grants as reported by Warhurst *et al* (2009). This changes slightly when the budget constraint of public expenditures in Scotland is acknowledged as student support and grants are, to a significant extent[96], funded by the Scottish block grant and therefore represent a re-allocation of Scottish Government spending within Scotland (see general discussion in Chapter 5.2). The student loans received by Scottish students are, however, treated as additional as they are provided by the Student Loans Company, a UK-level non-departmental public body. Informal transfers within the family do not constitute additional spending in Scotland as they are a re-allocation of total household spending[97]. However, as we shall see this takes on added significance when the displacement of expenditures occurs across sub-regions. Term-time labour market earnings are equally not-additional to the Scottish economy as, under the IO assumption of a passive supply-side, if the student was not earning that wage income some other Scotland resident would be. That leaves other income, which is assumed to be endogenous to the Scottish economy[98] and the student's income shortfall (expenditure in excess of income). Precise information is not available on the composition of this income shortfall, but it is expected to constitute some combination of informal income/credit not previously accounted for and commercial credit. New commercial credit taken out by Scottish domiciled students represents an exogenous impact on the local economy, while informal credits are assumed to be obtained locally and therefore represent a transfer within the economy rather than an additional impact.

Warhurst *et al* (2009) provide information on the amount of commercial credit taken out by Scottish students during their time of study, which is used to estimate the magnitude of commercial credit in funding the students' consumptions expenditures. Care must be taken to count only the net commercial credits obtained as students run up commercial debts during term

96 The category also includes support from private charities. Here the conservative stance is adopted that the charities are funded from Scottish contributions and therefore represent a re-distribution within the Scottish economy rather then an additional injection.

97 In principle parents could be funding these transfers by drawing on savings or taking out new credit, but we assume they are met with consumption switching from parents to student.

98 Information on the composition of other income is not available in Warhurst (2009). Therefore I adopt the conservative stance that it is non-additional to the Scottish economy.

time but typically repay these to some extent between years. Table 4.15 in Warhurst *et al* (2009, p. 100) reports the amount of commercial credit owed by students at the end of each of their year of study. They find a wide range of commercial debt incurred by year of study. Of course it must be borne in mind that their survey is a cross section but interpreted literally it suggests that students rely less on commercial credit as they progress through their studies (and a net repayment occurs between years 3 and 4). This is in line with their findings that students' earning power increases with year of study. Here the assumption is adopted that commercial debt levels at the end of year 4 are representative for their overall net-incurrence for the entire duration of undergraduate study.

Table 37 Commercial credit at the end of term by year, £. Source: Warhurst et al (2009, Table 4.15, p. 100).

	Year 1	Year 2	Year 3	Year 4
Commercial credit owed at the end of term time	968	1,240	1,699	1,384
Net change in commercial debt between years of study	968	272	459	-315
Implied average per year of study	968	620	566	346

Based on these assumptions the average additional ('exogenous') component of Scottish students' term time spending is £346 (1,384/4). The assumption suffers from a potential downward bias in that 4th year students are less than one quarter of the student population. However, it could be counter-argued that students will use income earned in the following summer to make additional payments to their commercial debt. Available evidence unfortunately does not allow a precise estimate but on balance the assumption adopted here should be seen as rather conservative.

Table 38 Average term time income and expenditures of Scottish undergraduates, £. Source: Warhurst et al (2009, Table 2.4 & 3.4, pp. 24, 56).

	£	% of income
Average income	**5,157**	**100%**
Student loan	1,430	28%
Informal housing contribution	163	3%
Informal living contribution	290	6%
Term-time earnings	1,945	38%
Education related grants and bursaries	759	15%
Other	570	11%
Average expenditure	**6,230**	**121%**
Housing costs	1,116	22%
Living costs	3,954	77%
Participation costs	957	19%
Child specific costs	203	4%
Other costs	110	2%
Income shortfall	**1,073**	**21%**

Available evidence (see Table 38 above) suggests that the average income shortfall of Scottish undergraduates is significantly larger each year, amounting to £1,073. Unfortunately Warhurst *et al* (2009) do not elaborate on how the income shortfall might be explained but here it is expected to be met by some combination of underreported informal contributions (within household transfers), earnings outwith term-time (drawing on savings), commercial credit and informal economic activities that the respondents do not want to disclose. In absence of further information on the nature or composition of this income shortfall I adopt the conservative assumption that it represents endogenous income sources, except for the part that is funded by new commercial credit.

Warhurst *et al* (2009) estimate the average term time employment income of Scottish undergraduates at £1,945. Here it is assumed that this average holds for incoming students from other parts of the UK, while foreign students are assumed not to participate in the labour market[99]. Finally we deduct the direct

[99] These assumptions are of course stylised but are used for simplification in the absence of more detailed information. Anecdotal evidence suggests that some foreign students participate in the labour market, most notably postgraduate students who may be employed by their HEIs for work such as tutoring. However, the magnitude of this labour market participation is unlikely to be of similar magnitude to that of local students.

import content of student's expenditure, which is assumed to equal that of Scottish households in general (32%) as reported in the Scottish Input-Output tables.

Table 39 below summarises how the results of the expenditure survey by Warhurst *et al* (2009) are used to derive the exogenous per student spending of students from Scotland, the rest of the UK and the rest of the World. Using the example of Scottish students the starting point is the gross term time spending of the average Scottish undergraduate student (£6,230). From this I deduct the endogenous components of student income: 'Income from employment', 'within household transfers', 'other income' and 'income shortfall'. 'Spending attributable to new commercial credit' is added back as this represents exogenous income. The column sum reveals that the exogenous expenditure of the average Scottish student equals £2,535. From this I need to deduct the direct import content of the consumption expenditure[100]. This reveals the net change in final demand per student (£1,719), which can then be multiplied by the number of students to obtain the additional contribution to final demand made by the population of Scottish students studying at Scottish HEIs. This process is slightly simpler for RUK and ROW students as there are less deductions of endogenous expenditures. However, as previously noted, the gross average expenditure per incoming student is proxied by the average per student expenditure of Scottish students living independently (£7,187). This higher expenditure level and the fact that a greater share of the overall expenditure is an exogenous injection to the Scottish economy (in the case of ROW students all of it) results in a bigger impact per incoming student than for a local student.

[100] The direct import content of students' consumption expenditures is taken to be equal to that of household expenditures in Scotland as revealed by the Scottish Input-Output tables at 32.2%

Table 39 Derivation of per student spending.

Location of domicile		SCO	RUK	ROW
Gross average student spending £	+	6,230	7187	7,187
Income from employment £	-	1,945	1,945	
Within household transfers £	-	453		
Other income £	-	570		
Dissaving £	-	1,073		
Spending attributable to new commercial credit £	+	346		
Exogenous average per student spending	=	**2,535**	**5,242**	**7,187**
Direct imports £ (32%)	-	816	1,688	2,315
Net change in final demand per student £	=	**1,719**	**3,554**	**4,872**
Number of students FTE's	x	115,398	22,630	25,737
Estimated net contribution to final demand by student population £ m	=	**198.3**	**80.4**	**125.4**

5.1.3.2 Students' consumption expenditures at the sub-regional level

In order to accurately identify the direct impact of students' consumption expenditures at the sub-regional level I need to determine the extent to which the displacement of expenditures (determined in the previous section) occurs within the same sub-region as the consumption expenditures. In Table 39 I identify 4 categories of displaced expenditures from student's consumption: 'income from employment', 'within household transfers', 'other income' and 'income shortfall'. In what follows I adopt the assumption that 'income from employment' is incurred in the region of study but that 'within household transfers', 'other income' and 'income shortfall' originate from the student's location of domicile. Furthermore, as detailed information on the geographical dispersion of students' consumption spending is not available I adopt the simplifying assumption that their term-time consumption occurs only within their location of study.

To state this more formally, generally the output impact of a student's consumption expenditure can be described as the product of that student's final demand f_S and the interregional output multiplier of student's consumption expenditures $\boldsymbol{m_S}$, such that the output across all three regions attributed to students can be represented as $\boldsymbol{Q_S} = \boldsymbol{m_S} f_S$. However, we need to acknowledge that not all of that final demand f_S represents a net additional injection in the regional economy, as some of it displaces final demand expenditures elsewhere in the regions being considered. If we denote displaced expenditures as f_D, the impact net of displaced expenditures, can be represented as $\boldsymbol{Q_S} = \boldsymbol{m_S}(f_S - f_D)$.

To adapt this simple presentation to an interregional framework first of all it is necessary to apply interregional multipliers as introduced in section 5.1.1.2. Furthermore, it should be noted that for the purposes of analysing the impact of students' consumption expenditures there are essentially two regional definitions that are relevant: these are the student's region of domicile, or home region, denoted by the superscript H and where the student studies at university, denoted by the superscript U. Furthermore, to simplify the analysis I adopt two assumptions: that students' term time consumption expenditures occur solely within the region of study (U) and that displaced expenditures exhibit an identical sectoral pattern as that of student spending, captured in the multiplier $\boldsymbol{m_S}$[101]. Given these simplifications the vector of interregional output impacts of students' consumption expenditures, given displacement of expenditures elsewhere in the economy, can be represented as:

$$\boldsymbol{Q_S} = \left(\boldsymbol{m_S^U} f_S^U\right) - \left(\boldsymbol{m_S^U} f_D^U\right) - \left(\boldsymbol{m_S^H} f_D^H\right) ,$$

or

$$\boldsymbol{Q_S} = \boldsymbol{m_S^U}(f_S^U - f_D^U) - \left(\boldsymbol{m_S^H} f_D^H\right)$$

If the regions of study (U) and the region of domicile (H) coincide, this can be further simplified as

$$\boldsymbol{Q_S} = \boldsymbol{m_S^U}(f_S^U - f_D^U - f_D^H)$$

A summary of how student's consumption expenditures impact upon region of study and region of domicile for different student groups is provided in the table below. Whereas before we had 3 representative types of students (SCO, RUK and ROW), now I identify two types of Scottish students: 'movers' and 'stayers'. For Scottish 'stayers' the exogenous and endogenous components of

[101] This is a reasonable approximation as although the sectoral pattern of consumption between students and households in general differs somewhat their output impact per unit of final demand is very similar.

their expenditures occur within the same region. However, for 'movers' these are spread across their home region and their region of study. The impacts are expressed in a general way in Table 40. Table 41 reports the numerical impacts derived for individual students by student type and destination of impact.

Table 40 Expenditure impact of different student groups upon region of study and region of domicile[102].

Student origin	Region of study	Region of domicile
SCO 'stayer' (studies in home region)	$\boldsymbol{m_S^U}(f_S^U - f_D^U - f_D^H)$	
SCO 'mover' (moves within Scotland for study)	$\boldsymbol{m_S^U}(f_S^U - f_D^U)$	$-(\boldsymbol{m_S^H} f_D^H)$
RUK	$\boldsymbol{m_S^U}(f_S^U - f_D^U)$	
ROW	$\boldsymbol{m_S^U} f_S^U$	

To summarise, as Table 40 reveals, the region of study and the region of domicile is the same for Scottish 'stayers' and hence both the expenditure injection and displacement are incurred within the same sub-region. Scottish 'movers' exert a positive direct net-impact upon their region of study whilst they result in a net displacement of expenditures in their region of domicile. For RUK students both positive direct impacts and displacement of expenditures (employment) is felt within their region of study. However, they will trigger displacement of expenditures in their region of domicile within the RUK, which is not modelled as part of this exercise. For ROW students a positive direct impact is felt in the region of study, whereas no displacement of expenditures is expected within Scotland.

[102] Of course the impact of RUK and ROW students is likely to involve displacement effects in the RUK and ROW as these students accept transfers from home. However, this study foccusses soley on impacts upon Scotland and therefore treats the RUK and ROW as completely exogenous.

Based on this, there is no difference in the treatment of the expenditure of incoming students from the RUK and ROW at the Scotland-wide level and the sub-regional level. Similarly, for students whose domicile and location of study coincide their treatment at the sub-regional level is identical to that at the Scottish level.

Given these definitions the next step is to estimate the amount of student consumption expenditures and displaced expenditures in each of the three regions GLA, RST and ROS.

Table 41 Derivation of per student spending of different student types separately identifying direct impacts for region of study (U) and region of domicile (H) compared to direct impact upon Scotland as a whole (SCO), £.

Student type	***SCO 'stayer'***		***SCO 'mover'***			***RUK***		***ROW***	
Impact of expenditure	**U**	**SCO**	**U**	**H**	**SCO**	**U**	**SCO**	**U**	**SCO**
Gross average student spending £	6,230	6,230	6,230		6,230	7,187	7,187	7,187	7,187
Income from employment £	-1,945	-1,945	-1,945		-1,945	-1,945	-1,945		
Within household transfers £	-453	-453		-453	-453				
Other income £	-570	-570		-570	-570				
Dissaving £	-1,073	-1,073		-1,073	-1,073				
Spending attributable to new commercial credit £	346	346	346		346				
Exogenous average per student spending	**2,535**	**2,535**	**4,631**	**-2,096**	**2,535**	**5,242**	**5,242**	**7,187**	**7,187**
Direct imports £ (32.2%)	-816	-816	-1,491	675	-816	-1,688	-1,688	-2,315	-2,315
Net change in final demand per student £	**1,719**	**1,719**	**3,140**	**-1,421**	**1,719**	**3,554**	**3,554**	**4,872**	**4,872**

Table 41 reveals how the direct impacts of individual students by type are spread across the sub-regions being examined within Scotland. This uses the information on per student spending found in Table 39 and how the expenditure injections and displacements are spread across the sub-regions as summarised in Table 40. For each student type the table details how expenditures and displacements are distributed across the region of study (U) and the region of domicile (H). Furthermore, the 'SCO' column shows how the impacts on individual sub-regions add up to the Scotland wide impact. For example, in the case of Scottish 'movers' the table reveals that they drive a positive direct impact of £3,140 (£6,230 - £1,945 + £346-1,491) in their region of study. However, they displace expenditures in their region of domicile to the tune of £-1,421 (£-453-£570-1,073+675). When these direct sub-regional impacts are added up it reveals a Scotland-wide net direct injection of £1,719 (£3,140-£1,421), which is equal to the single region derivation of per student spending presented in Table 39.

For three of the four identified student types their direct injection into the region of study (U) is identical to their direct injection into the economy as a whole (SCO), as already laid out in Table 39. However, those students who move within Scotland to study (SCO 'movers') exert a critically different direct impact at the sub-regional level. In particular, they have a positive net impact upon their region of study but leave a negative impact upon their region of domicile (H) through displaced expenditures. For sub-regions that receive more incoming students than they lose to other sub-regions, this will result in a disproportionately large student consumption impact, whereas for sub-regions that send away more students than they receive this will act to subdue the overall impact of students' consumption expenditures within the sub-region.

Table 42 Interregional flow of Scottish domiciled students within Scotland and net flow of students to/from each sub-region (FTEs).

		Home					Net flow of Scottish students	
		GLA	RST	ROS	SCO			
Study	GLA	10,443	22,779	8,653	**41,874**		**GLA**	28,795
	RST	1,221	7,595	1,191	**10,008**		**RST**	-26,961
	ROS	1,415	6,594	54,371	**62,380**		**ROS**	-1,834
	SCO	**13,080**	**36,968**	**64,215**	**114,262**			

Table 42 presents the internal flow of Scottish domiciled students within Scotland. The rows reveal the sub-region within Scotland where a student studies but the column reveal where those students come from. Looking for example at the first column we can see that in total 13,080 FTE students come from Glasgow, thereof 10,443 study at home, while 1,221 study in the RST and 1,415 in the ROS. In the far right column I summarise the difference between each region's column and row sum, to reveal the net flow of Scottish students within Scotland. The column reveals an interesting pattern: Glasgow receives 28,795 more Scottish students than it sends to study in other parts in Scotland. This positive balance is offset mostly through a net-outflow from RST, whereas ROS only hosts 1,834 fewer students than it sends to GLA and RST.

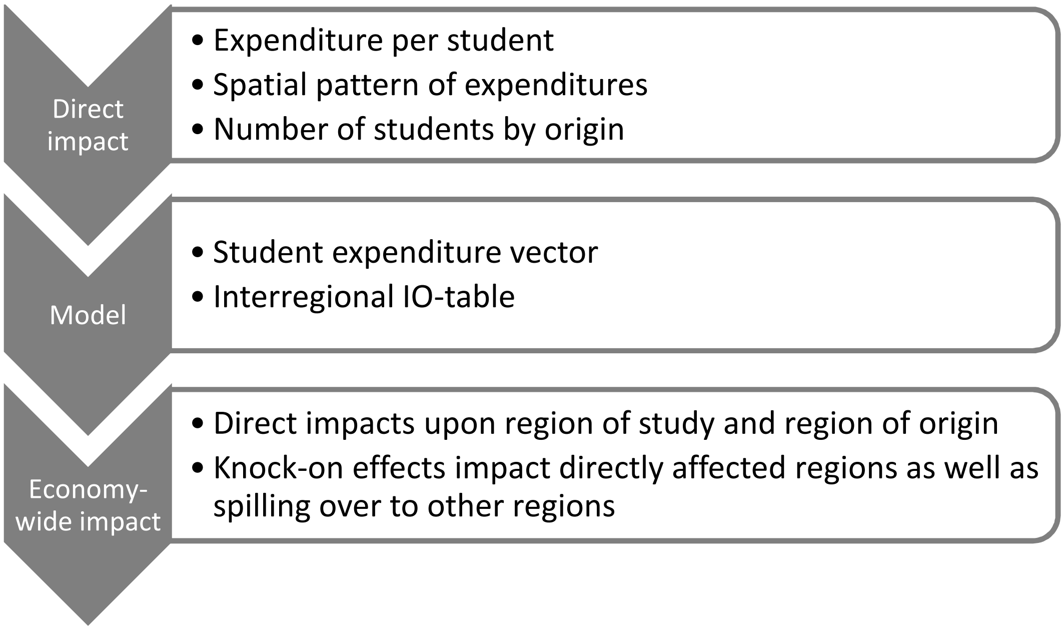
Table 43 Students by origin at HEIs in GLA, RST and ROS (2006, FTEs). Two rightmost columns indicate number of Scottish 'movers' and 'stayers'.

	FTE students by origin							
	GLA	**RST**	**ROS**	**RUK**	**ROW**	**Total**	**SCO 'movers'**	**SCO 'stayers'**
Caledonian	3,003	7,468	1,995	629	1,054	**14,149**	9,463	3,003
GSA	195	342	253	423	289	**1,501**	595	195
Glasgow	3,713	6,869	3,685	2,360	2,145	**18,773**	10,554	3,713
RSAMD	81	169	189	135	105	**678**	358	81
Strathclyde	3,451	7,931	2,531	611	1,729	**16,253**	10,462	3,451
HEIs in RST	1,221	7,595	1,191	134	665	**10,807**	2,412	7,595
HEIs in ROS	1,415	6,594	54,371	17,760	18,569	**98,709**	8,009	54,371
Total SCO	**13,080**	**36,968**	**64,215**	**22,052**	**24,555**	**160,870**	**41,853**	**72,409**
Total GLA HEIs	***10,443***	***22,779***	***8,653***	***4,158***	***5,321***	***51,354***	***31,432***	***10,443***

Table 43 reveals the number of FTE students by origin and institution/sector. Combining the number of students with earlier derivation of the direct spending impact of individual students it is possible to arrive at a spatially disaggregated direct impact (i.e. final demand impacts) of students for the five Glasgow HEIs and the aggregate HEI sectors in RST and ROS.

To recap, for each institution/sector we know the spatial origin of its students. From this it is possible to attribute each of these with a spending/displacement pattern. Drawing on Table 43 I can multiply the number of students by each origin with the expenditure pattern denoted in Table 41. This results in the total direct impacts of each student type by each institution/sector, reported in Table 44. A schematic overview of the modelling process for estimating the interregional output impact of students' consumption expenditures is provided in Figure 48 below.

Figure 48 Overview of the modelling process for the interregional output impacts of students' consumption expenditures.



The results for the exogenous net-injection from students' consumption expenditures by sub-region are presented in Table 44 below for each institution/sector reported. The rows reveal the impact of the students of each origin, upon each of the three sub-regions (GLA, RST, ROS) and the total, Scotland-wide impact. The top row for each HEI/sector (in bold letter) shows the aggregate impact of all students, whereas subsequent rows reveal the disaggregate impact of each student group, as defined by origin. Results are presented individually for the five Glasgow HEIs, whereas for the RST and ROS I report only aggregates of the entire HEI sectors in those sub-regions.

Looking at, for example, the case of Caledonian (one of the five Glasgow HEIs), the top row of the table reveals that on aggregate students at Caledonian provide a Scotland-wide net-injection of £28.8 m. This is not all-round positive as this direct impact is composed of a positive impact onto the host region Glasgow of £42.4m, offset by displacement impacts in RST and ROS of £-10.6m and £-2.8, respectively

Table 44 Spatially disaggregated exogenous net-injection of students' consumption expenditures by institution/region of study and origin (2006, £ millions).

	Institution	Region of impact			
	Caledonian	**GLA**	**RST**	**ROS**	**Total**
Student origin	GLA	5.2	0.0	0.0	5.2
	RST	23.4	-10.6	0.0	12.8
	ROS	6.3	0.0	-2.8	3.4
	RUK	2.2	0.0	0.0	2.2
	ROW	5.1	0.0	0.0	5.1
		42.2	**-10.6**	**-2.8**	**28.8**
	Glasgow	**GLA**	**RST**	**ROS**	**Total**
Student origin	GLA	6.4	0.0	0.0	6.4
	RST	21.6	-9.8	0.0	11.8
	ROS	11.6	0.0	-5.2	6.3
	RUK	8.4	0.0	0.0	8.4
	ROW	10.5	0.0	0.0	10.5
		58.4	**-9.8**	**-5.2**	**43.4**
	GSA	**GLA**	**RST**	**ROS**	**Total**
Student origin	GLA	0.3	0.0	0.0	0.3
	RST	1.1	-0.5	0.0	0.6
	ROS	0.8	0.0	-0.4	0.4
	RUK	1.5	0.0	0.0	1.5
	ROW	1.4	0.0	0.0	1.4
		5.1	**-0.5**	**-0.4**	**4.3**
	RSAMD	**GLA**	**RST**	**ROS**	**Total**
Student origin	GLA	0.1	0.0	0.0	0.1
	RST	0.5	-0.2	0.0	0.3
	ROS	0.6	0.0	-0.3	0.3
	RUK	0.5	0.0	0.0	0.5
	ROW	0.5	0.0	0.0	0.5
		2.3	**-0.2**	**-0.3**	**1.7**
	Strathclyde	**GLA**	**RST**	**ROS**	**Total**
Student origin	GLA	5.9	0.0	0.0	5.9
	RST	24.9	-11.3	0.0	13.6
	ROS	7.9	0.0	-3.6	4.4
	RUK	2.2	0.0	0.0	2.2
	ROW	8.4	0.0	0.0	8.4
		49.4	**-11.3**	**-3.6**	**34.5**
	HEIs in RST	**GLA**	**RST**	**ROS**	**Total**
Student origin	GLA	-1.7	3.8	0.0	2.1
	RST	0.0	13.1	0.0	13.1
	ROS	0.0	3.7	-1.7	2.0
	RUK	0.0	0.5	0.0	0.5
	ROW	0.0	3.2	0.0	3.2
		-1.7	**24.3**	**-1.7**	**20.9**
	HEIs in ROS	**GLA**	**RST**	**ROS**	**Total**
Student origin	GLA	-2.0	0.0	4.4	2.4
	RST	0.0	-9.4	20.7	11.3
	ROS	0.0	0.0	93.4	93.4
	RUK	0.0	0.0	63.1	63.1
	ROW	0.0	0.0	90.5	90.5
		-2.0	**-9.4**	**272.2**	**260.8**
	Total all HEIs	**153.6**	**-17.4**	**258.2**	**394.4**

If we then examine how individual student groups (by origin) contribute to this aggregate impact, we can see that students at Caledonian originating from Glasgow provide a direct impact amounting to £5.2m to the economy of GLA, but have no direct impact upon RST and ROS[103]. When, however, we look at the case of students from the rest of the Strathclyde region (RST) studying at Caledonian, a more complex pattern emerges. These students provide a £23.4m direct stimulus to the GLA economy through their consumption expenditures, while causing a negative direct impact of £10.6m to their region of domicile (RST) through displacement of expenditures. Similarly students from the ROS provide a positive stimulus to GLA, their region of study, to the tune of £6.3m, while displacing expenditures in their region of origin £-2.8m. However, the external students from RUK and ROS provide a positive stimulus to Glasgow to the amount of £2.2m and £5.1m, respectively. Although these students doubtless displace expenditures in their region of origin, these displacements are outside Scotland and hence those student groups exert no negative expenditure impacts upon Scotland.

At the bottom of the table there is a sum of the columns, which provides the aggregate net-direct injection of all student groups into each of the three sub-regions. When we look at the direct impacts upon each sub-region, we see that all of the regions are affected by displacement of expenditures driven by students studying outwith their home region. However, RST is distinctly different from the other two regions being examined in that, on balance, the region experiences a negative direct impact from students' consumption expenditures. Due to the relatively large number of students from the RST studying outwith the region, displacement impacts overwhelm the positive impacts of the relatively few students who come into the region for study. Furthermore, if we look at the RST rows (depicting the impact of students originating in RST) for the different institutions/sectors in Table 44, we can see

[103] These impacts are calculated by multiplying the per student exogenous expenditure of a Scottish 'Stayer' (from Table 41) by the FTE number of GLA students at Caledonian obtained from Table 43. The calculation then becomes for each sub-region: GLA £1,719 × 3,003 FTEs = £5,162,157; RST £0,0 × 3,003 FTEs = £0; ROS £0,0 × 3,003 FTEs = £0.

that these displacement impacts are primarily driven by students from RST moving to GLA for study (-£10.6m - £9.8m - £0.5m – £0.2m - £11.3 = -£32.4m) and to a lesser extent the ROS (-£9.4m). These negative impacts are only partially off-set by the positive impacts from local students studying within the rest of the Strathclyde region and incoming students (£24.3m), resulting in an aggregate negative impact upon the region of £-17.4m (£24.3 - £32.4m - £-9.4 = £-17.4).

Table 45 below provides a more aggregate view of the data presented in Table 44. More specifically it reveals the aggregate direct impact (exogenous net-injection of students' consumptions expenditures) of all students at each institution/region upon each of the three sub-regions. These results are fed into the Input-Output model to determine the knock-on impacts of student's consumption expenditures.

Table 45 Summary of spatially disaggregated exogenous net-injection of students by institution/region of study (2006, £ millions).

	Region of impact			
	GLA	**RST**	**ROS**	**Total**
Caledonian	42.2	-10.6	-2.8	28.8
Glasgow	58.4	-9.8	-5.2	43.4
GSA	5.1	-0.5	-0.4	4.3
RSAMD	2.3	-0.2	-0.3	1.7
Strathclyde	49.4	-11.3	-3.6	34.5
HEIs in RST	-1.7	24.3	-1.7	20.9
HEIs in ROS	-2.0	-9.4	272.2	260.8
Total	**153.6**	**-17.4**	**258.2**	**394.4**

Once students' net contribution to final demand has been determined the next step is to estimate the knock on impacts of their consumption spending. A student expenditure vector estimated by Kelly *et al* (2004) is used to derive the spending impact of the different student groups in Scotland. Based on this the Scotland-wide Type-II output multiplier for student spending in Glasgow, derived from the IO tables is 1.78. Hence, a direct injection of £153.6 million in GLA (the sum of the GLA column in Table 45), drives £272.7 million of output in the Scottish economy.

The starting point for deriving these knock-on impacts is Table 45, which provides the aggregate direct impact of students of all origins, by each institution upon each sub-region. The total knock-on impacts derived from these direct impacts are composed of many 'layers', as a direct impact on one sub-region results in knock-on impacts upon the host sub-region, in addition to knock-on impacts that spill-over to the other two sub-regions. In an attempt to disentangle these 'layers' I start by presenting individually the output impact driven by the direct impact upon each sub region in Table 46, Table 47 and Table 48. Each of the three tables separately presents the output impacts driven by direct impacts in GLA, RST and ROS respectively. Then in Table 49 I add up these three different sets of impacts to derive the aggregate output impact of the consumption expenditures of students at all the HEIs in Scotland upon each of the three sub-regions simultaneously.

Table 46 shows the output impacts triggered by direct impacts of students' consumption expenditures that affect Glasgow. For example, students at the University of Strathclyde bring exogenous consumption expenditures to the tune of £49.4m to the city. This triggers knock-on impacts amounting to £25.2m, £8.2m and £4.9m in GLA, RST and ROS respectively. When the direct and knock-on impacts have been added up, it reveals that the consumption expenditures of students at the University of Strathclyde drive a Scotland-wide output impact of £87.7m. Unsurprisingly, the direct effects are all positive for the case of the 5 Glasgow HEIs. However students (from Glasgow) at HEIs in RST and ROS exert a negative direct impact upon Glasgow, as they do not bring consumption expenditures to the city, but only displacement impacts. On balance approximately two thirds (66%) of the knock-on impacts are incurred in Glasgow, with 21% in RST and only 13% spilling over to the ROS.

Table 46 Knock-on impacts driven by direct impacts of students' exogenous consumption expenditures in Glasgow (output, £m).

GLA Institution/sector	Net direct injection GLA	Knock-on impacts GLA	RST	ROS	Scotland-wide impact (SCO)
Caledonian	42.2	21.6	7.0	4.2	**75.0**
GSA	5.1	2.6	0.8	0.5	**9.1**
Glasgow	58.4	29.8	9.7	5.8	**103.6**
RSAMD	2.3	1.1	0.4	0.2	**4.0**
Strathclyde	49.4	25.2	8.2	4.9	**87.7**
HEIs in RST	-1.7	-0.9	-0.3	-0.2	**-3.1**
HEIs in ROS	-2.0	-1.0	-0.3	-0.2	**-3.6**
Total	**153.6**	**78.4**	**25.5**	**15.2**	**272.7**

For the rest of the Strathclyde region (Table 47 below) the only positive direct impact is from the consumption expenditures of students at HEIs in RST. A large number of students from the region go to study at HEIs in GLA and ROS. Hence, there is a lot of displaced expenditures within the sub-region that can be attributed to local students that study at HEIs elsewhere in Scotland – to the extent that the aggregate direct impacts of students' consumption expenditures upon the region are negative. Unsurprisingly therefore, these result in negative knock-on impacts that not only affect RST, but spill-over to GLA and ROS. Knock-on impacts are mostly incurred within the host region (75%), with the remainder split between GLA and ROS.

Table 47 Knock-on impacts driven by direct impacts of students' exogenous consumption expenditures in the rest of the Strathclyde region (output, £m).

RST Institution/sector	Net direct injection RST	Knock-on impacts GLA	RST	ROS	Scotland-wide impact (SCO)
Caledonian	-10.6	-1.1	-6.3	-1.1	**-19.1**
GSA	-0.5	0.0	-0.3	0.0	**-0.9**
Glasgow	-9.8	-1.0	-5.8	-1.0	**-17.5**
RSAMD	-0.2	0.0	-0.1	0.0	**-0.4**
Strathclyde	-11.3	-1.1	-6.7	-1.1	**-20.2**
HEIs in RST	24.3	2.4	14.5	2.5	**43.7**
HEIs in ROS	-9.4	-0.9	-5.6	-1.0	**-16.8**
Total	**-17.4**	**-1.7**	**-10.3**	**-1.8**	**-31.3**

As we can see from Table 48 students from the rest of Scotland attending HEIs in GLA and RST, trigger negative direct impacts upon ROS as expenditures are displaced. However, these are dwarfed by the direct impact from the consumption expenditures' of students at HEIs in ROS. On balance the sub-region receives a net-direct injection attributable to students' consumption expenditures of £258.2m. This results in a Scotland-wide output impact of £465.5m. The knock-on impacts in this case are mostly felt within the ROS region itself (85%), but to a lesser extent in GLA (4%) and RST (3%). The overall pattern is that Glasgow is the most open of the three regions, with direct impacts there resulting in the largest spill-over impact onto the other regions, while the ROS is the most closed.

Table 48 Knock-on impacts driven by direct impacts of students' exogenous consumption expenditures in the rest of Scotland (output, £m).

ROS	Net direct injection	Knock-on impacts			Scotland-wide impact
Institution/sector	ROS	GLA	RST	ROS	(SCO)
Caledonian	-2.8	-0.1	-0.1	-2.1	**-5.1**
GSA	-0.4	0.0	0.0	-0.3	**-0.6**
Glasgow	-5.2	-0.2	-0.1	-3.9	**-9.4**
RSAMD	-0.3	0.0	0.0	-0.2	**-0.5**
Strathclyde	-3.6	-0.1	-0.1	-2.7	**-6.5**
HEIs in RST	-1.7	-0.1	0.0	-1.3	**-3.1**
HEIs in ROS	272.2	9.1	6.0	203.4	**490.7**
Total	**258.2**	**8.6**	**5.7**	**192.9**	**465.5**

The direct impacts affecting all three regions are presented in Table 49 along with the knock-on impacts they result in. In effect this table is the sum of the 3 previous tables that illustrate the impact from each region's stimuli separately. An interesting feature of these results is that the aggregate knock-on impacts upon RST are positive. This is due to spill-over impacts from students' consumption expenditures in other sub-regions, as when I analysed the results of the direct impacts upon RST in isolation the outcome was clearly negative. These extra regional knock on impacts are sufficiently large (£25.5 + £5.7 = £31.2m) to outweigh the negative intra-regional impact (£-10.3m) that arises from RST students studying elsewhere in Scotland. The Scotland-wide impact of students' consumption expenditures is £706.9m.

Table 49 Aggregate knock-on impacts driven by direct impacts in each of the three regions simultaneously (Output, £m).

GLA+RST+ROS	Net direct injection			Knock-on impacts			Scotland-wide impact
Institution/sector	GLA	RST	ROS	GLA	RST	ROS	(SCO)
Caledonian	42.2	-10.6	-2.8	20.4	0.6	1.0	**50.8**
GSA	5.1	-0.5	-0.4	2.6	0.6	0.2	**7.6**
Glasgow	58.4	-9.8	-5.2	28.6	3.8	0.9	**76.6**
RSAMD	2.3	-0.2	-0.3	1.1	0.2	0.0	**3.1**
Strathclyde	49.4	-11.3	-3.6	24.0	1.4	1.0	**60.9**
HEIs in RST	-1.7	24.3	-1.7	1.5	14.1	1.0	**37.6**
HEIs in ROS	-2.0	-9.4	272.2	7.1	0.1	202.2	**470.3**
Total	**153.6**	**-17.4**	**258.2**	**85.3**	**20.9**	**206.3**	**706.9**

By far the largest share of this impact is captured by the rest of Scotland, £464.5m or 65.7% of total Scotland-wide impacts. Students' consumption expenditures drive £238.9m of output in Glasgow or 33.8% of the total Scotland-wide impact. A slight impact is felt in the rest of the Strathclyde region, where students' consumption expenditures drive £3.5m of output or 0.5% of the total Scotland-wide expenditure impact of students.

5.2 "Balanced expenditure" impacts

Hermannsson *et al* (2010b, c) argue that a "policy scepticism" has emerged which challenges the extent to which HEIs in fact provide an additional demand stimulus to their host regions. This scepticism asserts that either demand-side binding budget constraints or supply-side binding resource constraints generate "crowding out" of HEI expenditure effects on the host regional economy, to the point where the regional impact of HEIs expenditures is regarded as negligible. While Hermannsson *et al* (2010b, c) reject the relevance of the binding supply-side resource constraint on *a priori* grounds and reject the extreme form of demand-driven policy scepticism, they acknowledge the importance of binding public sector budget constraints under UK devolution, and argue that future regional impact studies should be modified to accommodate these constraints. As a solution for estimating the impact of

HEIs while acknowledging the non-additionality of public funding provided under a binding budget constraint, Hermannsson *et al* (2010b, c) propose using a balanced expenditure multiplier.

In this section I analyse how a binding public sector budget constraint under devolution affects the interpretation of HEIs expenditure impacts, which are partially driven by funding from the Scottish Government. This section draws heavily on work previously published in Hermannsson *et al* (2010b, c).

5.2.1 **Policy scepticism and the impact of HEIs**

The analysis in Hermannsson *et al* (2010b, c) focuses on the expenditure impacts of HEIs at the Scotland-wide level. From that geographical perspective, the idea underlying "policy scepticism" is that an increase in public expenditure on HEIs will induce offsetting changes in demand through the operation of a binding regional public sector expenditure constraint. In a Scottish context, this operates through the Barnett formula, which determines the allocation of Scottish Government funding from the central government in Westminster[104]. The conventional regional multiplier analysis, as summarised in Section 2.1 implicitly assumes that the financing of the HEI expenditures in Scotland comes from outwith the country – for example from the Westminster Government – with no ramifications for other elements of government expenditure. At the level of the individual sub-region Scottish Government funding can arguably be treated as 'manna from heaven' i.e. there is no direct opportunity cost in terms of other Scottish Government expenditure within the sub-region. However, looking at the sub-regions collectively within an interregional context, it is clear that given the binding budget constraint of the Scottish Government (and indeed other devolved administrations in the UK) additional expenditure in one region has to mean that less is spent elsewhere. I further explore the implications of the binding budget constraint of Scottish Government expenditures for the interregional impact of HEIs in Section 5.3.

[104] For further details of the 'Barnett' formula for funding devolved regional administrations in the UK see e.g. Ferguson *et al* (2003, 2007) and Christie & Swales (2010).

Does taking account of the Scottish public sector budget constraint imply that host-region employment multipliers are zero? To address this question it is helpful to begin by focussing simply on changes in the public funding of HEIs in Scotland, and note that increased public spending on HEIs may have to be financed by contractions in other government expenditures. Although the Scottish Government has wide-ranging devolved powers in making spending decisions, its income is constrained each year by the block grant it receives from Her Majesty's Treasury[105]. Therefore, if the Scottish Government allocates additional funds to HEIs, less funds will be available for other public expenditures. Given this context it can be misleading for an impact study to treat the Scottish Government's funding of HEIs as an exogenous stimulus to the regional economy, although that is standard IO practice.

To illustrate the significance of the difference between the cases I conduct two simulations of the introduction of a hypothetical additional £100m of expenditure on HEIs in Scotland. In the first case I adopt the traditional impact study assumption that the exogenous increase in expenditure is entirely externally funded, for example from UK-level funding or foreign students' fees, and has no ramifications for other public spending in Scotland. The second case examines how the impacts change when there is a corresponding reduction of other public spending in Scotland. In the latter case the offsetting £100m reduction in public spending is applied to an aggregation of those sectors that receive 93%[106] of central and local government final demand in the Scottish IO tables.

The Type-II multiplier for the aggregate HEIs sector in Scotland as a whole is 2.12: without any offsetting cutbacks in public spending the additional spending on HEIs has an output impact of £212m. Approximately half of that impact is realised as a direct consequence of increased activity in the HEIs themselves,

---

[105] The Scottish Government does have limited powers to vary its expenditure through adjusting the standard income tax rate up or down by 3 pence in the pound. This is the Scottish Variable Rate. For details see e.g. McGregor and Swales (2005), and Lecca *et al* (2010).

[106] The public sector is an aggregation of 5 sectors in the HEI-disaggregated IO table (IO115, IO116, IO117, IO118 and IO119). Approximately 10% of the sector's final demand is from sources other than government.

whereas the other half is generated via “knock on” effects in other sectors, particularly the retail and service sectors. The total change in output and employment, and the distribution across sectors is summarised in Table 50. These impacts are shown graphically in the darker shaded bars in Figure 49.

A more complex picture emerges with expenditure switching. The Type-II multiplier for other public expenditure in Scotland is 1.97. If an increase in HEIs funding is met by cutbacks in other Scottish public expenditure the ‘multiplier’ for switching is equal to 2.12-1.97=0.15[107]. That is to say, for every £100 m directed from the public sector to HEIs the output impact of switching is £15 m. In particular the estimated import propensity of HEIs (13%) is lower than the public sectors’ import propensity (17%). Therefore for every £1 spent on HEIs more is retained within the regional economy than for government spending in general.

The recognition of the regional budget constraint implies that multiplier effects on individual sectors are no longer universally positive, as in the conventional case. The net changes are again shown in Table 50 and in the lighter shaded bars in Figure 49. In particular, there is a significant contraction in the public sector. This drives negative knock-on impacts resulting in a net contraction in sectors that are more sensitive to the changes in general public expenditure than the expenditure of the HEI sector. 'Banking and financial services', the 'Transport, post and communications' sector and 'Business Services' show small net reductions in activity. In a UK devolved context, changes in public expenditure, determined by the regional government and therefore financed through Barnett, typically involve expenditure switching (and certainly have an opportunity cost in terms of alternative uses within the region), and the multiplier effects are accordingly more subdued. Indeed, even the direction of the net impact cannot be known *a priori*. This is a crucial result that appears not to be widely appreciated in existing impact studies.

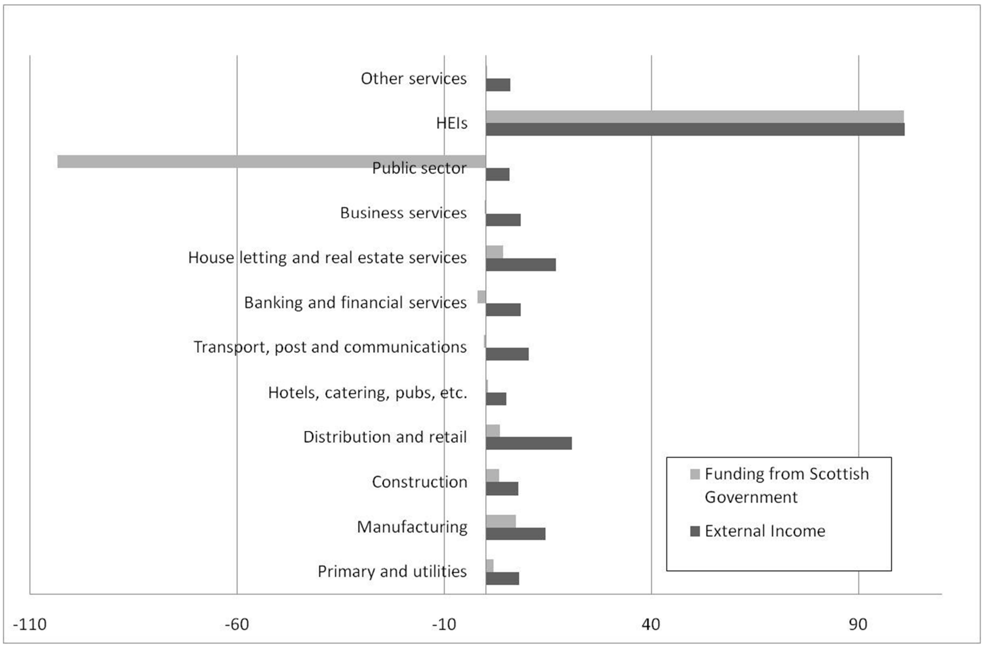
---

107 For further discussion of analysing the impact of expenditure switching within an IO context, see Allan *et al* (2007).

Table 50 Impact of £100m increase in final demand for Scottish HEIs

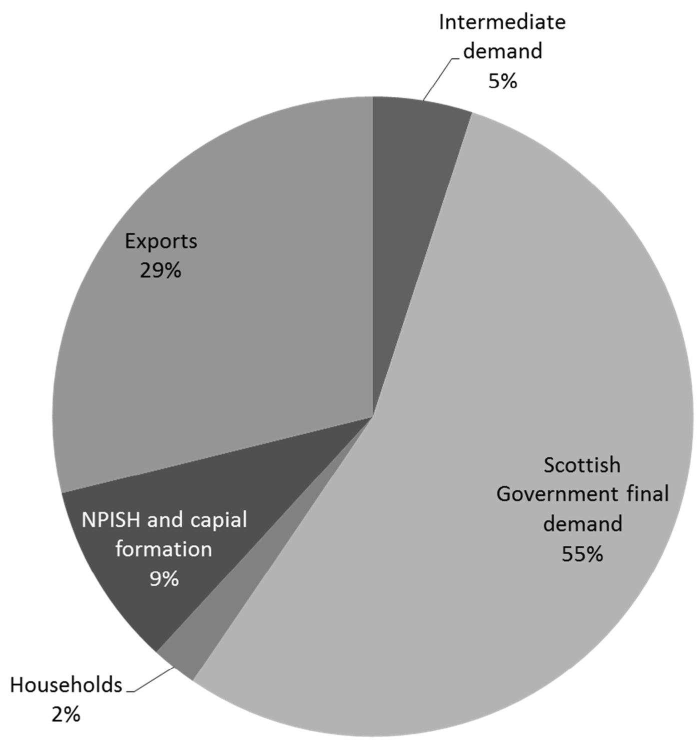
Sector	Without Spending Substitution			With Spending Substitution		
	Change in Final Demand (£m)	**Output Impact (£m)**	**Employment Impact (FTE)**	**Change in Final Demand (£m)**	**Output Impact (£m)**	**Employment Impact (FTE)**
Primary and utilities	0	8	37	0	2	9
Manufacturing	0	14	99	0	7	50
Construction	0	8	78	0	3	31
Distribution and retail	0	21	364	0	3	61
Hotels, catering, pubs, etc.	0	5	140	0	1	16
Transport, post and communications	0	10	90	0	0	-4
Banking and financial services	0	8	48	0	-2	-12
House letting and real estate services	0	17	44	0	4	11
Business services	0	8	134	0	0	-6
Public sector	0	6	95	-100	-103	-1,735
HEIs	100	101	1,666	100	101	1,662
Other services	0	6	88	0	0	2
	100	**212**	**2,882**	**0**	**15**	**86**

Figure 49 Output impact of £100m increase in final demand for Scottish HEIs



As can be seen from the analysis above, care must be taken in determining the source of financing for any impact study applied to a region with a devolved budget. While the example of HEIs is used here, the principle is, of course, quite general. Devolution matters a great deal for the appropriate conduct of regional impact analyses.

Figure 50 Income structure of the HEIs sector in the HEI-disaggregated Input-Output tables



These results might be interpreted as implying that the impact of HEIs' spending is very limited at the Scottish level, because of expenditure switching within Scotland, since in the absence of HEIs the funding would simply be allocated to public services. However, while HEIs are often perceived to be part of the public sector they are in fact non-profit organisations[108]. An analysis of their income based on data from HESA (see Section 3.2.2.2) reveals that on aggregate just 54% of their income can be traced back to the Scottish

108 In the Scottish Input-Output tables HEIs are classified as part of the NPISH category, i.e. Non-Profit Institutions Serving Households.

Government. Some 29% comes from sources outside Scotland and approximately 17% originates from Scottish households[109], businesses, charities and other institutions whose funding is independent of the block grant. The external income is unambiguously additional to the Scottish economy and it is reasonable to assume the latter part is as well (see discussion in Section 3.2.2.2). Even if the regional public sector budget constraint implies complete crowding out of public spending on HEIs within the region, only a part of HEIs' activities is publicly funded. In fact, HEIs are characterised by significant exports (to the rest of the UK and the rest of the world), and changes in export demand do not trigger any offsetting expenditure switching among final demands. The sources of income of Scottish HEIs are summarised in Figure 50. In the next section I explore the significance of this pattern of funding for the attribution of HEI impacts on the host region.

5.2.2 Accounting for the regional budget constraint within the Input-Output framework

The Input-Output tables provide a useful accounting framework. Based on the dichotomy of exogenous (final demand) and endogenous ('knock-on' effects) activity, each sector can be attributed with the total activity driven by its final demand within the regional economy. While this activity can be measured in terms of output, employment or GDP I illustrate the approach using output. The total impact of HEIs on output is composed of both the final demand for the output of the sector and also the knock-on impacts on other sectors, through directly and indirectly linked intermediate demand and household consumption. One key strength of Input-Output as an accounting framework is that it is consistent. When such an attribution exercise is carried out on a sector by sector basis, the sum of the impacts attributable to each sector equals the economy-wide total[110].

As discussed in the previous section, one of the criticisms levelled against deriving the economy-wide expenditure impact of HEIs in such a way is that,

---

[109] Which are treated as endogenous when appropriate, i.e. in Type-II analyses.

