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Household and skill disaggregation in multi-sectoral models of the Scottish Economy

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Abstract

This thesis constructs and applies multi-sectoral models that can be used by policy makers to assess potential system-wide impacts and trade-offs of policies set out in Scotland's Economic Strategy with particular focus on analysing the skill-dimension.

This thesis begins by building a Social Accounting Matrix (SAM) for Scotland and then disaggregates this by educational characteristics of the Scottish workforce. This forms the foundation upon which subsequent modelling frameworks are developed. Next, the SAM is used to compare methods for calculating Input-Output Type II multipliers. Significant differences across these methods do not appear to be explicitly acknowledged or understood in the current literature.

The potential distributional effects of exogenous demand shocks within the Scottish economy are analysed using a SAM model that contains disaggregated household accounts and two types of labour. The SAM is also used to identify the skill intensity of key structural component of the Scottish economy.

The SAM is then applied to calibrate an extended version of the AMOS Computable General Equilibrium (CGE) model. This model is subsequently employed to analyse the system-wide impacts of policy relevant shocks. A variety of export demand shocks are modelled to identify the likely impacts of export orientated policies. This facilitates the separate identification of disparate labour market impacts, whilst also detailing policy relevant system-wide effects in a multi sectoral modelling framework. The skill intensity of exports, as also assessed in the SAM model, is revisited in a CGE modelling context.

A key policy in the Economic Strategy is 'to make better use of skills in the workplace'. This is interpreted as a labour augmenting efficiency improvement where fewer workers are required to produce the same level of output. Given the importance of the skill dimension alternative cases of labour-augmenting efficiency improvements are explored within the skill-disaggregated AMOS model.

Declaration of author's rights

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed:

Date: 01 March 2017

Contribution of co-authors

Chapter 2 *	Emonts-Holley, T., Ross, A., Swales, K. (2014) A Social Accounting Matrix for Scotland. *Fraser Economic Commentary*, 38(7), 84-93.
A. Ross:	Formulation of research, literature review, developing and employing the method, building of the IncExp Accounts, building SAM framework, data analysis, write-up.
T. Emonts-Holley:	Formulation of research, literature review, developing and employing the method, building of the IncExp Accounts, updating and finding new sources for IncExp Accounts, data analysis, write-up.
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* Note this chapter is identical in the main sections to Chapter 2 in Emonts-Holley' thesis.

** Note this chapter is identical to Chapter 5 in Emonts-Holley' thesis.

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Chapter 1

Thesis prelude

The Scottish Government (2015) has set out an over-arching economic growth strategy to achieve a more productive, cohesive and fairer Scotland. This forms the strategic plan for existing and future Scottish Government policy. Scotland's Economic Strategy focuses on the two mutually 'supportive goals' of increasing competitiveness and tackling inequality and this is underpinned by four priorities for sustainable growth.

Figure 1.0.1 shows the four priorities and the key policy areas that underpin each of these, as depicted by the Scottish Government (2015) in their Economic Strategy. The four priorities are: to invest in people and infrastructure in a sustainable way; foster a culture of innovation and research and development; promote inclusive growth and create opportunities through a fair and inclusive jobs market and regional cohesion; and promoting Scotland on the international stage to boost trade and investment, influence and networks (Scottish Government, 2015). The following breaks down the individual policy areas that aid each of the four priorities.

Investments in human capital - education, skills and health - of the people of Scotland is a central focus of actions to deliver Scotland's Economic Strategy. The Scottish Government, and the wider public sector, undertake significant investments in education and skills through schools, colleges and universities. This includes the Modern Apprenticeships and other training programmes delivered by Skills Development Scotland (Scottish Government, 2015). Increased human capital investment is encompassed by policies to make better use of skills in the workplace, increase the skilled workforce, and to provide jobs that are highly skilled. The Scottish Government is thereby significantly concerned with the skill dimension of the potential impacts of policies and other shocks to the economy.

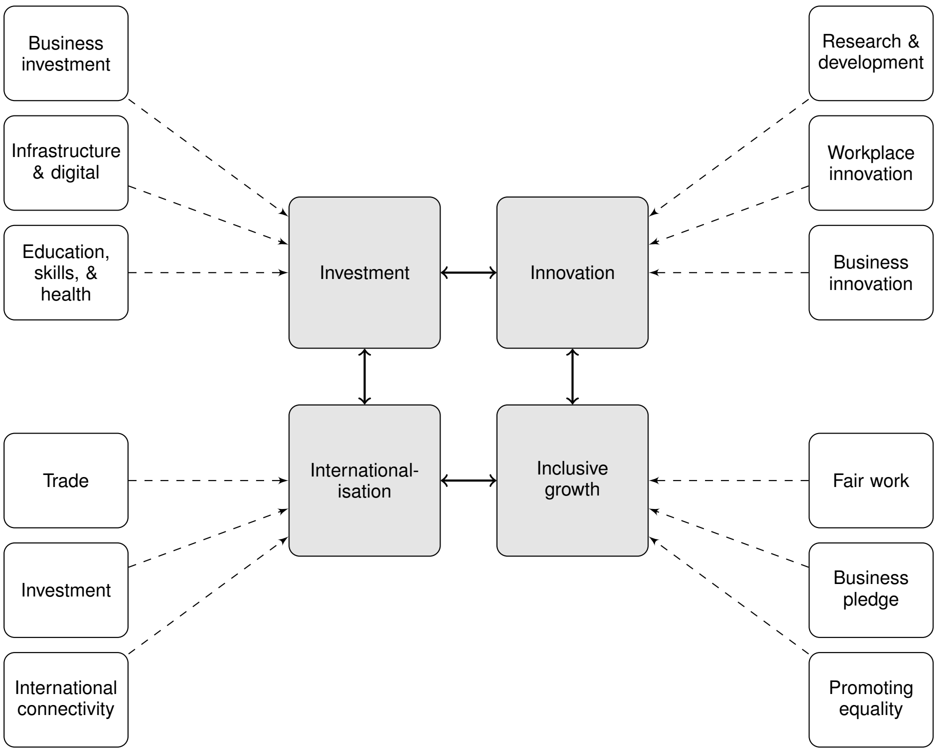
The skill dimension of policies also links to other key policy areas, such as technological innovation in the workplace (i.e. making better use of skills in the workplace), research and development, and inclusive growth. Improving these is a top priority, and a key aspect of the Business Pledge, and these activities are considered key drivers of economic growth (Scottish Government, 2015).

Making better use of skills in the workplace is thereby considered a central element of Scotland's economic performance over the long run as part of human capital investment, and the strategy to increase innovation. Policy makers are thereby significantly concerned with possible interactions between these two key policy areas.

Moreover, the skill dimension is also a key avenue for tackling a range of issues from poverty and income inequality to health and life expectancy, as addressed by the objective of inclusive growth. This strategy aims, at least in part, to tackle poverty and get people back into work (Scottish Government, 2015). The Scottish Government is thereby concerned with the potential distributional effects of policies across different types of households, and possible interactions with objectives set out in the skill strategy.

The remaining key priority is focused on promoting Scotland on the international stage to boost trade and investment. This is underpinned by policies that set out how the Scottish Government: supports exporters, such as the