[110] Moreover, the validity of this attribution method does not rest on the same strict assumptions as identified for IO modelling in Section 5.1.1.1.

given their funding arrangements in Scotland, attributing HEIs with the impact of spending public funds is disingenuous. Such an impact is not so much caused by the HEIs *per se* as it is by the availability of public funds and potentially similar results could be obtained if the funds were to be switched to be spent on other public services.

The Input-Output framework, combined with detailed information about the income sources of HEIs, enables a disaggregation of the sector's impacts in terms of the origin of the exogenous final demands. This allows an analysis of the extent to which the impacts attributed to the HEIs sector under a traditional IO approach should in fact be attributed to the expenditure of the Scottish Government.

Based on conventional assumptions, HEIs account for 2.28% of Gross Output, 2.63% of GDP and 2.76% of employment in Scotland. Adding the impact of student's consumption spending as derived in Section 2, Scottish HEIs support 2.82% of Gross Output, 3.08% of GDP and 2.94% of employment in the region. Taken at face value it is clear that the sector is important as a supporter of employment and output within the regional economy. The controversy concerns whether the traditional IO-accounting approach may be providing a misleading estimate of the sector's contribution.

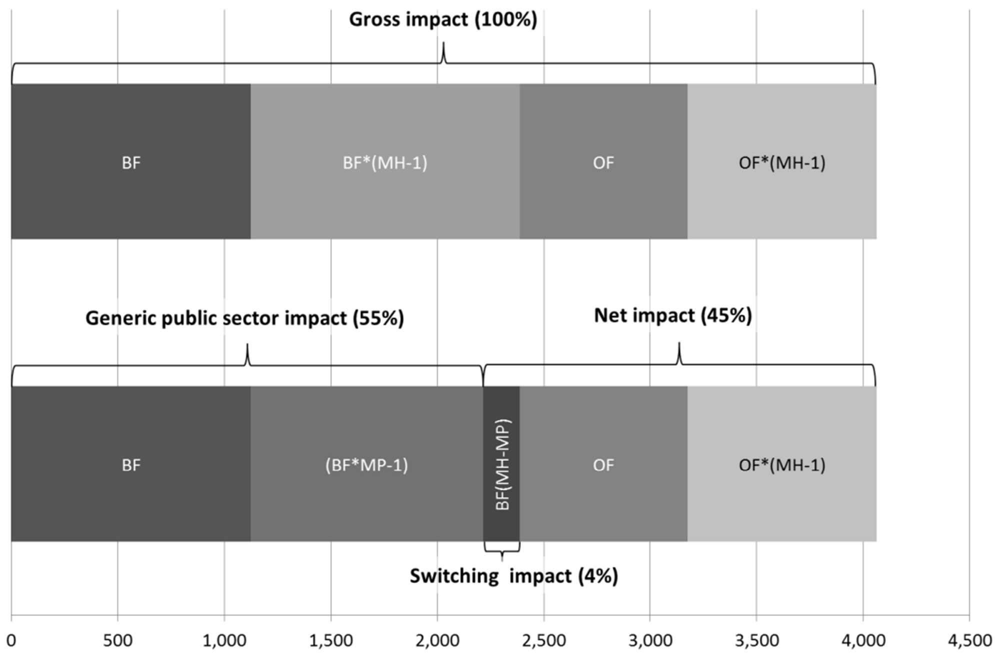
In order explicitly to take account of the public expenditure switching effects, as discussed in Section 5.2.1, I deduct the impacts of the Scottish Government ('Barnett') funding from the overall expenditure impact. The direct expenditure on the output of Scottish HEIs is divided into Barnett funding (*bf*), which comes through the Scottish Government, and other funding (*of*) which includes all other sources, including exports to the rest of the UK and the rest of the World. The conventional attribution to HEIs is simply $(bf+\mathrm{of})m_H$, where m_H is the multiplier value for the HEIs sector. The results of this attribution are summarised in Figure 51. The adjusted attribution subtracts the Barnett funded element and its own multiplier effects, which equals $bf*m_P$ where m_P is the multiplier for the aggregated public sector. The adjusted attribution is therefore given by the equation.

$$\bar{Q} = (bf + of)m_H - bf * m_P = of * m^H + bf(m_H - m_P) \qquad (5.13)$$

To summarise, the output impact of HEIs net of Scottish Government's budget constraint equals the output impact attributable to other funding sources $of*m_H$ in addition to the switching impact $bf(m_H-m_P)$.

To clarify, the impact of Scottish HEI spending partially funded by the Scottish Parliament can be decomposed into a 'generic' public expenditure impact and an impact 'net' of the public sector budget constraint. The output impacts of the HEIs sector are illustrated in these terms in the lower bar of Figure 51 below. As the diagram reveals, when the expenditure impact of HEIs is disaggregated according to the source of income, just under half of it can be classified as a generic public sector impact, leaving just over half of it as a 'net' impact, that is not subject to the budget constraint of the Barnett funding received by the Scottish Parliament.

Figure 51: Output impact of HEIs disaggregated by origin of final demand. Upper bar shows the components of the gross impact while the lower bar breaks the impact into a generic public sector impact and net impact by implementing expenditure switching (£ million).



An exactly analogous argument can be made in respect of the appropriate attribution of student expenditure impacts. In this case we have:

$$\overline{Q_s} = (bf + of)m_s - bf * m_p = of * m_s + bf(m_s - m_p) \qquad (5.14)$$

Where, the "balanced expenditure" output impact of students' consumption expenditures $\overline{Q_s}$ is composed of the student's consumption final demand attributable to Scottish Government student support (*bf*)[111], students' exogenous final demand for consumption from other sources (*of*), the output multiplier for students' consumption expenditures (m_S) and m_P, the output multiplier for the public sector.

When students' consumption expenditures are analysed in this way the results are qualitatively different from those for the HEIs' institutional expenditures. Primarily due to the strong direct import component of students' consumption expenditures the output multiplier is smaller than for public sector expenditure *per se*. In this case the Scottish Government gets a smaller demand stimulus for expenditures on student support than on other public expenditures on average.

[111] A part of Scottish students' expenditures is funded by student support grants provided by the Scottish Government.

In this case the switching impact is negative, whereas it is positive for HEIs' institutional expenditures. The impact of students' exogenous consumption expenditures are presented in Table 51 below.

Table 51 Output impact of students' consumption expenditures attributed to public and other income sources (output, £m).

	'Generic' public sector impact	'Net' impact	Total impact
Exogenous student spending	87	495	582
Knock on impacts of student's consumption	84	149	234
Switching impact		-58	-58
Student's consumption impact total	**171**	**586**	**757**
– % of total impact	***23%***	***77%***	***100%***

Scottish Government funding of students' consumption expenditures in Scotland through grants and bursaries amounts to £87m, which drives a knock-on impact of £84m. The bulk of students' consumption expenditures (£495m) are, however, independent of the public sector and drive a knock-on impact of £149m. However, once direct imports have been taken into account the student consumption multiplier (1.3) is lower than the public sector multiplier (1.97) resulting in a negative switching impact of £-58m (£87m * (1.30-1.97)=£-58m).

Table 52 Summary of overall spending impacts attributable to HEIs, by origin of final demand and type of impact (output, £m).

	'Generic' public sector impact	'Net' impact	Total impact
Institutional impact	2,216	1,846	4,062
– % of total impact	*55%*	*45%*	*100%*
Student impact	171	586	757
– % of total impact	*23%*	*77%*	*100%*
Total impact attributable to HEIs	**2,387**	**2,432**	**4,819**
– % of total impact	***50%***	***50%***	***100%***

Table 52 summarises the total impact attributable to HEIs and how this is composed of the impact of institutional expenditures and the impact of students' consumption expenditures. Furthermore, it illustrates to what extent each of these impacts are subject to the public sector budget constraint of the Scottish Government. As the table reveals the student impact differs from the institutional impact in that it is driven by public funding to a much lesser extent. However, the relatively small share of the student impact in the total impact that can be attributed to the HEIs means that on balance approximately half (49%) of the impact of HEIs in Scotland can be seen as a 'generic' public sector impact.

Following Hermannsson *et al* (2010b) I have examined the impact attributable to the HEI sector in Scotland in more detail than is true of typical impact studies. In addition to the traditional approach of attributing the sector its impact (as the final demand for institutional expenditures times the HEI multiplier plus the direct impact of exogenous student's consumption expenditure times the student consumption multiplier) the origin of the final demands is examined and knock-on impacts attributed to each of these. In an accounting sense the total impact of the HEIs' sector is the same in each of these exercises. However, instead of simply revealing an aggregate impact, I have disaggregated this into components that reflect the origin of the exogenous demand.

Although overall the impact of HEIs is unchanged by this attribution, the analysis reveals that there is some justification for a degree of policy scepticism based on the binding regional public budget constraint. Slightly less than half of the impact of the HEI sector in Scotland is a 'generic' public spending impact that would have materialised anyway had the public funds been used to expand the host region's public sector. Although, there is a small positive 'switching impact' of public funding for HEIs' own expenditures, and a small negative switching impact for students' consumption expenditures.

However, the analysis also reveals that the extreme form of policy scepticism, which argues that once the public budget constraint has been accounted for the impact of the HEIs' expenditures on the host region is negligible, is not supported by the evidence. These impacts are attributable to funding from sources independent of the Scottish block grant and the consumption expenditures of students that are not supported by the Scottish Government.

5.2.3 The balanced expenditure multiplier for individual HEIs: A scale-independent measure of impact net-of public funding

Hermannsson *et al* (2010c) further refine their approach to attributing the expenditure impact of Higher Education Institutions (HEIs) to a 'generic' public sector impact and a 'net' impact composed of the switching impact and the impact of 'other' (exogenous) funding. They move beyond the sector-wide analysis of the entire HEIs sector and analyse independently the balanced expenditure impacts of each Scottish HEI. Furthermore, they develop a "balanced expenditure" multiplier, as an indicator of the scale independent impact of HEIs, net-of public funding.

Augmenting equation 5.13 by adding a subscript indicating the individual institution *i* it is clear that the approach can be applied just as well to individual institutions as to whole sectors.

$$\overline{Q_i} = (bf_i + of_i)m_i - bf_i * m_P = of_i * m_i + bf_i(m_i - m_P) \qquad (5.13b)$$

$\overline{q_i}$ is the "balanced expenditure" attribution of HEI *i*'s output impact. This is composed of the gross expenditure impact of institution i $(bf_i + of_i)m_i$ less the impact of displaced public expenditure $bf_i * m_P$. Or alternatively the impact of 'other' funding $of_i * m_i$ plus the impact of switching expenditures from the public sector to HEI i $bf_i(m_i - m_P)$.

Dividing equation (5.13b) through by total final demand for the i'th HEI, $bf_i + of_i$, yields a "balanced expenditure" multiplier, $\overline{m_i}$, given by:

$$\overline{m_i} = \frac{of_i * m_i}{bf_i + of_i} + \frac{bf_i(m_i - m_P)}{bf_i + of_i} = \frac{of_i}{bf_i + of_i} m_i + \frac{bf_i}{bf_i + of_i}(m_i - m_P) \qquad (5.14)$$

Denoting the share of government expenditure in HEI *i*'s total final demand as α_i, this can be written as:

$$\overline{m_i} = (1 - \alpha_i)m_i + \alpha_i(m_i - m_P) = m_i - \alpha_i m_P \quad (5.15)$$

The balanced expenditure multiplier shows the impact of a £1 increase in final demand (with a constant composition) for HEI i. This multiplier value takes into account the fact that a portion of final demand will be switched from general public expenditure. The balanced expenditure multiplier is a weighted average of the individual HEI's multiplier and the switching multiplier ($m_i - m_p$). The weights are the proportions of Scottish Government and other funding in the HEI's total final demand. The intuition is clear: switching public expenditure to the HEI has no effect on the impact attributed to the HEI's other funding sources, which continue to exert the expected impact (m_i), weighted by the share of other funds ($1-\alpha_i$). The public expenditure that is switched has a multiplier value whose sign and scale is determined by the difference between the HEI's own multiplier and the aggregate public sector multiplier ($m_i - m_p$), and this is weighted by the share of public expenditure in total final demand for this HEI's output, α_i.

This discussion suggests that an extreme "policy scepticism" perspective implicitly assumes that $a_i = 1$ and $(m_i - m^p) = 0$. However, no Scottish HEI is funded 100% by the Scottish Government, so that for all institutions $a_i < 1$. Moreover the switching multiplier for Scottish HEI's is positive, so that $m_i - m^p > 0$. The balanced expenditure multipliers for all Scottish HEIs are therefore positive.

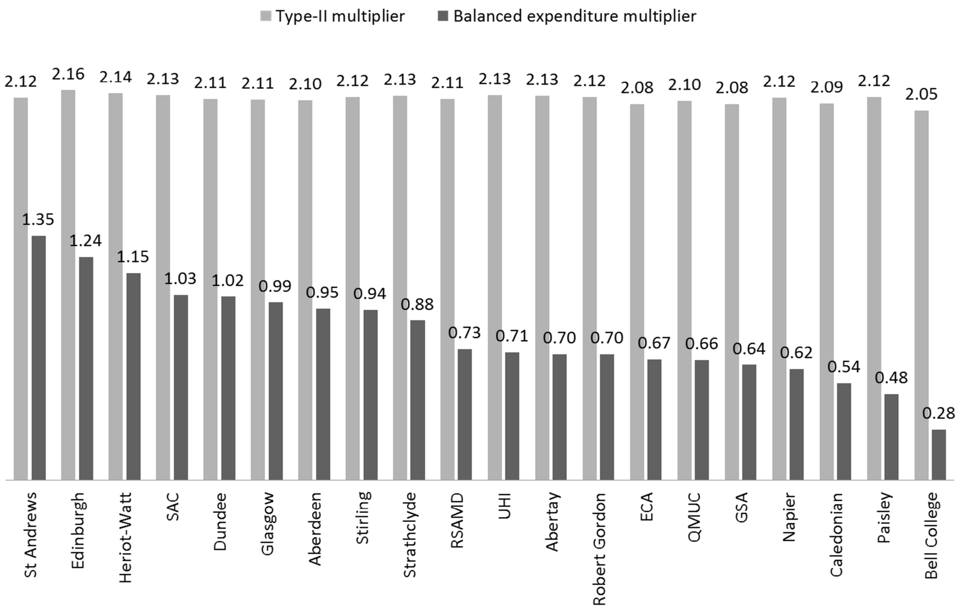
Nevertheless, accounting for the possibility of alternative uses of public funding is potentially very important. Firstly, $\overline{m_i}$ must be less than m_i if the HEI receives any public funding at all. Traditional impact studies neglect the possible alternative use of public expenditure and so might be regarded as exaggerating the net impact of HEIs on their host regional economies where both public funding and a regional public sector budget constraint operate.

Secondly, in principle, even the sign of $\overline{m_i}$ cannot be determined *a priori*. If an HEI is heavily dependent on constrained public funding and the HEI's own multiplier is smaller than the general public expenditure multiplier, its balanced expenditure multiplier might be negative[112].

The balanced expenditure multipliers for all Scottish HEIs are shown in Figure 52, together with their conventional IO counterparts. All of the balanced expenditure Type-II multipliers are positive but lower than their corresponding conventional values. All Scottish HEIs receive significant levels of government funding, and netting out the impact of this funding inevitably reduces the measured impact of HEIs' expenditures. However, HEIs as a whole are relatively export-intensive, and draw a significant portion of their funds from sources of final demand outwith Scotland. Also, HEIs' expenditures are, on average, less import-intensive than those of the public sector. Accordingly, Scottish HEIs exert positive expenditure effects relative to the public sector. The presence of a public expenditure constraint certainly does not imply negligible (or in the limit zero) expenditure impacts as is often implied by the "policy scepticism" perspective, though it does imply lower expenditure impacts attributable to HEIs *per se* than conventional IO impact studies imply.

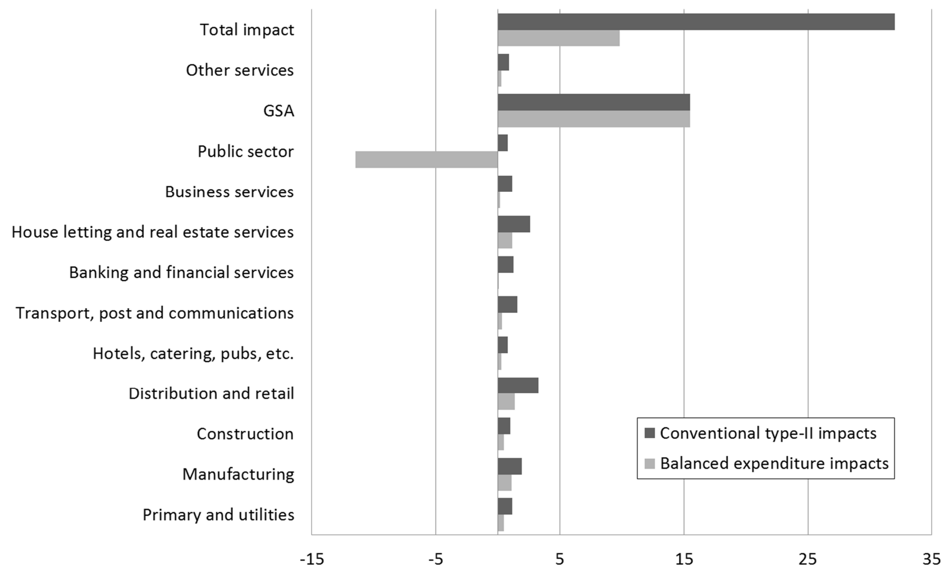
Figure 52 Balanced expenditure multipliers for Scottish HEIs (ranked by the size of the balanced expenditure multiplier).

[112] As we saw in the preceeding section students' consumption expenditures do exhibit a negative "switching" impact of 0.58 for every £1 of final demand switched from general public expenditures to supporting student spending. However, only a small share of student expenditures (15%) is supported by funds subject to the binding budget constraint of the Scottish Government. In order for thet balanced expenditure multiplier for students to be negative the share of 'Barnett' funded support for students would have to exceed 66% of their income.



The detailed operation of the balanced expenditure multiplier, as against the conventional multiplier, can be seen in Figure 53. The sectoral impacts are graphed in the lower part of the figure and all are positive since these are conventional IO results. However, the lighter bars illustrate the (Type-II) balanced expenditure output effects. Figure 53 shows the balanced expenditure impacts as the net outcome of an expansion due to the stimulus to total final demand together with a contraction due to the notional reduction in government expenditure that is required to reflect the government expenditure switching. There is a big negative impact on the public sector and small negative impacts on the 'Business services' and the 'Banking and financial services' sectors. Overall, the total output attributed to the GSA under the balanced expenditure scenario is only £10 million.

Figure 53 Traditional and balanced budget output impacts of the Glasgow School of Arts (GSA) disaggregated by sector (£m)



A key feature of the results presented in Figure 52 is that there is considerable variation in the balanced budget multipliers across HEIs in Scotland. The minimum value of this multiplier is 0.28 for Bell College (which is only 14% of its conventional IO multiplier value) and the maximum value is 1.35, for St Andrews (64% of the conventional multiplier value). Recall that, for conventional Type II multipliers, the smallest value was 95% of the largest: for the balanced budget multipliers the comparable figure is 21%. The range of multiplier values has increased significantly, as has the coefficient of variation, which is some 28 times as great (0.32 as against 0.012), relative to the conventional IO multipliers.

It is apparent from equation (5.15) that the proportion of HEIs' funding coming from the public sector is going to have a major impact on an HEI's balanced expenditure multiplier. We already know that there is limited variation in HEIs own expenditure multiplier[113] (m_i) and the aggregate public expenditure multiplier (m_p) is invariant across HEIs, so the main source of variation is in the size of the term $-\alpha_i m_p$ which is directly related to the share of Scottish Government funding in total final demand for the HEI (a_i).

[113] For a detailed discussion of this point see Hermannsson *et al* (2010c).

5.3 Interregional balanced expenditure impacts

So far I have presented traditional expenditure impacts (Section 2.1) and how these expenditure impacts have an interregional dimension across the sub-regions of Scotland (Section 5.1). In the preceding section I introduced the work of Hermannsson *et al* (2010b) on recognising the impact of HEIs net of their public funding and deriving a balanced expenditure multiplier for individual institutions (Hermannsson *et al,* 2010c). In this section I seek to expand the work of Hermannsson *et al* (2010b, c) to examine the spatial implications of HEIs' balanced expenditure impacts. Examining balanced expenditure impacts within an interregional framework is interesting because *a priori* it is not clear if the positive and negative terms in the net impact, i.e. the expenditure stimulus of an HEI $(bf_i + of_i)m_i$ and its displacement of other Scottish Government ('Barnett') funded expenditures $bf_i * m_P$ are represented in equal proportion in each sub-region. Hypothetically speaking increased public funding of HEIs could benefit some sub-regions disproportionately (if they have a relatively large HEIs sector and a relatively small public sector) or even exert a negative impact on other sub-regions (those that have a disproportionately small HEIs sector but a large public sector).

The additional challenge of moving from a single region to a 3-region interregional framework is to determine the spatial attribution of incomes and expenditures. In the beginning of the chapter this was done for incomes and expenditures of students at HEIs and the expenditures of the HEIs themselves. What is needed now is to take a further look at the spatial attribution of incomes of the HEIs, in this case their 'Barnett' funding from the Scottish Government. However, it is clear given the binding public sector budget constraint of the Barnett formula that the implicit opportunity cost of spending a part of the block grant on HEIs is that it cannot simultaneously be used for any of the other priorities of the Scottish Government. The question is therefore what expenditures does the Scottish Government's funding of HEIs displace and where? Following Hermannsson *et al* (2010b, c) I adopt the assumption that in sectoral terms public funding displaces expenditure on an aggregate of the public sector (apart from HEI funding)[114]. However, the question remains what is the spatial attribution of that displacement effect?

In what follows I derive balanced expenditure impacts in two alternative ways, based on two distinct assumptions. These two approaches can be seen as complements as each has some intuitive and analytical merit.

In the first instance I shall assume that the public sector budget constraint is balanced within each individual sub-region. This is "as if" each sub-region had devolved finances in its own right. That is for each £1 of Scottish Government funding spent additionally on HEIs in Glasgow an off-setting cut-back of equal magnitude would have to be made on other public expenditures within Glasgow. This is in effect the situation faced by local authorities in the UK and would be particularly suitable for analysing the impact of council-funded activities such as schools. For sub-regions this assumption could hold if the sub-region's bargaining power vis-á-vis the Scottish Government was fixed in the long run so that each sub-region would receive a fixed share of devolved expenditures. Furthermore, applying this approach is a simple extension of the single region approach so it is a useful benchmark.

An alternative approach is to assume that the displacement of public expenditures occurs in each region in proportion to that region's share of Scotland-wide public expenditures. This specification could *in extremis* permit a scenario in which a sub-region could enjoy all of the benefits of public spending on HEIs, but suffer none of the drawbacks if the displacement all occurred in other sub-regions. Within the current framework this outcome would, of course, cover the limiting case of a sub-region containing an HEI sector but no public sector activities.

---

[114] The public sector is aggregated from 5 sectors in the HEI-disaggregated IO table (IO115, IO116, IO117, IO118 and IO119) that receive 93% of central and local government final demand in the Scottish IO-tables. Approximately 10% of the sector's final demand is from other sources than government.

5.3.1 1 for 1 balanced budget within a sub-region

A useful starting point for deriving the attribution of interregional "balanced expenditure" impacts is the single-region individual institution variant of the "balanced expenditure" output attribution presented in equation (5.13b):

$$\overline{Q_i} = (bf_i + of_i)m_i - bf_i * m_P = of_i * m_i + bf_i(m_i - m_P) \tag{5.13b}$$

For the vector of interregional impacts of institution i in sub-region R this can be re-written as:

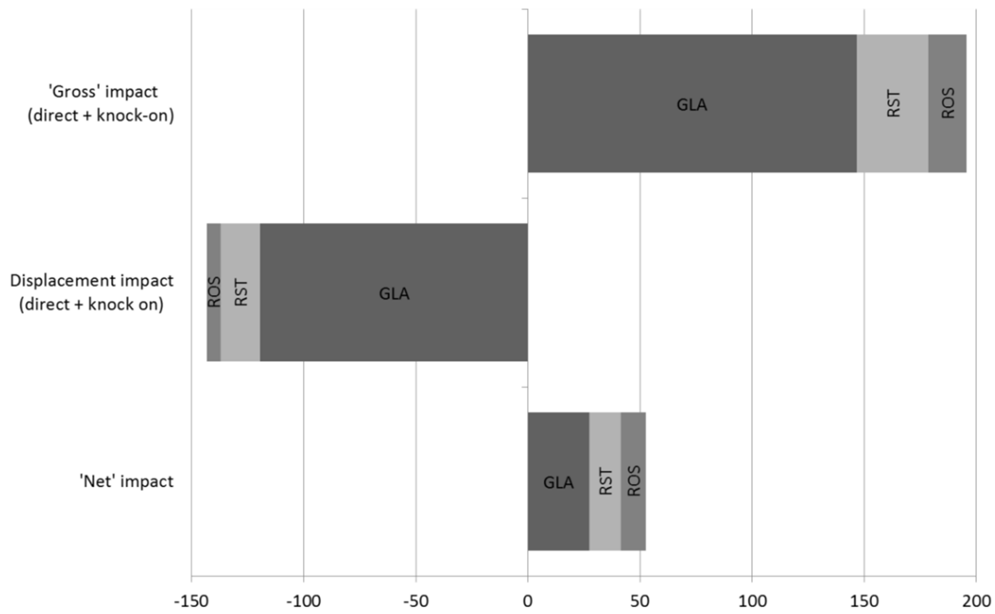
$$\overline{\boldsymbol{Q_i^R}} = \boldsymbol{m_i^R}(bf_i^R + of_i^R) - \boldsymbol{m_P^R} * bf_i^R = \boldsymbol{m_i^R} * of_i^R + (\boldsymbol{m_i^R} - \boldsymbol{m_P^R})bf_i^R \tag{5.16}$$

where the subscript R denotes the host sub-region of the HEI being examined.

As comparing the two equations reveals there is no conceptual difference between (5.13b) and (5.16). However, I use interregional multipliers to reveal separately and simultaneously the impact upon each of the three sub-regions. The balanced expenditure attribution of equation 5.13 is simply being made spatially explicit based on the assumption that effectively the public sector budget constraint applies to each sub-region individually. The intuition is the same as before. The balanced expenditure output impact can be seen as composed of: the gross (conventional) expenditure impact less the impact of displaced public expenditures; or the impact of other funding (net-impact) plus the impact of switching funds between the public sector and HEIs.

To demonstrate, the balanced expenditure impact of a single institution, Glasgow Caledonian University, is presented diagrammatically below. The top bar, reveals what I've termed the 'gross' impact. This is an output impact in the traditional sense, that is composed of final demand times the output multiplier $\left(\boldsymbol{m_i^R}(bf_i^R + of_i^R)\right)$. The next bar reveals the impact of displaced public expenditures $\left(\boldsymbol{m_P^R} bf_i^R\right)$. Adding these two up, forms the 'net' impact $\left(\boldsymbol{m_i^R} * of_i^R + (\boldsymbol{m_i^R} - \boldsymbol{m_P^R})bf_i^R\right)$. Each of these components of the balanced expenditure impact has a sub-regional dimension to it. For the 'gross' impact the direct injection into Glasgow has positive knock-on impacts on GLA as well as RST and ROS. Furthermore, the displacement of public expenditures within Glasgow, has negative knock-on impacts upon GLA, RST and ROS. On balance, once the displacement of public expenditures has been taken into account, Caledonian still exerts a small positive impact in all three of the sub-regions.

Figure 54 Interregional balanced expenditure impact of Glasgow Caledonian University assuming pro-rata displacement of public expenditures (£, m).



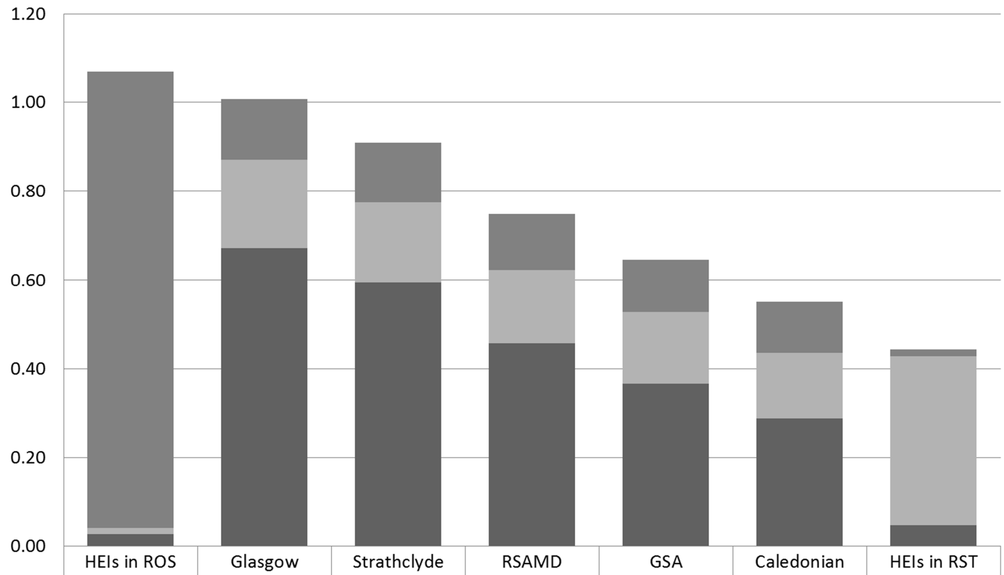
For comparison between institutions, a scale independent metric is more useful. Therefore, to derive the balanced expenditure multiplier, I divide through the attribution $\overline{\boldsymbol{Q}_i^R} = \boldsymbol{m}_i^R * of_i^R + (\boldsymbol{m}_i^R - \boldsymbol{m}_P^R) bf_i^R$ with total final demand $bf_i^R + of_i^R$ to obtain:

$$\overline{\boldsymbol{m}_i^R} = \boldsymbol{m}_i^R \frac{of_i^R}{bf_i^R + of_i^R} + (\boldsymbol{m}_i^R - \boldsymbol{m}_P^R) \frac{bf_i^R}{bf_i^R + of_i^R} \tag{5.17}$$

Again, denoting the share of government expenditure in HEI i's total final demand as α_i, this can be written as:

$$\overline{\boldsymbol{m}_{\boldsymbol{i}}^{\boldsymbol{R}}} = \boldsymbol{m}_{\boldsymbol{i}}^{\boldsymbol{R}}(1-\alpha_i) + \left(\boldsymbol{m}_{\boldsymbol{i}}^{\boldsymbol{R}} - \boldsymbol{m}_{\boldsymbol{P}}^{\boldsymbol{R}}\right)\alpha_i = \boldsymbol{m}_{\boldsymbol{i}}^{\boldsymbol{R}} - \boldsymbol{m}_{\boldsymbol{P}}^{\boldsymbol{R}}\alpha_i \qquad (5.17b)$$

Figure 55 Interregional balanced expenditure multipliers (ranked by size of Scotland-wide multiplier)



	HEIs in ROS	Glasgow	Strathclyde	RSAMD	GSA	Caledonian	HEIs in RST
ROS	1.03	0.14	0.14	0.13	0.12	0.12	0.02
RST	0.01	0.20	0.18	0.17	0.16	0.15	0.38
GLA	0.03	0.67	0.59	0.46	0.36	0.29	0.05

Drawing on the data contained in the interregional HEI-disaggregated Input-Output table I calculate the interregional balanced expenditure multiplier for each of the HEI sectors. These are presented diagrammatically in Figure 55 above.[115]. Table 53 relates the interregional balanced expenditure multiplier to the degree to which the HEI is dependent on 'Barnett' funding (α_i) and summarises how the net-impact is distributed across the host-region and other regions. The first column shows the percentage of the HEI's income that is obtained from the Scottish Government (α_i), the next three columns show how the output impact is distributed across GLA, RST and ROS. That is the values

[115] Due to aggregation bias the balanced expenditures multipliers derived from the 3-region IO-table will not be directly comparable to those based on the single-region IO-table although the overall difference will be small. For details see discussion in section 3.3.3.4.1.

in the columns reveal the net-impact of a £1 of final demand for each of the HEIs, assuming a constant composition of income sources[116] upon each of the sub-regions. The row sum of these is the Scotland-wide output impact (SCO). Finally, the three rightmost columns show a percentage breakdown of the extent to which the output impact is felt within the HEI's host-region.

Table 53 Interregional balanced expenditure multipliers based on the assumption of a sub-regional budget constraint

Institution	α_i	Spatial breakdown of balanced expenditure multiplier $\overline{m_i^R}$				Summary spatial breakdown of output Impact		
		GLA	RST	ROS	SCO	Host region	Other regions	Total
Caledonian	78%	0.29	0.15	0.12	**0.55**	52%	48%	100%
GSA	73%	0.36	0.16	0.12	**0.65**	56%	44%	100%
Glasgow	55%	0.67	0.20	0.14	**1.01**	67%	33%	100%
RSAMD	69%	0.46	0.17	0.13	**0.75**	61%	39%	100%
Strathclyde	61%	0.59	0.18	0.14	**0.91**	65%	35%	100%
HEIs in RST	84%	0.05	0.38	0.02	**0.44**	86%	14%	100%
HEIs in ROS	54%	0.03	0.01	1.03	**1.07**	96%	4%	100%

It is worth noting the spatial pattern of the extent to which the HEIs are dependent on funding from the Scottish Government for their income (α_i) The composite sector of the HEIs in ROS is the least dependent on Scottish Government funding at 54%. Less so than any of the individual HEIs in Glasgow or the composite sector of HEIs in RST. Furthermore, each of the individual GLA HEIs are less dependent on public funding than the HEIs in RST. These regional differences in HEIs income structure are important as the variation in total Scotland-wide impact, as is evident from the 'SCO' column in the table above, is primarily driven by the extent to which the HEIs are dependent on income from the Scottish Government. Since as we have seen the traditional multipliers are quite homogenous (Hermannsson *et al,* 2010c) the variation in α_i is what drives the variation between the balanced expenditure multipliers. The balanced expenditure multiplier for the Glasgow HEIs ranges from 0.55 for Caledonian to 1.01 for the University of Glasgow. In all cases

[116] The constant composition assumption is crucial here as the balanced expenditure multiplier is derived based on the composition of income of the HEIs, as revealed by accounting data.

this is higher than that for HEIs in the RST (0.45) and lower than for HEIs in ROS (1.07).

It is clear that, for the Glasgow HEIs, a greater share of the balanced expenditure impact is felt outwith their host region, Glasgow City, than is the case for HEIs in RST and ROS. This is not surprising as GLA is the most open of the three sub-regions modelled, with a significant share of indirect and, in particular, induced effects materialising outwith the city. Furthermore, among the GLA HEIs this tendency to impact neighbouring regions is inversely linked with the HEIs dependence on 'Barnett' funding. Since in this case I impose the displacement of public expenditure fully within the host sub-region, the larger the share of 'Barnett' income the relatively more subdued is the local impact, due to greater displacement of public sector spending. This is most acute for Caledonian where 48% of the impacts are felt outwith GLA, but is lowest for the University of Glasgow at 33%.

As already noted, there are compelling reasons why Glasgow is the most open of the three sub-regional economies being modelled. GLA is the smallest of the three sub-regions and exhibits the greatest degree of interdependence with other parts of Scotland as manifested by commuter flows. However, it should be borne in mind that some of the comparative interregional interrelatedness of the GLA HEIs could be driven by the fact that they are modelled slightly differently from the HEIs in RST and ROS. As was detailed in section 3.3.3.2 for the HEIs in RST and ROS the interregional flow of wage payments was based on the general pattern of commuter flows to and from their host regions. However, for the case of the GLA HEIs I had access to data from the University of Strathclyde, which revealed the destination of wage payments by postcode. These data, which were used to inform the interregional wage flows for all of the GLA HEIs, differed from the general commuting pattern in that it revealed Strathclyde (and by implication the other HEIs in GLA) to be much more dependent on in-commuters than the host-regional economy on average. It is likely that this pattern holds for other HEIs in Scotland and hence the interregional spillover of their expenditure impacts would be greater if based on HEI-specific data for commuter-flows rather than sub-region-wide averages[117].

5.3.2 **Pro-rata public sector displacement**

Attributing the impacts of HEIs becomes slightly more complicated if we assume that the displacement of publicly funded activities occurs across the sub-regions in proportion to their overall share of Scottish Government activities.

To denote the three regions GLA, RST and ROS I use the superscripts G, W and S, respectively. Each of these is an element in the set of regions R, where: $R = \{G, W, S\}$. I denote a region *R*'s share in overall Scottish Government expenditures as β^R, where

$$\beta^R = \frac{Scottish\ Government\ expenditure\ in\ region\ R}{Total\ Scottish\ Government\ expenditure}$$

Now we can write the "balanced expenditure" attribution of the interregional output impact of HEIs as:

$$\overline{\boldsymbol{Q_i^R}} = \boldsymbol{m_i^R}(bf_i^R + of_i^R) - \left(\mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{G}}\beta^G + \mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{W}}\beta^W + \mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{S}}\beta^S\right)bf_R^i$$
$$= \boldsymbol{m_i^R} of_i^R + \left(\boldsymbol{m_i^R} - \mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{G}}\beta^G - \mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{W}}\beta^W - \mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{S}}\beta^S\right)bf_i^R \qquad (5.18)$$

Where $\beta^G + \beta^W + \beta^S = 1$ and $\beta^G, \beta^W,\ \beta^S$ refer to the share of Scottish Government spending in Glasgow, the rest of the Strathclyde region and the rest of Scotland, respectively. The interregional multipliers for public spending in the same regions are represented by $\mathbf{m}_{\boldsymbol{P}}^{\mathbf{G}}$, $\mathbf{m}_{\boldsymbol{P}}^{\mathbf{W}}$ and $\mathbf{m}_{\boldsymbol{P}}^{\mathbf{S}}$. For expenditure in any region there will be a multiplier effect upon each of the three regions. What

---

[117] This could be rectified by collecting data from each of the Scottish HEIs (or at least a sample thereof) on the spatial pattern of their wage payments. However, getting all the HEIs to sign up to such an exercise in addition to actually retrieving the data, from presumably heterogeneous information systems, is likely to prove a formidable task. The administration of such an exercise is likely to be resource intensive to the extent that it is beyond the means of this dissertation.

happens in any one region is due to the interaction of expenditure in all three regions. Referring to the set of regions R, this can be put more succinctly as:

$$\overline{\boldsymbol{Q_i^R}} = \boldsymbol{m_i^R}(bf_i^R + of_i^R) - \mathbf{m_P^R} bf_i^R \textstyle\sum_{\mathrm{R}} \beta^R \;= \boldsymbol{m_i^R} of_i^R + \left(\boldsymbol{m_i^R} - \sum_R \mathbf{m_{\boldsymbol{Pi}}^{\boldsymbol{R}}} \beta^R\right) bf_i^R \tag{5.18b}$$

As before, the broad intuition is the same. However, in this case the displacement impact of public expenditures is felt in fixed proportions (according to β^R) across the three regions[118] and the switching impact is composed of the difference between the local HEI multiplier and the weighted average of the regional public sector multipliers.

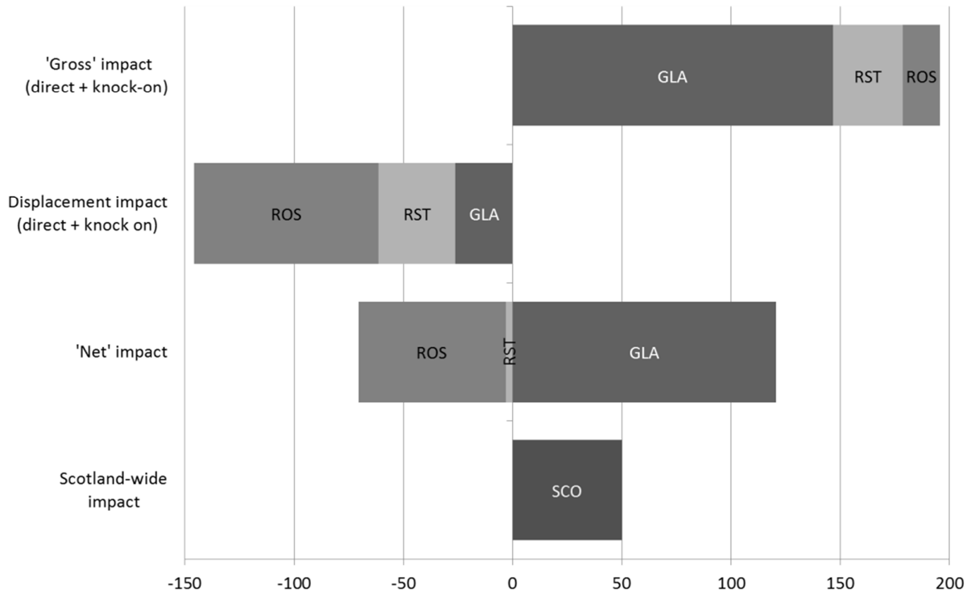
To illustrate, the balanced expenditure impact of a single institution, Caledonian, is presented diagrammatically in Figure 56 below. This figure is drawn in the same scale as Figure 54 in the previous sub-section, although this time based on the assumption of a *pro-rata* displacement of public expenditures. As before, we have the positive 'gross' impact $\left(\boldsymbol{m_i^R}(bf_i^R + of_i^R)\right)$ in the top bar and below that the negative impact of displaced public expenditures $\left(-\left(\mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{G}}\beta^G + \mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{W}}\beta^W + \mathbf{m}_{\boldsymbol{P}}^{\boldsymbol{S}}\beta^S\right)bf_R^i\right)$. However, there is a critical difference between the previous case where public expenditures were displaced only within the host region and the case below where the displacement of public expenditures occurs *pro-rata* across all three sub-regions.

In the present case the spatial pattern of the positive expenditure impact and the negative displacement impact differ: The bulk of the positive impacts are felt within GLA, whereas the greatest share of displacement occurs within ROS. The spatial distribution of displacement impacts is driven by each region's share of Scottish Government expenditures β^R, where β^G=18.0%, β^W=24.4% and β^S=57.6% . This has clear implications for the 'net' impact, which is composed of a positive impact upon GLA (£120m), but negative impacts upon RST (-

118 In effect the public sector multiplier used is the average of the public sector multipliers in each of the three sub-regions, wheighted by β^R.

£3m) and most significantly ROS (£-67m). Looking at Scotland as a whole, once the displacement of public spending has been taken into account, Caledonian drives an output impact of £50m. However, this is composed of spatially heterogeneous regional impacts (£120m-£3m-£67m=£50m). Therefore, underlying the Scotland-wide average, are some regionally disparate results.

Figure 56 Interregional balanced expenditure impact of Glasgow Caledonian University assuming pro-rata displacement of public expenditures (£, m).



To derive the balanced expenditure multiplier, I divide through the attribution $\boldsymbol{m_i^R} of_i^R + \left(\boldsymbol{m_i^R} - \sum_R \mathbf{m_{Pi}^R}\, \beta^R\right) bf_i^R$ with total final demand $(bf_i^R + of_i^R)$ to obtain:

$$\overline{\boldsymbol{m_i^R}} = \boldsymbol{m_{Ri}} \frac{of_i^R}{(bf_i^R + of_i^R)} + \left(\boldsymbol{m_i^R} - \sum_R \beta^R \mathbf{m_P^R}\right) \frac{bf_i^R}{(bf_i^R + of_i^R)} \tag{5.19}$$

Or as before, if I use α_i to denote the share of 'Barnett' funding in the HEIs income mix this can be put more succinctly as:

$$\overline{\boldsymbol{m_i^R}} = \boldsymbol{m_i^R}(1 - \alpha_i) + \left(\boldsymbol{m_i^R} - \sum_N \beta^R \mathbf{m_P^R}\right)\alpha_i \tag{5.19b}$$

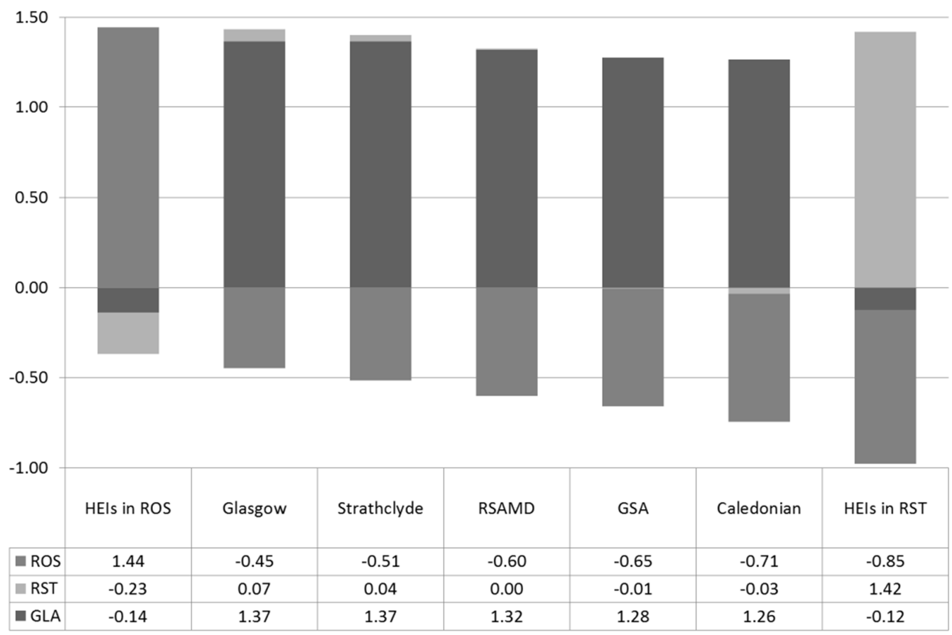
This interregional 'balanced expenditure' multiplier can be interpreted in a similar way as its single-region variant. It is composed of the interregional output multiplier of HEI *i* in region *R*, weighted by the share of 'other' income in the HEIs income mix and the difference between the interregional HEI multiplier and the interregional public sector multiplier. The novel feature here is that the interregional public sector multiplier is in fact a weighted average the interregional public sector multipliers in all of the three sub-regions.

The interregional balanced expenditure multipliers for each of the HEI sectors, presented in Table 54 and Figure 57, further illustrate how the Scotland-wide "balanced expenditure" multipliers of the HEIs are not only composed of positive sub-regional impacts but also negative ones, as the displacement of public expenditures outweighs the positive impact driven by the HEIs expenditures. For example it is clear that Caledonian exerts a positive "balanced expenditure" impact of 1.26 upon its host region of Glasgow (GLA). However, its displacement of Scottish Government expenditures in the other sub-regions is more powerful than the interregional spillover effects from the knock-on impacts of its expenditures. This results in negative impacts upon RST and ROS amounting to 3p and 71p in each sub-region respectively, for each £1 of final demand for the institution. Therefore, the Scotland-wide "balanced expenditure" impact of Caledonian (1.26-0.03-0.71=0.52) is much less than its host sub-region impact (0.52<1.26).

Table 54 Interregional balanced expenditure multipliers based on the assumption that displacement of public expenditures is spread evenly across the Scotland-wide public sector[119]

Institution	α_i	Spatial breakdown of balanced expenditure multiplier $\overline{m_i}$				Summary spatial breakdown of output Impact		
		GLA	RST	ROS	SCO	Host region	Other regions	Total
Caledonian	78%	1.26	-0.03	-0.71	**0.52**	242%	-142%	100%
GSA	73%	1.28	-0.01	-0.65	**0.62**	206%	-106%	100%
Glasgow	55%	1.37	0.07	-0.45	**0.99**	138%	-38%	100%
RSAMD	69%	1.32	0.00	-0.60	**0.73**	182%	-82%	100%
Strathclyde	61%	1.37	0.04	-0.51	**0.89**	154%	-54%	100%
HEIs in RST	84%	-0.12	1.42	-0.85	**0.44**	320%	-220%	100%
HEIs in ROS	54%	-0.14	-0.23	1.44	**1.08**	134%	-34%	100%

Figure 57 Interregional balanced expenditure multipliers based on the assumption that displacement of public expenditures is spread evenly across the Scotland-wide public sector (ranked by size of Scotland-wide multiplier).



[119] Comparing the Scotland-wide multipliers derived based on the two alternative approaches to the interregional balanced expenditure multiplier, it is evident that they do not produce entirely identical results for Scotland-wide impacts, although the differences are small. However, these errors cancel out between individual institutions/sectors, so that when interregional balanced expenditure multipliers are derived for the aggregate Scottish HEI-sector, the Scotland-wide multiplier is the same irrespective of the approach taken.

Looking at the multipliers in Figure 57, it is clear that the assumption of equiproportional displacement of public expenditures results in much more dramatic interregional results, with a strong positive host-region impact and a significant negative impact in other sub-regions as displacement impacts are spread across the Scotland-wide public sector. For the Glasgow HEIs home region impacts range from 138% of the total Scotland-wide impacts (Glasgow) to 242% (Caledonian). Similarly the negative impact upon adjacent sub-regions ranges from -38% of Scotland wide impacts in the case of the University of Glasgow to -142% for Caledonian.

This polarisation between positive host-sub-region impacts and negative interregional impacts is most distinct for the HEIs in RST but least so for HEIs in ROS. This tendency is positively associated with the extent of each institution's dependence on 'Barnett' funding (α_i), as the higher this percentage the larger is the displacement impact. Furthermore this contrast between host-region effects and interregional spillover effects is negatively associated with the size of the sub-region (or strictly speaking the sub-region's relative share of region-wide public expenditure) as the larger a sub-region the more of the displacement impact it 'internalises'. This is evident by the column for 'HEIs in RST' in the Figure above. As the HEIs in RST are highly dependent on Scottish Government funding (α_i=84%) and the region captures a relatively small share of the total expenditures of the Scottish Government, the HEI sector in RST exhibits strong positive host region effects but more markedly the most negative interregional displacement effects of any of the sectors examined.

5.4 Conclusions

In this chapter I make a number of contributions to the estimation of expenditure impacts of Higher Education Institutions and the related impact of their students' consumption expenditures.

The first section is devoted to extending the analysis of the expenditure impacts of HEIs and their students to an interregional framework. An analysis of the institutional expenditure impacts reveals that these clearly cut across sub-regional boundaries in Scotland. Most explicitly this was evident for the Glasgow HEIs where 25% of their Scotland-wide output impacts were felt outside their host region. This is due to the economic structure of their host sub-region Glasgow, which is very open, as reflected in the scale of wage payments to the rest of the Strathclyde region and to a lesser extent to the rest of Scotland. Perhaps unsurprisingly the HEIs in the largest sub region (ROS) exhibit the least tendency for impacts to spill-over onto neighbouring sub-regions, with 96% of the output impacts incurring within the region.

Furthermore, I analyse how HEI activities are distributed across the three regions by comparing shares of HEI expenditures with population shares. From this perspective HEIs are clearly over-represented in Glasgow. However, as I have suggested earlier it is misleading to view Glasgow in isolation as it is, in functional terms, very much part of the Strathclyde region. When focusing on the Strathclyde region as a whole (GLA+RST) it is evident that relative to the regions' population, HEI activity is under-represented vis-á-vis the rest of Scotland. When the output impacts (final demand + 'knock-on') of the HEIs are examined the Strathclyde region is at a further loss as an even greater share of output impacts is experienced in the ROS than of direct impacts. A casual observation would suggest that this reflects an in-equitable distribution of HEI funding across Scotland. However, this is not as straightforward as it may initially appear. Once HEIs income has been disaggregated into Scottish Government funding and other income sources it turns out that public funding is allocated approximately in line with population shares between the whole of the Strathclyde area (GLA+RST) and the rest of Scotland (though the Strathclyde area seems to be, if anything, slightly favoured by the Scottish Government). However, the HEIs in the rest of Scotland appear to be better able to draw income from sources independent of the binding public sector budget constraint imposed by the Barnett formula, i.e. external research funding and students' tuition fees. In principle therefore the HEIs in the Strathclyde region should be able to emulate the success of their counterparts in the rest of Scotland. I calculate that if these were able to complement their public income with external funds to the same extent as the HEIs in the ROS this could result in an additional income of £119m for the Strathclyde HEIs (a 16.8% increase in total income). This should be technically feasible given the precedent of the other Scottish HEIs (although clearly not a light task). However, it is an open question whether this would be desirable for the Scottish economy. If a focus on external income complements the HEIs' capacity for building human capital it is clearly a good thing overall. However, if there is some trade-off between focusing on external competiveness of the institutions and their role in producing graduates for the local labour market, the outcome would be ambiguous. This is because, as we will see in Chapter 6, the cultivation of human capital brings sizeable economic benefits through expanding the supply-side of the economy.

In order to analyse the impact of students' consumption expenditures I draw on Hermannsson *et al* (2010b,c) to introduce a novel treatment of student expenditures, whereby survey information is used to identify students' exogenous expenditures. My contribution in this chapter is to extend this approach to an explicitly interregional setting. This is important as students are highly mobile and often draw an income from one region, which they spend in another. Therefore their Scotland-wide direct expenditures are in fact an average of disparate sub-regional impacts. Most of these are positive, but a neglected angle which I seek to address is that these can be, and indeed are in some of the cases I identify, negative. My analysis reveals that the output impact of students' consumption expenditures spill-over sub-regional boundaries and that this occurs in two stages. Firstly through direct interregional expenditure- and displacement effects where mobile students exert a positive impact upon their region of study but a negative impact upon their region of domicile. Secondly, through knock-on impacts which spill-over sub-regional boundaries.

Combining these expenditure profiles with detailed data on the origin and destinations of students in Scotland it is possible to calculate just how students move expenditures about within the Scottish economy and to what extent their expenditures are truly additional to the regional economy. Looking at the results a striking heterogeneity of regional impacts is revealed. Glasgow city benefits from a net inflow of students while its hinterland (the rest of the Strathclyde region) loses since it receives far fewer students than it sends away. This results in significant negative economic impacts upon Glasgow's hinterland as students move out of the area (typically into Glasgow), taking their expenditures with them. However, once multiplier effects have been taken into account there is a mild positive impact upon the rest of the Strathclyde region, as much of the positive knock-on impacts from the city feed back into the hinterland in the form of wage payments to those who are employed in Glasgow, but live in the rest of the Strathclyde region. In this particular case the adverse negative direct impact of student outflow is off-set by positive spill-overs from the students' expenditures in their region of study. This is due to the close economic links between the two adjacent areas and will almost certainly not apply in other cases, for example those of remote areas that experience a net-outflow of students to the metropolitan areas.

In the second section I follow Hermannsson *et al* (2010b,c) and introduce the notion of the balanced expenditure multiplier and show how this concept can be applied to the case of students and institutions, both to aggregate sectors and individual institutions. The balanced expenditure multiplier is a reaction to a "policy scepticism", which asserts that either demand-side binding budget constraints or supply-side binding resource constraints generate "crowding out" of HEI expenditure effects on the host regional economy, to the point where the regional impact of HEIs expenditures is regarded as negligible. While Hermannsson et al (2010b,c) reject the relevance of the binding supply-side resource constraint on a priori grounds and reject the extreme form of demand-driven policy scepticism, they acknowledge the importance of binding public sector budget constraints under UK devolution, and argue that future regional impact studies should be modified to accommodate these constraints.

In the third section I apply the notion of the balanced expenditure multiplier in an interregional setting, more specifically to the case of GLA-RST-ROS. The main practical obstacle to this is identifying the spatial pattern of positive and negative impacts. For the positive direct expenditure stimuli this has already been achieved in the first section of this chapter where I identify the interregional expenditure impact of the HEIs. The remaining task therefore is to identify how the displacement of public expenditures is spread across the three sub-regions. Firstly, I assume that total Scottish Government expenditures are fixed within each sub-region, so that Scottish Government funding for HEIs displaces funding for other Barnett-funded activities within their host region. This is in effect akin to the budget constraint faced by local authorities. Secondly, I re-work this analysis under the assumption that Scottish Government funding is displaced equiproportionately in each sub-region, reflecting the initial spatial distribution of public spending in the IO-tables.

Even if both approaches result in the same Scotland-wide balanced expenditure impact of HEIs, the impacts across individual sub-regions vary substantially depending on which assumption is adopted. In the former case the negative displacement impacts are all contained within the HEIs host sub-region and therefore act to subdue its local impact. However in the latter case the displacement impacts are spread across the sub-regions resulting in much more heterogeneous impacts across space. Where a relatively large HEI sector is placed in a region containing a limited share of overall public expenditures this can result in large positive local impacts but negative displacement impacts upon other regions. For example in the case of Glasgow Caledonian University this results in a positive balanced expenditure impact upon Glasgow nearly 2.5 times the size of the Scotland-wide impact. This is however countered by a significant negative impact upon the rest of Scotland.

More generally, this reveals that even as partially publicly funded activities have positive Scotland-wide output impact the same cannot be uniformly expected at a sub-regional level. There is an, at least implicit, opportunity cost for the regions that are not subject to the positive stimuli of the public-sector injection. This suggests that an equitable distribution of public expenditures across space is an important consideration for regional policy. However, even if public expenditures were distributed over space so as to equalise per capita expenditures across sub-regions that would not necessarily represent the most equitable distribution. Some allowance has to be made for economic structure, for as we have seen, this can act to move impacts within space. For example, as in the case of Glasgow and the rest of the Strathclyde region, where direct impacts upon Glasgow have marked knock-on impacts upon the rest of the Strathclyde region as commuters 'expatriate' wage income earned in Glasgow.

6 CGE analyses of the supply-side impacts of students and graduates upon Glasgow

In the preceding chapter, I presented analysis of the economic impacts of HEIs and their students through their stimulus to the demand side of the regional economy. That is, examining the impact of the HEIs expenditures and the related consumption of their students, effectively treating the HEIs as businesses and their students as tourists. The aim of this chapter is to add an additional dimension to the story about the regional economic impacts of HEIs by analysing how they stimulate the supply-side of their host economy. That is, how the activities of the HEIs, their students and graduates, affect the productive capacity of the regional economy of interest. As we saw in Chapter 2, there are compelling reasons why we expect HEIs to have significant economic impacts on their host regions by stimulating their supply side. Indeed these supply-side impacts might spill over to other regions, although the focus here is on host-region effects.

Also as outlined in Chapter 2, HEIs and their students and graduates not only drive demand-side impacts, but also a range of supply-side impacts. Some of these have been extensively analysed in past work, such as the labour market benefits of education. For other effects the evidence base is less extensive, such as that for wage externalities[120] (Morretti 2004a,b). The main emphasis of the applications presented later in this chapter is to simulate the economy-wide impact that graduates exert through the labour market. This leaves aside a number of potentially very important channels through which HEIs impact the supply side of economies. There are a range of potentially very important impacts, whose precise transmission mechanism is yet to be identified and simulated, such as the links from HEIs to total factor productivity via innovation, R&D and knowledge exchange or the indirect ways in which education contributes to social outcomes such as health and crime rates.

[120] Some authors argue that wages in an area are positively correlated with average education levels, even after controlling for individual worker characteristics and interpret this empirical finding such that increased human capital increases the marginal product of other workers (e.g. Moretti 2004a). Furthermore, Moretti (2004b) finds the same effect at the plant level

Furthermore, spatial pull effects are potentially very important for regional/metropolitan economies. That is, the way in which HEIs re-arrange productive capacity in space by extending a pull on skilled labour and high-skill activities such as R&D. To some extent, however, these spatial pull effects are captured in the impacts of graduates in the labour market as it influences the retention rate of graduates, which, in turn, affects the magnitude of the labour productivity shock driven by a higher proportion of graduates in the labour market. For example, for the case of Glasgow, the level of HEI activities in the City affects the extent to which graduates are attracted to and retained within the local labour market and hence the share of graduates observed in labour market statistics.

In order to be able to simulate impacts on the supply side I need a model that specifies not only the demand side of the economy but also incorporates an active supply side. For these purposes I draw on the AMOS modelling framework (see Section 6.2) to calibrate a Computable General Equilibrium (CGE) model of the city economy of Glasgow.

As demonstrated in Chapters 3 and 5, HEIs are likely to exert economic impacts over space rather than solely on their host regions. The focus of this chapter, however, is exclusively on host region impacts. The reason for this tight focus is that the introduction of the additional dimension of an active supply side is a significant and complex undertaking, for which there is limited previous work on which to build. A compelling next step in this research agenda is to extend the spatial dimension, by adopting an interregional modelling approach. However, limitations of time and writing space preclude this, but I hope to address this in future research.

In the next section I offer a general introduction to CGE modelling and discuss the strengths and weaknesses of the CGE approach for economic policy appraisal. In Section 6.2 I present the AMOS CGE modelling framework. This is the main tool utilised for evaluating the supply-side contribution of HEIs and graduates to the Glasgow economy. The CGE model is calibrated to a Social

Accounting Matrix (SAM) of Glasgow for the base year 2006. The SAM and its construction process are described in Section 6.3.

The first model application in this chapter is used to demonstrate the additional insights obtained by moving from the fixed-price and passive-supply general equilibrium world of Input-Output to the CGE framework. Drawing on insights obtained in Chapter 5, I analyse the effects of a positive demand injection for the Glasgow economy and how the estimated impacts based on the IO and CGE results differ (and, as we will see, converge in the long run under certain circumstances). The scenario used for this purpose is one where I assume that the Glasgow HEIs are able to bring their export intensity up to the same levels as that for HEIs in the rest of Scotland, while not affecting other income sources. As we saw in Section 5.1.2.1 this would increase the export earnings of Glasgow HEIs by £119m.

The second application, presented in Section 6.5 estimates the economic importance of graduates for the Glasgow economy. For this I draw on the "micro to macro" approach of Hermannsson *et al* (2010d), where data on the wage premia of graduates in the labour market are used to calibrate the increase in productive capacity resulting from a growing share of graduates in the working age population. This boost to labour productivity enters the CGE model as a positive supply shock. The model is then used to simulate the transmission of this isolated shock into economy-wide impact, under a range of assumption about the functioning of the Glasgow economy. As we shall see, the qualitative result of this is that the impact of a rising share of graduates in the labour market is potentially large. However, as the macroeconomic impact is driven largely by external competitiveness effects, quantifying this impact is sensitive to assumptions about the link between Glasgow and the external transactors, the rest of Scotland (ROS) and the rest of the World (RUK/ROW).

6.1 CGE-modelling

The aim of this section is briefly to illustrate what a Computable General Equilibrium (CGE) model is and how it works; identify the strengths of CGE modelling for policy analysis and its weaknesses. It is difficult to provide a succinct generalised description of CGE models as inevitably the models' features vary depending on their application and origin. The approach taken here is to provide a broad illustration of CGE models and leave aside the relative merits of particular model types in different circumstances. This broad overview is complemented with a fuller description of the AMOS modelling framework and a discussion of how that model's features affect its use in the subsequent policy simulations in this chapter.

In brief, simulating with a CGE model combines an abstract general equilibrium structure, as formalised by Arrow and Debreu (1954) and Debreu (1959), with realistic economic data to solve numerically for the levels of supply, demand and price that ensure equilibrium across the specified set of markets defined in the model (Sue Wing, 2004). Their theoretical backdrop is the Walrasian general equilibrium structure which is expressed in mathematical terms as a system of simultaneous equations representing equilibrium conditions (Walras, 1926). Equilibrium occurs when prices reach a point where supply equals demand in the markets for all commodities simultaneously[121]. However, it is important to stress the point that applied CGE models are not restricted to a simple universally competitive Walrasian system.

CGE models are widely used in economic policy analyses[122]. The wide range of CGE applications includes for example: international development (Bandara, 1991, Robinson 1989), taxation (Shoven & Whalley 1984, Fullerton *et al* 1981) international trade (Piermartini & Teh 2005, Lloyd & MacLaren 2004), carbon emissions (Ferguson *et al*, 2005), regional policies (Partridge & Rickman, 1998, 2010), health system impacts (Rutten & Reid, 2009) and demographic changes (Lisenkova *et al,* 2010).

---

[121] For a further discussion of general equilibrium theory see Chapter 2 in Shoven & Whalley (1992). Sue Wing (2004) illustrates, by using a simple CGE-model, the link between general equilibrium theory and CGE-models.

[122] For a general discussion of CGE models I refer to two recent textbooks Burfisher (2011) and Hosoe et al (2010). For a broad discussion of the influence and role of CGE in policy work see: Devarajan & Robinson (2002) and for a discussion of CGE-models and their development, in the context of other multisectoral models, see Robinson (1989). Furthermore, Robinson et al (1999) provide a useful illustration of the application of a CGE model using the General Algebraic Modeling System (GAMS) software.

A major benefit of using CGE models for policy analysis is that they are economy-wide models. Unlike partial equilibrium analysis, where extensive *ceteris paribus* assumptions have to be invoked, CGE models account for all economic activity within a given economy. This implies the simultaneous determination of prices and quantities in production, consumption, employment and trade. CGE models represent a considerable step forward from earlier Input-Output (and SAM) multisectoral models, which are entirely demand driven with no supply constraints. CGE models contain an explicitly specified supply side and can therefore encompass both demand-side and supply-side analysis simultaneously.

Although a detailed discussion of the intellectual history of CGE-modelling is beyond the scope of this dissertation, a brief consideration provides a useful context for understanding the model. Arrow (2005) argues that the ability to apply CGE-models is due to research stretching back at least 130 years and involving very disparate lines of enquiry. "Economic theory and the vastly improved availability of economic data have played basic roles. But other research inputs have been equally crucial: Improvements in computing power and the development of algorithms for computing equilibria", (Arrow, 2005, p. 13). Moreover, Arrow (2005) argues that the decisive step towards realising CGE-models is the solution approach pioneered in Scarf (1967) and Scarf & Hansen (1973), which triggered the proliferation of these types of models.

Undoubtedly Arrow (2005) is correct in identifying the development of Scarf's solution algorithm as the undoing of a critical bottleneck in the deployment of applied general equilibrium models. However, Scarf's work represents a specific impetus to the development of CGE models, namely the intellectual desire to develop numerical solutions to theoretical general equilibrium models. This is important as apart from simple cases, general equilibrium models are not amenable to analytical solutions. As Shoven & Whalley (1984, p. 1007), former students of Scarf[123], state:

> The explicit aim of this literature is to convert the Walrasian general-equilibrium structure (formalized in the 1950s by Kenneth Arrow, Gerard Debreu, and others) from an abstract representation of an economy into realistic models of actual economies. The idea is to use these models to evaluate policy options by specifying production and demand parameters and incorporating data reflective of real economies.

Bandara (1991, pp. 12-13) labels three broad traditions within CGE-modelling and Robinson (1989, p. 889) identifies four different technical approaches to the solution of CGE models in the early literature. It is of course difficult to speculate about the motivation behind past work but it is clear that the narrative of Shoven & Whalley (1984) of a direct progression from theoretical to applied general equilibrium is only one aspect of the story about the origins of CGE modelling. The pedigree of CGE models can also be traced back to the application of linear multisectoral models for policy purposes. Bandara (1991) points out that the compilation of an IO-table for the US economy by Leontief (1936) laid the groundwork for multisectoral models and that further developments of IO (such as Leontief, 1937) "led to the popularity of input-output models as a planning tool up until the early 1970's" (Bandara, 1991, p. 6). However, as we discussed in the previous chapter (Section 5.1.1.1) IO models, although capable of capturing significant elements of interdependence in the economy, suffer from a number of shortcomings. In particular, IO-models cannot capture the influence of the supply-side on policy as they are completely demand driven[124].

Bandara (1991) points out that the development of Linear Planning (LP) models in the 1960s's, managed to overcome some of the shortcomings of IO

---

[123] Shoven & Whalley have published extensively on CGE modelling. Bandara (1991) labels their work as part of the 'Yale' tradition of students (or students of students) of Scarf.

[124] As noted earlier, there is the Goshian, or supply-driven, IO approach, where causality is reversed from demand to supply. However, this approach is much more restrictive than CGE. For details of Goshian IO-modelling see Miller & Blair (2009, Ch. 12, pp. 543-587).

by offering a methodology to introduce primary factor constraints and the possibility to treat prices explicitly. These models are operationalized by introducing an economy-wide objective function, which is optimised subject to linear constraints. However, Bandara (1991) suggests these LP models did not catch on widely in policy circles as micro behaviour in these models is difficult to interpret and their handling of factor and trade constraints is not sufficiently realistic. At the same time the first CGE-model was introduced, the Johansen (1960) model of Norway[125]. Johansen's approach was to linearise the equations of the models and then solve the system of equations through matrix inversion[126].

> The development of CGE modelling can be treated as a natural extension of input-output and LP models with the inclusion of an endogenous output and price system, neoclassical substitutability in production and demands, the optimization behaviour of individual agents and a complete treatment of income flows in an economy (Bandara, 1991, p. 9).

The subsequent development of CGE models has, to a significant extent, been driven by the need of policy makers for a flexible tool which can integrate both supply-side and demand-side impacts. CGE-modelling frameworks have been developed, and are maintained, by international institutions such as the OECD (GREEN), World Bank (MAMS) and the IMF, by think tanks and consultancies i.e. the International Food Policy Research Organisation (IFPRI) and the IMPLAN Group as well as academic institutions such as the University of Strathclyde (AMOS) and Monash University (Monash)[127]. Somewhere in between is the Global Trade Analysis Project (GTAP). GTAP is a network which maintains a model and collects databases for sharing among its members. CGE's are in routine use at international organisations where a general framework is typically calibrated on datasets for individual countries.

---

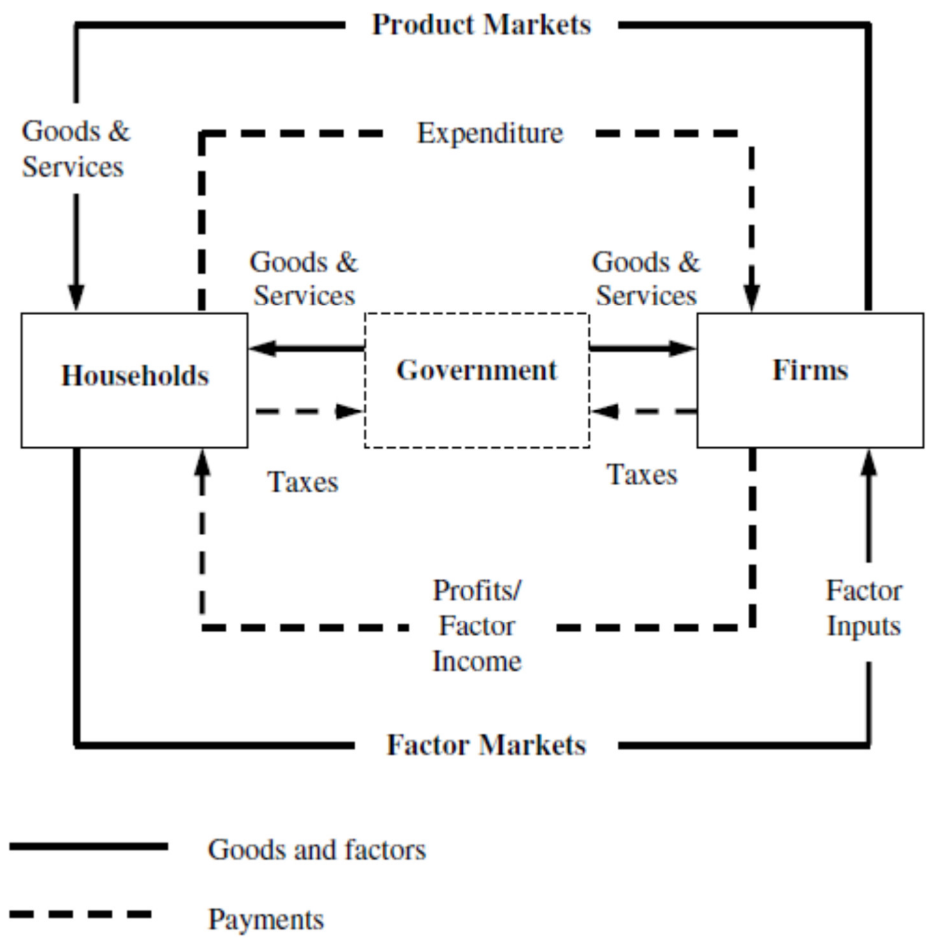
125 Although CGE-models did not proliferate until the 1970's with the introduction of algorithms that could handle non-linear solutions and increased availability of computer power.
126 For details of the contribution of Leif Johansen to CGE-modelling and the legacy of his solution approach in later applications see: Dixon & Rimmer (2010).
127 For an overview of the groupings of individuals, institutions and modelling traditions in the early phases of CGE see Bandara (1991, pp. 12-13).

Although the origin of these models is tied in with particular groups, affordable computing power, internet communications and readily available software for developing and running models has arguably led to a 'democratisation' of CGE models. For example, it is easy to share GAMS code with electronic communication methods. This has various manifestations. Some authors offer to share their modelling code upon request to those interested in replicating or verifying results, the IFPRI makes freely available the code and technical documentation to their 'standard' model, which has become something of a benchmark application for studies of LDCs. Furthermore, the modelling code for a variety of models is freely available online, including all of the models featured in the textbook of Hosoe *et al* (2010). Greenaway *et al* remark as early as 1993 in a report to H M Treasury, that the entry barriers to constructing and running CGE-models have become relatively low with the ability to run them on personal computers, instead of mainframes. Arguably the current state is that the technological barriers stemming from the availability of computing power and software are limited. However, going beyond basic applications still requires significant programming skills and knowledge of the underlying economics and databases that is time consuming to develop. The combined demands for data handling, programming and analytical skills mean that in practice maintaining and running a CGE model is difficult without a team.

6.1.1 **Foundations of CGE models**

Figure 58 presents a stylised illustration of the circular flow of incomes and expenditures within an economy. Sue Wing (2004) argues that this is the fundamental conceptual starting point for Walrasian general equilibrium theory and CGE models. In this sense, a CGE model can be seen as a mathematical model that numerically depicts the circular flow of income and expenditures within an economy. The main actors in the circular flow are the households and firms. The former own the factors of production and are the final consumers of commodities, while the latter rent the factors of production and produce commodities for consumption. CGE-models typically represent the government as well, which collects taxes and spends the income on transfers and final demand expenditures, subject to budget rules specified in the model setup. The circular flow can be traced from households to firms through factor inputs (labour, capital) and then on from the firms through commodities sold to households. On the other hand, we can track the circular flow as payments for factor services from firms to households. This circle is completed as households pay firms for goods and services provided.

Figure 58 A stylised illustration of the circular flow of income and expenditures in an economy. Source: Sue Wing (2004, p. 29).



The detailed depiction of the circular flow is not a unique feature of CGE models and is for example also inherent in the 'fixed-price' SAM models. However, an additional feature of CGE model is that it includes fully specified product and factor markets, where the behaviour of producers and consumers is informed by explicit (microeconomic) optimising behaviour and prices adjust to ensure simultaneous equilibrium in all markets.

Sue Wing (2004) illustrates the link between general equilibrium theory and CGE modelling in practice by deriving a simple CGE model from Walrasian general equilibrium conditions and the microfoundations of consumers' utility maximization and producers' profit maximization. Furthermore, Sue Wing (2004) uses this framework to illustrate step-by-step the calibration of the model from a Social Accounting Matrix (SAM): “CGE models' algebraic framework results from the imposition of the axioms of producer and consumer maximization on the accounting framework of the SAM“, (Sue Wing, 2004, p. 7).

Based on this approach, general equilibrium can be modelled in terms of barter trade in factors and commodities, “without the need to explicitly keep track of - or even represent - the compensating financial transfers. Consequently, CGE models typically do not explicitly represent money as a commodity“ (Sue Wing, 2004, p. 5). For this reason CGE-models are often said to be real models, in that they generally only solve for relative prices.

To sum up, we can say that in principle CGE-models are numerical illustrations of the Walrasian general equilibrium approach. However, as we will see in the next section these are not confined to simple models of perfect competition. The main equations of the model are derived from the constrained optimization of neoclassical production and utility functions. That is, producers minimise costs of producing outputs subject to constant returns to scale production functions; consumers choose their purchases so as to maximize utility subject to a budget constraint; factors of production are paid according to their marginal productivity. In equilibrium the model's solution is based on a set of prices that clear all product and factor markets simultaneously.

6.1.2 **Applying CGE-models**

Having discussed the broad link between general equilibrium theory and CGE-modelling the next step is to examine the application of CGE models in practice. This involves exploring: how CGE-models typically deviate (to a varying degree) from the stylised Walrasian model world to better handle real life policy issues; the process of CGE-modelling, i.e. their specification, calibration, solution and use for simulation; the strengths and limitations of CGE-models.

In CGE modelling there is an inherent friction in that the model's theoretical underpinning and tractability stems from Walrasian general equilibrium, which imposes some unrealistic assumptions. Yet, the driving force behind CGE-development is policy analysis, which requires the models to capture at least the stylized reality of the policy scenario being analysed. Therefore, some of the theoretical foundations are relaxed for what is perceived to be a more realistic model setup. Robinson (1989) discusses this in the context of models applied to developing countries. He argues that while these models are Walrasian and neoclassical in spirit:

> "most modellers quickly abandoned many of the strong assumptions of neoclassical theory when faced with the problem of capturing the stylised facts characterizing these economies […] modellers have incorporated a variety of "structuralist" rigidities into their models that seek to capture non-neoclassical behavioural relations, macro imbalances, and institutional rigidities characteristic of developing countries" (Robinson, 1989, p. 894).

However, Robinson (1989) also notes that responding to realism by deviating from the neo-classical/Walrasian paradigm, can cause problems of its own. Shoven & Whalley (1984, p. 1046) point out that: "Unfortunately the problem is, the models that make major departures from known theoretical structures can become difficult to interpret". This tension between theory and realism is probably most apparent in the case of models applied to developing countries. However, almost all CGE models deviate from the strict notion of Walrasian general equilibrium. For example, the Government sector is included (Bandara, 1991. p. 12) and labour markets exhibit unemployment. Devarajan & Robinson (2002) provide a retrospective view of the tension between economic theory and perceptions of realism and argue that it has acted as catalyst for intellectual development:

> In the past thirty years, there has been a healthy and productive tension between policy applications of CGE models and developments in theory, econometrics, and data. Sometimes the models have been ahead of the theory, incorporating ad hoc specifications to capture what are considered to be empirically important effects, or to achieve realism in applied models – a good example is the work on structural adjustment models. In many cases, the response of the research community has been to advance the theory, develop new data sources, improve estimation methods, and develop new solvers to meet the needs of modelers. On the other side, theoretical developments in modeling household behavior, dynamics, and the operation of markets are starting to show up in empirical models. With advances in software and computer capacity, the time gap between developing a new theory and implementing it in an empirical model is now quite short, so there is even more scope for productive collaboration between theorists, applied econometricians, and policy modelers. The numbers should get better, the policy debate will be better focused, and the result could be better policies (Devarajan & Robinson, 2002, p. 20).

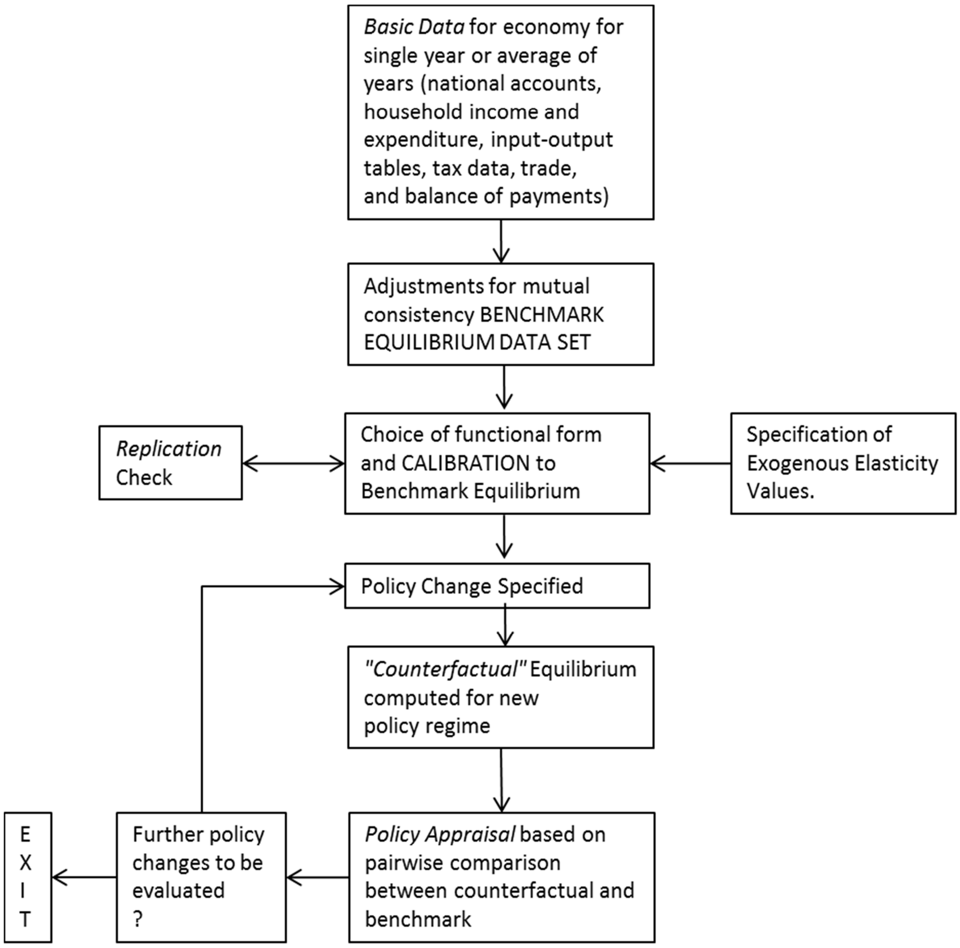
6.1.2.1 The process of CGE-modelling

The policy analysis typically undertaken with CGE models is sometimes referred to as 'counterfactual equilibrium analysis' (Bandara, 1991, p.16). That is, policy analysts compare the status quo (the base solution of the model) to a counterfactual outcome where a key policy parameter has been changed (or a range of parameters may have been changed to invoke a particular scenario). Often in policy simulations modellers are not only comparing the final outcomes of particular changes but also examining the adjustment path. The structure of the model will depend on its intended application. As discussed by Greenaway *et al* (1993, p.19), although CGE's are often based on similar core structures, they are adapted in their level of detail to suit particular applications.

A convenient approach for illustrating CGE models is to describe the modelling process involved in conducting simulations using CGE models. This is for example described in Shoven & Whalley (1984), Shoven & Whalley (1992, Ch. 5) and Greenaway *et al* (1993, Ch. 2). I shall adopt a similar approach by briefly describing the steps involved and the issues that arise at each step.

Figure 59 provides a schematic overview of the CGE modelling process, from database construction and calibration to comparison of outcomes from different simulation scenarios. The first step involves the collection of available data in order to construct the equilibrium dataset (often a SAM) on which the model is calibrated. Typically the various data sources used to construct the benchmark equilibria (e.g. national accounts, Input-Output tables, household surveys) will be inconsistent (e.g. payments to labour by firms will not equal labour income received by households), therefore a number of adjustments are required to ensure that accounting identities hold (Shoven & Whalley, 1984). For the model described in this dissertation this is achieved in the construction of the Social Accounting Matrix (SAM) described in Section 6.3.

Figure 59 Flow chart outlining calibration and use of a typical CGE-model (Shoven & Whalley, 1984, Figure 1, p. 1019).



Once the equilibrium benchmark dataset (in this case a SAM) is ready, this can be used to calibrate the model. That is, model parameters are determined in such a way that the model can be solved to recreate the equilibrium benchmark as its solution. In this regard the calibrated parameters are typically not problematic as such, as they are the constant terms in the relevant equations. However, the required assumption that the chosen benchmark year represents an equilibrium is a stronger condition. The issues involved in calibration are discussed more fully below. However, not all parameter values are determined endogenously via calibration. In general, "key" parameter values (e.g. elasticities of substitution) are specified exogenously. This is required for example when CES functions are used in the model. Typically these values are obtained through searching existing literature for econometric estimates of elasticities.

Another point to make is that if the model fails to recreate base (the replication check) this is an indication of a fault in programming (or possibly the dataset) (Shoven & Whalley, 1984, 1993, Greenaway *et al*, 1993) It should be noted that in addition to the replication check modellers typically apply a host of other tests to affirm that the model behaves as expected, Within the Fraser of Allander Institute these will include for example a homogeneity test (that prices are homogenous of degree zero) and an IO replication test to see if the model converges on an IO solution in the long run.

Once the calibration procedure is completed, a fully specified numerical model is available that is ready for use in policy simulation. A policy change can be specified through changing model values (shocking the model) and have it calculate an alternative equilibrium solution (counterfactual). Policy appraisal is then conducted as a pairwise comparison of the counterfactual and benchmark equilibria (Shoven & Whalley, 1984, 1992). A number of alternative scenarios can be specified and their impact on equilibrium solution calculated, to the extent that is needed to answer the policy question under scrutiny. That completes the summary of the CGE-modelling process.

Before moving on, a short digression on calibration is in order. As Shoven & Whalley (1984) point out, because the models are specified using deterministic calibration rather than stochastic estimation, they are often "troubling to econometricians" (Shoven & Whalley, 1984, p. 1020). However, since models often involve thousands of parameters, which would be extremely difficult to estimate simultaneously using time series methods, the procedure uses the key assumption that the benchmark data represents an equilibrium for the economy under investigation:

> In contrast to econometric work, which often simplifies the structure of the economic model to allow for substantial richness in statistical specification, here the procedure is quite the opposite. The richness of economic structure allows only for a much cruder statistical model that, in

the case of calibration to a single year's data becomes deterministic (Shoven & Whalley, 1992, p. 106).

6.1.2.2 Strenghts and weaknesses of CGE-models

A variety of authors have discussed the strengths and weaknesses of CGE-modelling, such as Kehoe & Kehoe (1994), Greenaway *et al* (1993), Bandara (1991) and Borges (1986). In this section I shall provide a brief overview of CGE modelling for policy analysis. As we will see, this provides the opportunity to probe deeper into some aspects of CGE-modelling, such as dynamics and model closure. However, for a fuller general discussion of the relative strengths of CGE vis-á-vis other modelling approaches see Chapter 4 in Greenaway *et al (*1993).

Greenaway *et al (*1993) argue that the main strength of the CGE approach lies in its microeconomic foundations, i.e. the explicit identification of households' and firms' consumption and production behaviour. Because of this explicit structure the models are able to deal with questions not only of efficiency but also address distributional issues.

Furthermore, CGE is a framework that allows the identification of interdependencies and feedbacks among different sectors and actors in the economic system. Of course this is to some extent the feature of Input-Output and SAM models as well. That is, interdependencies between sectors are identified and a stimulus to a particular sector can be traced through its knock-on effects to other sectors (and to other regions in interregional applications). A critical additional feature of CGE models is that they capture interdependencies and feedbacks not only through demand-side activities but also through the supply-side. That is, in addition to the pure demand effect we have an impact on prices in product and factor markets as well. For example, CGE's can capture Dutch-disease effects that occur as a (temporary) exogenous expenditure shock not only triggers positive demand impacts but also undermines exports through a higher real exchange rate. As Greenaway *et al*

(1993) point out interdependencies and feedbacks have an important impact on output but are in practice difficult to model in anything except a general equilibrium framework. “The very essence of general equilibrium is that 'everything depends on everything else'. […] Clearly, any approach which is partial equilibrium in flavour faces the 'other things being equal constraint'. The CGE approach not only exposes interdependences, it offers a facility for modelling them, if necessary in alternative ways“ (Greenaway et al, 1993, p. 84).

The explicit microeconomic structure of the CGE approach makes the models 'transparent' in the sense that results can be traced back to the model mechanisms that triggered them and be interpreted in light of a well documented economic framework. This tractability is particularly important when CGE simulations provide counterintuitive results. An example of such results are CGE simulations of the economy-wide impact of increased energy efficiency. Contrary to prior expectations CGE-models reveal that under certain conditions increased energy efficiency can actually trigger increased energy consumption in the economy (or at least less net-energy savings than the initial efficiency gain would suggest). This is known as rebound- and backfire effects and occurs if energy efficiency leads to a drop in the effective cost of energy use so that households and firms start substituting energy for other inputs. Obviously the exact outcome depends on production and consumption structures and parameter values. Using extensive sensitivity analysis it is possible to identify the domain of parameter values for which these effects are observed. For an example of the CGE literature on rebound and backfire see Hanley *et al,* (2006, 2009).

Finally, it should be noted that, although data needs are certainly not trivial, compared to the size of the model and other potential approaches, the data-requirements of CGE can be considered relatively light. This has made CGE-models particularly popular in applications to developing countries where sufficient statistical data may not be available (Hosoe *et al,* 2010). Similarly, this can be seen as an advantage at the regional level.

Greenaway *et al* (1993) argue that the main weaknesses of CGE-models stem primarily from two sources: difficulties encountered from parameterising the models on a single year's dataset that is assumed to represent the economy under analysis in equilibrium and the mathematical difficulties inherent in solving a system of many non-linear equations.

As an example of the latter is a criticism of the simple functional forms typically applied in CGE-models. Although, in principle, CGEs can accommodate any functional form conceivable, they are typically restricted to well-behaved functional forms (e.g. Cobb-Douglas, CES) to avoid solution problems. Of course this isn't problematic as long as the chosen functional form is a reasonable approximation of agent's behaviour. Greenaway *et al* (1993) argue that this cannot be verified for each case but that the use of these functional forms reflects an overall judgement that such functions have performed well in econometric studies. To address this weakness modellers typically conduct sensitivity analysis around parameters and functional forms that are deemed to be critical for the simulation result. Again, the explicit structure of the models is a mitigating factor in these circumstances, as the transparency makes it easier to pass a judgement as to what parts of the system should be subjected to most scrutiny in particular applications.

CGE-models are generally considered ill-suited to deal with modelling aspects of monetary and dynamic phenomena (Greenaway *et al,* 1993). CGE's production functions are homogenous of degree zero with regards to prices and therefore money has no real impact in these models. Typically, the models only deal with relative prices and real phenomena. However, there are exceptions to this where CGE models incorporate the role of money and credit, for example Decaluwé. & Nsengiyumva (1994) and Naastepad (2002). Many CGE models are static but can accommodate different conceptual time horizons in their solutions (short run, medium run and long run) where population and capital stock are fixed in the short run but these restrictions are relaxed for the medium run and long run respectively. It is somewhat misleading to talk of CGE models as either static or dynamic as the approaches for introducing dynamism varies. Many CGE-models, including most versions of AMOS, incorporate what is known as recursive dynamics. In these models, consumers and producers exhibit optimising behaviour within any single period, but are myopic. An adjustment path over time is generated as a sequence of static equilibria, where gradual relaxation of factor constraints generates a different outcome in each period. In AMOS these recursive dynamics are driven through the investment and migration functions, as I shall explain in Sections 6.2.3 and 6.2.5. Some models introduce forward looking dynamics where agents exhibit intertemporal optimisation behaviour (e.g. Lecca *et al*, 2010). In these intertemporal dynamic CGE models, economic agents optimise between periods over an infinite time horizon as well as within periods.

A somewhat tricky aspect of CGE-models is their 'closure'. As CGE models are essentially a set of equations that are solved simultaneously, the number of endogenous variables that can be solved for are constrained by the number of independent equations. Therefore, in order to solve the model it has to be 'closed' by determining which variables are to be determined endogenously and which are to be exogenous[128]. This is often achieved by imposing balanced budget, balanced trade or an identity between savings and investments. As Greenaway *et al* (1993) point out simulation results are typically sensitive to the particular closure rule chosen. Dewatripont & Michel (1987) discuss the implications of common closure rules. Essentially, these reflect the modellers judgement as to what is the most appropriate assumption to adopt given the economy being modelled. However, this is not necessarily obvious. As Dewatripont & Michel (1987, p. 68) point out "there is no clear-cut theoretical justification for the choice of a particular closure except modeler's 'general view of the world' and, not surprisingly, there is no agreement on this choice among modeleres". We shall discuss this further in the context of the specific closure rules of the AMOS modelling framework and their appropriateness for the Glasgow economy, presented in the next section.

---

128 For a general discussion of model closures see Chapter 7 in Hosoe *et al* (2010) and Dewatripont & Michel (1987).

6.2 The AMOS modelling framework

In this section I introduce the AMOS CGE-modelling framework, which I shall apply to the economy of Glasgow city. The model is calibrated using a 2006 Social Accounting Matrix for Glasgow. The construction of the SAM is described in Section 6.3. AMOS is an acronym for A Macro-micro Model Of Scotland. The initial single region static version is described in Harrigan *et al* (1991). Subsequent refinements include the introduction of recursive dynamics (McGregor & Swales 1994, McGregor *et al* 1996), an emissions link (Ferguson *et al*, 2005), an interregional variant (Gilmartin *et al*, 2011) and forward looking households (Lecca *et al*, 2010). AMOS has been applied to a range of economies in addition to Scotland, including Jersey (Turner 2002), Chicago and Illinois (Ha *et al*, 2008), Greece (Pappas, 2008), Ethiopia (Gelan 2000, 2002) and Malawi (Hermannsson, 2011). In this section I provide a brief summary of the main features of the framework, including the multi-period variant. Furthermore I discuss its application to Glasgow, how the model is set up to capture features of the urban economy and what assumptions are required to validate the approach. Detailed discussion of the model and underlying algebraic structure are available in Harrigan et al (1991) for the myopic variant and in Lecca *et al* (2010) for the inter-temporal version of AMOS.

Harrigan *et al* (1991) point out that AMOS can be regarded as a modelling framework, as it "encompasses a range of behavioural assumptions, reflected in equations which can be activated and configured in many different ways. In a sense AMOS is more of a modelling environment than a model. It provides a set of templates which transcend any single vision of the operation of markets in a small open regional economy such as Scotland", (Harrigan *et al,* 1991 p.424). Hence, it is a framework that can be applied to any small open regional economy for which the relevant data are available. A full description of the initial AMOS framework, including a listing of the model equations is given in Harrigan *et al* (1991).

As Hermannsson *et al* (2010d) point out, AMOS can be regarded as a fully specified, empirical implementation of a regional, (inter-temporal), general equilibrium variant of the Layard, Nickell and Jackman (1991) model. It has three domestic transactor groups, namely the personal sector, corporations and government; and four major components of final demand: consumption, investment, government expenditure and exports. In this application the model is specified as containing 16 sectors, of which each of the five Glasgow HEI is a separate sector. Financial flows are not modelled explicitly based on the assumption that Glasgow is a price-taker in financial markets. Real government expenditure is exogenous and is determined by the base year calibration.

6.2.1 **Trade**

In the Glasgow version of AMOS, two external transactors are defined: the rest of Scotland (ROS) and the rest of the World (ROW), which includes the rest of the UK. Imports and exports are determined via an Armintgon link (Armington, 1969) where domestic and external products are imperfect substitutes. This specification means imports and exports are relative price sensitive, subject to a trade substitution elasticity[129]. I discuss the specification of the Armington link more fully below, in the context of how the interactions of the Glasgow economy with the external transactors is captured in the model. The default parameter for this elasticity in AMOS is 2.0 based on an estimate by Gibson (1990). However, as I discuss further below, this may not be appropriate for the more open city economy of Glasgow, where you would expect a higher value.

6.2.2 **Production structure**

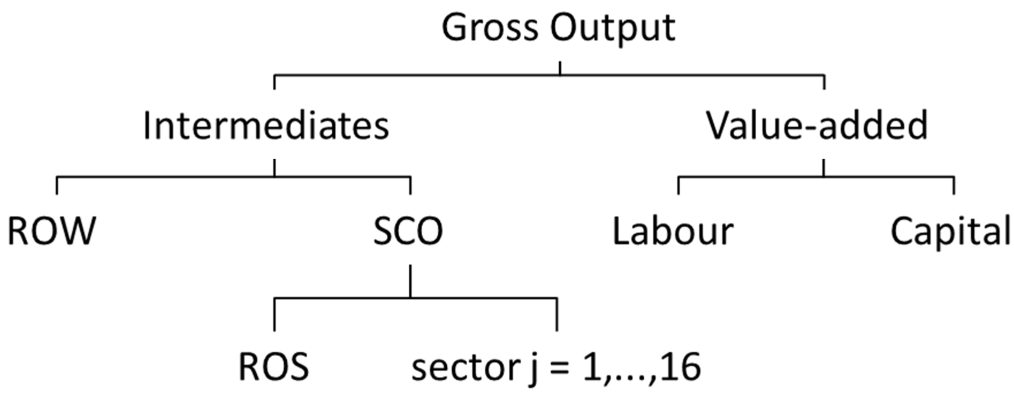
It is assumed that production takes place in perfectly competitive industries using multilevel production functions. This means that in every time period all commodity markets are in equilibrium, with price equal to the marginal cost of production. Value-added is produced using capital and labour via standard production function formulations so that, in general, factor substitution occurs in response to changes in relative factor-prices. Constant elasticity of substitution (CES) technology is adopted here with elasticities of substitution

---

129 For a further discussion of the application of Armington's assumptions for trade in CGE-models see Chapter 6.5 in Hosoe *et al* (2010).

of 0.3 (Harris, 1989). In each industry intermediate purchases are modelled as the demand for a composite commodity with fixed (Leontief) coefficients. These are substitutable for imported commodities via an Armington link, which is sensitive to relative prices. The composite input then combines with value-added (capital and labour) in the production of each sector's gross output. Cost minimisation drives the industry cost functions and the factor demand functions. Figure 60 illustrates the production structure.

Figure 60 Production structure in the 16 sector Glasgow-AMOS model



6.2.3 **Investment**

Investments in AMOS are handled in a variety of ways depending on the model closures selected. The simulations presented in this dissertation are run under the multi period variant, where capital stocks are updated between each period according to a simple capital stock adjustment mechanism. Investment in each period is equal to depreciation plus some fraction of the gap between actual and desired capital stocks, where desired capital stock is a function of commodity output, the nominal wage and the user cost of capital. This capital accumulation process is consistent with a simple theory of optimal firm behaviour, given the assumption of quadratic adjustment costs. Desired capital stocks are driven by cost-minimisation criteria and actual stocks are composed of last period's stocks adjusted for depreciation and investment.

An alternative way of thinking about the capital stock adjustment mechanism, which is useful because capital rental rates are recorded, is to look at the relationship between the capital rental rate and the user cost of capital. As Turner (2002) points out the capital rental rate is the rental rate that would have to be paid in a competitive market for the (sector specific) capital, while the user cost is the total cost to the firm of employing a unit of capital. As the interest rate, depreciation rate and tax rates are exogenously set, the capital price index is the only endogenous component of the user cost. If the rental rate exceeds the user cost, the desired capital stock is greater than the actual capital stock and therefore there is an incentive to increase the capital stock. The subsequent capital accumulation puts downward pressure on rental rates until equilibrium is restored.

6.2.4 **Labour markets**

A distinct feature of the AMOS modelling framework is its flexibility in accommodating alternative labour market regimes. Harrigan *et al* (1991. p. 427) argue that these can be seen as “fairly standard“ but that the novel feature is their juxtaposition within a single framework. Five different labour market regimes are described in Harrigan *et al* (1991), while the sixth option of regional bargaining was added subsequently:

1. Neoclassical, market clearing. Under this setting the labour market clears in every period with real wage adjusting to equate supply and demand, based on a conventional (econometrically parameterised) labour supply function.
2. Keynesian/national bargaining. The nominal wage is set exogenously and the aggregate labour supply function is suspended, with labour supply being infinitely elastic up to the point of full employment. “Such a procedure might be motivated by an institutional view of wage setting in which wages at the UK level are transmitted to Scotland (say through centralised collective bargaining agreements)“ (Harrigan *et al*, 1991, p. 428).

3. Real wage resistance. The real wage is fixed with the nominal wage being a markup on the consumer price index (cpi). Harrigan *et al* (1991) point out that to the extent that this pushes real wages above a market clearing level, this will trigger unemployment, which could be considered involuntary from the individual's perspective. “Some models of union-firm wage bargaining are consistent with real wage resistance type models, but only under fairly extreme conditions (eg government maintenance of full employment)“, (Harrigan *et al,* 1991, p. 428).
4. Regional Philips curve. Under this closure nominal wages are related to a consumer price index and responsive to unemployment. The default specification of the Philips curve in AMOS is informed by econometric work on Scottish data (Harrigan *et al*, 1991).
5. Exogenous labour supply. A fixed proportional relationship exists between employment and working population. This is often used as the labour market closure for national models and was used by Turner (2002) for the island economy of Jersey, where there are both geographical and institutional boundaries that limit the responsiveness of the labour supply.
6. Regional wage bargaining (or bargained real wage). In this setting the regional wage is directly related to worker's bargaining power and inversely related to the unemployment rate. The bargaining function is parameterised using the regional econometric work reported in Layard, Nickell and Jackman (1991).

Generally regional wage bargaining is considered the most appropriate representation of the Scottish labour market and this has become the *de facto* default setting for AMOS. Other closures are often used forensically to investigate the role of the labour market in generating a particular outcome in the multisectoral model.

6.2.5 **Flow migration**

The labour market is characterised by perfect sectoral mobility under all closures and the size of the labour force adjusts through migration. Net migration is seen to be positively related to the real wage differential and negatively to the unemployment rate differential in accordance with the estimated model reported in Layard et al (1991, Ch. 6). The net migration equation employed is:

$$m = \beta - 0.08(u_g - u_r) + 0.006(w_g - w_r)$$

Where m is the net-migration rate – as a proportion of the indigenous population; w_g and u_g are the natural logarithms of the real consumption wage and unemployment rates, respectively, in Glasgow; w_r and u_r are the equivalent values for the rest of the UK. Under medium and long run time horizons net migration flows re-establish zero net-migration equilibrium.

6.2.6 **Applying AMOS to Glasgow**

In the preceding section I describe the generic AMOS modelling framework and list some of its default parameter values. In this section I discuss how the AMOS framework is adapted to the city economy of Glasgow. As is evident from the analyses in Chapters 3 and 5, Glasgow City is not an isolated economic island but exhibits close economic links to the rest of Scotland. A prominent feature of this is the flow of wage payments and consumption expenditures between Glasgow and the rest of Scotland. An ideal simulation framework would be to use an interregional CGE-model to capture the interdependencies between Glasgow and the rest of Scotland in a similar way as exhibited by the 3-region IO-table. However, extending the analysis of HEI impacts to include the role of the supply-side is already a significant enough undertaking to exhaust the time and writing space available for this dissertation. Therefore I chose to illustrate the role of the supply-side impacts of HEIs, using a single region model, leaving further extensions, such as the interregional dimension of HEIs' supply-side impacts, aside for future work.

Partridge & Rickman (1998) point out that early CGE studies made insufficient effort to capture the greater degree of openness of regional economies. This is often solved in multi region models, which tend to have more completely specified interregional linkages, i.e. interregional flow of goods, factors and payments (Partridge & Rickman, 2010). However, Partridge & Rickman (2010, p. 4) argue that more common are "models that simply contain a single atomistic region and an amorphous rest of the world", where the "region usually is assumed to be too small to affect the national or international aggregates. Yet, single-region models can miss important interregional or nation-region feedbacks [...], which are critical for small-region economic development analysis".

Partridge & Rickman (2010) are right to be critical of the 'single atomistic region and an amorphous rest of the world' environment of some CGE models. Fortunately, however, the single region variant of the AMOS framework offers capabilities to accommodate spatial aspects, such as flow migration and the specification of two separate external transactors. Therefore I argue that a single region analysis that is interpreted in the context of available information on interregional flows can provide valuable results for the potential economic impacts of HEIs upon Glasgow City and provide insight into the likely interregional implications.

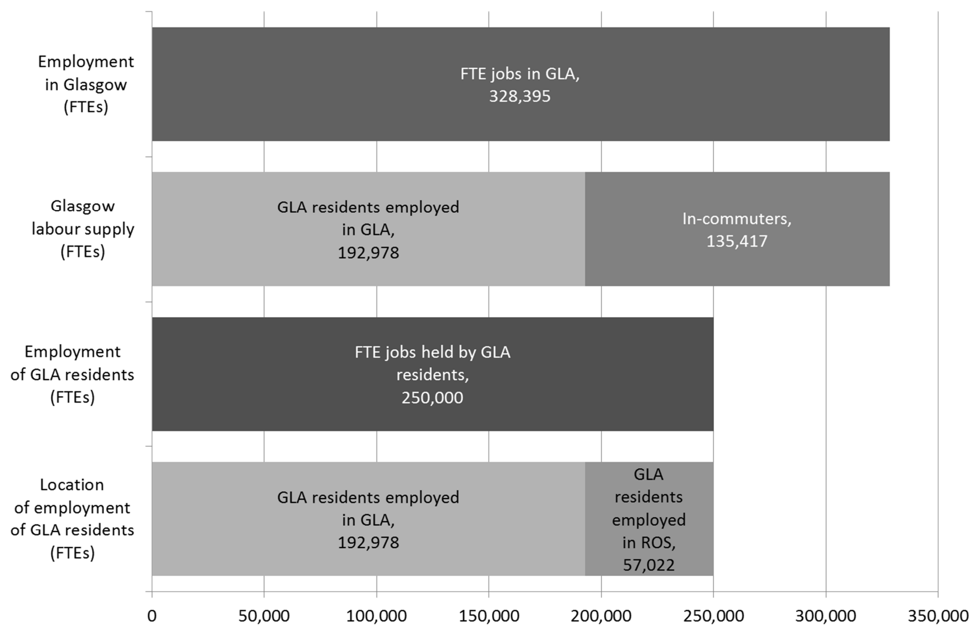
As discussed in Section 3.3.1 Glasgow is the economic centre of a larger metropolitan area, the Strathclyde sub-region. A salient feature of the Glasgow labour market is that it is characterised by significant in-commuting, from the rest of Scotland (primarily from within Strathclyde). Likewise, a number of Glasgow residents seek employment outside Glasgow City Council. This is summarised in Figure 61 below. The top bar shows the total FTE employment in Glasgow. This number is obtained from the 3-region IO table[130].The next bar below shows how jobs in Glasgow are filled by locals (59%) and in-commuters (41%). These figures are also obtained from the IO-table where commuting data was used to disaggregate the labour supply (see Section 3.3.3.3). According to the Scottish Economic Statistics, Glasgow residents hold 250,000 FTE jobs (SES 2006, Table 4.3). This is displayed in the third bar, whereas the bottom

[130] The derivation of IO FTE employment for Scotland is described in Section 3.2.3. The FTEs for each sector are then spatially disaggregated based on headcount data from the Annual Business Inquiry (ABI).

bar shows how Glaswegians in employment are disaggregated into two groups: those working locally within Glasgow (77%) and those commuting out to the ROS (23%).

To summarise there are 31% more jobs in Glasgow than residents in employment. There are gross commuting flows both in and out of the city, with 23% of employment residents filling jobs outside the city. The gross inflow is more than twice that size, or equivalent to 54% of employment in Glasgow. This is modelled here as a net in-commuting flow of 31% of Glasgow employment.

Figure 61 Overview of employment in Glasgow and the employment of Glasgow residents



As the AMOS model is specified with a single unified labour market, in-commuters from the Rest of Scotland are not separately identified in the Glasgow labour market but taken to be part of the labour supply as captured in the base year calibration. Their wage income however, is transferred out of the region. The average FTE worker in Glasgow can therefore be thought of as a composite: 59% local and 41% in-commuter. Based on this, only 59% of the wages paid in Glasgow go towards stimulating household expenditure, as only wages paid to Glasgow households exert a Type-II link, triggering induced intermediate demand. Wages of Glasgow residents working outside the city also drive the final demand expenditures of Glasgow households but wage flows from out-commuters are fixed based on the initial calibration (for details of how external wage flows are determined see Section 6.3.2.1.1.4). Furthermore, (as we saw in Section 3.3.3.3.1.) households in the ROS contribute significant final demand expenditures to the Glasgow economy. These are treated as Glasgow exports to ROS and are therefore relative price sensitive as specified by the Armington link. This is a significant driver of final demand in the Glasgow economy as on average 21% of the export earnings of Glasgow production sectors are sales to households in the rest of Scotland. This varies greatly between sectors, from 0% in manufacturing to 94% for other services.

There are some examples of commuter flows being modelled within a CGE framework. Schwarm & Cutler (2003) and Cutler & Strelnikova (2004) specify changes in commuting from base year as negatively linked to unemployment and positively linked to relative wages. However, they also specify a migration function with similar attributes. Therefore commuting and migration move in conjunction to restore flow equilibrium. The two adjustment mechanisms have the same supply side implications, but diverge in their demand impacts: for the case of commuters their induced consumption remains within their community of residence, whereas migrants directly impact household consumption levels. In the Schwarm & Cutler (2003) model there is no mechanism to determine who migrates and who commutes and hence the relative burden of adjustment depends on parameter values in the base year.

AMOS does not contain an explicit commuting mechanism of this kind. That does not mean that spatial linkages of the labour market are ignored as the model is equipped with a flow migration function. When simulations are carried out with migration on, disturbances in the labour market will trigger in- or out migration through changes in unemployment rates and real wages. Ultimately migration will drive unemployment and real wages to their initial levels to restore flow equilibrium. Given the base year calibration of the model the average additional participant added to the local labour market will impact the city economy as if he were 59% in-migrant and 41% commuter. That is, 59% of his wage will increase income of local households therefore triggering knock-on impacts through induced consumption, while 41% will leak out to the ROS as transfers, as if he were an in-commuter. If the labour market is shrinking the reverse occurs, that is 59% of the reduced wages will result in less household income (and therefore reduce induced consumption), while 41% will not have expenditure impacts upon the Glasgow economy as it would have been transferred out to the ROS anyway.

6.2.6.1 Labour supply data

In Table 23 of Chapter 3.3.3 I report the Full Time Equivalent (FTE) labour employed by each of the 16 production sectors in the base year 2006[131]. This reveals that, in total, employment in Glasgow amounts to 328,395 FTE's. This is sufficient for a demand-driven modelling framework like Input-Output. However, since I want to move to the more flexible CGE-framework with an active supply side, more information is required on supply conditions in the labour market. Therefore I must also know about the structure of the aggregate labour market, such as base year working age population, participation rate and unemployment. There is a further complication in that only a part of those employed in Glasgow are in fact Glasgow residents, as a significant part of the labour supply is provided by in-commuters, mostly from the rest of the Strathclyde area. Unfortunately, developing a CGE-model that actively models the labour market interactions between Glasgow and neighbouring sub-regions is beyond the scope of this dissertation. Therefore, in order to demonstrate my applications I calibrate the standard AMOS framework, effectively imposing linearity assumptions, assuming that in-commuting labour is a fixed proportion of the labour input of Glasgow production sectors.

131 The IO-table was constructed for 18 sectors but in the case of Glasgow two sectors are effectively reduntant: HEIs in RST and HEIs in ROS.

For the following simulations I adopt the bargaining labour market closure. The bargaining function adopted is the econometrically-parameterised relationship identified by Layard *et al* (1991):

$$\ln\left(\frac{W_R}{CPI_R}\right) = a_R - b_R \ln u_r \tag{6.1}$$

where W is the nominal wage rate, CPI is the consumer price index, u is the unemployment ratet, b is an empirically estimated parameter (equal to 0.113 as obtained from Layard *et al,* 1991) and R is a subscript that indicates the region, a is calibrated to ensure that the model replicates the base year data set. According to this specification the bargaining power of workers is inversely related to the unemployment rate so that the lower the unemployment rate the higher a real wage workers can obtain.

The wage equation for Glasgow is then calibrated based on labour statistics drawn from the Scottish Economic Statistics (SES) for the year 2006 (see Table 56). I augment these with my earlier calculations of commuting rates in and out of Glasgow based on the 2001 census.

Table 55 Local residents, commuters and number of FTE jobs in Glasgow.

Labour market variable		FTE's	% of total
Glasgow residents in employment	+	250,000	76%
In-commuters to Glasgow	+	135,417	41%
Out-commuters from Glasgow	-	57,022	17%
Total number of jobs in Glasgow	**=**	**328,395**	**100%**

For the initial state of the Glasgow model I calibrate the Glasgow labour demand on the approximately 328,000 FTE's, which is total labour demand in Glasgow. As we can see from Table 55 above, 41% of the total labour demand in Glasgow is met by in-commuters while 59% is met by local residents. We should also note that the commuting flow is a two way stream, where workers equivalent to 17% of total Glasgow labour demand commute for work outside the city.

Table 56 Glasgow labour market statistics 2006. Based on Scottish Economic Statistics 2006 (Scottish Executive, 2006, Table 4.3, p. 108) and commuting data.

Labour market variable		FTE's
Glasgow residents in employment	+	250,000
Unemployed	+	23,000
Total (local) labour force	=	273,000
In-commuters to Glasgow	+	135,417
Out-commuters from Glasgow	-	57,022
Total (effective) labour force	=	351,395
Non-participants	+	104,000
Effective working age population	=	455,395

6.2.6.1.1 Modelling Glasgow as a standalone labour market

The high degree of commuting implies that the labour market in which the wage is determined is greater than the Glasgow area. In this case I am only modelling changes in the narrow Glasgow City labour market, keeping the influence of the rest of the metropolitan area upon Glasgow constant as captured in base year parameters. A critical task therefore is to calibrate the wage function for Glasgow so as to avoid a biased result from not modelling interactions with the rest of the Strathclyde area. In practice, the two labour markets of Glasgow and the rest of Strathclyde are actively interconnected so that the determination of wages and unemployment in each is affected by the other. Therefore the correct unemployment rate for determining the wage in, let's call it Strathclyde region is:

$$u_S^C = \frac{U_G + U_{RS}}{U_G + U_{RS} + E_G + E_{RS}} \tag{6.2}$$

where the subscripts G and RS stand for Glasgow and Rest of Strathclyde respectively with e_{RS} standing for employment in Glasgow supplied by workers located in RS. The wage in Glasgow will equal the wage in Strathclyde as a whole which is given as:

$$\log w_G = \log w_S = a - b \log u_S^C \tag{6.3}$$

Now what we actually observe as the unemployment rate in Glasgow under these circumstances is:

$$u_G^O = \frac{U_G}{U_G + E_G + E_{RS}} \tag{6.4}$$

The question is: can it be correct to use the observed unemployment rate given in (6.4) in the equation (6.3) to determine the Glasgow wage rate with the value of b unchanged (given that we know that $u_S^C > u_G^O$: that is, the correct unemployment rate for the Strathclyde region is greater than the observed unemployment rate in Glasgow?

Let us assume that there is a fixed relationship between u_G and u_{RS}, so that:

$$U_{RS} = \alpha U_G \tag{6.5}$$

Substituting (6.5) into (6.2) gives:

$$u_S^c = \frac{(1-\alpha)U_G}{U_G + U_{RS} + E_G + E_{RS}} \approx \frac{(1-\alpha)U_G}{U_G + E_G + E_{RS}} = (1-\alpha)u_G^0 \tag{6.6}$$

This works as long as the proportionate relationship works and U_{RS} is small relative to the total Strathclyde labour force.

If (6.6) holds, then substituting into (6.3) gives:

$$\log w_G = \log w_S = a - b \log u_S^C = a - b \log\left[(1+\alpha)u_G^O\right] \tag{6.7}$$

This implies that

$$\log w_G = a - b\log(1+\alpha) - b\log u_G^0 = c - b\log u_G^0 \qquad (6.8)$$

where c is the constant term that is identified when the equation is initially calibrated on the base year labour market data set and equals a-blog(1+a). It is therefore appropriate to use the unaltered wage equation in the simulations and b is the appropriate coefficient on u_G^O.

6.2.6.2 Imports, exports and Armington elasticities

The Armington (1969) approach which treats locally and externally produced goods as imperfect substitutes is commonly adopted in CGE models to reflect the empirical observation of cross-hauling in trade data. Under this approach substitution occurs between locally-produced goods and imports in production. Similarly, transformation occurs between domestic goods supply and exports[132]. The degree of difference/similarity between the local and the external goods is measured by an elasticity of substitution in a CES function. This elasticity is commonly referred to as an Armington elasticity. If the products are significantly different from each other, the Armington elasticity is small, but conversely if the products are relatively close substitutes, the elasticity is large.

McGregor *et al* (1998) simulate the integration of a regional economy by varying the Armington elasticities. As the elasticities increase the model moves towards a law of one price setting, where domestic price changes cease to occur as the domestic firms become price takers in the external markets. McGregor *et al* (1998) vary the Armington elasticities to an upper limit of 9.9, which approximates a 'law of one price' setting and note that higher values start to result in difficulties solving that version of the model.

For the Scottish AMOS model the default value for the trade elasticities is 2.0 (Gibson, 1990). This can be regarded as a relatively low Armington parameter. Higher parameter values are for example suggested for the GTAP model (3.03)

[132] For details see Hosoe *et al* (2010, pp. 98-102).

and the World Bank's Linkage model (4.09) (Anderson *et al*, 2006, p. 392). Given that an Armington elasticity of 2.0 is seen to hold for Scotland it is reasonable to assume that for the more open economy of Glasgow the elasticity will be higher. An alternative is to follow Turner (2002), which selects a higher value of 5 for the Island economy of Jersey. For my base case I adopt an Armington parameter of 5 for the City of Glasgow based on the expectation that exports and imports in and out of Glasgow are more price sensitive than for the larger economy of Scotland as a whole.

6.2.6.3 Investment demands

In the IO-table and the SAM the capital formation final demand categories provide information on which sectors' outputs are used for capital formation. However, these tables contain no information as to where demand for this capital formation comes from. I know about the supply of capital formation but for the purposes of CGE-modelling I also need to know about the demand for capital formation in the Glasgow economy.

In order to obtain a distribution of investment demand across the sectors in the Glasgow economy I draw on information on Other Value Added by sector provided in the IO-table. I assume that each sector's share of overall Glasgow OVA is equal to its share in Glasgow-wide investment demand. In any period the total investment demand is equal to the difference between current and optimal capital stocks, less depreciation, as described in Section 6.2.3. Furthermore, the distribution of investment demand allows me to estimate capital stocks. To this end I assume that investment is equal to depreciation in the base year (where all markets are taken to be in long run equilibrium). Thus, the base year capital stock in each sector is estimated by grossing up investment demands using the depreciation rate for capital – i.e. dividing each sector's investment demand by the depreciation rate, which I assume, in the absence of econometric estimates to be equal to 0.15 in each sector.

6.3 Construction of a Glasgow Social Accounting Matrix and calibration of the CGE-model

In this section I construct a Social Accounting Matrix (SAM) that is used to calibrate the CGE-model applied later in this chapter. The SAM draws on and augments the Input-Output Accounts developed in Chapter 3. Constructing a SAM from scratch, directly from survey-data, is a formidable task typically only left to national statistical offices and large scale international donor agencies such as the World Bank[133]. A less resource intensive alternative, often adopted for the analysis of individual policy issues and the calibration of CGE-models, is to build on an existing IO-table using secondary data-sources to estimate non-production flows. One such construction approach is illustrated by Hosoe *et al* (2010, pp. 41-60). In this dissertation I draw on a method frequently applied within the Fraser of Allander Institute where Income and Expenditure accounts are used to derive the non-production flows needed to convert an IO-table into a SAM. Turner (2002) illustrates this approach for the case of the island economy of Jersey.

Because of data limitations, in some cases the spatial attribution and volume of non-production flows can be difficult to determine precisely. Therefore priority is on estimating as accurately as possible, the transactions that are most likely to influence the results of the CGE simulations based on this SAM. This, for example, applies to the identification of wages transferred into and out of the city, as this is crucial for determining to what extent an impact on value added is retained within the city and to what extent it is transferred out. In some cases where sufficient data are not available and entries are unlikely to significantly influence the functioning of the CGE-model, simple assumptions are adopted. As we will see, this, for example, applies to some small transfers in the household account.

[133] Although there are notable exceptions such the case of Scotland's Western Isles, where a detailed SAM-database has been constructed involving extensive surveying of households and industries.

In the remainder of this section I briefly discuss SAMs generally and show how they relate to IO-tables, before detailing the process underlying the construction of the Glasgow SAM. The broad approach and presentation style adopted here is taken from Turner (2002, pp. 198-222). However, the economy under analysis and the data sources used are different, requiring some different practical solutions.

An Input-Output table gives a sector-by-sector account of the production that takes place within a given year, thereby revealing the composition of Gross Domestic Product (GDP). However, it does not show how the income is distributed among the main transactors who engage in economic activity. For example, we cannot determine from the IO-table how much of the income generated within the local economy actually accrues to the people living within its boundaries and how much accrues to external transactors. Conversely the size of some entries in the IO-table are partly determined by transfers from outwith the region, such as government transfers or investment earnings, although these income flows are not explicitly identified. For example, even if the IO-table gives a quite detailed illustration of the consumption pattern of local residents it does not fully disclose the sources of income. In the case of households the IO-table identifies wage income, which is insufficient to finance total household expenditure. Therefore, we do not know where the additional income comes from, be it from local or external sources, nor do we know how much is saved and invested. In order to model and analyse behaviour in the economy using the CGE-model we need to close the circular flow of income and expenditures in the economy. By constructing the SAM I obtain a comprehensive account of the state of the Glasgow economy in the base year 2006. This can then be used to derive the equilibrium conditions imposed in the CGE model (see Section 6.2).

6.3.1 Structure of the Glasgow SAM

A SAM is similar to an Input-Output table in that rows record incomes and columns record expenditures. They both represent single-entry book keeping, where every entry is recorded both in a row and column. That is, each entry is an item of income for one transactor, while simultaneously being an expenditure for another transactor so that total receipts equal total outlays. Unlike an IO-table, however, a SAM does not just record incomes and expenditures from the sale and purchases of products and services. A SAM also records transfers of income among the identified transactors, such as flow of profits, social security payments and income taxes. The five transactors identified are:

1. Households (H)
2. Corporate (C)
3. Government (G)
4. Capital Formation (I)
5. External (ROS, RUK/ROW and tourists)

Figure 62 below provides a schematic structure of the basic SAM framework that is used as a template for constructing the Glasgow SAM for 2006. The bold capital letters in each of the blocked areas in Figure 62 represent a sub-matrix of cells. Individual elements along the rows identify the income flowing to that transactor identified down the left hand side of the SAM. Correspondingly, these elements represent expenditures by the transactors identified along the top of the SAM. Where a block is empty, so that no letter is shown, this means that no interaction takes place. Where the letter is shown in a standard bold format this means that the data can be taken directly from the IO-table. Where the letter is shown in bold and underlined format additional data are required for the construction of the SAM.

Figure 62 Schematic structure of the basic SAM for Glasgow, 2006

Expenditure by / **Income to**	Production activities (the I production sectors)	Institutions H C G I E	Factors of Production: Labour (L), Capital (K)	Row totals:
Production activities	**T**	**U**		
Institutions H C G I E	**V**	**W**	**X**	
Factors of Production: L, K	**Y**			
Column totals:				

Production sectors are identified using the subscript i (where i=1,...,I), institutions/aggregate transactor groups by a (where a=1,..,A) and factors of production by b (where b=1,…,B). Therefore:

- **T** is an I×I matrix of intersectoral transactions between the I production sectors of the economy. This sub-matrix **T** is identical to the intermediate transactions quadrant in an IO-table.
- **U** is an I×A matrix of final demand expenditures by the A institutional transactors identified above on the outputs of the I local production sectors. The entries for sub-matrix **U** are given by the final demand block of the IO-table (the aggregate transactor 'Corporate' is not a final demander so all the column entries for C in matrix **U** are equal to zero).
- **V** is an A×I matrix of income flows from the I production sectors to the A institutional transactors. In the Glasgow SAM the only positive elements of sub-matrix **V** are payments from production sectors to the non-tourist external (E) transactors in the form of purchases of imports and net commodity taxes paid to Government (G). These entries are obtained from the IO-table.
- **W** is an A×A matrix of income transfers between the A institutional transactors. Data can be taken from the IO-table on import purchases

from the external sector by each of the institutional transactors (except 'Corporate', where import purchases are already recorded for each individual production sector in **V**) and net commodity taxes paid to Government (again with the exception of 'Corporate'). Data requirements for the remaining elements of sub-matrix **W** are additional to the IO-table – these are detailed individually in the following subsections on the construction of the income-expenditure accounts.

- **X** is an A×B matrix of factor income payments to each of the aggregate transactors based on factor services supplied. The total factor income payments are the totals of the 'other value-added' and 'income from employment' rows of the IO-table. However, these totals must be attributed to the relevant transactors. As we know from the IO-table, Glasgow households only provide a part of the labour services used by Glasgow production sectors so only wages accruing to Glasgow-households are counted as payments to labour. Wages to households in the rest of Scotland are transferred to the external sector. 'Other value-added' (payments to capital) are allocated based on the ownership of production sectors by the three aggregate transactors Households, Government and Corporate. Share of 'other value-added' accruing to foreign owners are transferred to the external sector.
- **Y** is a B×I matrix of payments to value-added/factors of production by each of the I production sectors. Sub-matrix Y is identical to the 'income from employment' to Glasgow households and 'other value added' rows of the IO-table.

6.3.2 **Additional data requirements and construction process**

The additional data requirements for the SAM are mainly concentrated in sub-matrix ***W***, i.e. transfers of income between the 5 main transactors: Corporate, Government Households, Capital Formation and External. The only other additional piece information required is for sub-matrix ***X***: the share of other value added going to the corporate (privately operated firms), government (publicly held companies) and households (firms operated by self-employed owners). Since all the entries that require additional data to that provided by the IO-table are contained within the rows and columns of the five aggregate/institutional transactors, it is possible to deal with all these data gaps by constructing a set of income-expenditure accounts for each transactor.

In the remainder of this section I construct the income-expenditure accounts for Glasgow in 2006 in such a way that these are sufficient to meet all additional data-requirements for constructing the SAM. I achieve this by ensuring that each missing entry in the framework illustrated in Figure 62 is included as an item in the appropriate account. Furthermore, completing a set of internally consistent income-expenditure accounts means that I also automatically balance the SAM. Balancing is constrained by the fixed IO entries and it is therefore convenient to manually balance the SAM on the basis of the additional entries in the income-expenditure accounts alone.

In constructing the income-expenditure accounts I begin with the three local transactors – households, government and corporate – for which data are more readily available from existing published sources.

Table 57 Income-expenditure accounts – Glasgow 2006 (£ million)

Households					
Income	**10,738**	HA	**Expenditure**	**10,738**	HA
Income from employment	5,662	IO	IO expenditure	6,520	IO
Profit income (OVA)	766	HA	Payments to corporations	613	RE
Income from corporations	770	RE	Payments to government	3,011	HA
Income from government	2,172	HA	Payments to capital	319	EST
Transfers from ROS	597	EST/RE	Transfers to ROS	137	HA
Transfers from RUK/ROW	770	RE	Transfers to RUK/ROW	137	HA
Government					
Income	**9,135**	EST	**Expenditure**	**9,135**	EST
Profit income (OVA)	530	EST	Final demand (IO) expenditure	5,578	IO
Net commodity taxes	1,691	IO	Payments to corporations	560	RE
Income from households	3,011	HA	Payments to households	2,172	HA
Income from corporations	1,470	EST	Transfers to RUK	659	EST
Income from ROS/RUK	2,432	RE	Payments to capital (savings)	166	EST
Corporate					
Income	**5,665**		**Expenditure**	**5,665**	
Profit income (OVA)	3,918	EST	Payments to households	770	RE
Income from households	613	RE	Payments to government	1,470	EST
Income from government	560	RE	Transfers to ROS	588	EST
Income from ROS	172	RE	Transfers to RUK/ROW	1,371	EST
Income from RUK/ROW	402	RE	Payments to capital (savings)	1,466	EST
Capital					
Income	**1,635**		**Expenditure**	**1,635**	
Households	319	EST	IO expenditure	1,635	IO
Corporate	1,466	EST			
Govt	166	EST			
ROS/RUK/ROW	-317	RE			
External					
ROS income from Glasgow	**5,730**		**ROS expenditure in Glasgow**	**5,211**	
Goods & Services	929	IO	Goods & Services	3,225	IO
Transfers	4,801	HA/EST	Transfers	1,986	RE
RUK/ROW income from Glasgow	**10,428**		**RUK/ROW expenditure in Glasgow**	**10,767**	
Goods & Services	8,261	IO	Goods & Services	8,378	IO
Transfers	2,167	HA/EST	Transfers	2,389	RE
			Tourist expenditure in Glasgow	498	IO
Total income	**16,158**		**Total expenditure**	**16,476**	
			Surplus/deficit	-317	

Data sources:	IO: Input-Output table HA: Household Accounts EST: Estimated based on secondary data sources RE: Residual

To create a SAM for the Glasgow City Council area the Glasgow Input-Output table, obtained as part of the 3-region IO-table constructed in Section 3.3, is combined with data available at a sub-regional level to create Income-Expenditure accounts as a basis for a SAM.

The Income-Expenditure accounts are presented in Table 57. Following each entry is an abbreviation indicating the method used to obtain that entry. Many important entries can be taken directly from the Glasgow Input-Output table (these are indicated by the abbreviation IO). Secondly, much information about household incomes and expenditures (including household exchanges with other transactors) was obtained from the ONS's household accounts, which I describe more fully below. The abbreviation for these entries is HA. Note that the income- and expenditure totals are marked with HA to indicate that these were obtained as control totals from the household accounts. The entries labelled EST are estimated by drawing on a range of secondary data sources (as is described below in more detail for each entry). Finally the entries labelled RE are determined as a residual based on the accounting constraint Income = Expenditure. It should be noted that a number of entries are in fact 'endogenous' to the accounts. For example household payments to government equal government income from households. Once household payments to government have been determined in the Household Account, they enter automatically on the income side of the Government accounts. This is particularly relevant for the Corporate Account. Since very limited data is available to determine non-production flows of corporations at the regional level most of the income side of the corporate account is determined as expenditures by other transactors.

In the Glasgow Income-Expenditure accounts transactions with the external sector are allocated to two locations the Rest of Scotland (ROS) and the Rest of World (including the rest of the UK) (ROW). There are two reasons why I identify the rest of Scotland separately as an external transactor. Firstly, there is a qualitative difference between ROS and ROW, as flows to and from ROS include inflows of consumption demand and outflow of wage payments. Secondly, I want to be able to simulate shocks originating from the ROS.

Scotland-wide employment, population, other value added and household income data are used to apportion values in the Income-Expenditure accounts between the sub-regions Glasgow and the Rest of Scotland. These numbers are summarised in Table 58 below. Employment in Glasgow as a portion of overall employment in Scotland (17.2%) is obtained from the labour force survey via NOMIS, the Office for National Statistics' portal for accessing official labour market statistics. Population data from Table 4.1 of the 2006 SES (Scottish Executive, 2006) reveals that Glasgow City Council contains 11.36% of the population of Scotland. Comparing the Glasgow stand-alone IO-table to the Scotland-wide IO table reveals that Glasgow production sectors contribute 18.04% of total OVA in Scotland. The ONS's Regional Household Accounts reveals that 10.39% of Gross Disposable Household Income (GDHI) in Scotland can be attributed to Glasgow households. Furthermore analysing sectoral employment data from the Annual Business Enquiry (ABS) reveals that 17.95% of all public sector employment in Scotland is contained within Glasgow.

Table 58: Some indicators of the Glasgow economy relative to the economy of Scotland as a whole.

Glasgow's share of:	%	Source
Scottish FTE jobs	17.18%	Annual Business Enquiry (via NOMIS)
Scottish population	11.36%	2006 SES (Scottish Executive, 2006)
Scotland's GDHI	10.39%	ONS household accounts
Public sector employment in Scotland	17.95%	Interregional IO
Scottish OVA	18.04%	Interregional IO

In the remainder of this section I shall discuss individual entries in the income-expenditure accounts presented in Table 57 and how they are derived. I shall proceed step-by-step, starting with a discussion of the household account, followed by the government account, the corporate account, the capital account and the external account. For each account I first discuss the individual items on its income side and then proceed to discuss its expenditure side before moving on to the next account. After presenting the completed SAM I discuss the collection of additional data needed to calibrate a CGE-model for Glasgow.

6.3.2.1 The Household Account

The household account is constructed first as this account is typically the one for which information is most readily available. A particularly useful resource is the ONS's household income accounts. Table 59 below is based on the ONS's household accounts.

Table 59 Glasgow Gross Disposable Household Income by components, 2006 (£m)

Resources	**£ m**
Compensation of employees	6,100
Operating Surplus/Mixed Income	926
Property Income	1,042
Primary resources total	**8,067**
Imputed social contributions/Social benefits other than social benefits in kind	2,172
Other current transfers	499
Secondary resources total	**2,670**
Sum of primary and secondary resources	**10,738**
Uses	
Property income	502
Primary uses total	**502**
Current taxes on income, wealth etc	1,305
Social contributions/Social benefits	1,706
Other current transfers	275
Secondary uses total	**3,286**
Sum of primary and secondary uses	**3,788**
Gross Disposable Income	**6,950**

Table 59 above gives a broad breakdown of what constitutes the GDHI of Glasgow households[134]. This is a key source for constructing the household

[134] The ONS household accounts provide a detailed breakdown of Gross Disposable Household Income (GDHI) at a NUTS 2 level. To obtain a detailed breakdown for Glasgow I use GDHI at a NUTS 3 level to disaggregate household incomes and expenditures for South-West Scotland (NUTS 2 region) into Glasgow and the rest of South West Scotland. This implicitly assumes that the

component of the SAM as it identifies households' incomes from wages, transfers and asset income. Furthermore it reveals the primary and secondary uses of households, which constitute property income paid, taxes on income and wealth and current transfers. The derivation of individual items in the account follows subsequently for household income and expenditure and their sub-components.

6.3.2.1.1 Household income

6.3.2.1.1.1 Household income: Income from employment

Glasgow households' income from employment can be obtained directly from the Glasgow IO table for 2006. This amounts to £5,662.00 million and is taken from the sum of the compensation of employees resident in Glasgow row from the IO-table[135]

As is detailed in Chapter 3, commuting data was used to determine the amount of compensation of employees from Glasgow production sectors accruing to workers of different origin, i.e. those residing in Glasgow as well as those residing in other parts of Scotland. Because of this I also know the amount of wage income accruing to residents in Glasgow from elsewhere in Scotland (as will prove useful for determining transfers from the external sector in sub-section 6.3.2.1.1.4 below). The amount of compensation of employees paid by Glasgow production sectors to workers residing elsewhere in Scotland is captured in the external account, as I discuss further in Section 6.3.2.5.

6.3.2.1.1.2 Household income: Profit income

I take the share of total profits transferred to Glasgow households to consist of payments to OVA in firms that are owned and operated by self-employed persons. This figure is derived from the regional household income accounts

---

composition of incomes is the same in Glasgow as elsewhere in South West Scotland. This is of course an imperfect assumption, but the most accurate one available. Based on this I can add up the income categories to reveal that the total income of Glasgow households in 2006 was £10,738 million. This provides a useful control total.

135 This does not equal compensation of employees in Table 24 above, as that figure also includes the wages of Glaswegians earned outside the city. Earnings of in-commuters living outside Glasgow are transferred to the Rest of Scotland.

published by the ONS. Total profits transferred to Glasgow households are equal to the income category 'Operating Surplus/Mixed Income' (£926m). However, a number of sole proprietors might be working outside the city and their profit income should be accounted for through transfers from ROS. Therefore, I use the share of Glaswegians working within the city (83%) as a proxy for the share of sole proprietors working within the city. Once this adjustment has been made I estimate the profit income of Glasgow households as £766m.

6.3.2.1.1.3 Household income: Payments from government

The payments from government are obtained from the ONS's household income accounts. These accounts report household income at a quite aggregated level. Payments from government are identified as consisting of the category: 'Imputed social contributions/Social benefits other than social benefits in kind'. This amounts to £2,172 million.

6.3.2.1.1.4 Household income: Payments from corporations and the external sector

Based on the three entries above (income from employment, profit income and payments from government) I have been able to attribute £8,600m of household's income using the ONS's household accounts. This amounts to 80% of their income. Furthermore, there are two more elements that I know constitute transfers from the ROS:

- Wages of Glasgow residents working outside the city. This is calculated as the difference between the compensation of employees reported in the ONS's household accounts and the compensation of employees paid by Glasgow production sectors to Glasgow residents as derived in the IO-table. This amounts to £6,100m - £5,662m = £438m.
- The difference between OVA transferred to Glasgow households from Glasgow based activities (as estimated in section 6.3.2.1.1.2 above) and the total 'Operating Surplus/Mixed Income' as reported in the ONS's household income accounts. This represents the OVA transferred to Glasgow residents from activities outside the city (assumed for

simplicity to be confined to the ROS) and is calculated as £926m - £766m = £160m.

- Based on the aforementioned I have already allocated £598m (£438m + £160m) to Glasgow households as transfers from the ROS.

Having thereby allocated £9,198m of household income leaves a residual income of £1,541m or 14.3% of total household income that needs to be allocated. As I have already made full account of any income from employment, OVA or the government, this residual must represent property income or some external non-government transfers. The question is, to what extent does this income originate from corporations (dividend payments from Glasgow firms) or transfers from the external sector (ROS and ROW). Unfortunately there is no data available that permits a precise attribution of this income residual. Therefore, in the absence of better information, I choose to apportion it in equal parts among the three transactors: Corporations, ROS and ROW

6.3.2.1.2 Household expenditures

6.3.2.1.2.1 Household expenditures: IO expenditures

Final demand expenditures by households are obtained from the Glasgow IO-table. This amounts to £6,987 million.

6.3.2.1.2.2 Household expenditures: Payments to corporations

This item constitutes transfer payments from households to corporations in the form of rents, interest payments or any other miscellaneous payments. This is difficult to estimate due to data constraints and is therefore treated as the balancing item in the household account. This figure is estimated at £613m.

6.3.2.1.2.3 Household expenditures: Payments to government

Payments by Glasgow households to government are based on two entries in the household income accounts:

- 'Current taxes on income, wealth etc.' (£1,305 million)
- 'Social contributions/Social benefits' (£1,706 million)

This gives a total household payment to government of £ 3,011 million.

6.3.2.1.2.4 Household expenditures: Payments to the external sector

Payments from Glasgow household to the external sector are taken to equal 'Other current transfers' (£275m) reported in the secondary uses of the Glasgow household accounts (Table 59 above). In the absence of more detailed information I assume this is split equally between the ROS (£137m) and RUK/ROW (£137m).

6.3.2.1.2.5 Household expenditures: Payments to capital

This entry is estimated by allocating a proportion of total household income as investments/payments to capital using the household savings rate. The UK-wide household gross savings rate for 2006 is 3.0% (obtained from Table 6.1.6 p. 209 in the 2009 Blue Book). This gives a figure of £319m for household payments to capital.

6.3.2.2 The Government Account

In the context of Glasgow, it is somewhat awkward to interpret the 'Government' as a single transactor. In this city context the boundaries of the government are somewhat unclear and effectively the government account shows an amalgamation of the activities of the Glasgow City Council, the Scottish Government and the Westminster Government that take place within the boundaries of Glasgow City. Additionally, as I discuss further in Section 6.3.2.2.1.5 below, there isn't a direct link between government income and expenditures in Glasgow as the bulk of government revenue obtained from the city economy is collected by H M Revenues and Customs and then a separate mechanism is used to transfer central government funds to the Scottish Government and the Glasgow City Council.

Before proceeding to describe how the individual entries of the Government account are determined I shall explain how I derive total government expenditure in Glasgow, which I use as a control total. First I estimate total government expenditure in Scotland and then use Glasgow's share of government employment in Scotland (17.95%) to apportion it a share. Total government expenditure in Scotland is found as the sum of three elements from Public Expenditure Statistical Analyses (PESA) (HM Treasury, 2007).

1. Total identifiable expenditure in Scotland (£43,076 million)
2. Estimated non-identifiable expenditure (£5,798 million)
3. Other estimated expenditure (£2,008 million)

That is, I use total identifiable expenditure within the boundaries of Scotland in addition to the Scottish population's share of UK-wide non-identifiable and other expenditures. This process is detailed below.

As defined in PESA, Identifiable expenditure is expenditure that can be recognised as having been incurred for the benefit of individuals, enterprises or communities within particular regions. Examples of expenditures in this category would be most health, education and transport services, in addition to spending on social security and pensions. Total identifiable expenditure in Scotland is obtained as an annualised value of the Total Identifiable Expenditure (PESA, Table 9.1) for 2005-06 and 2006-07 for services in Scotland.

Non-identifiable expenditure is expenditure that cannot be attributed to particular regions because it is deemed to be incurred on behalf of the United Kingdom as a whole, e.g. defence expenditure, overseas aid and tax collection. To derive Scotland's share of non-identifiable expenditure I use Scotland's share of UK-wide population. The UK value of non-identifiable expenditure is again taken from PESA Table 9.1.

Other estimated expenditure takes Scotland's share of the difference between total identifiable plus non-identifiable expenditures and Total Managed Expenditure, taken from PESA Table 9.1 as well – again using Scotland's share of UK-wide population. These three calculations provide us with the control total for Scotland's government expenditure account for 2006 - £50,881million. By using Glasgow's share of public sector employment in Scotland (17.95%) I estimate that £9,135 is therefore attributable to the government account in Glasgow.

6.3.2.2.1 Government Income

6.3.2.2.1.1 Government income: Profit income (OVA)

This entry is estimated based on the Glasgow Input-Output table for 2006. I take income from Other Value Added (OVA) to be the sum of OVA from the public sectors in the 2006 IO table for Glasgow. The sectors classified as "public" in this case are water (SIC 87), Public Administration (115), Education (other than HEIs) (116), Health Services (117), Social Work (118) and Sanitary Services (119). Government profit income (OVA) amounts to £530m.

6.3.2.2.1.2 Government income: Net commodity taxes

The payment of net commodity taxes in Glasgow can be obtained directly from the Glasgow IO-table. This amounts £1,691m.

6.3.2.2.1.3 Government income: Payments from households

This entry is obtained directly from within the income expenditure account. Payments from households to government amount to £3,011 million. This is equal to the payments to government entry in the household expenditure account.

6.3.2.2.1.4 Government income: Payments from corporations

This entry is obtained directly from within the income expenditure account. Payments from corporations to government amount to £1,470 million. This is equal to the payments to government entry in the corporate expenditure account.

6.3.2.2.1.5 Government income: Transfers from the external sector

Looking at the government account in the context of Glasgow there isn't a direct link from 'government' income to 'government' expenditures. The explanation for this lies in particulars of the boundaries between particular levels of government in the UK. Tracing income from the bottom up, local authorities in Scotland, like Glasgow City Council, only collect limited taxes but rely significantly on funding from the Scottish Government. The Scottish Government, in turn, does not collect taxes, as the central Westminster government collects taxes in Scotland and supplies the devolved Scottish Government with a block grant. Therefore any income shortfall on the Glasgow government accounts has by definition to be offset by a transfer from either the rest of Scotland, the rest of the UK, or both. Therefore, I treat transfers from the rest of the UK/ROS as a balancing entry in the government income account.

This amounts to £2,502m, which I apportion to ROS and RUK in equal measure, in the absence of more detailed information.

6.3.2.2.2 Government expenditure

6.3.2.2.2.1 Government expenditure: Final demand expenditure

This entry is obtained directly from the 2006 Glasgow Input-Output table, where final demand expenditure by government equals £5,111m.

6.3.2.2.2.2 Government expenditure: Payments to corporations

The value of government's payments to corporations is very difficult to estimate, and is obtained as a balancing entry in the government expenditure account.

6.3.2.2.2.3 Government expenditure: Payments to households

This entry is obtained directly from within the income expenditure account. Payments from government to households amount to £2,172 million. This is equal to the income from government entry in the household income account, where it is determined based on the ONS household accounts.

6.3.2.2.2.4 Government expenditure: Payments to the external sector

Government payments to the external sector relate to transfers to the rest of the UK. Following established convention I estimate these first for Government in Scotland as a whole and then use Glasgow's share of Scotland-wide population (11.36%) to apportion the share of these transfers that accrue to Glasgow. Using information published in GERS, Scottish government payments to the rest of the UK are taken to be equivalent to Scottish population share (8.44%) of non-identifiable government expenditure annualised for the year 2006. The value here is therefore £5,798million. Of this Glasgow's share is £659m.

6.3.2.2.2.5 Government expenditure: Payments to capital (savings)

Payments to capital by the government would ideally be the balancing entry in this account. However, given the problems with estimating government's payments to corporations, I need to estimate government savings directly. I use the share of 'Public sector' OVA of total OVA in the Glasgow IO-table as an indicator of the Government's share of investment demand. As I do not have direct information on investment demand from local sectors I assume it is equal to total final demand from capital formation. The Government's share of total OVA is 10.17% and total final demand from capital formation is £1,636.4 million. Therefore I estimate Government payments to capital as 10.17% thereof, or £166 million. Effectively I am estimating government's final demand for capital formation and assuming that this government investment equals government saving.

6.3.2.3 The Corporate Account

The Glasgow corporate account is particularly difficult to specify accurately due to lack of relevant data. Hence many transactions to and from corporations have to be determined as residuals. This is obviously disappointing from an informational point of view but is not necessarily detrimental to the use of the SAM for CGE modelling purposes. In the simulations that follow I am concerned with economic impacts rather than distributional aspects. The corporate account is essentially a distributional mechanism allocating the profit income and inbound transfers of the corporate sector to local and external actors. It does not contain any direct links to expenditures such as wage payments or purchases of intermediate goods. Payments to households indirectly affects household's consumption. However, payments to government are independent of government's consumption since (as we discussed in 6.3.2.2.1.5) government expenditures are not linked to government income in the model. Similarly, investment is independent of savings in the CGE-model so corporate savings do not influence investment levels.

6.3.2.3.1 Corporate income

6.3.2.3.1.1 Corporate income: Profit income (OVA)

Profit income (OVA) accruing to corporations is derived from the Glasgow IO table. This is determined as the total OVA for all sectors from the 2006 GLA IO table, less OVA in the government and household income accounts. I have discussed in the relevant section above the way in which I have attributed OVA to each of these accounts. This results in a figure for OVA in the corporate account of £3,625m.

6.3.2.3.1.2 Corporate income: Income from households

Income from households is obtained directly from the corresponding entry in the household accounts (payments to corporations) where it is determined as a residual. Corporate income from households equals £613m.

6.3.2.3.1.3 Corporate income: Income from government

This entry is obtained directly from within the income expenditure account. Corporate income from government amount to £560m. This is equal to the payments to corporations entry in the government expenditure account, where it is determined as a residual.

6.3.2.3.1.4 Corporate income: Transfers from the external sector

There are likely to be large flows between the corporate and external accounts as Glasgow firms receive profits from operations elsewhere and Glasgow branches transfer profits to their headquarters. However, it is difficult to estimate these flows without engaging in primary data collection, such as a detailed survey of Glasgow businesses. From an informational point of view it is desirable to know these profit flows in and out of the region. From a modelling perspective, however, these accounting transactions in and out of the corporate account are not important as such, but rather how much profit is retained within the local economy through dividend payments and taxes. This has already been established. I already know the asset income of households through the household survey and I know how much is paid from the Corporate account to the Government account as taxes (although as discussed in 6.3.2.2.1.5 in the Glasgow case there isn't a direct link from Government income to Government expenditures).

As the external income of the corporate sector does not directly influence modelling results and since data are not available to estimate it, I simply determine this entry as the difference of total corporate income and total corporate expenditures. This amounts to £575m. Effectively, instead of attempting to estimate the gross inflow from the corporate sector to the external sector I determine the net outflows to the external sector as a balancing entry, as the total expenditure of the corporate sector must equal its income. Of this residual I attribute 30% to the ROS and 70% to the ROW.

6.3.2.3.2 Corporate expenditures

6.3.2.3.2.1 Corporate expenditures: Payments to households

Corporate payments to households are obtained from the corresponding entry in the household accounts (income from corporations) where it is determined as a residual. Corporate payments to households equal Corporate payments to households equal £770.

6.3.2.3.2.2 Corporate expenditures: Payments to government

To determine corporations' payments to government I use the Government Expenditures and Revenues In Scotland (GERS) publication to estimate corporate payments to government in Scotland and then use Glasgow's share of Scotland-wide OVA (18.04%) to determine the city's corporate sector's share of payments to government.

This is the same as the payments from corporations figure in the income side of the government account. The figure is made up from a series of different corporate taxes: corporation tax, windfall tax, insurance tax premium, landfill tax, non-domestic rates, other taxes and royalties, and interest and dividend payments. To provide information on the taxes raised in Scotland, I examine the individual taxes supplied in GERS Table 4.1 for 2006-07. For Scotland as a whole these payments of Corporations to Government are amount to £8,151million. Thereof I attribute £1,470million to Glasgow City.

6.3.2.3.2.3 Corporate expenditures: Payments to the external sector

Following convention established in similar income-expenditure accounts constructed for Scotland, I assume that 50% of Other Value Added (OVA) is repatriated. Of the amount repatriated from Glasgow, I assume that 30% of this goes to the rest of Scotland, and 70% to the rest of the World and the rest of the UK. This suggests that £544 million is repatriated to the rest of Scotland, and £1,269 million repatriated to the rest of the UK and the rest of the World.

6.3.2.3.2.4 Corporate expenditures: Payments to capital (savings)

For the payments to capital entry in the corporate account I assume that for Glasgow corporations, savings equal investments. Investments in this case are determined as the private sector's share of final demand for capital formation. This amounts to £1,466m. Although S=I is assumed to hold for the base year calibration of the model it should be noted that in the model specification (as reported in Section 6.2) investments are determined independently of savings as Glasgow is assumed to be well integrated into capital markets.

6.3.2.4 The Capital Account

Receipts to the capital account consist of savings from the household, government, corporate and the external accounts. Capital expenditures are gross fixed capital formation and stock building, which are determined in the IO table for Glasgow in 2006. The extra information required for the income part of this account comes from the payments to capital values in the expenditure sections of the household, government and corporate accounts I have already constructed.

6.3.2.5 The External Account

Income from the sale of goods and services in Glasgow by each of the external transactors are given in the import rows in the IO table. Similarly, the export expenditure columns in the IO-table give expenditure on Scottish goods and services by each external transactor. The additional items to account for in the SAM are transfers of income in both directions – i.e. between corporations, households and government, and each external transactor. An important consideration here is that I treat the IO rows depicting compensation of employees paid by Glasgow production sectors to in-commuters living elsewhere in Scotland as transfers to ROS. Other transfers have all been accounted for in the government, corporate and household accounts detailed above.

The only items I have to account for are savings by external transactors in Glasgow in terms of the trade balance: if the income earned by an external transactor in Glasgow exceeds its expenditures (i.e. it runs a trade surplus with Glasgow) this amounts to positive savings by the transactor in the city. Conversely if an external transactor spends more than it earns in Glasgow (i.e. it runs a trade deficit with Glasgow) this amounts to negative saving, or borrowing, by the transactor in the Glasgow economy. The external income-expenditure account shows the aggregate balance for all transactors with Glasgow. This is a negative number, showing that the rest of the world as a whole runs a balance of payments deficit with Glasgow and effectively borrows rather than saves in Glasgow. However, Glasgow does not run a surplus in its interactions with all external transactors. Glasgow maintains balance of payments deficit vis-á-vis the ROS. Although the trade balance is positive, significant outflow of wages renders the overall balance of payments negative. On the other hand Glasgow maintains a small balance of payments surplus with the RUK/ROW. This holds both for trade flows and transfers.

6.3.2.6 The Glasgow SAM for 2006

All the new entries required for completing the SAM for Glasgow in 2006 can be taken directly from the balanced set of income-expenditure accounts. Therefore the method ensures that no further balancing is necessary.

Table 60 Glasgow SAM 2006 (£ million)

IO data | SAM data

			Production activities																Institutions / Aggregate transactors				Capital formation (I)		External (E)			Factors of Production: Labour (L)	Capital (K)		
		Sectors / Transactors	Primary and utilities	Manufacturing	Construction	Distribution and retail	Hotels & catering	Transport, post, communications	Banking and financial services	House letting and real estate	Business services	Public sector	Other services	Caledonian	GSA	Glasgow	RSAMD	Strathclyde	Households	Corporate	Government	Net Commodity Taxes	Capital	Stocks	Tourist expenditure	Exports to ROS	Exports to RUK/ROW	Income	Value Added	Income totals	
Production activities		Primary and utilities	171	122	10	11	4	5	9	1	10	22	3	0	0	2	0	1	188	0	1	0	7	2	1	44	577	0	0	1,191	
		Manufacturing	12	171	41	37	10	24	30	3	44	58	6	4	1	13	0	9	252	0	0	0	90	5	11	2	2,669	0	0	3,492	
		Construction	13	8	218	10	1	7	64	167	8	65	4	2	0	7	0	5	30	0	0	0	762	5	0	10	172	0	0	1,559	
		Distribution and retail	18	105	21	24	5	22	38	5	31	23	5	0	0	1	0	1	1,212	0	1	0	47	0	46	513	297	0	0	2,417	
		Hotels & catering	1	1	0	17	1	4	13	1	4	22	1	0	0	1	0	0	286	0	0	0	0	0	159	153	30	0	0	694	
		Transport, post, communicatic	24	64	11	149	9	445	398	23	98	133	13	1	0	3	0	2	276	0	0	0	18	7	21	336	353	0	0	2,384	
		Banking and financial service:	51	105	50	73	10	83	595	109	137	210	26	1	0	2	0	1	205	0	8	0	4	1	3	557	2,640	0	0	4,871	
		House letting and real estate	6	9	27	121	4	26	132	27	14	36	5	2	0	7	0	5	802	0	0	0	53	0	11	1,070	49	0	0	2,408	
		Business services	60	64	59	93	14	105	496	80	428	192	62	2	0	7	0	5	33	0	16	0	179	5	4	239	1,418	0	0	3,563	
		Public sector	5	14	3	5	2	15	56	79	62	340	8	2	0	6	0	4	131	0	4,906	0	16	1	3	116	17	0	0	5,793	
		Other services	2	8	1	5	4	17	65	6	46	38	113	0	0	0	0	0	293	0	221	0	38	0	27	162	8	0	0	1,053	
		Caledonian	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	79	0	0	0	0	1	16	0	0	98	
		GSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	4	0	0	16	
		Glasgow	0	0	0	0	0	0	1	0	1	1	0	0	0	3	0	0	9	0	198	0	0	0	0	14	85	0	0	312	
		RSAMD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	2	0	0	10	
		Strathclyde	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	5	0	131	0	0	0	0	7	44	0	0	191	
Institutions	(H)	Households	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	770	2,172	0	0	0	0	597	770	5,662	766	10,738	
	(C)	Corporate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	613	0	560	0	0	0	0	172	402	0	3,918	5,665	
	(G)	Government	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,011	1,470	0	1,691	0	0	0	2,432	0	0	530	9,135	
		Taxes on Expenditure	3	33	8	82	43	65	397	0	55	263	18	2	0	8	0	5	678	0	-3	0	-2	0	34	0	0	0	0	1,691	
	(CF)	Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	319	1,466	166	0	0	0	0	270	-587	0	0	1,635	(I)
	(E)	ROS	166	235	114	42	11	27	63	63	50	89	16	3	1	12	0	9	4,242	588	0	0	0	0	0	0	0	0	0	5,730	(E)
		Goods and Services	166	235	114	42	11	27	63	63	50	89	16	3	1	12	0	9	28	0	0	0	0	0	0	0	0	0	0	929	
		Transfers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	137	588	0	0	0	0	0	0	0	4,076	0	4,801	
		RUK/ROW	245	1,255	252	370	73	444	986	146	609	982	155	13	2	40	1	25	2,228	1,371	659	0	396	0	177	0	0	0	0	10,428	(E)
		Goods and Services	245	1,255	252	370	73	444	986	146	609	982	155	13	2	40	1	25	2,091	0	0	0	396	0	177	0	0	0	0	8,261	
		Transfers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	137	1,371	659	0	0	0	0	0	0	0	0	2,167	
Factors of production	(L)	Other Value Added	214	318	253	443	149	305	803	1,515	502	530	167	2	0	6	0	4	0	0	0	0	0	0	0	0	0	0	0	5,214	
	(K)	Income from Employment	199	980	490	935	355	788	723	182	1,461	2,789	452	63	10	193	6	113	0	0	0	0	0	0	0	0	0	0	0	9,738	
		Expenditure totals	1,191	3,492	1,559	2,417	694	2,384	4,871	2,408	3,563	5,793	1,053	98	16	312	10	191	10,738	5,665	9,135	1,691	1,608	26	498	6,697	8,963	9,738	5,214	91,233	
		Balance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0			0.0	0.0	0.0		
																								(I)			(E)				

6.4 CGE and IO: Illustration through demand impacts

In this section I shall revisit the expenditure impacts analysed in the last chapter and use these to illustrate the link between Input-Output and CGE analyses. More specifically I shall re-run a simulation reported in Section 5.1.2.1, where I showed that if the HEIs in the Strathclyde area managed to become as export intensive as the HEIs in the rest of Scotland, this would increase the income of the sector in Glasgow and the rest of the Strathclyde region by as much as 17%.

Input Output can be regarded as a simple general equilibrium system with fixed coefficient technologies, an absence of capacity constraints and an infinitely elastic supply of labour (McGregor *et al*, 1996). However, the CGE-model offers the ability to explicitly model capacity constraints, alternative production technologies and labour market settings. Furthermore, it allows exploration of the adjustment path from the initial shock to a long-run equilibrium as capacity and the labour force gradually adjust. I shall explore this adjustment process using the CGE-model; investigate how the model converges on the long run solution and how this adjustment process is sensitive to parameter settings.

Before proceeding with the simulations it is helpful to review the parameter assumptions I adopt for the CGE-model and how these are likely to influence simulation outcomes. For the analysis presented in this subsection I shall conduct simulations adopting the default AMOS parameter assumptions (originally derived for Scotland as a whole). As we saw in Section 6.2 the default parameters of AMOS are informed by a range of econometric evidence. The elasticity of substitution for the CES production function (0.3) is taken from Harris (1989), the flow migration parameters from Layard *et al* (1991)[136] and the Armington elasticities (2) from Gibson (1990). This setting is judged to be appropriate for Scotland as a whole. However, a city economy like Glasgow

[136] As we saw in Section 6.2 the net migration equation employed is: $m=\beta-0.008(u_g-u_r)+0.006(w_g-w_r)$ where m is the net-migration rate – as a proportion of the indigenous population; w_g and u_g are the natural logarithms of the real consumption wage and unemployment rates, respectively, in Glasgow; w_r and u_r are the equivalent values for the rest of the UK.

can be expected to be more open both in terms of trade flows as well migration. Therefore I shall repeat this simulation adopting parameter assumptions that represent a more open economy, such as Glasgow City, to explore the sensitivity of the outcome to parameter settings. For this 'city' case I raise the Armington parameter to 5 (following Turner, 2002) and increase the migration sensitivity parameters from Layard *et al* (1991) by a factor of 2. In the absence of appropriate econometric evidence these represent reasonable assumptions to illustrate the sensitivity of the simulation outcome to changes in parameter values.

Where appropriate I shall conduct more extensive sensitivity analysis around parameter values that are critical for a particular outcome. In particular I expect the Armington elasticities that govern the price sensitivity of trade to be particularly important due to the openness of the Glasgow economy.

Figure 63 Import/Export intensity of Glasgow production sectors (Imports/Exports as % of gross output).

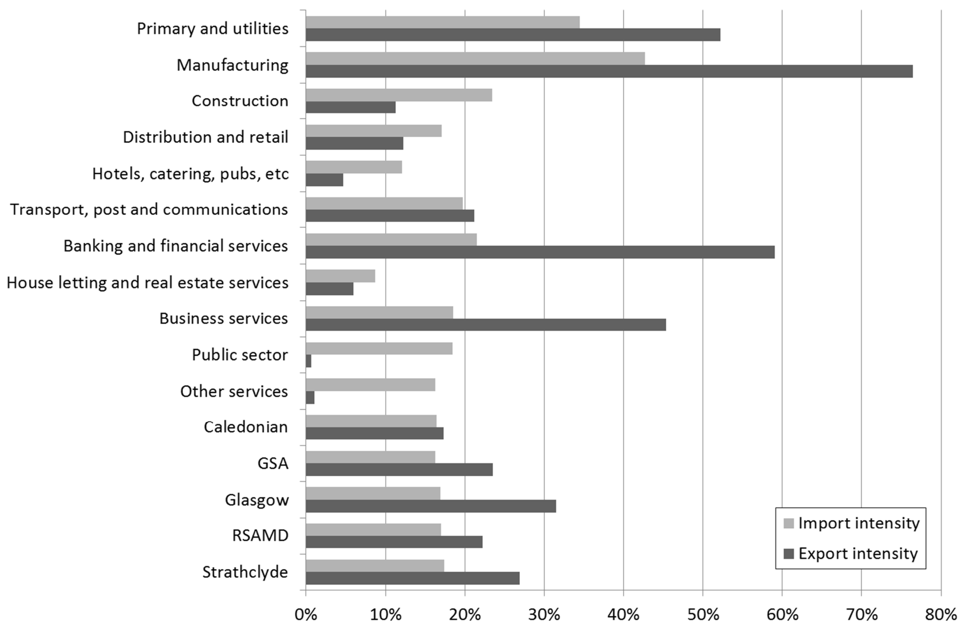


Figure 63 above describes the import and export propensities of the 16 Glasgow production sectors specified in the CGE-model. This is defined as exports or imports as percentage of the sector's gross output. As we can see the 'Manufacturing' sector is by far the most export intensive with roughly 76% of its output being exported. This is closely followed by 'Banking and financial services' (59%), 'Primary and utilities' (52%) and Business services (45%). Interestingly the fifth most export intensive sector in Glasgow (at this level of aggregation) is an HEI, the University of Glasgow (31%). This is slightly more export intensive than the Glasgow economy on average (30%). The other HEIs are therefore less export intensive than production sectors in the City of Glasgow on average. The more export intensive a sector, the more sensitive is its output level to changes in the terms of trade. Similarly, the more integrated are local and external product markets (higher Armington elasticities) the greater is sensitivity of output to terms of trade changes.

In AMOS, the terms of trade can be affected by exogenous shocks imposed by the modeller on export prices or endogenously through price changes. In the example examined in this section Glasgow prices are affected as a result of a demand shock, which in turn affects the competitiveness of exports. In the next section we shall see an example of how a supply shock (productivity improvements) affects local prices and therefore export competitiveness.

Exposure to imports also plays an important role in the adjustment of sectors. The greater the integration of product markets (as captured by the size of the Armington elasticity) the more price-sensitive is the substitution between locally produced and imported input. The import intensity of Glasgow production sector is less varied than their export intensity. The most import intensive are 'Manufacturing' (43%), 'Primary and utilities' (34%) and 'Construction' (23%). The service sectors, however, are less import intensive. For the Glasgow economy as a whole the share of imports is 22% of gross output. Therefore the HEIs are slightly less import intensive than Glasgow production sectors on average.

6.4.1 **Increased HEI exports**

In Section 5.1.2.1, I showed that if the HEIs in the Strathclyde area would manage to increase their income from sources independent of Scottish Government funding to the same rate as the HEIs in the rest of Scotland, this could increase the income of the sector in Glasgow and the rest of the Strathclyde region by as much as 17%. This could for example occur if these institutions were to market themselves more successful to foreign students or improve their approach bidding for competitive research funding at UK and European levels. I shall now use the CGE-model of Glasgow to explore what would be the implications for the Glasgow economy if this were to happen. In Section 5.1.2.1 I discussed this in terms of the entire HEIs sector in Strathclyde region (GLA+RST). The CGE-analysis, however, focuses only on the GLA HEIs and the model can accommodate each institution separately. Therefore I shall start by recalculating this shock focusing on each of the five Glasgow HEIs.

As we saw in Section 5.1.2.1 the key difference between the income structure of the HEIs in the Strathclyde region (GLA+RST) and the Rest of Scotland (ROS) is that HEIs in the Strathclyde area are more dependent on income from the Scottish Government (61%) than HEIs in the Rest of Scotland (52%). If we focus only the Glasgow HEIs these are slightly less dependent on the Scottish Government (58%). The question is, what if the GLA institutions continue to receive the same absolute amount of funding from the Scottish Government but are able to supplement these with income from other sources to the same extent as HEIs in the ROS are able to. That is, holding the Barnett funding constant, how much additional income is needed so that the income of GLA HEIs is composed of 'Barnett' and 'Other' funding in the proportions 52%/48%?

This is illustrated in Table 61 below. The left hand side of the table shows the actual income structure of HEIs in Glasgow. In the middle column I calculate how much more additional income is required so that these institutions can supplement Scottish Government income at the same rate as the HEIs in the

Rest of Scotland. That is achieving the target of earning 48% of their income from sources other than the Scottish Government. The right hand side of the table shows what the HEIs income structure would look like if they were to achieve this target. To illustrate, if we take a look at the case of the Glasgow Caledonian University (top row) we can see that in the base year 75.9% of its income comes from the Scottish Government, while only 24.1% is obtained from other sources. If Caledonian is to achieve the target of supplementing Scottish Government funding to reach the 52/48 ratio, it would need to raise an additional £44.8m ((£74m/0.52)-£98m) from sources other than the Scottish Government. If this were to happen it would still receive £74m in income from the Scottish Government. However, now this would only amount to 52% of total income as the other income category would have risen to £68m. An interesting feature of this 'what if' scenario is that in the base year one of the GLA HEIs, the University of Glasgow, earns more than 48% of its income from sources other than the Scottish Government. In this case, other income would actually have to be reduced slightly to reach the target of 48% of income from sources other than the Scottish Government. As the sum of the middle column of the table reveals, for all the HEIs in Glasgow this would amount to an injection of £73.2 for the Glasgow economy or 11.7% of the current total income of the Glasgow HEIs sector.

In this case I have not made any allowance for potential additional impacts from students' consumption expenditures. If the increase in supplementary income of the HEIs were mostly from research funding this would negligible. However, if this rise in income were driven by the tuition fees of incoming students, then this would bring significant additional impacts through the consumption expenditures of these students, which are treated like tourists.

Having estimated the direct expenditure impacts of this scenario, we can now use the CGE-model to estimate its system wide implications for the economy of Glasgow. However, it is not clear if this extra income of £73.2 represents an exogenous injection to the GLA economy or would be endogenous to some extent. For example, it could be composed of tuition fees from local residents or research grants from local firms. For simplicity I assume that this additional income is entirely composed of export income, which is entirely exogenous to the Glasgow economy.

Table 61 Actual income of GLA HEIs by origin (left) and their hypothetical income (right) if they can supplement income from the Scottish Government at the same rate as HEIs in the ROS.

	Income ex ante						Additional other income needed, £m	Income ex post					
	Barnett		Other		Total			Barnett		Other		Total	
Institution	£m	%	£m	%	£m	%		£m	%	£m	%	£m	%
Caledonian	74	75.9%	24	24.1%	98	100%	44.8	74	52%	68	48%	142	100%
GSA	11	71.2%	5	28.8%	16	100%	5.8	11	52%	10	48%	22	100%
Glasgow	161	51.7%	151	48.3%	312	100%	-2.0	161	52%	149	48%	310	100%
RSAMD	7	65.6%	4	34.4%	10	100%	2.7	7	52%	6	48%	13	100%
Strathclyde	111	57.9%	80	42.1%	191	100%	21.8	111	52%	102	48%	213	100%
	364	**58.1%**	**263**	**41.9%**	**627**	**100%**	**73.2**	**364**	**58%**	**336**	**54%**	**701**	**100%**

In an IO-sense, examining the impact of this expenditure shock is straightforward in practice and as we saw in Section 5.1.1.1 the IO results can be rationalised either as short-run impacts under excess capacity (i.e. unemployment, idle capital) or the long-run impacts on the economy, once capacity constrains have been relaxed through investment and labour in-migration. However, there are always lingering concerns that demand shocks can induce crowding out in the short run and that the long run impacts might be elusively far off in time. Examining these issues is where the added complexity of the CGE model offers value added over the IO-framework for examining expenditure shocks. I begin by presenting the results for this export shock based on the default parameter settings of the AMOS model. Then I proceed to examine how the outcome differs if the parameters are adjusted to reflect the expectation that Glasgow is a more open economy than Scotland as a whole. Finally I explore the sensitivity of outcome to the Armington trade elasticity in slightly more detail.

Table 62 below relates the export shock of the Glasgow HEIs to the scale of income and exports of each institution. As we can see this represents a 12% increase in the total income of the Glasgow HEIs and a more robust 42%

increase in their export earnings. However, within this average there is significant variation. The biggest increase in export earnings is for Glasgow Caledonian University, a more than doubling of export earnings, whereas for the University of Glasgow, export earnings are reduced by 2%.

Table 62 Export shock to Glasgow HEIs

	Export shock		
Institution	**£m**	**% increase of income**	**% increase of exports**
Caledonian	44.8	46%	265%
GSA	5.8	37%	157%
Glasgow	-2.0	-1%	-2%
RSAMD	2.7	26%	118%
Strathclyde	21.8	11%	42%
	73.2	**12%**	**42%**

A summary of results is presented in Table 63 below. In addition to economy-wide changes in employment and Gross Regional Product (GRP) I present results for three sectoral aggregates: Production, Services and HEIs[137]. As a response to this sustained increase in the export earnings of Glasgow HEIs, both employment and GRP increase in the first period. However, due to short run capacity constraints the full economy-wide impacts of the export shock are only realised gradually. in fact, for Period 1, the stimulus to the HEIs sector crowds out activity in the non-stimulated sectors. Total employment change reaches 75% of the IO figure by the third period, 85% by the fifth period and 95% by period 11. Due to capacity constraints wages and input prices are bid up for all sectors, causing a net crowding out of exports in the Production and Services sectors. However, higher prices trigger both investment and in-migration, which gradually relieve price pressures. After period 30 the simulation outcome converges on an IO-solution, where additional inputs are sourced in fixed proportions (fixed coefficients technology) and original export levels are restored in the Production and Services sectors. Relatively, the largest

[137] The Production sector is an aggregate of 'Primary and utilities', 'Manufacturing' and 'Construction'. The Services sector is an aggregate of 'Distribution and retail', 'Hotels, catering, pubs, etc', 'Transport, post and communications', 'Banking and financial services', 'House letting and real estate services', 'Business services', 'Public sector' and 'Other services', while the HEIs sector is an aggregate of 'Caledonian', 'GSA', 'Glasgow', 'RSAMD' and 'Strathclyde'.

changes are incurred in the HEI sector where employment increases by 11.75%. However a significant proportion of the overall impacts are realised as knock-on impacts on other sectors in the economy.

Table 63 The percentage change in key economic variables over time after a hypothetical increase in export demand for Glasgow HEIs (% changes from base year).

Period	1	5	10	15	20	25	30	IO
Total Employment	0.33%	0.51%	0.56%	0.58%	0.58%	0.59%	0.59%	0.59%
GRP	0.21%	0.35%	0.40%	0.42%	0.44%	0.44%	0.45%	0.45%
Production								
Employment	-0.15%	0.06%	0.13%	0.15%	0.16%	0.17%	0.17%	0.18%
Value added	-0.11%	0.04%	0.12%	0.15%	0.16%	0.17%	0.17%	0.18%
Value added price	0.19%	0.09%	0.04%	0.02%	0.01%	0.00%	0.00%	0.00%
Capital Stocks	0.00%	0.01%	0.10%	0.14%	0.16%	0.17%	0.17%	0.18%
Exports	-0.17%	-0.08%	-0.04%	-0.02%	-0.01%	0.00%	0.00%	0.00%
Services								
Employment	-0.11%	0.03%	0.07%	0.09%	0.10%	0.11%	0.11%	0.12%
Value added	-0.07%	0.02%	0.06%	0.09%	0.10%	0.11%	0.11%	0.12%
Value added price	0.20%	0.08%	0.04%	0.02%	0.01%	0.01%	0.00%	0.00%
Capital Stocks	0.00%	0.00%	0.05%	0.08%	0.10%	0.11%	0.11%	0.12%
Exports	-0.26%	-0.09%	-0.04%	-0.02%	-0.01%	-0.01%	0.00%	0.00%
HEIs								
Employment	10.83%	11.69%	11.74%	11.75%	11.75%	11.75%	11.75%	11.75%
Value added	10.30%	11.66%	11.74%	11.75%	11.75%	11.75%	11.75%	11.75%
Value added price	1.71%	0.11%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
Capital Stocks	0.00%	10.81%	11.70%	11.74%	11.75%	11.75%	11.75%	11.75%
Exports	53.07%	58.73%	59.05%	59.07%	59.08%	59.08%	59.08%	59.08%

As McGregor et al (1996) note the speed to which the outcome of the CGE-simulations converge on IO-results is positively associated with the flexibility of the economic system, as for example captured in the substitution elasticities inputs (capital, labour) in the CES production functions and negatively linked to the integration of local and external product markets (as captured in the Armington elasticities). Therefore, I shall run the same shock again under 'city' economy parameter assumptions, namely with a higher Armington elasticity and faster population adjustment (capital/labour substitution is left as before). These results are presented in Table 64 below. Although the results under the two alternate parameter settings as identical in the long run, the adjustment is slower under the 'city' settings. Total employment reaches 75% of the IO figure by the third period, 85% by period 7 and 95% by period 22.

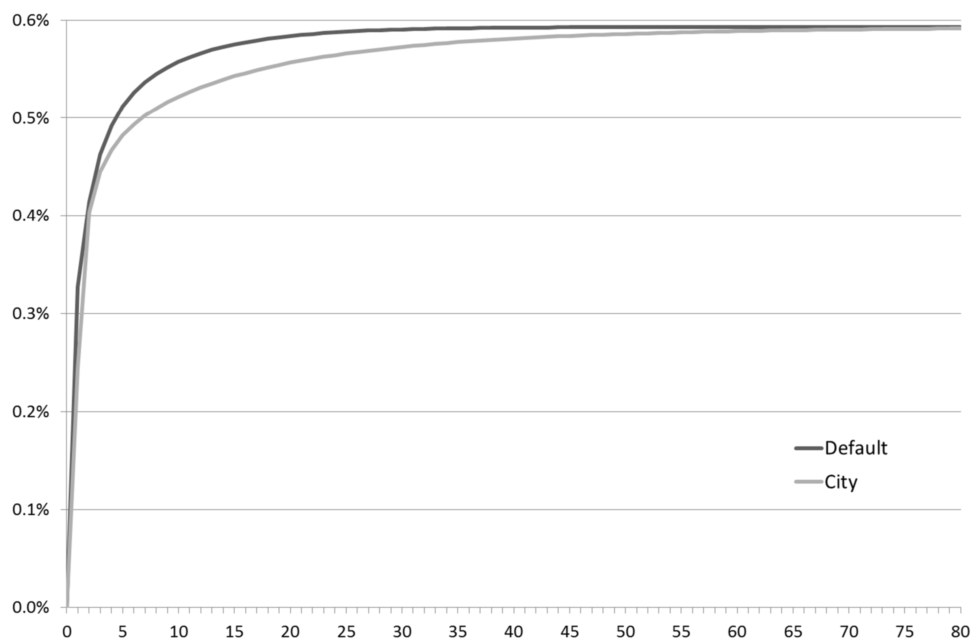
Table 64 The percentage change in key economic variables over time after a hypothetical increase in export demand for Glasgow HEIs. This time using alternative parameter assumptions to simulate the characteristics of a city economy (% changes from base).

Period	1	5	10	15	20	25	30	40	50	60	IO
Total Employment	0.24	0.48	0.52	0.54	0.56	0.57	0.57	0.58	0.59	0.59	0.59
GRP	0.15	0.32	0.36	0.38	0.40	0.41	0.42	0.43	0.44	0.44	0.45
Production											
Employment	-0.18	0.02	0.07	0.10	0.12	0.14	0.15	0.16	0.17	0.17	0.18
Value added	-0.13	0.01	0.06	0.10	0.12	0.13	0.15	0.16	0.17	0.17	0.18
Value added price	0.07	0.05	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Capital Stocks	0.00	-0.02	0.05	0.09	0.11	0.13	0.14	0.16	0.16	0.17	0.18
Exports	-0.16	-0.10	-0.07	-0.04	-0.03	-0.02	-0.02	-0.01	-0.01	0.00	0.00
Services											
Employment	-0.13	0.01	0.04	0.06	0.07	0.08	0.09	0.10	0.11	0.11	0.12
Value added	-0.09	0.00	0.03	0.05	0.07	0.08	0.09	0.10	0.11	0.11	0.12
Value added price	0.10	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Capital Stocks	0.00	-0.01	0.02	0.05	0.06	0.08	0.09	0.10	0.11	0.11	0.12
Exports	-0.31	-0.10	-0.07	-0.05	-0.04	-0.03	-0.02	-0.01	-0.01	-0.01	0.00
HEIs											
Employment	9.48	11.58	11.73	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75
Value added	9.04	11.55	11.73	11.74	11.75	11.75	11.75	11.75	11.75	11.75	11.75
Value added price	1.43	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Capital Stocks	0.00	10.46	11.67	11.74	11.74	11.75	11.75	11.75	11.75	11.75	11.75
Exports	46.83	58.17	59.01	59.06	59.07	59.07	59.08	59.08	59.08	59.08	59.08

A comparison of employment changes under the two parameter settings is provided in Figure 64 below. As the diagram reveals the employment impact are similar in the short run and indeed converge on the same long run solution. However, the employment adjustment profiles start to diverge after approximately 3 periods as: Higher price sensitivity of exports cause high prices to have more significant negative impacts in the indirectly affected sectors. These results show that for demand shocks the influence of the models' parameter settings is on the speed of adjustment towards the long run IO solution, rather than affecting the magnitude of the long run impact.

It is somewhat counterintuitive that the more responsive parameter settings of the 'city' case result in slower adjustment. This result is in line with McGregor et al (1996, p. 489) who found that the "more spatially integrated are factor markets, the more rapidly will a long-run neoclassical model replicate I-O results. However, the more spatially integrated are product markets, the slower will this adjustment be". This is not a universal result, but one that is driven by the mechanisms of this type of a CGE model. The demand shock increases the final demand from exports for the outputs of the shocked sectors. This increases the output of the shocked sectors and leads to knock-on impacts on other sectors through indirect and induced effects, all adding to the gross output of the economy. Due to short-run supply restraints the demand stimulus bids up prices, which has an adverse effect on net exports (the more so the more integrated are product markets). This endogenous impact on net-exports partially offsets the positive output impact of the original stimulus. Higher prices however, lead to a gradual adjustment process where in-migration and investments act to relieve capacity constraints. However, this adjustment is gradual as the model's agents are myopic and investment is determined as a fixed proportion of the difference between the actual and desired capital stock.

Figure 64 Adjustment of total employment to export shock under alternative parameter settings (% change from base).



What causes the slower adjustment under more product market integration is that the endogenous reduction in net exports is stronger (than it would be under a lower Armington elasticity) and hence the gap between desired and actual capital stock is smaller and the end result is less investment in each period than would have been under a lower Armington elasticity. However, as the capital stock rises, prices recede and the pressure on net exports is lessened. This acts to make the adjustment process more drawn out. Even though migration sensitivities have also been increased, this is not sufficient to offset the slowing down of adjustment from more spatially integrated product markets.

6.5 Productivity impacts of human capital accumulation

In this section I use the Glasgow CGE-model to estimate the system-wide impact of increase in labour productivity as skills in the workforce increase through production and retention of graduates. To calibrate the transmission mechanism from a higher share of graduates in the labour market to improved productivity I use micro-econometric evidence on the wage premia of graduates combined with a projection of future skills composition in the labour market. This provides me with a projection of future increases in labour productivity, which I use to simulate the economy-wide implications of this shock.

As we shall see there are a number of stages in the process for determining the productivity impact of graduates and how this productivity shock translates into a macro impact that warrant further scrutiny, as the particulars of the approach can affect simulation outcomes:

- For the interpretation of wage premia as an indicator of labour productivity I need to determine how much of this can be attributed to education itself and how much should be attributed to other factors such as innate abilities.
- For the skills projection I need to make assumptions about the extent to which graduates are retained in Glasgow in the future.

- Similarly, for the transmission of the productivity shock into a macro impact I need to determine the appropriate model setup so as to reasonably characterise the economy under analysis.

I shall elaborate on each of these points as they arise. To deal with these issues I draw on arguments informed by the most recent evidence. Inevitably in some cases the evidence base is limited or its interpretation ambiguous, where I shall resort to sensitivity analysis. In the next sub-section I shall describe the simulation strategy adopted. I discuss how wage premia can be interpreted as an indicator of labour productivity, what assumptions are adopted in the simulation process and how I project future skill levels. Then I shall proceed to illustrate simulation results, how they can be interpreted and what are the main sensitivities, before concluding.

6.5.1 Simulating the economic impact of more skills in the labour market

For my simulation strategy I draw on the "Micro-to-Macro" approach of Hermannsson *et al* (2010d). Essentially this involves interpreting micro econometric evidence on the wage premia of graduates as an indicator of their increased labour productivity and using a CGE-model to capture the transmission from a supply-side stimulus to a an economy-wide macro impact. The practical problems this raises include determining to what extent wage premia of graduates can be interpreted as a sign of their increased productivity, what is the cumulative productivity impact of an increasing share of graduates in the working age population over time and how that productivity impact is transmitted to the wider economy. In the remainder of this section I shall discuss how I treat graduates in the labour market and what is the rationale for the approach. In the next sub-section I shall project the number of graduates in the labour market and determine the resulting productivity impact. Then in the following sub-sections I shall proceed to simulate the economy-wide impact of this productivity stimulus under a range of assumptions, relating both to model settings and assumptions about the skill-projections of the labour force.

Following Hermannsson *et al* (2010d) I adopt a simplifying assumption where human capital is treated as homogenous. This means that the difference between graduates and non-graduates is simply the quantity of human capital that these two groups possess on average. This approach enables me to treat the labour market as unified, and so avoid a number of complexities. Graduates and non-graduates are treated like perfect substitutes; it is "as if" it simply takes more non-graduates to perform the same task as graduates. Hermannsson *et al* (2010d, p. 10) refer to the "the evidence of the comparative constancy of the graduate wage premium in recent UK history" to motivate this assumption. This evidence is discussed in detail in Section 2.2. However, before proceeding it is worth recalling some broad points:

- Participation in higher education increased sharply in Scotland in the 1990s from about 20% in 1990 to over 50% at the end of the decade. Despite this the graduate wage premia has remained high and stable. This suggests that production sectors have been able to absorb these graduates and put them to productive use.
- Wage levels and the likelihood of being in employment have been found to increase with attainment of formal education in a large number of studies conducted in a range of countries worldwide at different points in time.
- In international evidence the graduate wage premia has been found to be high and remarkably stable over long historical periods. Goldin & Katz (2007) study the development of the graduate wage premia in the USA over a 90 year period from 1915 to 2005. Over that period, as we saw in Figure 1 in Chapter 2, the graduate wage premia has fluctuated between approximately 35% and 65%.

A range of views could be adopted to explain why graduate wage premia has held up despite rising participation in higher education. Goldin & Katz argue that the graduate wage premia is determined both by supply and demand for graduate skills in the labour market. Even if the supply of graduates increases, that does not automatically imply that the graduate wage premia has to fall. In a general equilibrium setting the outcome would depend on combined changes in both supply and demand. The changes in graduate demand are then argued to be driven by skill biased technical change. A more succinct story would be that demand for skilled labour is simply quite elastic, i.e. industry is flexible to absorb more skilled labour and put it to productive use when available. This view is more consistent with the modelling approach adopted here, where the labour market is unified so that a skilled worker is qualitatively identical to an unskilled worker from the point of view of a production sector but simply offers more input per natural unit (more efficiency units).

This still leaves one critical issue, how much of the graduate wage premia can actually be attributed to the university training as such and how much of it is driven by other factors such as personal characteristics or ability. As we discussed in Section 2.2.7 the signalling and screening literatures see graduate wage premia not only as a manifestation of a treatment effect of attending higher education but suggests that the wage premia is also driven by other factors such as the individual's abilities. That is to say, wage premia is not driven only by the experience of pursuing a degree but also because those who complete degrees tend to have above average personal abilities. In signalling parlance, one would obtain a graduate degree in order to signal in the labour market that one possesses the superior abilities of those able to attain a degree. Whether one choses to refer to this attribution error as ability bias or signalling does not matter, both propositions capture the same empirical effect.

As the aforementioned suggests, the practical obstacle therefore is to determine the extent to which graduate wage premia can be attributed to a treatment effect of higher education (and therefore represents additional labour productivity) and to what extent it is merely driven by signalling/ability bias and is therefore rewarding existing productive capacity instead of additional human capital obtained at an HEI. Various empirical approaches have been used to "clean" the wage premia of ability bias/signalling effects, such as studying samples of identical twins to control for individual fixed effects as was discussed in Section 2.4. A detailed explanation of one such corrective procedure is for example provided in McMahon (2009, Appendix A, pp. 331-346). However, I follow Hermannsson *et al* (2010d) and draw on evidence provided by Lange & Topel (2006) who find, using a model of employer learning, that 10% of wage premia can be explained by signalling.

6.5.1.1 Skill composition of the labour force

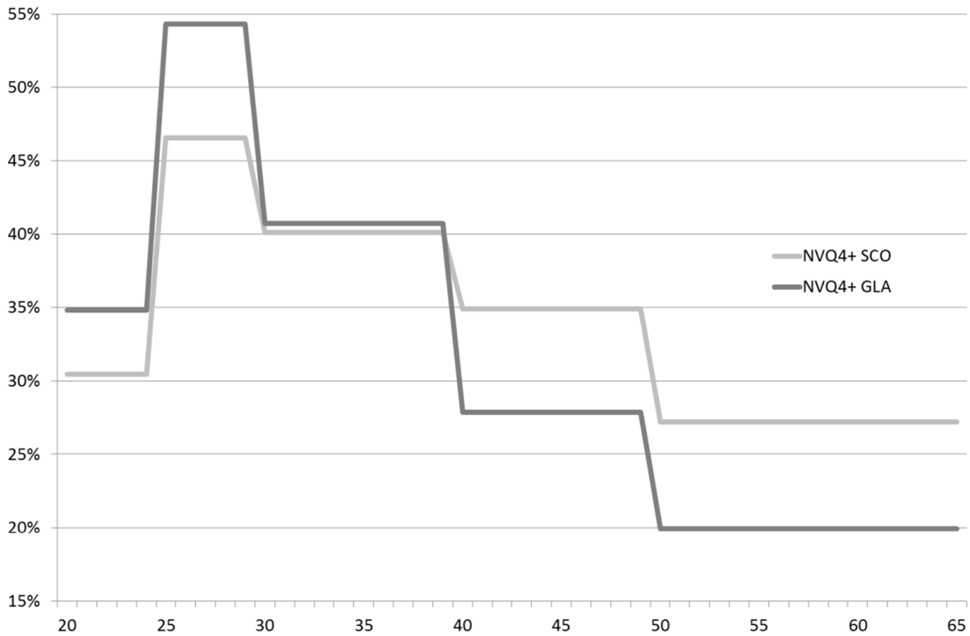
For my base case scenario I draw on an approach utilised by Hermannsson *et al* (2010d) to project the future skill composition of the Glasgow labour force. In brief, the future skill mix of the economy is projected under the assumption that the hitherto highest graduation rate (and retention rate) will hold into the future until graduates are found in equal proportions for each age cohort.

First I derive the share of graduates in the Glasgow labour market for every working age cohort. My starting point for this is a skills/age cross section from the Labour Force Survey showing the share of graduates by age cohort for Scotland in 2006 obtained from Hermannsson *et al* (2010d). As I do not have data specifically on the share of graduates in the working age population at a sub-regional level, I determine skills in the population of Glasgow by disaggregating the skills/age cross section for Scotland. For this I use the age-specific shares of those with Level 4 National Vocational Qualifications (NVQ4) or higher qualifications in the year 1996 obtained from the Annual Population Survey (ABS) via the NOMIS portal.

As we saw in Table 7 in Section 2.2.1 an NVQ4 qualification refers to an undergraduate degree and advanced qualifications obtained through vocational routes: either Higher National Certificates (HNC) or Higher National Diplomas (HND). Unfortunately the dataset lumps together two types of qualifications, academic and vocational, which are formally classified as equal but differ significantly in the associated wage premia (see Table 6, Section 2.2.1). However, I expect the share of academic and vocational graduates to be similar in Glasgow and Scotland as a whole. Hence this data provides the best available weights for disaggregating the share of graduates in the working age population of Scotland and Glasgow. The share of the population holding qualifications at

NVQ4 level or higher is shown in Figure 65 below for Glasgow and Scotland as a whole.

Figure 65 Holders of NVQ4 or above qualifications as a share of working age residents in Glasgow and Scotland.



Using NVQ4+ qualifications as weights to disaggregate the share of graduates in Glasgow from the Scotland-wide skills/age profile produces a cross sectional view of the working age population, revealing how skill levels vary between age groups, as can be seen in Figure 66 below. As we can see, Glasgow (dark line) differs from Scotland as a whole (light grey line) in that the youngest cohort of the working age population (20-30) contains a higher share of graduates. The skills mix is approximately identical for Glasgow and Scotland in the 30-40 year old cohort, whereas for the older groups (40+) Glasgow has a lower share of graduates than does Scotland as a whole[138].

---

[138] As is evident from Figure 65 the Annual Population Survey data used to construct the disaggregation weights is only available from NOMIS as averaged over 5-10 year age cohorts to maintain statisticial significance of results for the smaller samples at the sub-regional level. Using these lumpy weights generates quite abrubt changes in the estimated skills/age profile for Glasgow vis-á-vis Scotland every 5-10 years. If more disaggregate data were directly available for Glasgow this would reveal a more gradual transition. However, both approaches would result in the same long run results.

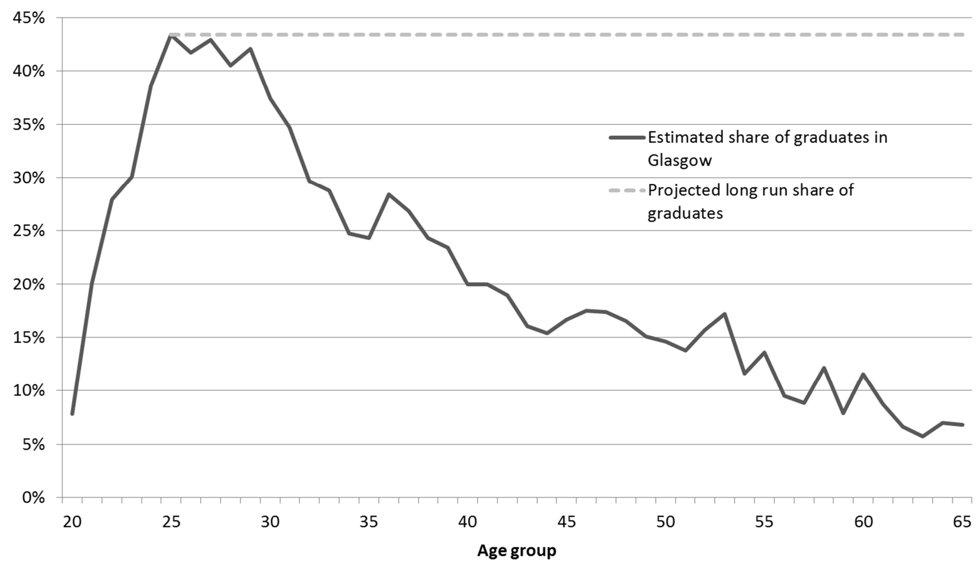
Figure 66 Graduates as a share of working age residents in Glasgow and Scotland[139].

I project the future skill composition of the Glasgow workforce by extrapolating from the skills profile for Glasgow. That is I take the existing share of graduates among the younger population and run it forward until a steady state is reached. The highest share of graduates can be found in the 25 year old age group at 43%[140]. I assume that in the next period (2007) a new 25 year old cohort will come along and that 43% of its members will also be graduates. Simultaneously the 65 year olds from the previous year retire. However, the share of graduates in the 65 year old cohort was only 7% in 2006 and hence this natural aging process has increased the average share of graduates in the working age population. This process continues year on year, finally stabilising when all the age cohorts have reached a graduate share of 43% and hence as many graduates enter the labour force as those who retire.

[139] One potential interpretation of this cross-sectional view is that younger skilled workers prefer living in in the city, whereas with age they tend to move out to more suburban/rural locations. If this is the case and there is a built-in tendency for graduates to move out at a higher age then my projection method will tend to overstate the future impact of graduates upon Glasgow. Given available evidence it is impossible to test this effect, whereas I conduct sensitivity analysis exploring the sensitivity of impacts to a 'leak' of graduates. See Section 6.5.1.2.1.

[140] Typically in Scotland the youngest age to complete a degree is 21, hence the share of graduates rises rapidly from age 20.

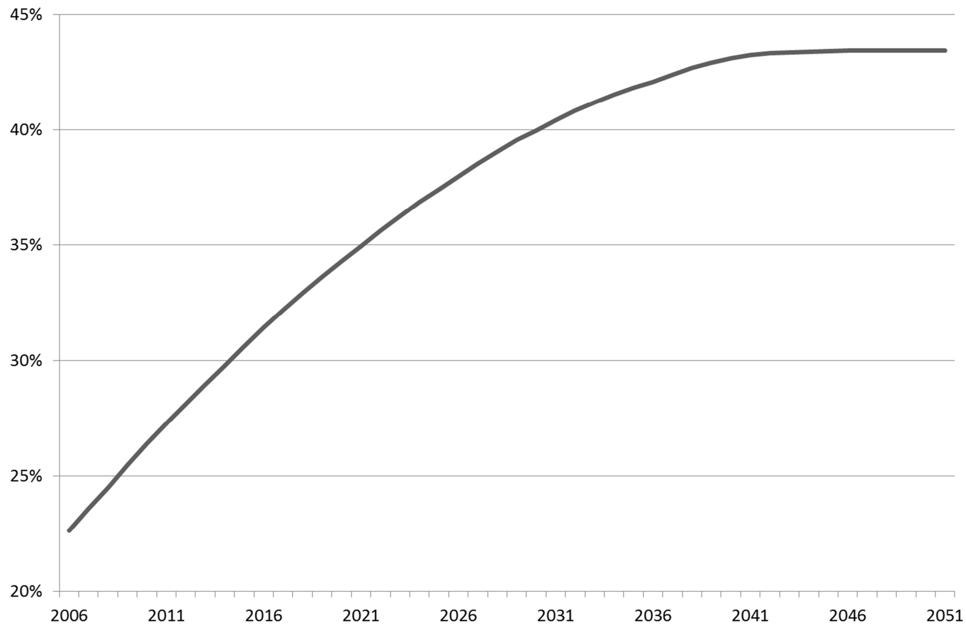
Figure 67 Current skills profile for Glasgow and projected long run skills.



This is further illustrated in Figure 67 above. The dark grey line represents the observed skills profile of Glasgow's working age population in 2006 (this is the same line as presented in Figure 66). The broken light grey line shows the projected skills composition of the working age population. That is, in the long run all the age cohorts from 25 to 65 will contain the same share of graduates as the current cohort of 25 year olds. Extrapolating from a cross-sectional observation like this is a simple approach, which economises on data requirements. In particular I do not need to explicitly derive the net retention rate of graduates in Glasgow, bur rely on the implicit net retention rate contained in the current cross-sectional data. That is, I do not know precisely the net-retention rate of graduates from Glasgow HEIs but simply assume that the share of graduates observed in the 25-year old age cohort will hold for older age cohorts in the future. For alternative approaches to skills-projections I refer to Hermannsson *et al* (2010d) who experiment with scenarios where the skills projection is explicitly linked to current graduation rates of Glasgow HEIs, based on different assumptions about net-retention rates. Some of these scenarios result in a higher long run share of graduates in the labour market than the approach used here of extrapolating from the observed cross-section. The results of the projection are presented in Figure 68 below.

It should be noted that in order to focus only on the impact of skills in the working age population I abstract from demographic changes and adopt the assumption of a fixed population and a fixed population structure, i.e. for any age cohort its share of the total population and its participation in the labour force is constant throughout the simulation period. More specifically, I use the base year population structure for Glasgow for all periods and only change the skill composition within the age cohorts but not their size. For example, the 30 and 40 year old age cohorts represent 2.5% and 2.4% of the initial working age population respectively. These shares remain constant throughout every period of the simulation.

Figure 68 Projection of the share of graduates in the Glasgow working age population.



Now that I have determined the baseline projection for the future number of graduates the next step is to determine the productivity difference between graduates and non-graduates attributable to higher education. As we saw in Section 2.2.1. Houston *et al* (2002) and Walker & Zhu (2007b) obtain very similar estimates for the 'college wage premium', that is the difference between graduate wage and the wages of those qualified to attend higher education (suitable A-levels/Highers), at just above 30%. These estimates, however, are not compatible with my binary view of the labour force, where I divide the working age population into graduates and non-graduates. A recent estimate of the wage premia of graduates vis-á-vis non-graduates on average has put this at 58% for Scotland[141]. In this case the simplifying assumption is that when somebody becomes a graduate he is not drawn from the sub-set of the population holding post-secondary education (A-levels/Highers) but it is as if he is randomly selected from the entire pool of skills below degree level.

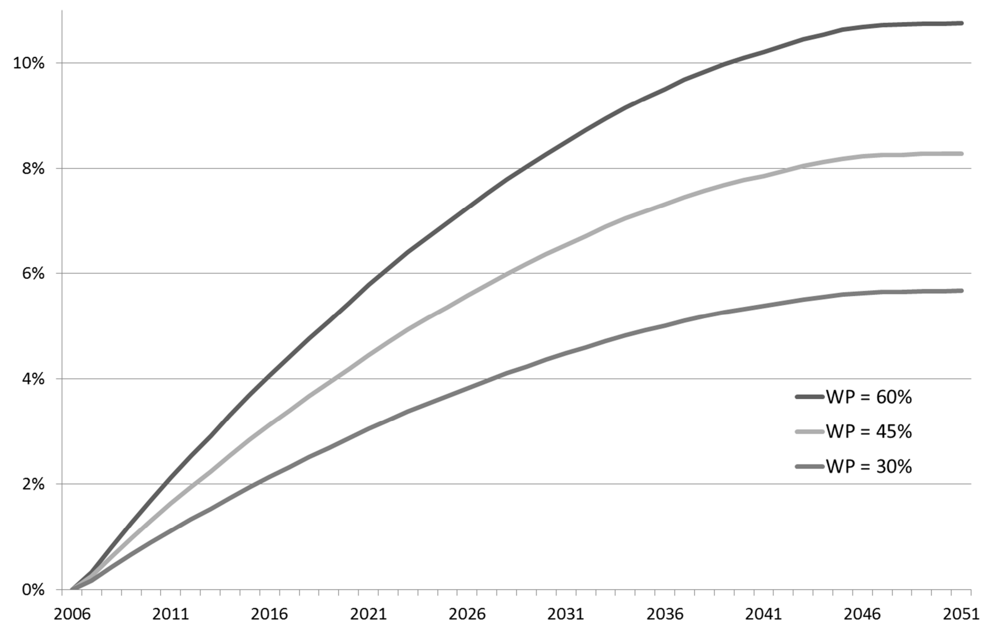
I follow Hermannsson *et al* (2010d) in adopting the somewhat agnostic view that the graduate wage premium can fluctuate in the long run between 30% and 60%. As in the Scotland-wide analysis of Hermannsson *et al* (2010d) I take 45% as my baseline wage premium but also explore 60% and 30% as upper and lower bounds. This should be seen as cautious assumptions about the long run graduate wage premium. It is further assumed that 10% of this is driven by a signalling effect (Lange & Topel, 2006) and hence does not reflect increased labour productivity that can be attributed to education.

Based on these assumptions I can estimate the productivity adjusted size of the labour force. This is done quite simply by counting each non-graduate worker as a single efficiency unit, whereas for every graduate the efficiency units are adjusted upwards to reflect the signalling-adjusted wage premium. For my baseline scenario a graduate is attributed with 1.405 efficiency units. For the first round of simulations I calculate these for three scenarios (I shall explore more in sensitivity analysis): the baseline scenario where wage premium is set at 45%, plus upper and lower bound scenarios where the wage premium is set at 60% and 30%. As previously mentioned I attribute 10% of the wage premium to signalling in all of these cases. The growth in the productivity-adjusted labour force represents the labour productivity shock that I feed into the CGE-model. The magnitude of the shock grows over time as skills accumulate in the working age population. This is illustrated in Figure 69 below, where the

[141] Unpublished estimates from Professor Robert Wright at the Department of Economics, University of Strathclyde.

baseline scenario is in the middle, but the upper bound and lower bound scenarios are show as the lines above and below. Over time the increase in the share of graduates in the working age population will lead to an increase in labour productivity of 10.8%, 8.3% or 5.7% depending on assumptions about wage premia.

Figure 69 Growth of the productivity adjusted work force depending on assumption about wage premia.



The stimulus is introduced as a labour productivity shock across all 16 sectors of the model. It takes the form of labour-augmenting, or Harrod-neutral, technical progress. It is difficult to determine *a priori* the employment effect of such a change. An increase in labour efficiency reduces the effective price of an efficiency unit of labour, and so stimulates the demand for labour in efficiency units. Employment rises, falls or remains the same depending on whether the general equilibrium wage elasticity of labour demand is greater, less or equal to unity. This, in turn, depends on all the key elasticities in the model, including of course, the elasticity of substitution between labour and capital in each sector; the sectoral shares of labour in value-added and the elasticity of supply of capital. In the Glasgow CGE-model capital accumulation takes time and so the value of the latter increases through time, as does the wage elasticity of labour demand.

In all of the simulations presented below the migration function is switched off. This means that there is no inflow or outflow of labour generated by the change in the returns on labour. Because the goal is to isolate the impact of the increased productivity of the labour force due to the increasing proportion of graduates within it, I preclude endogenous population adjustment. If the size of the labour force is allowed to adjust through migration the change in employment and GRP for a given increase in the labour productivity is larger.

6.5.1.2 Simulation Results

Table 65 below presents results from my base case scenario, where skills in the working age population increase, based on an assumption of a 45% wage premium, 10% of which is attributable to signalling. This leads to a gradual increase in labour productivity, which peaks at 8.3% in period 46. After that there is no subsequent increase in labour productivity but the adjustment process to this new higher level of productivity continues. Notably, the magnitude of this labour productivity impact is just over twice that estimated for a Scotland as a whole by Hermannsson *et al* (2010d). Although as we saw in Figure 66 Glasgow has a higher share of graduates in its younger age cohorts than does Scotland as a whole, the primary explanation for this relatively large impact is because Glasgow is growing its stock of human capital from a much lower base than is Scotland as a whole.

As would be expected for a beneficial supply shock there is a stimulus to gross regional product (GRP) and a downward pressure on prices. The long run impact of this stimulus is substantial, with an increase of 11.58% by period 60. Recall that this is result is based on an assumption of an unchanged HE policy, i.e. participation rates are held constant. As I shall discuss further in Section 6.5.1.2.3, a key transmission mechanism is from improved regional competitiveness, through a stimulus to trade, with exports to ROS and RUK/ROW rising by 9.99% and 9.4% respectively by period 60.

The effect of the positive labour productivity shock is to increase effective labour supply, that is labour supply is unchanged in natural units but increases in efficiency units. This extra supply puts downward pressure on wages per efficiency unit. However, the reduction in the relative price of an efficiency unit of labour stimulates the demand for it relative to capital through a substitution effect, and the ratio of efficiency units of labour to capital increases. As we can see from the table, this glut of labour has the short-run effect of depressing wages and prices. This boosts the competitiveness of exports and increases the return to capital, resulting in an increase in exports and investments. Already by period 10 this export and investment stimulus has offset the initial depressing effect of wages by bidding up the price of an efficiency unit of labour.

The increase in the efficiency units of labour has the initial effect of suppressing employment, however, in this simulation employment impacts become positive as the economy adjusts (by period 7). That is, ultimately the stimulus to employment from improved competitiveness dominates the fact that any given level of output can now be produced with less labour input. Of course, the fall in the prices of an efficiency unit of labour acts to stimulate the demand for labour in efficiency units, but in general employment can fall and in this case does in the short run.

The employment increase has the effect of boosting household consumption, triggering further output growth. However, this household consumption effect is relatively subdued in the Glasgow case as a large share of household income goes to external transfer payments (commuters' wages) and therefore does not stimulate consumption expenditures.

Moving towards the long run, effective labour supply keeps on increasing as the efficiency of the labour force continues to rise in line with the increase in graduate share. However, wages keep rising as this is more than offset by an export and investment stimulus, which in turn feeds into household consumption. In the AMOS model it takes time for the capital stock to adjust to a new optimum, but in this case this process is further drawn out as the optimal capital stock keeps shifting as labour productivity keeps increasing. The long run GRP rise (11.58%) exceeds the labour productivity increase because both employment and capital stock are increasing.

In this model setup the final outcome is a positive impact upon wages and employment as the competitiveness effects trigger sufficient enough export and investment stimulus to offset the initial negative impact on wages and employment.

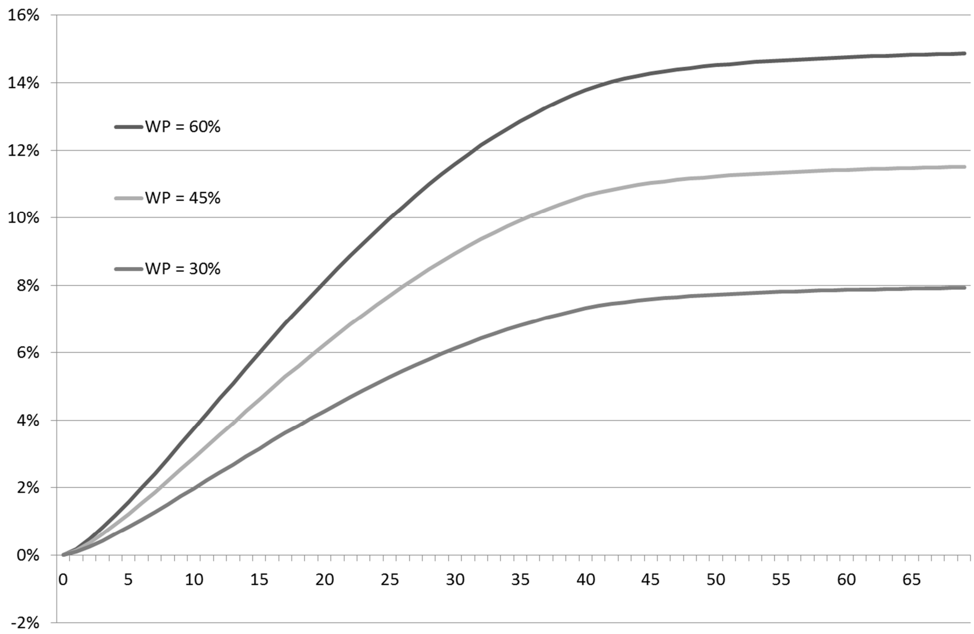
The increase in demand for labour pushes up the real wage, but the overall level of domestic prices is falling because of the competitiveness effect. While the real wage is rising (3.46%) it does so less than the increase in labour productivity (8.3%). This suggests that the wage in efficiency units falls, so that the unskilled get squeezed as a consequence.

Table 65 Impacts over time of an increase in labour productivity due to an updating of skills in the working age population, assuming 45% wage premium (% change from base year).

	5	10	15	20	30	40	50	60
GRP	0.91%	2.54%	4.26%	5.92%	8.71%	10.53%	11.20%	11.41%
Consumption	0.14%	0.76%	1.53%	2.31%	3.67%	4.63%	5.06%	5.19%
Government expenditure	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Export ROS	0.73%	1.96%	3.28%	4.61%	6.99%	8.72%	9.57%	9.99%
Export RUK/ROW	0.80%	2.25%	3.76%	5.18%	7.49%	8.92%	9.34%	9.40%
Investment	1.60%	3.48%	5.20%	6.78%	9.39%	11.01%	11.48%	11.72%
Capital-Stock	0.31%	1.52%	3.06%	4.67%	7.64%	9.86%	11.03%	11.51%
CPI	-0.01%	-0.02%	-0.04%	-0.05%	-0.06%	-0.07%	-0.08%	-0.08%
Unemployment-Rate	0.61%	-2.25%	-6.36%	-10.57%	-17.72%	-22.62%	-24.99%	-25.58%
Employment	-0.07%	0.25%	0.71%	1.17%	1.97%	2.51%	2.78%	2.84%
Nominal wage	-0.08%	0.23%	0.71%	1.22%	2.16%	2.86%	3.22%	3.31%
Real wage	-0.07%	0.26%	0.74%	1.27%	2.23%	2.94%	3.30%	3.40%

I repeat this simulation adopting the scenarios of wage premia at 60% and 30% respectively. The results are qualitatively identical to those presented above, but the overall magnitude of the impacts varies depending on what is assumed about graduate wage premia. In Figure 70 below I compare these results to the results of the base case scenario, where I assume a 45% wage premium. The long run impact on labour productivity under each of these scenarios amounts to 5.7%, 8.3% and 10.8% respectively. The corresponding long run impacts on Gross Regional Product are 8.0%, 11.6% and 15.0%.

Figure 70 The impact on Gross Regional Product of an increase in labour productivity due to an updating of skills in the working age population (based on 60%, 45% and 30% wage premia, respectively).



6.5.1.2.1 Sensitivity to the share of graduates in the economy

In order to increase the share of graduates in the working age population it is not sufficient to produce graduates at local HEIs and attract graduates moving in from other areas. The graduates must also stay within the local economy in order to accumulate a skilled workforce. By projecting forward the graduate share of the 25 year old cohort as I do in the baseline scenarios I am already taking into account the short run net retention rate that is manifested in the data on skills by age. That is to say, I use the graduate share of an age group that is a few years older than the typical graduation age, allowing a few years for in- and out migration to take place, to make sure that the skills data from the Annual Population Survey is not just catching a wave of recent graduates in Glasgow that might have migrated out within a few months. However, there is no guarantee that the share of graduates in each cohort of the working age population will remain stable over time, especially as graduates tend to be more footloose than people with lesser qualifications. Of course there is nothing to say that this has to result in a negative effect. It could as well be argued that a city like Glasgow with a significant HEIs sector (which as we saw in Section 2.4.1. acts to attract skilled labour) could experience a net in-migration of skilled labour. Furthermore participation rates could fall (or rise), which would feed into the share of graduates in the working age population[142]. In any case, to err on the side of caution, it is useful to know how robust the productivity impacts are to assumptions about the share of graduates in the working age population.

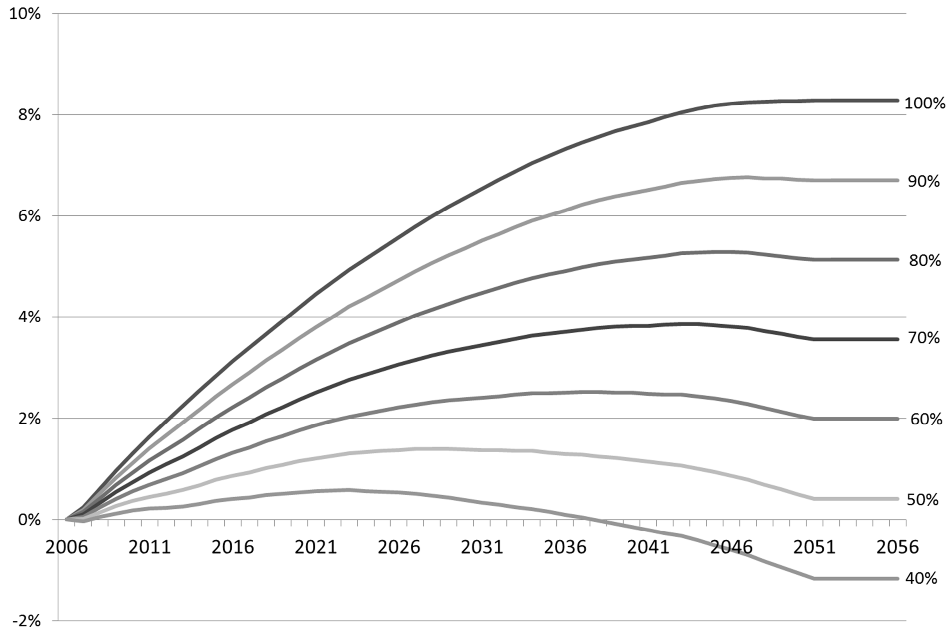
For this sensitivity analysis I impose a simple mechanism whereby I vary the share of graduates that move between age cohorts 25 and 26. That is I impose an outflow when I update the skills mix of the population through natural demographic change so assume that not all of the 25 year old graduates stay in Glasgow as 26 year olds, but vary this rate from 100% down to 40% in 10% increments. The resultant productivity shocks are presented in Figure 71 below. All the scenarios are calculated using wage premia of 45% and assuming that thereof 10% can be attributed to signalling.

Figure 71 below presents the profiles for the labour productivity shocks over time under these different assumptions. As the diagram indicates the labour productivity shocks stabilise after year 2051. If only 40% of graduates get carried over from age 25 to age 26 the long run labour productivity impact would be negative as the bottom line suggest. However, the hump shape of the profile is generated because early on there would be beneficial impacts because when the oldest age cohorts (with the lowest share of graduates) retire, these would be replaced by a new 26 year old cohort with a still higher share of graduates. Later on, however, when cohorts with a higher share of graduates start retiring the marginal labour productivity impact becomes negative and by year 2039 the overall labour productivity impact has become negative.

[142] Although that link is not explicitly identified in this study it could be calibrated in principle. Indeed, Hermannsson *et al* (2010d) experiment with a range of scenarios where the future share of graduates is projected based on assumptions about current graduation and net-retention rates only.

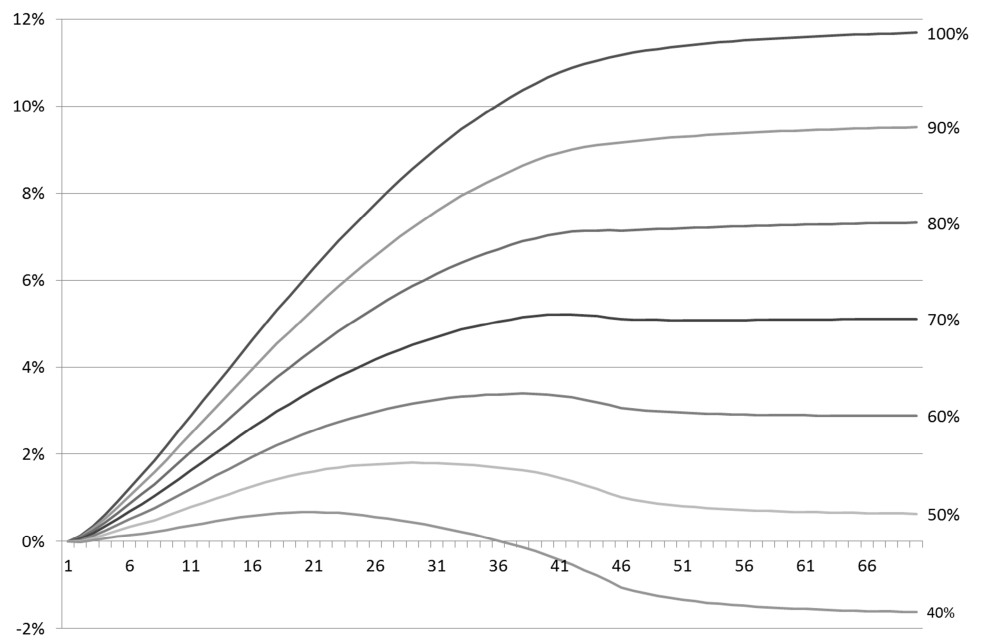
Furthermore, it should be noted that the top 100% line in this diagram is equivalent to the middle line (base case scenario) in Figure 70.

Figure 71 Sensitivity of productivity shock to graduate outflow.



The top line in the diagram shows what is my baseline scenario, i.e. 45% wage premium, 10% signalling and 100% net retention of 25 year olds with graduate qualifications until they retire. The lower bars reveal a gradual reduction in the retention of graduates over the age of 25 all the way down to 40%. As we can see this results in a positive long run productivity impact even when we assume only a 50% retention rate, although by then the impact is very small. For a 40% net retention rate the impact is positive for the first 30 years. For this scenario, even if the share of graduates in the younger cohorts is quite low (43% x 40% = 17.2%) these are replacing cohorts with an even lower graduate share that move into retirement. That is to say the marginal cohort of new entrants is less skilled than the average cohort but more skilled than the initial marginal cohorts of retirees. Over time as the cohorts retiring become more skilled the overall impacts becomes negative. It should be noted that the aggregate population does not vary in these scenarios. A graduate that moves out is assumed to be replaced by a non-graduate.

Figure 72 Sensitivity of GRP impact of an increase in labour productivity to assumptions about the outflow of graduates after age 25 (based on 45% wage premium, varying the retention of graduates after age 25 from 100% to 40%).



Feeding these productivity shocks into the Glasgow CGE-model we can see that the positive shocks have the same qualitative impact as the baseline scenarios, only of a reduced magnitude. However, for the negative shock the process is reversed. Competitiveness is eroded, which triggers a contraction in investments and exports, which then feed into household's consumption, resulting in an overall contraction in economic activity. The economy-wide impacts of these scenarios are presented in Figure 72 above.

6.5.1.2.2 Sensitivity to model parameters

As we have seen the transmission mechanism from improved labour productivity to increased output and employment hinges critically on the ability of local producers to transform increased competitiveness from more productive labour into increased export sales. In the CGE-model export performance is driven only by the price competitiveness of local producers (and an exogenous export demand parameter which is held constant in these simulations). The Armington elasticity determines the extent to which external trade responds to price changes and is therefore a key determinant of the economic impact of increasing skills in the labour market. I vary the Armington elasticity for imports and exports simultaneously. This creates a double effect. First, the higher the Armington elasticity the bigger is the export response from increased productivity of local producers. Second, the more responsive is the substitution between locally produced intermediate inputs and imported inputs, the more flexible is the supply side.

For the base case scenarios the CGE model is solved using the set of 'city' parameters, including setting the Armington elasticity equal to 5. For this sensitivity analysis I vary the Armington elasticity from the default value of 2 up to 5. Table 66 below shows the adjustment of the economy over time as labour productivity gradually increases in a model set to an Armington parameter of 2 (the default setting in AMOS). We can see that exports and investments grow in similar proportions driving a positive GRP impact, which stabilises in the long run at approximately 7.75% above its base year level. However, this export and investment stimulus is not sufficient to absorb the increased supply of labour (in efficiency units) resulting in an aggregate drop in employment, lower wages and weak stimulus to household consumption. From this it is clear that we cannot assume *ex ante* that a beneficial GRP stimulus will necessarily benefit local households on aggregate. But at what level of the Armington elasticity does this cross over so that the productivity stimulus actually increases employment? I shall explore this issue by examining some key economic indicators from simulations based on varying Armington parameters.

Table 66 Impacts over time of an increase in labour productivity based on 45% wage premium and Armington elasticity reduced to 2 (% change from base year).

	1	5	10	15	20	30	40	50	60
GRP	0.00%	0.73%	1.94%	3.16%	4.31%	6.19%	7.35%	7.69%	7.75%
Consumption	0.00%	-0.24%	-0.29%	-0.26%	-0.19%	-0.03%	0.11%	0.24%	0.26%
Government expenditure	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Imports	0.00%	1.04%	1.98%	2.72%	3.33%	4.24%	4.68%	4.61%	4.60%
Export ROS	0.00%	0.65%	1.71%	2.81%	3.88%	5.69%	6.86%	7.27%	7.38%
Export RUK/ROW	0.00%	0.65%	1.75%	2.83%	3.81%	5.38%	6.33%	6.58%	6.60%
Investment	0.00%	1.25%	2.61%	3.78%	4.80%	6.38%	7.25%	7.33%	7.33%
Capital-Stock	0.00%	0.24%	1.16%	2.27%	3.39%	5.30%	6.62%	7.18%	7.30%
CPI	0.00%	-0.02%	-0.04%	-0.06%	-0.08%	-0.11%	-0.13%	-0.14%	-0.14%
Unemployment-Rate	0.00%	2.86%	4.21%	4.59%	4.60%	4.25%	3.49%	2.48%	2.29%
Employment	0.00%	-0.32%	-0.47%	-0.51%	-0.51%	-0.47%	-0.39%	-0.28%	-0.25%
Nominal wage	0.00%	-0.33%	-0.51%	-0.57%	-0.59%	-0.58%	-0.52%	-0.41%	-0.39%
Real wage	0.00%	-0.32%	-0.46%	-0.51%	-0.51%	-0.47%	-0.39%	-0.28%	-0.25%

Figure 73 and Figure 74 below reveal the impact on Gross Regional Product (GRP) and Glasgow exports to the rest of the UK and the rest of the world (RUK/ROW) from increases in labour productivity, triggered by a growing share of graduates in the working age population. The results vary with the Armington parameter, which starts at 5 but is gradually reduced to 2. Each line in the graph is labelled with a number indicating the Armington elasticity used to generate that result. As is to be expected the weakest export impact is found when the CGE-model is run with an Armington parameter of 2. In this case exports increase by 6.6% and 7.38% from the base year (for exports to the ROW/RUK and the ROS respectively) and the GRP stimulus amounts to 7.75%. As the Armington elasticity rises the exports become more responsive to changes in the production price. With an elasticity of 5 the long run export stimulus is 9.9% and 9.4% from the base year (for exports to the ROW/RUK and the ROS respectively) and GRP is boosted by 11.4%

Figure 73 GRP impact of increased labour productivity through accumulation of skills in the working age population. Based on a wage premium of 45% and an Armington elasticity varying from 2 to 5 (% change from base year).

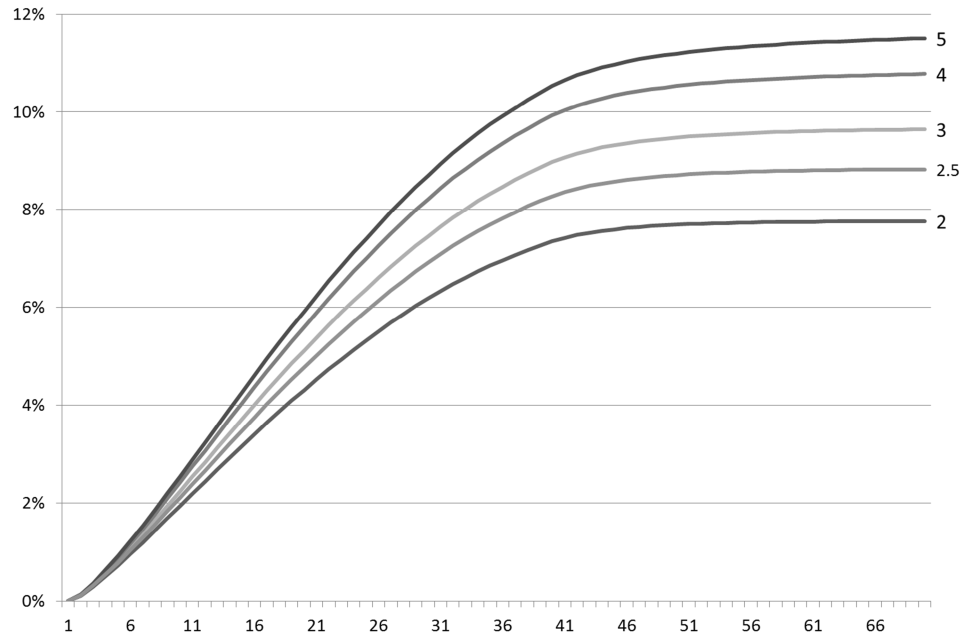
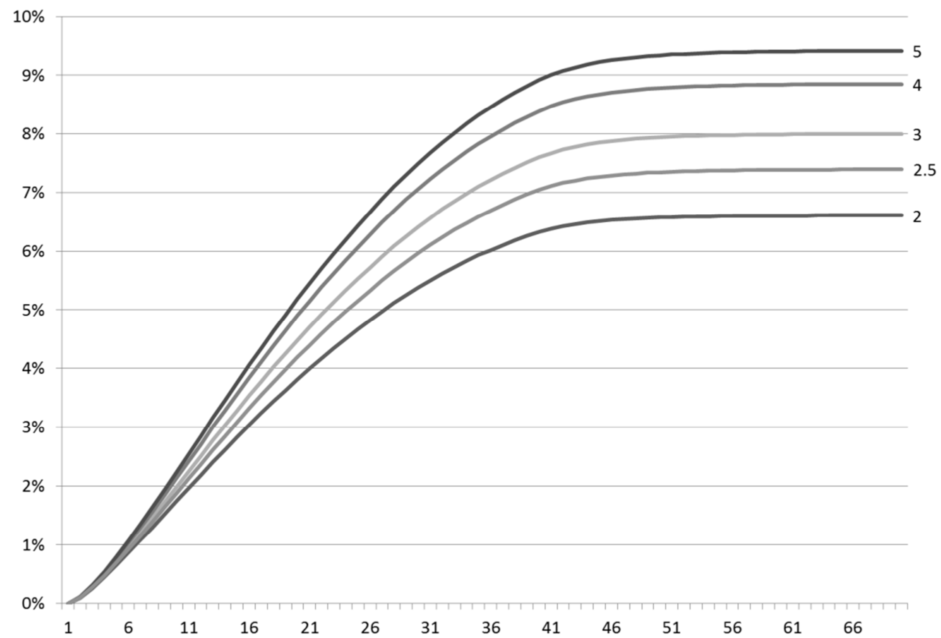
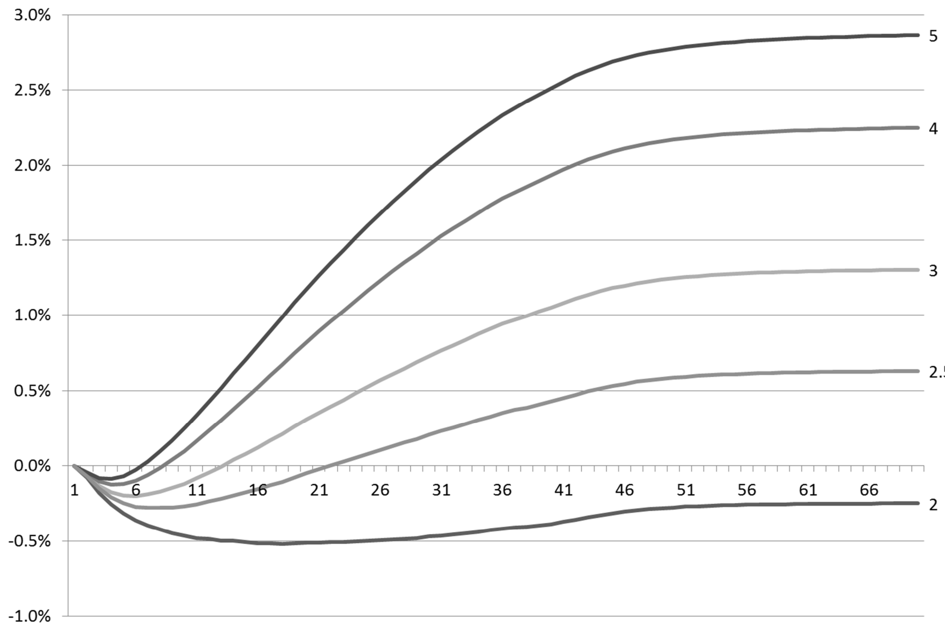


Figure 74 Impact on RUK/ROW exports of increased labour productivity through accumulation of skills in the working age population. Based on a wage premium of 45% and an Armington elasticity varying from 2 to 5 (% change from base year).



As a GRP stimulus does not automatically mean that local residents are better off, a better indicator of the benefits captured by local households is household consumption. This is in turn is to a significant extent driven by wage income and hence the balance of the labour market outcome is important.

Figure 75 Employment impact of increased labour productivity through accumulation of skills in the working age population. Based on a wage premium of 45% and an Armington elasticity varying from 2 to 5 (% change from base year).



As Figure 75 above reveals there is a significant qualitative difference between our GRP and employment results. Whereas the GRP results are all positive irrespective of the level of the Armington elasticity, a low Armington parameter can result in a negative employment impact. When the Armington parameter is set at 2 the employment outcome is negative for the entire duration of the simulation. A marginal increase in the Armington parameter to 2.5 brings a positive long run employment impact of 0.65% and the overall outcome becomes gradually more positive as the Armington parameter rises. At a value of 5 the productivity shock results in an employment growth of 2.9% from the base year. However, these are all long run results. The adjustment period is also of relevance. In all cases there is some initial reduction in employment as the shock feeds through the system and the economy adjusts. In the most optimistic scenario a positive impact on employment is not obtained until period 7. For a lower Armington elasticity of 4, 3, and 2 this crossover point is moved back to periods 8, 13 and 22 respectively.

Figure 76 Impact on household consumption of increased labour productivity through accumulation of skills in the working age population. Based on a wage premium of 45% and an Armington elasticity varying from 2 to 5 (% change from base year).

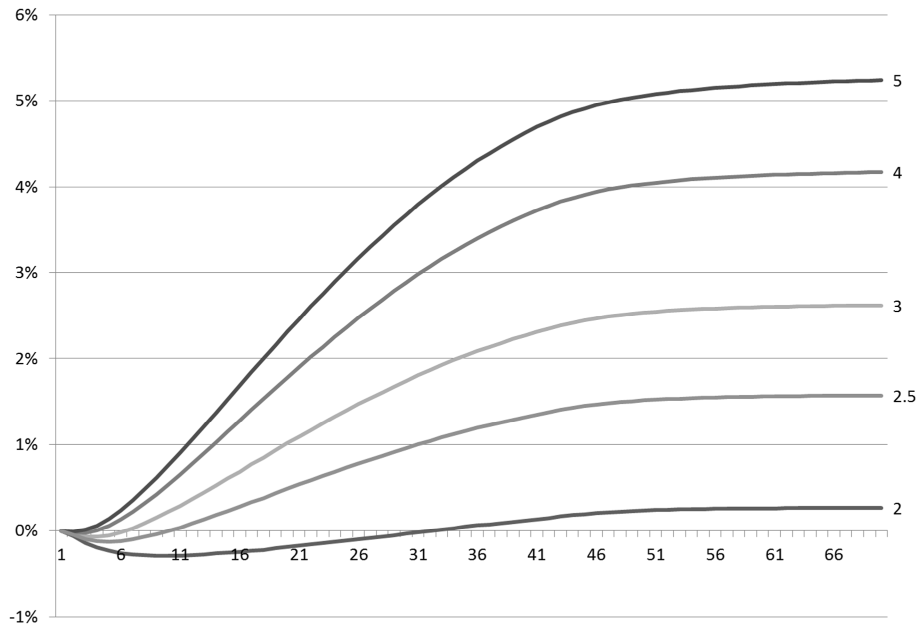


Figure 76 shows the impact over time on household consumption depending on what is assumed about the Armington elasticity. A casual comparison of Figure 75 and Figure 76 suggests a degree of correlation between the employment and household consumption impacts. A negative employment impact is likely to depress household consumption, whereas a positive employment impact drives a stimulus to household consumption. This positive consumption impact further reinforces the stimulus to GRP from exports and investment.

As this sensitivity analysis has shown the price sensitivity of external trade is critical for determining the impact of increased labour productivity on local households. In all of the cases examined here the productivity stimulus from an increasing share of graduates has a positive impact on GRP. However, this does not automatically mean that the benefits of this will accrue to local households.

The income structure of households is determined in the SAM constructed in Section 6.3. As we saw there 53% of Glasgow households' income comes from employment, whereas transfers from local production sectors only amount to 14%. Therefore, even if there is a direct link from production sectors to households bypassing the labour market, this is small in comparison to the role of wage income. In this case household consumption increased in the long run despite a small reduction in employment. However, a positive employment impact is important for stimulating household consumption through increased wage income. The Armington elasticity does not have to be very high to achieve this. Already at a value of 2.5 the simulations generate a positive long-run employment impact. Therefore, we can generalise that increasing the share of graduates in the working age population can result in a positive impact for local households as long as there is a significant enough response in the export sector so that the competitiveness benefits driven by the relative abundance of local labour supply (in efficiency units) can result in a sufficiently large export stimulus to raise employment levels or at least only reduce them slightly (no more than approximately -0.4%).

6.5.1.2.3 Interpreting results

The overall message that can be distilled from the results of these simulations is that increasing skills in the working age population brings significant positive economy-wide benefits. Furthermore, although these impacts vary in response to a number of sensitivities, they remain positive across a wide range of input values:

- Even when the wage premia is at the lower bound increasing the share of graduates in the working age population still provides significant economic impacts. In any case the baseline scenario of a 45% wage premium (specified as the wage premium of graduates on top of the wages of non-graduates on average) is lower than recent econometric estimates for Scotland, which put this at 58% The 30% wage premia adopted as my lower bound, is significantly less than the historical lower bound observed by Goldin & Katz (2007) from 90 years of US data as their 30% lower bound is a college wage premium (wages of graduates vis-á-vis the wages of those qualified to enter university study).

- The level of graduates that are retained within the local economy is clearly an important variable for determining the overall impact. Obviously the overall impact is reduced as graduate outflow increases. However, quite a low retention of graduates after age 25 (50%) is needed so that there is no positive benefit to the local economy in the long run.
- As we have seen the price responsiveness of external trade is a key parameter in determining whether the labour productivity stimulus results in a positive employment impact. This is particularly important since, as we have observed in the case of Glasgow, positive, or at least very small negative, employment impacts are needed for the productivity stimulus to benefit local households. The Armington elasticity needs to be less than <2.5 in order to drive positive employment impacts, which is quite low relative to the assumption for a city economy of an Armington parameter of 5, but still slightly higher than the Scottish default value of 2.

These simulations abstract from the role of in-commuters in affecting the share of skills in the Glasgow labour market. Effectively I assume in-commuters have the same skill distribution as the indigenous population and that it changes at the same rate as that of the indigenous population. This is potentially problematic, as for example Hårsman & Quigley (1998) found that for longer distances (trips over 20 minutes) highly educated individuals are much more likely to commute than those with lower levels of education. If in-commuters are more skilled than locals, then the simulations presented here would overstate the impact of increasing the education level of locals as the overall skill base in the labour market (locals + in-commuters) would be higher than that of locals only. On the other hand, if this was the case and at the same time the share of graduates among in-commuters would increase as much as among the locals the simulation outcomes would be unaffected. Ideally I would like to verify what exactly is the contribution of in-commuters to skill levels in the Glasgow labour market (e.g. using census data). However, this is a much more substantive undertaking than the time and resources allocated to this analysis allows.

A more challenging aspect of interpreting these results is that the competitiveness effect is contingent upon the assumptions that labour productivity is improving in Glasgow relative to the rest of the world. As Hermannsson *et al* (2010d) point out if other regions are experiencing similar increases in productivity, the competitiveness advantage would be muted. Of course, on the other hand, if Glasgow's trading partners are increasing the share of graduates in the labour force, thereby augmenting their productivity, an increase in the share of graduates in Glasgow's working age population can be seen as offsetting what would otherwise be a decline in Glasgow's competitiveness.

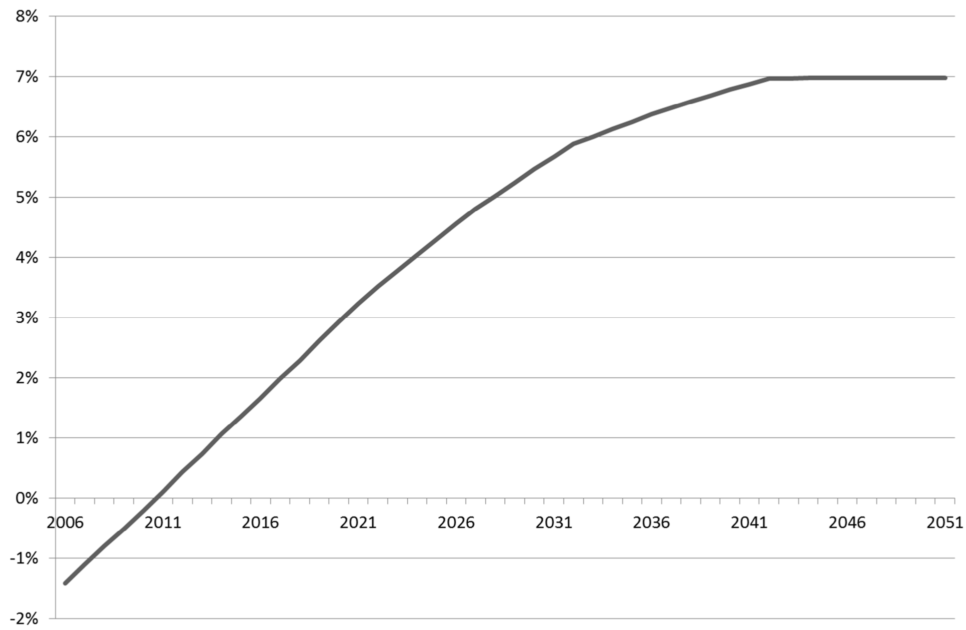
6.5.1.2.4 Single-region approximation of interregional impacts

Ideally, estimating the economic impacts of increasing skills would need to be simulated in an multi-regional setting, where one would not only project skill-increases in the economy of interest but also in the economies which it trades with. Although feasible, this would be a resource intensive undertaking and certainly one that is beyond the scope of this dissertation. However, it is possible within a single-region model to conduct a simulation, which gives an approximation of what would be the outcome if the human capital accumulation among Glasgow's trade competitors is simultaneously increased.

Figure 77 Graduates as a share of working age residents in Glasgow and the rest of Scotland.

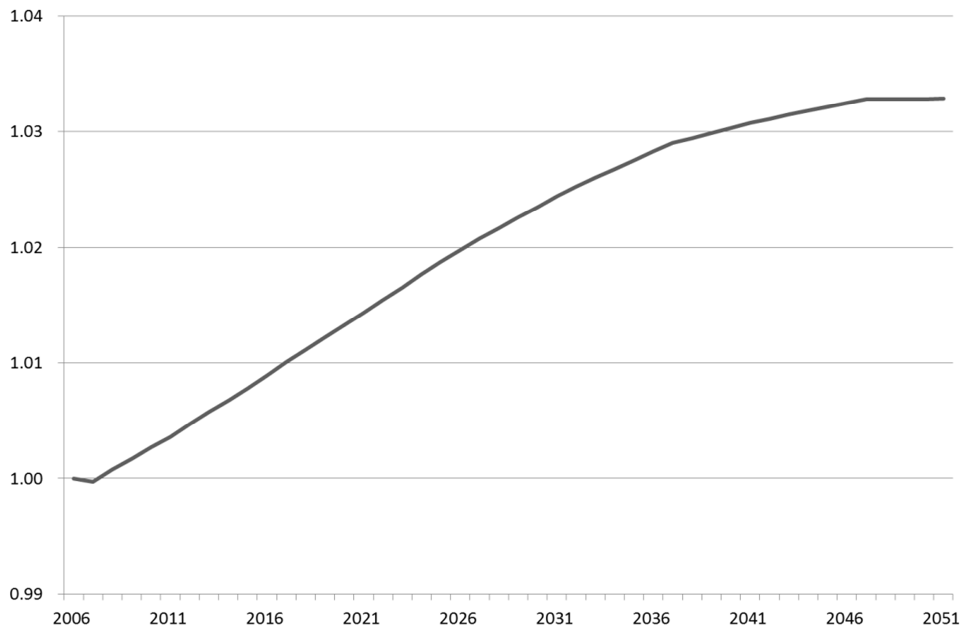
For the rest of Scotland I project the skill accumulation in the working age population using the same methods as illustrated previously for Glasgow. For simplicity, as I do not have information on the future skill levels in the rest of the World, I assume that this follows the same path as the rest of Scotland. Comparing the two skill profiles of Glasgow and the rest of Scotland I can derive a net skill projection for Glasgow. This is determined as the share of graduates in each age cohort in Glasgow less the share of graduates in each age cohort in the rest of Scotland. In the first periods this results in a negative number as share of graduates in the working age population is lower in Glasgow than in the rest of Scotland. As I run this forward however, Glasgow accumulates skills faster than the rest of Scotland and hence gains an overall higher share of graduates in the working age population. This is illustrated in Figure 78 below.

Figure 78 The share of graduates in the Glasgow working age population less the share of graduates in the rest of Scotland working age population.



In 2006 the share of graduates in the Glasgow working age population is 1.4 percentage points less than in the rest of Scotland. Moving forward however, we reach a new steady state where the share of graduates in the Glasgow working age population is 7 percentage points high than in the rest of Scotland. A flat line, i.e. remaining at -1.4 throughout the simulation period would indicate there would be no change in the relative productivity of the Glasgow working age population vis-á-vis the rest of Scotland. Figure 78, however, suggests the productivity of the Glasgow working age population should increase significantly over time. In fact, based on my base case assumptions of 45% graduate wage premia and 10% thereof attributed to signalling, the workforce of Glasgow as measured in efficiency units grows by 3.3% over that time period, as is illustrated in Figure 79 below.

Figure 79 Growth of the productivity adjusted workforce in Glasgow over and above that of the rest of Scotland.

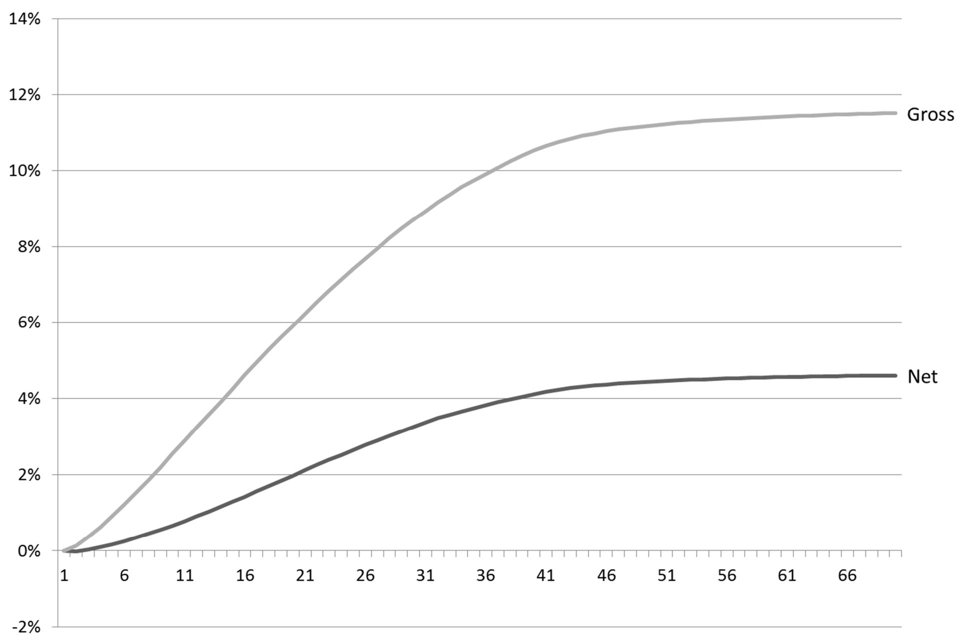


Feeding this labour productivity shock into the Glasgow CGE-model, based on the 'city' parameter assumptions I find that this results in a qualitatively identical impact to earlier simulation scenarios, albeit of a smaller magnitude. As we can see from Table 67 below the results from stimulating labour productivity only relative to the skills-increase in the Glasgow working population over and above that which has occurred in the rest of Scotland are considerably smaller. The long run rise in the level of Glasgow GRP is 4.56% compared to 11.62% in my base case. This is further illustrated in Figure 80 below.

Table 67 Impacts over time of an increase in labour productivity due to an updating of skills in the working age population over and above that occurring in the rest of Scotland, assuming 45% wage premium (% change from base year).

	5	10	15	20	30	40	50	60
GRP	0.17%	0.66%	1.29%	1.98%	3.26%	4.11%	4.45%	4.56%
Consumption	0.02%	0.18%	0.44%	0.74%	1.35%	1.80%	2.02%	2.09%
Government expenditure	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Export ROS	0.14%	0.51%	1.00%	1.54%	2.61%	3.40%	3.81%	4.01%
Export RUK/ROW	0.15%	0.59%	1.14%	1.75%	2.84%	3.53%	3.77%	3.81%
Investment	0.33%	0.96%	1.65%	2.36%	3.59%	4.33%	4.58%	4.69%
Capital-Stock	0.04%	0.36%	0.87%	1.49%	2.78%	3.80%	4.37%	4.59%
CPI	0.00%	-0.01%	-0.01%	-0.02%	-0.03%	-0.03%	-0.03%	-0.03%
Unemployment-Rate	0.23%	-0.39%	-1.67%	-3.25%	-6.63%	-9.24%	-10.59%	-10.94%
Employment	-0.03%	0.04%	0.19%	0.36%	0.74%	1.03%	1.18%	1.22%
Nominal wage	-0.03%	0.04%	0.18%	0.36%	0.75%	1.07%	1.24%	1.28%
Real wage	-0.03%	0.04%	0.19%	0.37%	0.78%	1.10%	1.27%	1.32%

Figure 80 The impact on Gross Regional Product of an increase in labour productivity due to an updating of skills in the working age population base on all of the skills increase being seen as relative to competing regions (gross) or only that which is above and beyond the rest of Scotland (net) (% change from base).



Compared to the original base case simulation this suggests an impact of approximately 40% of the magnitude of the original estimate. However, while the base case is likely to overestimate the impact of skills, this simulation of a 'net' increase in skills is probably an under estimation. Although using the increase in skills over-and above that of the rest of Scotland is a reasonable approximation for impacts driven via external trade it underestimates the internal impacts from households and production sectors being able to source inputs and consumption from more efficient local production sectors.

6.6 Conclusions from CGE-analyses

In this chapter I have introduced CGE-models as a useful extension over the fixed price Input-Output analysis. As CGE models incorporate a fully-specified supply side this, in principle, allows an explicit simulation of the benefits of HEIs that occur through the direct stimulation of the host economy's supply side. I use the Scottish AMOS CGE modelling framework to specify a CGE-model for Glasgow. The CGE model is calibrated on a purpose built Glasgow Social Accounting Matrix (SAM) and is used to illustrate the impact on the local economy of a rising share of graduates in the working age population.

CGE models trace their roots to a few clusters of researchers aiming to develop modelling frameworks for policy analysis. Broadly these researchers approached their task within a spectrum bounded by two different approaches: those trying to expand analytical general equilibrium models by using numerical solution methods (as only quite restricted GE models can be solved using analytical methods) and those wanting to relax the implicit fixed price assumptions of input-output models by adding an active supply side.

Although the theoretical origins of CGE lie in Walrasian general equilibrium theory, the policy oriented nature of CGE models means their structure tends to deviate from general equilibrium theory to a varying degree. CGE models have been applied to a number of fields, such as development policy, trade analysis, taxation, regional policy, environmental issues and population and ageing.

The use of CGE models has proliferated over approximately the last 3 decades. Although much work has been done in academic circles, some of the most well-known CGE frameworks in use have been developed by large policy institutions such as the OECD, The World Bank and the WTO. The availability of standardised software and cheap computing power has reinforced the proliferation of CGE models in smaller organisations and in individual use. However, although hardware and software is no longer an effective barrier to their use, their application requires a wide range of knowledge/skills that is best suited to team work, where individual members can specialize.

In order to calibrate a CGE model of Glasgow I construct a Social Accounting Matrix (SAM) for Glasgow in 2006. The SAM extends the Glasgow Input-Output table by including non-production flows and incomes of transactors as well as their expenditures. With the SAM it is possible to get a comprehensive view of the income and expenditures of households within the Glasgow City Council area. For example I find that by far the largest share of household's income comes from employment with local production sectors (53%) and the remainder stems from Government (20%), profit income and transfers from the corporate sector (14%) and external transfers (13%).

A CGE model of Glasgow allows analysis of demand- and supply side impacts of HEIs. Moreover, the CGE model identifies the adjustment path towards a long-run equilibrium. This is a valuable feature as often for policy short-run outcomes are important, for example due to pressures from the political cycle.

I start by analysing the impact of Glasgow's HEIs raising the share of their income from non-Scottish Government sources to that of HEIs in the rest of Scotland. I show that in the long run the CGE model converges on the results from an extended (population and investment endogenous) Input-Output system. The long-run impacts would be significant for the overall economy of Glasgow, leading to a 0.51% increase in GRP and 0.64% increase in employment. In the short run this stimulus to the HEIs results in crowding out of activities of other local production and service sectors. This is gradually relieved as investment and in-migration relax supply constraints.

I find that the long run impact of increasing skills in the Glasgow working age population could result in increase in the level of GRP of just under 12%. Furthermore, I find that although this result varies in sensitivity analysis around wage premia, graduate net retention rates, and model parameters, a large change in input values is needed to generate a negative result. Notably, this result does not assume any increase in the higher education participation rate but simply reflects the impact on average qualification levels as the age cohorts with higher graduate shares grow older and replace cohorts of retirees, who studied in an era of much lower participation rates. More broadly these results show that retaining graduates in local economies can have a significant long run impact on their success. An important contributor to this is attracting graduate in-migrants, but perhaps most important is producing graduates locally as these are more likely to stay and furthermore, the presence of a vibrant HEIs sector has been shown to influence the pull and retention of highly skilled labour. Furthermore, it should be remembered that my analysis only encompasses a narrow aspect of HEIs supply side impacts, that is the productivity benefits of graduate work sold in the labour market. Although a significant breakthrough over only analysing HEIs' expenditure impacts, this still leaves aside a number of impact channels, such as the influence of the HEIs on pulling in highly skilled activities like R&D, the role of (often graduate facilitated) knowledge exchange, the beneficial impact on graduates outwith their labour market participation and longer term socioeconomic feedback such as the influence of education levels on health and crime rates.

However, these strong results for the direct impact of graduates on their host economy via labour productivity should be seen as somewhat tentative. A significant driver of these impacts is the stimulation of exports and the modelling approach is based on a single region. Although an important milestone, the results are contingent upon skills in Glasgow rising relative to its trading partners. However, other regions and nations have also been increasing their participation and in some cases these are still higher than in the Scotland[143]. Projected share of graduates in the working age population will most likely lead to increases in labour productivity. However, the question future research needs to analyse is whether this increase in labour productivity will be sufficient to improve competitiveness vis-á-vis trading partners, thereby resulting in an export stimulus. If this skills increase in Glasgow is slower than that of neighbouring regions and countries it will only suffice to slow down the city's relative decline. Therefore, an important step for future research will be to explore the impact of future human capital accumulation in an explicitly interregional and international setting.

I attempt to predict the magnitude of impacts obtained from such analysis by deriving a productivity shock based solely on the increase of skill-levels in Glasgow over and above that in the rest of Scotland, to eliminate the potential overestimation of competitiveness effects. This however, has the shortcoming of underestimating the internal benefits of more productive production sectors supplying each other with intermediate inputs and households with consumption. Nonetheless, it is indicative of broad orders of magnitude. I find that this impact only amounts to 40% of the impacts of my earlier base case scenario. However, these impacts are by no means trivial, suggesting a 4.6% long run increase in the level of Glasgow GRP.

143 Based on available data (OECD, 2010, Table A3.2) in 2006 the average OECD graduation rate (completion of first degree for the 1st time) was 37% and the average graduation rate in the UK was 39%. The share of graduates in younger cohorts in Glasgow is 43% indicating that in the long run the city will accumulate human capital faster than the OECD on average and faster than the UK as a whole and hence improve its terms of trade. However, two countries as a whole have graduation rates equal to 43% (Netherlands, Norway) and 6 countries maintained graduation rates there above (Australia, Denmark, Finland, Iceland, New Zealand and Poland).

7 Conclusions

In this dissertation I have explored the economic impact of HEIs upon their local host communities from a variety of perspectives. I conclude each chapter (and many sub-chapters) with an overview of findings: I shall not repeat those in detail here but attempt to present key results that are of particular relevance for the academic literature and the policy discourse.

7.1 Answers to research questions

At the outset I raised four simple questions to guide this research:

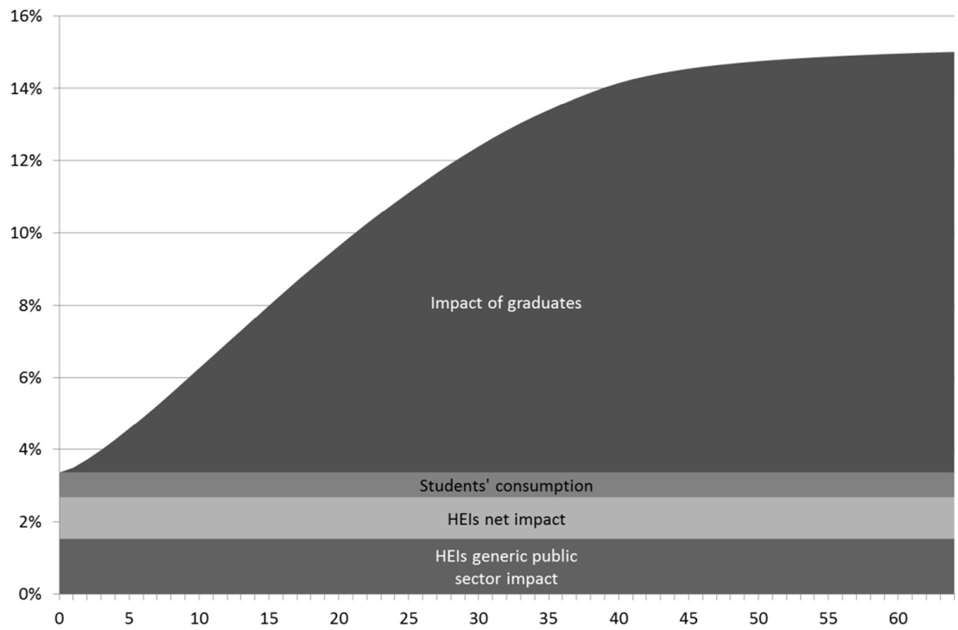
- How big are the overall economic impacts of HEIs in Glasgow relative to the local economy?
- Over what time horizons are these impacts expected to manifest themselves?
- What are the uncertainties relating to the realisation of these impacts?
- What are the key parameters that affect the level of the impacts and what is the range of potential outcomes?

Given the availability of the analyses presented hitherto these questions can be clearly addressed for those economic impacts that I have quantified, i.e. the expenditure impacts of institutions and students and the impact of increasing skills in the working age population. The Input-Output attribution analysis reveals what share of economic activity in Glasgow in the year 2006 can be attributed to the expenditures of the HEIs themselves and the consumption expenditures of their students. This amounts to 2.7% and 0.7% of Gross Regional Product (GRP) respectively. Of the institutional impact, 1.5% can be classified as generic public sector impact, whereas 1.1% can be regarded as additional to the public sector impact. Apart from these impacts upon Glasgow there will be expenditure impacts felt elsewhere in Scotland, such as from wages paid to commuters.

Some care needs to be taken in comparing expenditure impacts to the impacts of increasing the share of graduates in the labour market as even though both impacts can be represented in terms of share of local GRP they are not directly comparable. An analogy to physical investments is useful to explain this point. The impact of HEIs can be likened to that which is generated through capital investments. Every year some investments are made, which provide a demand stimulus to the economy. These feed through the economy and trigger knock-on impacts through intermediate purchases and consumption. The same goes for HEIs and their students, which every year provide a demand stimulus to the local economy. Analogously to physical investments these activities contribute to a stock of human capital that grows over time. As the stock of human capital grows this increases the productive capacity of the economy, thereby enabling increased output.

In the diagram below I show the impacts of repeated expenditures of HEIs and their students and the impact of gradually accumulating human capital as a result of the HEIs activities, from period 1 onwards. It should be noted that there are significant skills already present in the working age population that contribute to the current GRP of Glasgow, although that impact has not been quantified here. Starting at the modelling base year, 2006, by 2011 simulation results indicate that human capital accumulation will have raised the level of GRP in Glasgow by 1.2%. Furthermore, by 2016 this should be up by 2.9%, in 2026 by 6.3%. by 9.0% in 2036, 10.8% in 2046 and 11.4% in 2056. By the time we have reached a new steady state of skills in the working age population and the economy has adjusted to this productivity shock, a higher share of graduates would raise the level of GRP in Glasgow by as much as 11.8%. These impacts are compared in Figure 81 below. As is evident from the diagram realising the full impacts of increasing skills takes a long time. However, partial impacts start to manifest themselves much earlier and by Period 12 these have overtaken expenditure effects in overall magnitude. Additionally, as we saw in sensitivity analysis, these results hinge on retaining graduates within the local economy.

Figure 81 Comparison of expenditure impacts and impacts of human capital accumulation on the Glasgow economy over time.



As for key uncertainties about this outcome, it should be noticed that the result presented in Figure 81 is based on a status quo assumption. Therefore, any increase in the size of the HEIs sector or an increase in participation rates would result in a bigger impact. Overall, there is not much uncertainty to the magnitude of the expenditure impacts as these are based on current expenditures of HEIs which are captured in accounting data and the expenditures of students, which have been estimated using a survey. However, it should be noted that more than half of the expenditure impacts of the HEIs themselves are generic public sector impacts, which could have been achieved by spending those public funds on some other activity (although if that were the case the supply-side impacts of the HEIs would be significantly altered).

There are of course more explicit uncertainties in realising the impact of graduates. Conservative assumptions have been used for estimating the productivity impact of skills (wage premia). However, the outcome is of course quite sensitive to the actual share of graduates, whether fluctuations are driven by change in the participation rate or the retention of graduates. These factors are of course difficult to project, but deviations could as well be upwards as downwards. The most significant uncertainty relates to human capital accumulation among Glasgow's trading partners. As to a significant extent the GRP impacts of human capital accumulation are realised as increased productivity boosts external trade, it is important to consider not only the extent to which human capital increases relative to past levels, but also to what extent this increase is realised relative to competing regions. If other regions increase their competitive position via human capital accumulation an increase in Glasgow would in any case act to counter the city's relative competitive decline. Therefore, relative to a counterfactual of constant human capital we can expect an effect of the magnitude described in my baseline simulations. How large impacts would be realised relative to current GRP, however, hinges on the actions of competing regions. Still, even using the most restrictive assumptions where I gauge only the impacts of human capital increases in Glasgow in excess of that in Scotland, I find that the long run contribution to GRP would be an increase of 4.7%, or equivalent to almost double the expenditure impact of the institutions (2.7%).

7.2 Contribution of the research

In Chapter 2 I review the disparate literatures that analyse the economic impact of HEIs. The novel feature of this is that reviews hitherto have only focussed on particular sub-sections of these literatures in isolation. However, a holistic overview is a prerequisite for gauging the overall impact of HEIs. The chapter reveals that HEIs provide economic impacts through a wide range of channels, some of which have been quite extensively documented, whereas in other cases limited formal work has been carried out. Broadly it can be concluded that HEIs exert three types of impacts: they stimulate the demand side of the economy through their expenditures; they add to the productive capacity of economies by stimulating the supply-side both directly and indirectly; they affect the spatial distribution of existing productive capacity by exerting a gravity on skilled labour and highly skilled activities such as R&D.

The expenditure impacts of HEIs have been widely studied worldwide. Academic studies of this kind in Scotland go back almost half a century with the earliest peer reviewed publication on the subject being Blake & McDowell (1967). Studies of the demand-side impacts of HEIs typically examine both the expenditure impacts of the institutions themselves as well as the impact of their students' consumption expenditures. Typically an HEI impact study will use accounting and survey data in conjunction with a demand-driven model (such as a Keynesian multiplier or IO) to derive knock-on impacts. A major shortcoming of this literature is that it does not take into account the sometimes binding budget constraint of public funding to HEIs and their students.

In Chapter 3 I construct a 3-region Input-Output table for Glasgow city, the Rest of the Strathclyde area and the rest of Scotland. This is achieved by a spatial disaggregation of the Scottish (HEI-disaggregated) Input-Output table using location quotients. Furthermore I use data on commuter flows to capture the interregional wage flows within Scotland and propose using on sub-regional Gross Disposable Household Income to identify the net flow of consumption expenditures between the 3-regions. This is particularly important for capturing a key aspect of the nature of the Glasgow metropolitan area (Glasgow and the rest of the Strathclyde area) which is the intensive interaction through commuting- and shopping trips. As is well documented in existing literature, location quotients are frequently employed to construct local input-output tables as this is far less resource-intensive than alternative approaches. The downside, however, is that this method tends to overestimate the purchases of local intermediates and underestimate trade. In an interregional setting this would tend to overestimate local impacts and underestimate spillovers. To verify the extent of potential bias I conduct a range of sensitivity analyses. I find the almost exclusive focus on intermediate trade, which is characteristic of existing literature, to be inadequate at the metropolitan level. In cases such as that of Glasgow and the rest of the Strathclyde-region, I find that the interregional wage and consumption flows are as important for the accurate estimate of Type-II multipliers as is the accurate identification of intermediate trade.

In Chapter 4, I provide a descriptive analysis of the characteristics of Glasgow HEIs within the context of the overall Scottish HEIs sector. For this I draw on a variety of data sources, including publicly available data from the Higher Education Statistics Agency (HESA), specially commissioned data from HESA databases and previously unpublished data from the University of Strathclyde. The analysis reveals, amongst other things, that Glasgow HEIs comprise the largest sub-regional grouping of HEIs in Scotland as gauged by income, earning 31% of the income of the overall Scotland wide sector[144]. Payroll information from the University of Strathclyde reveals that approximately half of its wage payments are made to in-commuters living outside Glasgow.

Glasgow City also hosts the largest community of students at HEIs in Scotland. The composition of this student population differs significantly from that found elsewhere in Scotland, with a higher share of Scottish students, in particular those local to the Strathclyde area. It follows that graduates from Glasgow HEIs exhibit higher retention rates within the vicinity of the city than can for example be observed for graduates from HEIs in Edinburgh, which tend to disperse more widely.

In Chapter 5 I make a number of contributions to the estimation of expenditure impacts of Higher Education Institutions and the related impact of their students' consumption expenditures. An analysis of the institutional expenditure impacts within the 3-region interregional framework reveals that these clearly cut across sub-regional boundaries in Scotland. Most explicitly this is evident for the Glasgow HEIs where 25% of their Scotland-wide output impacts were felt outside their host region. This is due to the economic structure of their host sub-region Glasgow, which is very open, as reflected in the scale of wage payments to the rest of the Strathclyde region and to a lesser

[144] The cluster of HEIs in Edinburgh is only marginally smaller in income terms, but less dependent on Scottish Government funding. Hence Edinburgh HEIs are likely to exert a larger balanced expenditure impact than Glasgow HEIs.

extent to the rest of Scotland (ROS). Perhaps unsurprisingly the HEIs in the largest sub region (ROS) exhibit the least tendency for impacts to spill-over onto neighbouring sub-regions, with 96% of the output impacts incurring within the region.

Furthermore, I analyse how HEI activities are distributed across the three regions by comparing shares of HEI expenditures with population shares. From this perspective HEIs are clearly over-represented in Glasgow. However, when focusing on the Strathclyde region as a whole (GLA+RST) it is evident that relative to the regions' population, HEI activity is under-represented vis-á-vis the rest of Scotland. This uneven distribution of HEI activities over space is not driven by an inequitable allocation of Scottish Government funding, but reflects the fact that HEIs in the ROS are better at complementing their Scottish Government funding with income from other sources. I calculate that if the Strathclyde HEIs were able to complement their public income with external funds to the same extent as the HEIs in the ROS this could result in an additional income of £119m for the Strathclyde HEIs (an 16.8% increase in total income). It is difficult to predict whether additional emphasis on external income would be overall beneficial for the host economy. If a focus on external income complements the HEIs' capacity for building human capital it is clearly a good thing overall. However, if there is some trade-off between focusing on external competiveness of the institutions and their role in producing graduates for the local labour market, the outcome would be ambiguous as producing graduates that are retained within the local economy brings sizeable economic benefits.

For the analysis of students' consumption expenditures I draw on Hermannsson *et al* (2010b,c), who use a survey of students' income and expenditures to identify the endogenous and exogenous components of students' consumption expenditures within an Input-Output framework. I extend their approach to an interregional setting. This is important as students are highly mobile and often draw an income from one region, which they spend in another. Therefore their Scotland-wide direct expenditures are in fact an average of disparate sub-regional impacts. In aggregate most of these net sub-regional impacts are positive, but a neglected aspect which I address is that through displacement of expenditures these can also be negative. I find that the output impact of students' consumption expenditures spill-over sub-regional boundaries and this occurs in two stages. Firstly through direct interregional expenditure- and displacement effects where mobile students exert a positive impact upon their region of study but a negative impact upon their region of domicile. Secondly, through knock-on impacts which spill-over sub-regional boundaries. Looking at the results from my analysis a striking heterogeneity of regional impacts is revealed. Glasgow city benefits from a net inflow of students while its hinterland loses since it receives far fewer students than it sends away. This results in significant negative economic impacts upon Glasgow's hinterland as students move out of the area (typically into Glasgow), taking their expenditures with them. However, once multiplier effects have been taken into account there is a mild positive impact upon the rest of the Strathclyde region, as much of the positive knock-on impacts from the city feed back into the hinterland through wages of commuters. In this particular case the adverse negative direct impact of student outflow is off-set by positive spill-overs from the students' expenditures in their region of study. This is due to the close economic links between the two adjacent areas and will almost certainly not apply in other cases, for example those of remote areas that experience a net-outflow of students to the metropolitan areas.

The final contribution of Chapter 5 is in applying the notion of the balanced expenditure multiplier to an interregional setting, more specifically to the case of GLA-RST-ROS. For this I explore two cases where I adopt different assumptions about the spatial distribution of displacement impacts. Firstly, I assume that total Scottish Government expenditures are fixed within each sub-region, so that Scottish Government funding for HEIs displaces funding for other Barnett-funded activities within their host region. This is in effect akin to the budget constraint faced by local authorities. Secondly, I re-work this analysis under the assumption that Scottish Government funding is displaced equiproportionately in each sub-region, reflecting the initial spatial distribution of public spending in the IO-tables. Both approaches result in the same Scotland-wide balanced expenditure impact of HEIs, but the impacts across individual sub-regions vary substantially depending on which assumption is adopted. In the former case the negative displacement impacts are all contained within the HEIs host sub-region and therefore act to subdue its local impact. However in the latter case the displacement impacts are spread across the sub-regions resulting in much more heterogeneous impacts across space. This reveals that even as partially publicly funded activities have positive Scotland-wide output impact the same cannot be uniformly expected at a sub-regional level. There is an, at least implicit, opportunity cost for the regions that are not subject to the positive stimuli of the public-sector injection. This suggests that an 'equitable' (equal per capita) distribution of public expenditures across space is an important consideration for regional policy. However as we have seen economic structure can act to move impacts within space and hence ideally the predicted impacts of public expenditures should be levelled across space rather than the direct public expenditures.

In Chapter 6 I introduce CGE models and calibrate a CGE model of Glasgow City. This allows analysis of both demand-side and supply-side impacts of HEIs. In addition to long-run equilibrium outcomes, the CGE model permits the analysis of short-run impacts and the adjustment path towards long-run equilibrium. This is an important feature as often in the policy context short-run outcomes are disproportionately important for stakeholders, for example democratically elected leaders need to renew their mandate regularly in elections.

I analyse the impact of Glasgow's HEIs raising their share of income complementing Scottish Government funding to the same rate as that of HEIs in the rest of Scotland. I show that in the long run the CGE model converges on the results from an extended (population and investment endogenous) Input-Output system. The long run impacts are significant for the overall economy of Glasgow, leading to a 0.51% increase in GRP and 0.64% increase in employment. However, the fully specified supply-side of the CGE model allows a richer analyses than just replicating the IO result of a demand impact. For example, it is revealed that in the short run this stimulus to the HEIs results in crowding out of activities of other production and service sectors in the Glasgow economy. In the short run the economy faces rigidities on the supply side so that a demand stimulus not only increases output but raises prices, adversely affecting those sectors not directly stimulated. Gradually though, as investment and in-migration relieve supply pressures prices normalise and the long-run impact of the demand stimulus is realised.

Perhaps the most important advantage of using CGE models in this context is that they allow the modeller to simulate the impacts of the supply-side stimulus HEIs provide for their host economies. As is evident from the literature review in Chapter 2, a range of potential supply-side impacts could in principle be introduced. I follow Hermannsson et al (2010d) in simulating the impact of increasing skills in the labour market through a rising share of graduates in the working age population. This does not assume any increase in the higher education participation rate but merely reflects the impact on average qualification levels as the (initially younger) age cohorts containing a higher share of graduate grow older and replace cohorts of retirees, who studied in an era of much lower participation rates. The graduate wage premium, adjusted for signalling, is used as an indicator of the productivity difference between graduates and non-graduates. For my base case assumptions I find that the long-run impact of increasing skills in the Glasgow working age population generates an increase of GRP of just under 12%. Furthermore, I find that although this result is sensitive to assumptions about wage premia, graduate net retention rates, and model parameters, large changes in input values are required to eliminate this positive impact.

These results show that retaining graduates can have a significant long run impact on the local economy's success. Producing graduates locally is an important contributor to this as these graduates are more likely to stay and furthermore, the presence of a vibrant HEIs sector has been shown to influence the pull and retention of highly skilled labour. Furthermore, it should be remembered that my analysis only encompass a narrow aspect of HEIs supply-side impacts, that is the productivity benefits of graduate work sold in the labour market. This is a significant extension over only analysing HEIs' expenditure impacts. However, this still leaves aside a number of impact channels, such as the influence of the HEIs on pulling in highly skilled activities like R&D, the role of (often graduate-facilitated) knowledge exchange, the beneficial impact on graduates outwith their labour market participation and longer term socioeconomic feedback such as the influence of education levels on health and crime rates.

However, these strong results for the direct impact of graduates on their host economy via labour productivity should be seen as somewhat tentative. A significant driver of these impacts is the stimulation of exports and the modelling approach is based on the skills stimulus applying only to a single region. Although an important milestone, the results are contingent upon skills in Glasgow rising relative to its trading partners. However, other regions and nations have also been increasing their participation and in some cases these are still higher than in the UK. Projected share of graduates in the working age population will most likely lead to increases in labour productivity. However, the question that future research needs to analyse is whether this increase in labour productivity will be sufficient to improve competitiveness vis-á-vis trading partners, thereby resulting in an export stimulus. If this skills increase in Glasgow is slower than that of neighbouring regions and countries it will only suffice to slow down the city's relative decline in labour productivity and hence the adverse impacts upon its terms of trade. But of course the city would be better off than if it had not benefitted from any human capital policies at all.

The analysis has revealed that human capital impacts are very important and possibly deserve more attention from policy makers. A large literature documents the link between human capital and labour market outcomes. However, a lacuna that this dissertation and related work attempt to address is analysing the impact of human capital in a system-wide context. Important as efforts to refine the microeconometric evidence on the return to education are, from a policy perspective identifying individual benefits is not sufficient as these have to be related to impacts on the wider economy. A casual observation of debate in UK policy circles suggests that when it comes to prominence on the agenda for the economic contribution of HEIs, policies relating to fostering human capital are up against tough competition from the multiple other roles of HEIs. However, indications are that human capital policies exert a large economic impact directly and are potentially even more important if wider socioeconomic feedbacks are taken into account. Understandably the economic potential of activities such as knowledge exchange, where the emphasis is on the transmission mechanism towards the wider economy, has featured prominently on the policy agenda. However, the evidence suggests HEIs should emphasise the economic contribution provided by their traditional teaching role as this has significant and direct implications for competitiveness, in addition to large potential indirect effects and wider social impacts, which have yet to be further explored. Therefore I conclude that there is a need to reinforce the research agenda for studying the impacts of human capital accumulation in a system-wide context. A compelling next step would be to analyse the transmission mechanisms of wider socioeconomic impacts, which have been little explored in a systematic way, but indications are that these could be very important (McMahon 1999, 2004, 2009; Hermannsson *et al* 2010g). However, the notion of HEIs and their students driving expenditure impacts should not be dismissed. These are probably not as important as the supply-side impacts and it is true that to considerable extent HEIs expenditure impacts are driven by the expenditure of limited public funds. However, in the case of Scotland HEIs are an export-intensive sector and the impacts of their expenditures are immediately felt in their host communities.

7.3 Suggestions for future research

The research presented in this dissertation can be extended in a number of directions. Firstly, there are a number of direct extensions/refinements of the work already presented that can be undertaken. I shall go through these in the order of the chapters they relate to. Secondly, the present analysis raises some fresh questions, which I shall examine subsequently.

Revisiting the 3-region interregional HEI-disaggregated Input-Output table is obviously desirable in order to enhance its validity. The most significant improvement, but probably the most resource intensive, would be to conduct a survey to determine the flow of interregional intermediate transactions. A potential less resource intensive improvements would involve obtaining existing data, such as on credit card transactions to inform assumptions about the interregional flow of household consumption and conducting a more detailed investigation of commuting data to disaggregate commuting flows by sector.

An interesting extension to the use of the Input-Output table to estimate interregional expenditure and displacement impacts of students' consumption expenditures would be to examine other geographical disaggregations of the Scottish table. For example, a contrasting case to the impacts on the metropolitan economies of Glasgow and the Strathclyde region would be to look at the impact of mobile students upon peripheral regions in Scotland. Using the 3-region framework, an ideal setup would be to identify separately as two peripheral regions: the Higlands and Islands; and the rural communities of Dumfries, Galloway and the Borders in the South of Scotland. This would leave the rest of Scotland as a residual that includes all the significant student centres: Glasgow, Edinburgh, Dundee, St Andrews and Aberdeen. Furthermore, there is an interesting *a priori* difference between the two peripheral regions as the University of the Highlands and Islands, which was founded with explicit regional policy aims, operates in its namesake region, whereas Dumfries, Galloway and the Borders only contain outposts from Scottish universities based elsewhere (Scottish Agricultural College, University of Glasgow). It is an interesting question therefore whether the UHI drives a significantly different outcome for the Highlands & Islands than can be observed in Dumfries, Galloway and the Borders.

The interregional balanced expenditure multiplier framework offers a range of potential applications. Firstly, it is possible to apply interregional balanced expenditure multiplier analysis to the case of students. As Hermannsson *et al*

(2010b,c) reveal a part of student's income expenditures is financed with income subject to the binding budget constraint of the Scottish Government. Secondly, the framework can be applied to any region where the relevant data are available, such as other parts of the UK or EU. Thirdly, it can be applied to other sectors that are partially publicly funded. Fourthly, the framework can be used to analyse the sub-regional impacts of budget proposals, where any change (positive or negative) could be fed into the model to simulate not only the region-wide impacts of proposals, but how these are distributed at the local level.

A further possible extension based on the Input-Output database would be to use the HEI-disaggregated IO-table as a starting point for deriving efficiency metrics for each of the Scottish HEIs. This would be a logical extension as already the IO-database contains detailed information on income and expenditures by institution. The IO-database could then be linked with data on the outputs of HEIs to derive efficiency estimates in a relatively straightforward manner. This would be of significant interest at the public policy level. For example the Tripartite Advisory Group on higher education in Scotland has recently commissioned a study into what efficiency metrics are appropriate for the Scottish higher education system[145].

CGE-models are particularly useful tools to synthesise within a unified framework the wide array of economic and social impacts associated with HEIs. A number of extensions await future work. Firstly it would be useful to conduct CGE-analysis of the overall impact of HEIs within an explicitly interregional framework. The interregional dimension comes into play at two levels: in the first instance at the regional level, since as we saw in the case of Glasgow it would be highly beneficial to model the city's interaction with the rest of Scotland. Furthermore, an analysis of this type should arguably be set within a global CGE context. As we saw in the case of Glasgow, stimulating the supply side is transmitted to an economy-wide impact largely through competitiveness

[145] The report is available to download from the Scottish Government's website: http://www.scotland.gov.uk/Publications/2010/11/09155920/0

effects, which stimulate trade. The realised economy-wide impact of HEIs, delivered via this transmission mechanism, depends on the progress of competitors. Therefore, for increased realism simulations should be carried on vis-á-vis a rest of the world that is not static but where the increase in skills and productivity are also being simulated.

Secondly, the application of the CGE-model to capture the supply-side impacts of increasing skills in the working age population represents only one illustration of a range of economic and social impacts of HEIs upon their host economies. A new application, which is a natural progression of analysing the impact of skills, is to draw on results on student's labour market participation (Munro *et al,* 2009) to model the supply side impact of the student population. Indications are that student labour supply can potentially be very important, in particular in metropolitan areas, for sectors like retail and entertainment. Munro *et al* (2009) collect data for a number of cities. The effects of student labour force in the population are likely to be particularly important in places like Glasgow where a large student population and a large urban service sector coincide. Furthermore, the CGE-approach can be extended to analyse a host of other effects, attributed to HEIs, including notably those coming through innovation and knowledge spillovers (e.g. Harris *et al*, 2010a,b) and to the extent that the micro-econometric evidence exists I can also investigate the wider impacts of HEIs, notably social returns and non-market private returns (McMahon 2009, Hermannsson *et al* 2010g). Thirdly, a future model could include more detailed treatment of the role of skills in the labour market, which would allow a richer analysis of the transmission mechanism of labour market impacts. The simulations presented here were based on the simplifying assumption of a unified labour market. However, the notion of dual labour markets of skilled and non-skilled labour is widely employed in labour market analysis (e.g. Goldin & Katz 2007.)

In addition to the refinements and extensions, engaging with the work contained in this dissertation provokes many additional questions, some of which I identify here. A theme of this dissertation is how HEIs affect their host regional economies. However, in order to formulate policy to maximise the benefits of resources spent on HEIs it would be desirable to understand how things work inside the HEIs and how internal processes related to their external impact. This is apparent for different types of analysis. For example, we do not have a model of how HEIs respond to funding pressures. When we analyse the impact of changes in public funding how do the HEIs respond to cuts or increases? Does public funding crowd out their initiative to seek alternative income sources or does public funding complement the ability to find research grants and attract fee paying students? A related, but possibly more important, question is how does the university experience affect human capital? Does teaching and contact with academics (or lack thereof) affect labour market outcomes? As we saw in Section 2.2.1 Bell & Sarajevs (2004) found that both cognitive and non-cognitive skills affect labour market outcomes, but that it is more feasible to influence the "softer" non-cognitive skills. It seems plausible that these non-cognitive skills are enhanced through the socialising effects of formal education. Of course we already know that the pattern of labour market outcomes is changing. As Walker & Zhu (2008) point out the average outcome is the same as before but the distribution has widened. Is that entirely driven by increasing heterogeneity of the HEIs' intake or is perhaps some of it driven by internal changes in the way HEIs provide training?

Finally, I would like to suggest that the methods demonstrated here can be extended to look at the impacts of other stages of education. These impacts are important as both wages and likelihood of employment drop sharply the earlier a student leaves the formal education system. This is in addition to potentially very strong links to wider social impacts and feedbacks onto the next generation. For example, Machin *et al* (2011) find a strong negative link between early schooling completion rates and property crime in the UK.

This dissertation has found much support for the economic benefits of higher education, both accruing to the graduates themselves as well as society at large. Significant benefits can be had from better understanding the social and economic impacts of higher education. Although advancing this broad research field will certainly require new evidence, it should be noted that much evidence already exists, scattered across various academic disciplines and sub-disciplines. Therefore, much remains to be done working across the disciplines to synthesize evidence and analysis within a system-wide framework.

References

Acemoglu, D. (2002). Technical Change, Inequality, and the Labour Market. Journal of Economic Literature, Vol. 40, No. 1, pp. 7-72.

Ackerlof, G.A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. Quarterly Journal of Economics. Vol. 84, No. 3., pp. 488-500.

Acs, Z. (2010). Jaffe-Feldman-Varga: the Search for Knowledge Spillovers. In Varga, A. (ed.). Universities, Knowledge Transfer and Regional Development: Geography, Enterpreneurship and Policy. Cheltenham: Edvard Elgar.

Akita, T. & Kataoka, M. (2002). Interregional Interpedendence and Regional Economic Growth: An Interregional Input-Output Analysis of the Kyushu region. Review of Urban and Regional Development Studies. Vol. 14, No. 1, pp. 18-40.

Allan, G., Dunlop, S. & Swales, K. (2007). The Economic Impact of Regular Season Sporting Competitions: The Glasgow Old Firm Football Spectators as Sports Tourists. Discussion Paper No. 07-03. Department of Economics, University of Strathclyde, Glasgow, Scotland.

Anderson, K., Martin, W. and van der Mensbrugghe, D. (2006). Market and Welfare Impacts of Doha Reform Scenarios. In Anderson, K. & Martin, W. (eds) Agricultural Trade Reform and the Doha Development Agenda. London: Palgrave Macmillan, co-published with the World Bank.

Andersson, M., Gråsjö, U. & Karlsson, Charlie (2010). The Role of Higher Education and University R&D for Industrial R&D Location. In Varga, A. (ed.). Universities, Knowledge Transfer and Regional Development: Geography, Enterpreneurship and Policy. Cheltenham: Edvard Elgar.

Andersson, R., Quigley, J.M. & Wilhelmsson, M. (2004). University Decentralization as Regional Policy: the Swedish Experiment. Journal of Economic Geography. August 2004. Vol 4. No. 4. PP. 371-388.

Andersson, R., Quigley, J.M. & Wilhelmsson, M. (2005). Urbanization, Productivity and Innovation: Evidence from Investment in Higher Education. University of California, Berkeley, working paper.

Angrist, J.D. & Krueger, A.B. (1999). Empirical Strategies in Labour Economics, in Handbook of Labour Economics, Volume 3A (Ashenfelter & Card (eds)). Amsterdam and New York: North Holland.

Anselin, L., Varga, A. & Acs, Z. (1997). Local Geographic Spillovers between University Research and High Technology Innovations. Journal of Urban Economics. Vol. 42. pp. 422-448.

Anselin, L., Varga, A. & Acs, Z. (2000). Geographic and Sectoral Characteristics of Academic Knowledge Externalities. Papers in Regional Science. Vol. 79, No. 4, pp. 435-443.

Appiah, E.N. & McMahon, W. (2002). The Social Outcomes of Education and Feedbacks on Growth in Africa. Journal of Development Studies. Vol. 38, No. 4, pp. 27-68.

Appleseed (2004). Innovation & Opportunity: Harvard University's Impact on the Boston Area Economy. Retrieved from the World Wide Web: http://www.appleseedinc.com/reports/Harvard2004.pdf

Armington, P. (1969). A Theory of Demand for Products Distinguished by Place of Production. IMF Staff Papers, Vol. 16, pp. 157-78.

Armstrong, H. & Taylor, J. (2000), Regional Economics and Policy, 3rd edition. Oxford: Blackwell Publishers.

Armstrong, H.W, Darrall J. & Grove-White, R. (1994). Building Lancaster's Future: Economic and Environmental Implications of Lancaster University's Expansion to 2001, Lancaster: CSEC, Lancaster University.

Armstrong, H.W. (1993). The Local Income and Employment Impact of Lancaster University. Urban Studies. Vol. 30, No. 10, pp. 1653-1668.

Arrow, K. (1973). Higher Education as a Filter. Journal of Public Economics. Vol. 2, no. 3, pp. 193-216.

Arrow, K. (2005). Personal Reflections on Applied General Equilibrium Models. In Kehoe, T.J., Srinivasan, T. N. & Whalley, J. (Eds.). Frontiers in Applied General Equilibrium Modeling: in Honor of Herbert Scarf. Cambridge: Cambridge University Press.

Arrow, K. J., & Debreu, G. (1954). Existence of an equilibrium for a competitive economy. Econometrica, 22, 265-90.

Bandara, J.S. (1991). Computable General Equilibrium Models for Development Policy Analysis in LDCs. Journal of Economic Surveys, Vol. 5, No. 1, pp. 3-69.

Barret, R. (2010). Disadvantaged groups in the labour market. Economic & Labour Market Review. Vol 4, No 6, pp. 18-24.

Barro, R. J. & Sala-i-Martin, X. (1995). Economic Growth. New York: McGraw-Hill.

Barro, R. J. & Sala-i-Martin, X. (2004). Economic Growth – 2nd edition. Cambridge: The MIT Press.

Batten, D. (1982). The Interregional Linkages between National and Regional Input-Output Models. International Regional Science Review. Vol. 7, No. 1, pp. 53-67.

Battu, H., Belfield, C. and Sloane, P. (2000). How Well Can We Measure Graduate Over-Education and its Effects? National Institute of Economic Review, 171, pp.82-93.

Battu, H., Belfield, C.R. & Sloane, P.J. (2003). Human Capital Spillovers within the Workplace. Evidence for Great Britain. Oxford Bulletin of Economics and Statistics. Vol. 65, No. 5, pp. 575-594.

Battu, H. & Sloane, P. J. (2004). Over-Education and Ethnic Minorities in Britian. The Manchester School, Vol. 72., No. 4, pp. 535-559.

Battu, H. (2007). Overeducation Amongst the Young in the OECD: A Review. OECD commissioned report.

Battu, H., Bellfield, C.R. & Sloane, P.J. (2000). How Well Can I Measure Graduate Overeducation and Its Effects. National Institute Economic Review, No. 17, pp. 82-93.

Battu, H., Finch, J.H. & Newlands, D. (1998). Integrating Knowledge Effects into University Impact Studies: A Case Study of Aberdeen University. Department of Economics, University of Aberdeen.

Becker, G. (1964). Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education. 3rd edition (1993). Chicago: University of Chicago press.

Beeson, P. & Montgomery, E. (1993). The Effects of Colleges and Universities on Local Labor Markets. Review of Economics and Statistics, Vol. 75, pp. 753-61.

Bell, D. & Sarajevs, V. (2004). Scottish Eduction: Spending More – Earning Less? Department of Economics, University of Stirling & Scottish Economic Policy Network. Retrieved from the World Wide Web: http://www.scotecon.net/publications/Bell%20and%20Sarajevs%20Summary.pdf

Belfield, C.R. & Fielding, A. (2001). Measuring the relationship between resources and outcomes in higher education in the UK. Economics of Education Review. Vol. 20, pp. 589-602.

Benahabib, J. & Spiegel, M.M. (1994). The role of human capital in economic development Evidence from aggregate cross-country data. Journal of Monetary Economics, Vol. 34, pp. 143-173.

Black, D.A. & Smith, J.A. (2004). How robust is the evidence on the effects of college quality? Evidence from matching. Journal of Econometrics, Vol. 121, pp. 99-124.

Blake, C. & McDowell, S. (1967). A Local Input Output Table. Scottish Journal of Political Economy. Vol. 14, pp. 227-242.

Bleaney, M.F., Binks, M.R., Greenaway, D., Reed, G.V. & Whynes, D.K. (1992). WhatDoes a University Add to Its Local Economy. Applied Economics, vol. 24, pp. 305-311.

Blundell, R. & Deardren, L. (2000). The returns to Higher Education in Briain: Evidence from a British Cohort. The Economic Journal, Vol. 110, No. 461, February 2000, pp. F82-F99.

Blundell, R., Deardren, L. & Sianesi, B. (2005). Measuring the Returns to Education, in Machin, S. & Vignoles, A. (eds) What's the Good of Education: The Economics of Education in the UK. Princeton & Oxford: Princeton University Press.

Bonfiglio A. (2009) On the Parameterization of Techniques for Representing Regional Economic Structures. Economic Systems Research. Vol. 21, pp. 115−127.

Bonjour, D., Cherkas, L.F., Haskel, J.E., Hawkes, D.D. & Spector, T.D. (2003). Returns to Education: Evidence from UK Twins. The American Economic Review. Vol. 93, No. 5, December 2003, pp. 1799-1812.

Borges, A.M. (1986). Applied General Equilibrium Models: An Assessment of Their Usefulness for Policy Analysis. OECD Economic Studies, Vol. 7, pp. 7-43.

Borland, J., P. Dawkins, D. Johnson, & R. Williams. (2000). Returns to Investment in Higher Education. The Melbourne Economics of Higher Education Program Report No. 1, Report to the Vice Chancellor of the University of Melbourne. University of Melbourne.

Bound, J., Groen, J., Kézdi, G. & Turner, S. (2004). Trade in University Training: Cross-State Variation in the Production and Stock of College-Educated Labour. Journal of Econometrics. Vol. 121, pp. 143-173.

Brand, S. (1997). On the Appropriate Use of Location Quotients in Generating Regional Input-Output Tables: A Comment. Regional Studies, Vol. 31.8, pp. 791-794.

Brown, S. & Sessions, J. (2004). Signalling and Screening. In Geraint, J. & Johnes. J. (eds.) International Handbook on the Economics of Education. Cheltenham: Edward Elgar.

Brownrigg, M. (1973). The Economic Impact of a New University. Scottish Journal of Political Economy. Vol. 10, No. 2. June 1973. pp. 123-139.

Burfisher, M.E. (2011). Introduction to Computable General Equilibrium Models. Cambridge: Cambridge University Press.

Callander, C. & Wilkinson, D. (2003). 2002/03 Student Income and Expenditure Survey. DFES, Research Report, no. 487 2003.

Campbell, D.E. (2006). What is education's impact on civic and social engagement? In Desjardins, R. & Schuller, T. (eds.) Measuring the Effects of Education on Health and Civic Engagement: Proceedings of the Copenhagen Symposium. Paris: OECD. Retrieved from the World Wide Web: http://www.oecd.org/document/61/0,3746,en_2649_35845581_37425853_1_1_1_1,00.html

Card & Krueger (1996). School Resources and Student Outcomes: An Overviews of the Literature and New Evidence from North and South Carolina. The Journal of Economic Perspectives, Vol. 10, No. 4, pp. 31-50.

Card, D. (1995). Using Geographic Variation in College Proximity to Estimate the Return to Schooling. National Bureau of Economic Research, Working Paper 4483.

Card, D. (1999). The Causal Effect of Education on Earnings. Card, D. & Ashenfelter, O. (eds.) Handbook of Labor Economics, Volume 3. Amsterdam: Elsevier.

Card, D. (2001). Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems. Econometrica, Vol. 69, No. 5, pp. 1127-1160.

Carneiro, P. & Heckman, J.J. (2002). Human Capital Policy. In Heckman, J.J. & Krueger, A.B. (eds.) Inequality in America: What Role for Human Capital Policies? Cambridge & London: The MIT Press.

CBI, the Confederation of British Industry. (2009). Stronger Together: Businesses and universities in turbulent time. A report from the CBI Higher Education Task Force. Retrieved from the World Wide Web: http://highereducation.cbi.org.uk/uploaded/CBI_HE_taskforce_report.pdf

CBRE Consulting (2006). A Study of the Economic Impacts and Benefits of theUniversity of California, Riverside. Retrieved from the World Wide Web:http://www.impact.ucr.edu/documents/2004-05UCREconomicImpactReport.pdf

Checchi, D. (2006). The Economics of Education: Human Capital, Family Background and Inequality. Cambridge: Cambridge University Press.

Chevaliear, A. (2000). Graduate Over-Education in the UK. Centre for Economics of Education. London School of Economics and Political Science. Retrieved from the World Wide Web: http://cee.lse.ac.uk/cee%20dps/CEEDP07.pdf

Chevalier, A. (2009). Does Higher Education Quality Matter in the U.K? Royal Holloway, University of London, mimeo.

Chevalier, A. & Conlon, G. (2003). Does It Pay to Attend a Prestigious University? IZA Discussion Paper, No. 848. Bonn: IZA.

Christie, A. & Swales, J.K. (2010). The Barnett Allocation Mechanism: Formula Plus Influence? Regional Studies, Vol. 44, No. 6, pp. 761-776.

Clifton-Fearnside, A. (2001). Regional Accounts 1999: Part 2, Regional household sector income and individual consumption expenditure. Economic Trends, No. 573, August 2001, Retrieved from the World Wide Web: http://www.statistics.gov.uk/articles/economic_trends/Regional_Accounts_1999_part2.pdf

CPPR – Centre for Public Policy for Regions. Network on the Overall Impact of the HEIs on Regional Economies - Final Report. Retrieved from the World Wide Web: http://www.cppr.ac.uk/media/media_5539_en.pdf

Cutler, H. & Strelnikova, I. (2004). The Impact of the US Sales Tax Rate on City Size and Economic Activity: A CGE Approach. Urban Studies. Vol. 41, No. 4, pp. 875-885.

D'Amato, M. and Mookherjee, D. (2008) Educational Signaling, Credit Constraints and Inequality Dynamics, Working paper, Boston University

Dale, S.B. & Krueger, A. B. (2002). Estimating the Payoff to Attending a More Selective College: An Application of Selection on Observables and Unobservables. The Quarterly Journal of Economics. Vol. 117, No. 4, November 2002, pp. 1491-1527.

De Muelemeester, J.L. & Diebolt, C. (2004). The Economics of Education: Unkept Promises? Brussels Economics Review. Vol. 47, no. 3/4, Winter 2004.

Debreu, G. (1959). The theory of value: an axiomatic analysis of economic equilibrium. Cowles Foundation Monograph (No. 17). New York: John Wiley & Sons.

Decaluwé, B. & Nsengiyumva, F. (1994). Policy Impact under Credit Rationing: a Real and Financial CGE of Rwanda. Journal of African Economies. Vol. 3, No. 2, pp. 262-308.

Devarajan, S. & Robinson, S. (2002). The Influence of Computable General Equilibrium Models on Policy. International Food Policy Research Institute: Trade and Macroeconomics Division. TMD Discussion Paper No. 98.

Dewatripont, M. & Michel, Gilles (1987). On Closure Rules, Homogeneity and Dynamics in Applied General Equilibrium Models. Journal of Development Economics. Vol. 26, pp. 65-76.

Dixon, P.B. & Madden, J.R. (2003). Economic impact of continued ARC research funding. CoPS report for Allen Consulting Group. Centre of Policy Studies, Melbourne.

Dixon, P. & Rimmer, M. (2010). Johansen's contribution to CGE modelling: originator and guiding light for 50 years. Monash University, Centre of Policy Studies. General Paper No. G-203. Retrieved from the World Wide Web: http://www.monash.edu.au/policy/ftp/workpapr/g-203.pdf

Downs, A. (1996). Are suburbs really independent from central cities? National Real Estate Investor. Vol. 38, No. 11, pp. 28-38.

Drucker, J. & Goldstein, H. (2007). Assessing the Regional Economic Development Impacts of Universities: A Review of Current Approaches. International Regional Science Review. Vol. 30, No. 20.

Eskelin, H. (1983). Core and Periphery in a Three-Region Input-Output Framework. The Annals of Regional Science. Vol. 17, No. 3, pp. 41-56.

Faggian, A. & McCann, P. (2006). Human Capital Flows and Regional Knowledge Assets: A Simultaneous Equation Approach. Oxford Economic Papers. Vol. 58, No. 3, pp. 475-500.

Faggian, A., McCann, P. & Sheppard, S. (2010). Higher Education, Graduate Migration and Regional Dynamism in Great Britain. In Varga, A. (ed.).

Universities, Knowledge Transfer and Regional Development: Geography, Entrepreneurship and Policy. Cheltenham: Edvard Elgar.

Feehan, J.P. (1995). The Economic Impact of Memorial University of Newfoundland: A Benefit-Cost Approach. Institute of Social and Economic Research, Memorial University of Newfoundland. ISER Report No. 10.

Feinstein, L., Sabates, R., Anderson, T.M., Sorhaindo, A. & Hammond, C. (2006). What are the effects of education on health? In Desjardins, R. & Schuller, T. (eds.) Measuring the Effects of Education on Health and Civic Engagement: Proceedings of the Copenhagen Symposium. Paris: OECD. Retrieved from the World Wide Web: http://www.oecd.org/document/61/0,3746,en_2649_35845581_37425853_1_1_1_1,00.html

Feldman, M. (1994). The University and Economic Development. The Case of John Hopkins University and Baltimore. Economics Development Quarterly, Vol. 8, No. 1, February 1994.

Ferguson, L, Learmonth, D, McGregor, P G, Swales, JK and K Turner (2003). The Regional Distribution of Public Expenditure in the UK: An Exposition and Critique of the Barnett Formula. In Mønnesland, J. (ed.) Regional Public Finance, European Research in Regional Science 13. London: Pion.

Ferguson, L., Learmonth, D., McGregor, P.G., Swales, J.K., and Turner, K. (2007). The Impact of the Barnett Formula on the Scottish Economy: Endogenous Population and Variable Population Proportions. Environment and Planning A, vol. 39, No. 12, pp 3008-3027.

Ferguson, L., McGregor, P., Swales, K., Turner, K. & Ying, Y.P. (2005). Incorporating sustainability indicators into a computable general equilibrium model of the Scottish economy. Economic Systems Research. Vol. 17, No. 2, pp. 103-140.

Finch, S., Jones, A., Parfrement, J., Cebulla, A., Connor, H., Hillage, J., Pollard, E., Tyers, C., Hunt, W. & Loukas, G. (2006). Student Income and Expenditure

Survey 2004/05. Department for Education and Skills, Research Report 725. Nottingham: DfES Publications.

Fischer, M. & Varga, A. (2003). Spatial knowledge spillovers and university research: Evidence from Austria. Annals of Regional Science. Vol. 31, No. 2, pp. 303-322.

Flegg. A.T., Webber, C.D. & Elliott, M.V. (1995). On the appropriate use of location quotients in generating regional input-output tables. Regional Studies, Vol. 29, No. 6, pp. 547-561.

Flegg, A.T. & Webber, C.D. (1996a). Using Location Quotients to Estimate Regional Input-Output Coefficients and Multipliers. Local Economy Quarterly. Vol. 4, pp. 58-86.

Flegg, A.T. & Webber, C.D. (1996b) The FLQ formula for generating regional input-output tables: an application and reformation, Working Papers in Economics No. 17, University of the West of England, Bristol.

Flegg, A.T. & Webber, C.D. (1997). On the appropriate use of location quotients in generating regional input-output tables: Reply. Regional Studies, Vol. 31, No. 8, pp. 795-805.

Flegg, A.T. & Webber, C.D. (2000). Regional size, regional specialisation and the FLQ formula. Regional Studies. Vol. 34, No. 6, pp. 563-569.

Flegg, A.T & Tohmo, T. (2010). Regional Input-Output Tables and the FLQ Formula: A Case Study of Finland. University of the West of England, Department of Economics, Discussion Paper. Retrieved from the World Wide Web: http://carecon.org.uk/DPs/1005.pdf

Fleming, A.D. (2006). Scotland's Census 2001 Statistics on Travel to Work or Study. General Register Office for Scotland. Occasional Paper No. 12.

Florax, R.J.G.M. (1992). The University: A Regional Booster? Aldershot: Avebury.

Freeman, S. (1996) "Equilibrium Income Inequality among Identical Agents", Journal of Political Economy, vol. 104(5), pp. 1047–1064.

Fullerton, D., A.T. King, J.B. Shoven & J. Whalley (1981). Corporate tax integration in the United States: a general equilibrium approach, American Economic Review, Vol. 71, No. 4, pp. 677-691.

Galor, O. and Zeira, J. (1993). Income Distribution and Macroeconomics. Review of Economic Studies January. Vol. 60, No. 1, pp. 35-52.

Gasteen, A., Houston, J. & Davidson, C. (2003). Scottish Educational Qualifications – the Returns to Educational Routes. Division of Economics and Enterprise, Glasgow Caledonian University & Scottish Further Education Unit. Scottish Economic Policy Network. Retrieved from the World Wide Web: http://www.scotecon.net/publications/Houston%20Gasteen%20Return%20to%20Educ.pdf

Gelan, A. (2000). Impacts of Devaluation on Urban-Rural Interactions: A Computable General Equilibrium Model for the Ethiopian Economy. PhD thesis submitted to the Department of Economics, University of Strathclyde.

Gelan, A. (2002). Trade liberalisation and urban-rural linkages: a CGE analysis for Ethiopia. Journal of Policy Modeling, Vol. 24, pp. 707-738.

Gibson, H. (1990). Export Competitiveness and UK Sales of Scottish Manufacturers. Paper delivered to the Scottish Economists Conference, the Burn.

Giesecke, J.A. & Madden, J.R. (2006). A CGE Evaluation of a University's Effects on the Regional Economy: An Integrated Assessment of Expenditure and Knowledge Impacts. Review of Urban & Regional Development Studies. Vol. 18, No. 3, pp. 229-251

Gilmartin, M., Learmonth, D., McGregor, P., Swales, K. & Turner, K. (2011). Regional Policy Spillovers: The National Impact of Demand-Side Policy in an

Interregional Model of the UK Economy. Strathclyde Papers in Economics. 11-28.

Ginsberg, B. (2011). The Fall of the Faculty: The Rise of the All-Administrative University and Why It Matters. Oxford: Oxford University Press.

Goldin, C. & Katz, L. (2007). The Race between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005. National Bureau for Economic Research (NBER) Working Paper 12984. Retrieved from the World Wide Web: http://www.nber.org/papers/w12984.pdf

Goldstein, H.A. & Renault, C.S. (2004). Contributions of Universities to Regional Economic Development: A Quasi-experimental Approach. Regional Studies, October 2004, Vol. 38. No. 7, pp. 733-746.

Greenaway, D., Leybourne, S.J., Reed, G.V. & Whalley, J. (1993). Applied General Equilibrium Modelling: Applications, Limitations and Future Development. London: HMSO.

Groen, J.A. (2004). The Effect of College Location on Migration of College-Educated Labor. Journal of Econometrics, Vol. 121, pp. 125-142.

Ha, S.J., Hewings, G. & Turner, K. (2008). Econometric Estimation of Armington import elasticities for regional CGE models of the Chicago and Illinois Economies. Strathclyde Discussion Papers in Economics 08-10.

Hanley, N. D., McGregor, P. G., Swales, J. K. & Turner, K. (2006). The impact of a stimulus to energy efficiency on the economy and the environment: A regional computable general equilibrium analysis. Renewable Energy, 31, 161-171.

Hanley, N.D., McGregor, P. G., Swales, J. K. & Turner, K. (2009). Do increases in energy efficiency improve environmental quality and sustainability? Ecological Economics, 68, 692-709.

Hanushek, A. (1986). The economics of Schooling: Production and Efficiency in Public Schools. Journal of Economic Literature. Vol. 24, No. 3, pp. 1141-1177.

Harmon, C. & Walker, I. (2003). The Returns to Education: Microeconomics. Journal of Economic Surveys, Vol. 17, No. 2, pp. 115-153.

Harrigan, F., McGilvray, J.W. & McNicoll, I.H. (1981a). The Estimation of Interregional Trade Flows. Journal of Regional Science. Vol. 21, No. 1, pp. 65-78.

Harrigan, F., McGilvray, J.W. & McNicoll, I.H. (1981b). A Comparison of Regional and National Technical Structures. The Economic Journal, Vol. 19, pp. 795-807.

Harrigan, F., McGilvray, J.W. & McNicoll, I.H. (1981c). Simulating the Structure of a Regional Economy. Environment and Planning A. Vol.12, pp. 927-36.

Harrigan, F., McGregor, P., Perman, R., Swales, K. and Yin, Y.P. (1991). AMOS: A Macro-Micro Model of Scotland. Economic Modelling, vol. 8, pp. 424-479.

Harris, R.I.D., (1989). The growth and structure of the UK regional economy, 1963-1985. Aldershot: Avebury.

Harris, R.I.D. (1997). The Impact of the University of Portsmouth on the Local Economy. Urban Studies, Vol. 34, No. 4, pp. 605-626.

Harris, R.I.D. (2006). Determinants of Regional Growth. In Centre for Public Policy for the Regions' Network on the Overall Impact of HEIs on Regional Economies: Final Report. Centre for Public Policy for Regions, August 2006.

Harris, R.I.D. & Liu, A. (1998). Input-Output Modelling of the Urban and Regional Economy: The Importance of External Trade. Regional Studies, Vol. 32, No. 9, pp. 851-862.

Harris, R., Li, Q. C. and Moffat J. (2010). The Impact of Higher Education Institution-Firm Knowledge Links on Firm-level Productivity in Britain, Strathclyde Discussion Papers in Economics, 10-17.

Harris, R., Li, Q. C. and Moffat, J. (2010). The Impact of Higher Education Institution – Firm Knowledge Links on Establishment-level Productivity in British Regions, Strathclyde Discussion Papers in Economics, 10-18.

Hårsman, B. & Quigley, J.M. (1998). Education, Job Requirements and Commuting: An analysis of network flows. In M.J. Beckman *et al* (eds.) Knowledge and networks in a dynamic economy. Springer Verlag.

Heckmann, J. (2000). Policies to Foster Human Capital. Research in Economics Vol. 54, No. 1, pp. 3-56.

Heckman, J. & Carneiro, P. (2005). Human Capital Policy. In Heckman, J. & Krueger, A. (eds.) Inequality in America: What Role for Human Capital Policies. Cambridge: The MIT Press.

Heckman, J., Lochner, L. & Taber, C. (1999a). General Equilibrium Cost Benefit Analysis of Education and Tax Policies. National Bureau of Economic Research. Working Paper 6881.

Heckman, J., Lochner, L. & Taber, C. (1999b). Human Capital Formation and General Equilibrium Treatment Effects: A Study of Tax and Tuition Policy. Fiscal Studies, vol. 20, no. 1, pp. 25-40.

Hedges, L.V., Laine, R.D. & Greenwald, R. (1994). Does Money Matter? A Meta-Analysis of Studies of the Effects of Differential School Inputs on Student Outcomes. Educational Researcher, Vol. 26, No. 5.

Hermannsson, K. (2011). Retained graduates as a supply-impact in LDC's: A CGE Analysis for Malawi. Forthcoming: Strathclyde Discussion Papers in Economics.

Hermannsson, K. & Swales, K. (2010). Capturing the Overall Economic Impact of HEIs. Report commissioned by the Scottish Government on behalf of the

Tripartite Advisory Group (TAG) on higher education in Scotland. Retrieved from the World Wide Web: http://www.scotland.gov.uk/Publications/2010/11/09155629/0

Hermannsson, K., Lisenkova, K., McGregor, P. & Swales, K. (2009). The impact of higher education institutions (HEIs) on the Scottish economy: New evidence from an HEI-disaggregated input-output approach. Fraser of Allander Institute: Fraser of Allander economic commentary, June 2009, Vol. 33 No. 1. Retrieved from the World Wide Web: http://www.strath.ac.uk/frasercommentary/

Hermannsson, K., Lisenkova, K., McGregor, P. & Swales, K. (2010a). An HEI-Disaggregated Input-Output Table for Scotland. Strathclyde Discussion Papers in Economics, 10-14.

Hermannsson, K., Lisenkova, K., McGregor, P. & Swales, K. (2010b). "Policy Scepticism" and the Impact of Scottish Higher Education Institutions (HEIs) on their Host Region: Accounting for Regional Budget Constraints under Devolution. Strathclyde Discussion Papers in Economics, 10-15.

Hermannsson, K., Lisenkova, K., McGregor, P. G and Swales, K. (2010c). The Expenditure Impacts of Individual Higher Education Institutions (HEIs) and their Students on the Scottish Economy under Devolution: Homogeneity or Heterogeneity? Strathclyde Discussion Papers in Economics, 10-16.

Hermannsson, K., Lecca, P., Lisenkova, K., McGregor, P. & Swales, K. (2010d). The Importance of Graduates to the Scottish Economy: A "Micro-to-Macro" Approach, Strathclyde Discussion Papers in Economics, 10-26.

Hermannsson, K., Lisenkova, K., McGregor, P. & Swales, K. (2010e). An HEI-Disaggregated Input-Output Table for Wales. Strathclyde Discussion Papers in Economics, 10-21.

Hermannsson, K., Lisenkova, K., McGregor, P. & Swales, K. (2010f). An HEI-Disaggregated Input-Output Table for Northern-Ireland. Strathclyde Discussion Papers in Economics, 10-23.

Hermannsson, Lecca, P., K., Lisenkova, K., McGregor, P. & Swales, K. (2010g). The System-Wide Impacts of the Social and Private Non-Market Benefits of Higher Education on the Scottish Economy: An illustrative "Micro-to-Macro" Approach. Unpublished Manuscript.

Herzog, H., Schlottmann, A. & Johnson, D. (1986). High-Technology Jobs and Worker Mobility. Journal of Regional Science. Vol. 26, pp. 445-459.

HESA – Higher Education Statistics Agency (2007). Resources of Higher Education Institutions 2005/06.

Heurman, D. (2011). Human Capital Externalities in Western Germany. Spatial Economic Analysis, Vol. 6, No. 2, pp. 139-166.

Hewings, J.D., Okuyama, Y. & Sonis, M. (2001). Economic Interdependence Within the Chicago Metropolitan Area: A Miyazawa Analysis. Journal of Regional Science, Vol. 41, No. 2, pp. 195-217.

Hewings, J.D. & Parr, J.B. (2007). Spatial Interdependence in a Metropolitan Setting. Spatial Economic Analysis. Vol. 2, No. 1, pp. 7-23.

Hicks, J. R. (1932) The Theory of Wages (London: Macmillan).

Hill, I. and Taylor, R. (2001). Recent Trends in Dividends Payments and Share Buy-Backs. Economic Trends, No. 567, February 2001, Retrieved from the World Wide Web: http://www.statistics.gov.uk/articles/economic_trends/Recent_trends_dividends_payments.pdf

Hill, K., Hoffman, D. & Rex, T.R. (2005). The Value of Higher Education: Individual and Societal Benefits (With Special Consideration for the State of Arizona). L. William Seidman Research Institute, W.P. Carey School of Business, Arizona State University. Retrieved from the World Wide Web: http://wpcarey.asu.edu/seid/upload/Value%20Full%20Report_final_october%202005a.pdf

Hillis, I. (1998). Sub Regional Government Accounts (experimental). Office for National Statistics (ONS). Retrieved from the World Wide Web: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=9580&More=Y

Hipple, F.S. (2001). A Cost-Benefit Analysis of Higher Education in Tennessee. Journal for Economic Educators. Vol. 3, No. 3. Retrieved from the World Wide Web: http://frank.mtsu.edu/~jee/PDF_Files/hipple.pdf

HM Treasury (2003). Public Expenditure Statistical Analyses 2002-03. May 2002, Retrieved from the World Wide Web: http://www.hm-treasury.gov.uk/media//FBD0F/pesa_2002to2003.pdf

HM Treasury (2007). Public Expenditure Statistical Analyses 2007. April 2007, Retrieved from the World Wide Web: http://www.hm-treasury.gov.uk/d/pesa07_complete.pdf

HM Treasury (2003). The Green Book: Appraisal and Evaluation in Central Government. London: TSO. Retrieved from the World Wide Web: http://www.hm-treasury.gov.uk/data_greenbook_index.htm

Holmlund, H., Lindahl, M. & Plug, E. (2011). The Causal Effect of Parents' Schooling on Children's Schooling: A Comparison of Estimation Methods. Journal of Economic Literature, Vol. 49, No. 3, pp. 615-51.

Hosoe N., Gasawa, K. & Hashimoto, H. (2010). A Textbook of Computable General Equilibrium Modelling: Programming and Simulations. New York: Palgrave MacMillan.

Houston, J., Gasteen, A. & Davidson, C. (2002). Investigation of the Private Employment and Earnings Returns to Further Education in Scotland. Division of Economics and Enterprise, Glasgow Caledonian University & Scottish Further Education Unit. Scottish Economic Policy Network. Retrieved from the World Wide Web: http://www.scotecon.net/publications/houstonreport.pdf

Hussein, I., McNally, S. & Telhaj, S. (2009). University Quality and Graduate Wages in the UK. IZA Discussion Paper No. 4043. Bonn: IZA.

Jaffe, A.B. (1989). Real Effects of Academic Research. The American Economic Review. December 1989. Vol. 79. No. 5.

Johansen, L. (1960). A Multisectoral Study of Economic Growth, Contributions to Economic Analysis 21. Amsterdam: North-Holland Publishing Company.

Johnes, G. & Johnes, J. (2004). International Handbook on the Economics of Education. Cheltenham: Edward Elgar.

Jun, M.J. (1999). An Integrated Metropolitan Model Incorporating Demographic-economic Land-use and Transport Models. Urban Studies, Vol. 36, pp. 1399-1408.

Jun, M.J. (2004). A Metropolitan Input-Output Model: Multisectoral and Multispatial Relations of Production, Income Formation and Consumption. Annals of Regional Science, Vol 31., pp 131-147.

Kehoe, P.J. & Kehoe, T.J. (1994). A Primer on Static Applied General Equilibrium Models. Federal Reserve Bank of Minneapolis Quarterly Review. Spring 1994, Vol. 18, No. 1.

Kelly, U., McNicoll, I & McCluskey, K. (1997). The Economic Impact of Universities and Colleges on the UK Economy. CVCP London 1997.

Kelly, U., McNicoll, I. & Donald, McClellan. (2004) The Impact of the University of Strathclyde on the economy of Scotland and the City of Glasgow. Project Report. University of Strathclyde, Glasgow, United Kingdom.

Kelly, U., McNicoll, I. & McLellan, D. (2005). Towards the estimation of the economic value of the outputs of Scottish Higher Education Institutions. University of Strathclyde: Report to the Scottish Higher Education Funding Council.

Kelly, U., McNicoll, I., McLellan, D. & Brooks, R. (2008). Towards the estimation of the economic value of the outputs of Scottish Higher Education Institutions. University of Strathclyde: Summary reports from a study undertaken for the Scottish Funding Council.

Kitson, M., Abreu, M., Grinevich, V. & Hughes, A. (2009). Knowledge Exchange Between Universities and The Business, Public and Third Sectors. Centre for Business Research and Judge Business School, University of Cambridge. Report published by the UK Innovation Research Centre at Imperial College London and the University of Cambridge. Retrieved from the World Wide Web: http://www.ukirc.ac.uk/object/rproject/3203/doc/AcademicSurveyReport%20201009.pdf

Klaiber, H.A. & Smith, V.K. (2010). General Equilibrium Benefit Analyses for Social Programs. Paper presented at the annual meeting of the American Economic Association, Denver Colorado, January 2011. Retrieved from the World Wide Web: http://www.aeaweb.org/aea/2011conference/program/retrieve.php?pdfid=158

Krueger, A. B. & Lindahl, M. (2001). Education for Growth: Why and For Whom? Journal of Economic Literature, Vol. 39, No. 4, pp. 1101-1136.

Krueger, A.B. (2002). Inequality, Too Much of a Good Thing. In Heckman, J.J. & Krueger, A.B. (eds.) Inequality in America: What Role for Human Capital Policies? Cambridge & London: The MIT Press.

Lahr, M.L. (1993). A Review of the Literature Supporting the Hybrid Approach to Constructing Regional Input-Output Models. Economic Systems Research. Vol. 5, No. 3, pp. 277-293.

Lahr, M. & de Mesnard, L. (2004). Biproportional Teqhniques in Input-Output Analysis: Table Updating and Structural Analysis. Economic Systems Research. Vol. 16, No. 2, pp. 115-134.

Lange, F. & Topel, R. (2006). The Social Value of Education and Human Capital. In Hanusheck, E. & Welch, F. (eds.) Handbook of Education Economics, Vol.1.

Layard, R., Nickell S. & Jackman, R. (1991). Unemployment: Macroeconomic Performance and the Labour Market. Oxford: Oxford University Press.

Layard, R. & Glaister, S. (eds.) (1994). Cost Benefit Analysis. Cambridge: The Press Syndicate of the University of Cambridge.

Learmonth, D., McGregor, P., Swales, K., Turner, K. & Yin, Y.P. (2007). The importance of the regional/local dimension of sustainable development: an illustrative computable general equilibrium analysis of the Jersey economy. Economic Modelling, Vol.24, pp. 15-41.

Lecca, P., McGregor, P. & Swales, K. (2010). Balanced Budget Government Spending in a Small Open Regional Economy. Strathclyde Papers in Economics 10-20: Retrieved from the World Wide Web: http://www.strath.ac.uk/media/departments/economics/researchdiscussionpapers/10-20.pdf

Leontief, W. W. (1936). Quantitative input and output relations in the economic system of the United States. Review of Economics and Statistics, Vol. 18, pp. 105-25.

Leontief, W. W. (1937). Inter-relation of prices, output, savings and investment. Review of Economics and Statistics, Vol. 19, pp. 109-32.

Lisenkova, K., McGregor, P., Pappas, N., Swales, K., Turner, K. & Wright, R. (2010). Scotland the Grey: A Linked Demographic – Computable General Equilibrium (CGE) Analysis of the Impact of Population Ageing and Decline. Regional Studies, Vol. 44, No. 10, pp. 1351-1368.

Lloyd, P.J. & MacLaren, D. (2004). Gains and Losses from Regional Trading Agreements: A Survey. The Economic Record, Vol, 80, No. 251, pp. 445-467.

Love, J. & McNicoll, I. (1988). The Regional Economic Impact of Overseas Students inthe UK: A Case Study of Three Scottish Universities. Regional Studies. Vol. 22.1, pp. 11-18.

Love, J. & McNicoll, I. (1990). The economic impact of university funding cuts. Higher Education. Vol. 19, No. 4, pp. 481-495.

Loveridge, S. (2004). A Typology and Assessment of Multi-sector Regional Economic Impact Models. Regional Studies Vol. 38. No. 3, pp. 305-317.

MacGill, S.M. (1977). The Lowry Model as an Input-Output Model and its Extension to Incorporate Full Intersectoral Relations.

Machin, S. (2004). Skill-Biased Technical Change and Educational Outcomes. In Geraint, J. & Johnes. J. (eds.) International Handbook on the Economics of Education.Cheltenham: Edward Elgar.

Machin, S., Marie, O. & Vujic, S. (2011). The Crime Reducing Effect of Education. The Economic Journal. Vol. 121, pp. 463-484.

Madden, M. (1985). Demographic-economic Analysis in a Multi-zonal Region: A Case Study of Nordrein-Westfalen. Regional Science and Urban Economics. Vol. 15, pp. 517-540.

Mankiw, G., Romer, D. & Weil, D. (1992). A Contribution to the Empirics of Economic Growth. The Quarterly Journal of Economics, Vol. 107, No. 2, pp. 407-437.

Marais, J. Thomas, A., Holmes, E. and Vincent, D. (2005). Regional Household Income.Retrieved from the World Wide Web: http://www.statistics.gov.uk/articles/nojournal/Regional_HH_%20Income_1995-2003.pdf

McCann, P. & Dewhurst, J. (1998). Regional Size, Industrial Location and Input-Output Expenditure Coefficients. Regional Studies, Vol. 32.5, pp. 435-444.

McGregor, P. and Swales, K. (1994). An Investigation Into a Neo-Classical Interpretation of Regional Input-Output Analysis. Strathclyde Papers in Economics. 94/1.

McGregor, P. and Swales, K. (2005). Economics of devolution/decentralization in the UK: Some questions and answers. Regional Studies, Vol. 39, No. 4, pp.477-494.

McGregor, P., Swales, K & McLellan, D. (2006). The Overall Impact of Higher Education Institutions on Regions: A Critical Review. In Centre for Public Policy for the Regions' Network on the Overall Impact of HEIs on Regional Economies: Final Report. Centre for Public Policy for Regions, August 2006.

McGregor, P., Swales, K. & Yin, Y.P. (1996). A Long-Run Interpretation of Regional Input – Output Analysis. Journal of Regional Science, vol. 36, pp. 479-501.

McGregor, P.G., Swales, J.K. & Yin, Y.P. (1998). Some Simple Macro Economics of Increased Accessibility and Spatial Integration. The Case of a Small Open Region. Development in The Question of Choice. In Reggiani, A. (ed.) Accessability, Trade and Locational Behaviour. Aldershot: Ashgate.

McGregor, P., Swales, K. & Yin, Y.P. (1999). Spillover and feedback effects in general equilibrium interregional models of the national economy: a requiem for interregional input-output? In Hewings, G., Sonis, M., Madden & Kimura, Y. (eds.) Understanding and interpreting economic structure. Berlin: Springer Verlag.

McGuinness & Bennett (2005). Intra and Inter-Generational Changes in the Returns to Schooling 1991-2002. Economic Research Institute of Northern Ireland Working Paper Series, No. 6.

McGuinness, S. (2003. University Quality and Labour Market Outcomes. Applied Economics, Vol. 36, pp. 1943-1955.

McGuinness, S. (2006). Overeducation in the Labour Market. Journal of Economics Surveys, Vol. 20, No. 3.

McIntosh, S. (2005). Evidence on the Balance of Supply and Demand for Qualified Workers. In Machin, S. & Vignoles, A. (eds.) What's the Good of Education. Princeton & Oxford: Oxford University Press.

McLellan, D. (2006). The Contribution of Higher Education to the Scottish Economy. University of Strathclyde. Report prepared for Universities Scotland.

McNicoll, I. (1993). The impact of Strathclyde University on the economy of Scotland. Monograph. Glasgow: University of Strathclyde, Department of Economics.

McNicoll, I. (1995). The impact of the Scottish higher education sector on the economy of Scotland. Glasgow: Committee of Higher Education Principals (COSHEP).

McNicoll, I., Kelly, U. & McLellan, D. (1999). Economic aspects of Scottish higher education institutions: report to the Committee of Scottish Higher Education Principals. Glasgow: Committee of Higher Education Principals (COSHEP).

McNicoll, I., Kelly, U. & McLellan, D. (2003). The Economic Impact of Scottish Higher Education. Edinburgh: Universities Scotland.

McMahon, W.W (1999). Education and Development: Measuring the Social Benefits. Oxford: Oxford University Press.

McMahon, W.W. (2004). The Social and External Benefits of Education. In Geraint, J. & Johnes. J. (eds.) International Handbook on the Economics of Education.Cheltenham: Edward Elgar.

McMahon, W.W. (2009). Higher Learning, Greater Good: The Private & Social Benefits of Higher Education. Baltimore: John Hopkins University Press.

Miller, P.W., Mulvey, C. & Martin, N. (2004). A test of the sorting model of education in Australia. Economics of Education Review. Vol. 23, pp. 473-482.

Miller, R.E. & Blair, P.D. (1985). Input-Output Analysis: Foundations and Extensions, 1st. edition. Prentice Hall.

Miller, R.E. & Blair, P.D. (2009). Input-Output Analysis: Foundations and Extensions, 2nd edition. Cambridge: Cambridge University Press.

Mincer, J. (1974). Schooling, Experience and Earnings. New York: National Bureau of Economic Research. Retrieved from the World Wide Web: http://www.nber.org/books/minc74-1

Mookherjee, D. and Ray, D. (2003) Persistent Inequality. Review of Economic Studies. Vol. 70, No. 2, pp. 369-394.

Moretti, E. (2004a). Human Capital Externalities in Cities. In Henderson, V. & Thisse, J.F. (eds.) Handbook of Urban and Regional Economics. Amsterdam: North Holland-Elsevier.

Moretti, E. (2004b). Workers' Education, Spillovers and Productivity: Evidence from Plant-Level Production Functions. American Economic Review Vol. 94, No. 3, pp. 656-690.

Moretti, E. (2004c). Estimating the social return to higher education: evidence from longitudinal and repeated cross-sectional data. Journal of Econometrics. Vol. 121, pp. 175-212.

Musgrave, R., Musgrave, P. & Bird, R. (1987). Public Finance in Theory and Practice. Toronto: McGraw-Hill.

Munro, M., Turok, I. and Livingston, M. (2009). Students in cities: A preliminary analysis of their patterns and effects. Environment and Planning A, forthcoming.

Naastepad, C.W.M. (2002). The Macro-Economic Effects of Directed Credit Policies: A Real-Financial CGE Evaluation for India. Development and Change. Vol. 32, pp. 491-520.

National Assembly for Wales (2009). The Economic Contribution of Higher Education in Wales. National Assembly for Wales, Enterprise and Learning Committee, October 2009. Retrieved from the World Wide Web: http://www.assemblywales.org/cr-ld7730

Norcliffe, G.B. (1983). Using location quotients to estimate the economic base and trade flows. Regional Studies. Vol. 17, No. 3. pp. 161-168.

OECD – Organisation for Economic Cooperation and Development (2010). Education at a Glance. Retrieved from the World Wide Web: http://www.oecd-ilibrary.org/education/education-at-a-glance-2010_eag-2010-en

O'Leary, N. & Sloane, P. (2005). The Return to a University Education in Great Britain. National Institute Economic Review, Vol. 193, No. 1, pp. 75-89.

ONS – Office for National Statistics (2007a). Regional Disposable Household Income 1995-2006. Retrieved from the World Wide Web: http://www.statistics.gov.uk/downloads/theme_economy/Regional_Disposable_Household_Income_1995-2006.xls

ONS – Office for National Statistics (2007b). United Kingdom National Accounts: The Blue Book 2007. Retrieved from the World Wide Web: http://www.statistics.gov.uk/downloads/theme_economy/Blue_Book_2007_web.pdf

ONS – Office for National Statistics (n.d., a).Commute APS. Retrieved from the World Wide Web: http://www.neighbourhood.statistics.gov.uk/dissemination/Info.do?page=analysisandguidance/analysisarticles/commuting-from-the-annual-population-survey.htm

ONS – Office for National Statistics (n.d., b). Regional Household Income. Retrieved from the World Wide Web: http://www.statistics.gov.uk/statbase/product.asp?vlnk=14651

Oosterhaven, J. & Stelder, D. (2007). Regional and Interregional IO Analysis. Monograph: University of Groningen, Faculty of Economics and Business.

Oreopoulos, P. & Page, M.E. (2006). The Intergenerational Effects of Compulsory Schooling. Journal of Labor Economics. Vol. 24, No. 4, pp. 729-760.

Oreopoulos, P. & Salvanes, K.G. (2011). Priceless: The Nonpecuniary Benefits of Schooling. Journal of Economic Perspectives, Vol. 25, No. 1, pp. 159-84.

Pappas, N. (2008). Can Migrants Save Greece from Ageing? A Computable General Equilibrium Approach Using G-AMOS. Strathclyde Discussion Papers in Economics 08-01.

Parker, D.D. & Zilberman, D. (1993). University Technology Transfers: Impacts On Local And U.S. Economies. Contemporary Economic Policy. Vol. 11, No. 2, pp. 87-99.

Partridge, M. & Rickman, D. (1998). Regional Computable General Equilibrium Modeling: A Survey and Critical Appraisal. International Regional Science Review, Vol. 21, No. 3, pp. 205-248.

Partridge, M. & Rickman, D. (2010). Computable General Equilibrium (CGE) Modelling for Regional Economic Development Analysis. Regional Studies. Vol. 44, No. 10, pp. 1311-1328.

Pears, I. (2010). Universities are not businesses. Times Higher Education. April 1st 2010. Retrieved from the World Wide Web: http://www.timeshighereducation.co.uk/story.asp?storycode=411032

Pereira, A. and Shoven, J. (1988). Survey of Dynamic Computational General Equilibrium Models for Tax Policy Evaluation. Journal of Policy Modeling, Vol. 10, No. 3, pp. 401-436.

Piermartnini, R. & Teh, R. (2005). Demystifying Modelling Methods for Trade Policy. WTO Discussion Papers, No. 10, 2005. Geneva: World Trade Organisation.

Psacharopoulos, G. & Patrions, H. A. (2002). Returns to Investment in Education: A Further Education. Policy Research Working Paper: WPS 2881. The World Bank, Latin America and the Caribbean Region, Education Sector Unit.

Psacharopoulos, G. & Patrions, H. A. (2004). Human Capital and Rates of Return. In Geraint, J. & Johnes. J. (eds.) International Handbook on the Economics of Education.Cheltenham: Edward Elgar.

Psacharopoulos, G. (1980). Higher Education in Developing Countries: A Cost-Benefit Analysis. World Bank, Staff Working Paper No. 440, November 1980.

Psacharopoulos, G. (1981). Returns to Education: An Updated International Comparison. Comparative Education, Vol. 17, No. 3, pp. 321-341.

Psacharopoulos, G. (2004). Economics of Education: From Theory to Practice. Brussels Economics Review. Vol. 47, no. 3/4, Winter 2004.

Raa, T. T. (2005). The Economic of Input-Output Analysis. Cambridge: Cambridge University Press.

Richardson, H. W. (1985). Input-Output and economic base multipliers: Looking backward and forward. Journal of Regional Science Vol. 25, No. 4, pp. 607-61.

Riddington, G., Gibson, H. & Anderson, J. (2004). A Comparison of National Accounts, Survey and Location Quotient based Local Area models and multipliers. Paper presented at the Annual meeting of the Scottish Economic Society, Perth, Scotland, April 2004.

Robinson, S. (1989). Multisectoral Models. In Chenery, H. & Srinivasan, T.N. (eds.) Handbook of Development Economics, Volume II. Amsterdam: North Holland.

Robinson, S., Yúnez-Naude, A. Hinojosa-Ojeda, R., Lewis, J.D. & Devarajan, D. (1999). From stylized to applied models: Building multisector CGE models for policy analysis. North American Journal of Economics and Finance, Vol. 10, pp. 5-38.

Robison, M.H. (1997). Community input-output models for rural area analysis with an example from central Idaho. Annals of Regional Science. Vol. 31, pp. 325-351.

Robison, M.H. & Miller, J.R. (1988). Cross-Hauling and Nonsurvey Input-Output Models: Some Lessons from Small-Area Timber Economies. Environment and Planning A, Vol. 20, pp. 1523-1530.

Robison, M.H. & Miller, J.R. (1991). Central Place Theory and Intercommunity Input-Output Analysis. Papers in Regional Science. Vol. , No. 4, pp. 399-417.

Round, J.I. (1978). An Interregional Input-Output Approach to the Evaluation of Nonsurvey Methods. Journal of Regional Science. Vol. 18, No. 2., pp. 179-194.

Round, J.I. (1979). Compensating Feedback Effects in Interregional Input-Output Models. Journal of Regional Science. Vol. 19, No. 2, pp 145-155.

Round, J.I. (1983). Nonsurvey Techniques: A critical Review of the Theory and Evidence. International Regional Science Review. Vol. 8, No. 3, pp. 189-212.

Rutten, M. & Reid, G. (2009). A comparative analysis of some policy options to reduce rationing in the UK's NHS: Lessons from a general equilibrium model incorporating positive health effects. Journal of Health Economics, Vol. 28, pp. 221–233.

Schaffer, W.A. & Chu, K. (1969). Nonsurvey Techniques for Constructing Regional Interindustry Models. Papers in Regional Science. Vol. 23, No. 1, pp. 83-104.

Scarf, H. E. (1967). The Approximation of Fixed Points of a Continuous Mapping. SIAM Journal of Applied Mathematics, 15, 1328-43.

Scarf, H. E., and Hansen, T. (1973). The Computation of Economic Equilibria. Cowles Foundation for Research in Economics at Yale University, Monograph (Number 24). New Haven: Yale University Press.

Schultz, T. (1961). Investing in Human Capital. American Economic Review. Vol. 51, no. 1, pp. 1-17.

Schwarm, W. & Cutler, H. (2003). Building Small City and Town SAMs and CGE Models. Review of Urban and Regional Development Studies. Vol. 15, No. 2, pp. 132-147.

Scottish Executive (2006). Scottish Economic Statistics 2006. Retrieved from the World Wide Web:
http://www.scotland.gov.uk/Publications/2006/11/28151648/90

Scottish Government (2007a). Input-Output Tables and Multipliers for Scotland 2004. Edinburgh: Scottish Government.

Scottish Government (2007b). Higher Education Students' income, Expenditure and Debt: A Comparative Study of Students in Scotland and England 2004-2005.

Scottish Government (2008). Government Expenditure and Revenue in Scotland 2006-2007. Retrieved from the World Wide Web:
http://www.scotland.gov.uk/Resource/Doc/228544/0061858.pdf

Seafish (2007). The economic impacts of the UK sea fishing and fish processing sectors: an Input-Output analysis. Report commissioned by Sea Fish Industry Authority.

Shoven, J.B. & Whalley, J. (1984). Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey. Journal of Economic Literature. Vol. 22., No. 3, pp. 1007-1051.

Shoven, J. B., & Whalley, J. (1992). Applying general equilibrium. Cambridge: Cambridge University Press.

Sianesi, B. & Van Reenen, J. (2003). The Returns to Education: Macroeconomics. Journal of Economic Surveys, Vol. 17, No. 2.

Solow, R. (1956). A Contribution to the Theory of Economic Growth. The Quarterly Journal of Economics, Vol. 70, No. 1, pp. 65-94.

Spence, M. (1973). Job Market Signaling. The Quarterly Journal of Economics. Vol. 87, No. 3, pp. 355-374.

Smith, A. (1776). An Inquiry into the Nature and Causes of the Wealth of Nations. Cannan, E. ed. (1904). Library of Economics and Liberty. Retrieved December 14, 2010 from the World Wide Web: http://www.econlib.org/library/Smith/smWN6.html

Smith, P. & Morrison, W.I. (1974). Simulating the Urban Economy: Input-Output Techniques. Pion, London.

Snickars, F. (1979). Construction of Interregional Input Iutput Tables by Efficient Information Adding. In Bartels, C.P.A. & Ketellapper, R.H. (eds). Exploratory and Explanatory Statistical Analysis of Spatial Data. Berlin: Springer.

Snickars, F. & Weibull, J.W. (1977). A Minimum Information Principle: Theory and Practice. Regional Science and Urban Economics. Vol. 7, pp. 137-168.

Stevens, P. & Weale, M. (2004). Education and Economic Growth. In Geraint, J. & Johnes. J. (eds.) International Handbook on the Economics of Education.Cheltenham: Edward Elgar.

Stiglitz, J.E. (1975). The Theory of "Screening," Education, and the Distribution of Income. The American Economic Review. Vol. 56, No. 3, pp. 283-300.

Stoeckl, N. (2010). International Regional Science Review. Comparing Multipliers from Survey and Non-Survey Based IO Models: An Empirical Investigation from Northern Australia. International Regional Science Review. Published online 30.12.2010 ahead of printing.

Sue Wing, I. (2004). Computable General Equilibrium Models and Their Us in Economy-Wide Policy Analysis. MIT Joint Program on the Science and Policy of Global Change, Technical Note No. 6.

Tohmo, T. (2004). New Developments in the Use of Location Quotients to Estimate Regional Input-Output Coefficients and Multipliers. Regional Studies, Vol. 381, No. 1, pp. 45-54.

Turner, K. (2002). Modelling the Impact of Policy and Other Disturbances on Sustainability Policy Indicators in Jersey: An Economic - Environmental Regional Computable General Equilibrium Analysis. PhD Thesis. University of Strathclyde, Department of Economics.

Universities UK (2006). The Economic Impact of UK Higher Education Institutions. Retrieved from the World Wide Web: http://bookshop.universitiesuk.ac.uk/downloads/economicimpact3.pdf#search=%22the%20economic%20impact%20of%20uk%20higher%20education%20institutions%22

Varga, A. (1997). Regional Economic Effects of University Research: A Survey. Research Paper 9729, Regional Research Institute, West Virginia University. Retrieved from the World Wide Web: http://www.rri.wvu.edu/wpapers/pdffiles/surveyattila.pdf

Venhorst, V, Van Dijk, J. & Van Wissen, L. (2011). An Analysis of Trends in Spatial Mobility of Dutch Graduates. Spatial Economic Analysis. Vol. 6, No. 1, pp. 57-82.

Voith, R. (1998). Do Suburbs Need Cities? Journal of Regional Science. Vol. 38, No. 3, pp. 445-464.

Walker, I. & Zhu, Y. (2005).The College Wage Premium, Overeducation and the Expansion of Higher Education in the UK. IZA Discussion Paper No. 1627. Retrieved from the World Wide Web: http://www.iza.org/

Wilson, A.G. (1970). Entropy in Urban and Regional Modelling. London: Pion.

Walker, I. & Zhu, Y. (2007a). The Labour Market Effects of Qualifications: Technical Report. Futureskills Scotland - Research Series. Retrieved from the World Wide Web:
http://www.scotland.gov.uk/Resource/Doc/919/0065442.pdf

Walker, I. & Zhu, Y. (2007b). The Labour Market Effects of Qualifications: Summary Report. Futureskills Scotland - Research Series. Retrieved from the World Wide Web:
http://www.scotland.gov.uk/Resource/Doc/919/0065443.pdf

Walker, I. & Zhu, Y. (2008). The College Wage Premium and the Expansion of Higher Education in the UK. The Scandinavian Journal of Economics, Vol. 110, No. 4, pp. 695-709.

Walras, L. (1926). Elements d'economique politique pure. Edition definitive, translated by: Jaffe, W. (1954), Elements of pure economics or the theory of social wealth. London: George Allen & Unwin Ltd.

Warhurst, C., Commander, J., Nickson, D., Symeonides, A. Furlong, A., Findlay, J., Wilson, F. & Hurrell, S. (2009). Higher and Further Education Students' Income, Expenditure and Debt in Scotland 2007-08. Edinburgh: Scottish Government Social Research. Retrieved from the World Wide Web: http://www.scotland.gov.uk/Publications/2009/06/24115743/02

Weiss, A. (1995). Human Capital vs. Signalling Explanation of Wages. The Journal of Economic Perspectives, Vol. 9, No. 4, pp. 133-154.

Willis, K.G. (1987). Spatially disaggregated input-output tables: an evaluation and comparison of survey and nonsurvey results. Environment and Planning A. Volume 19, pp. 107-116.

Wright, R. & Mosca, I. (2011). Graduate Migration and Employment in the UK. University of Strathclyde, unpublished manuscript.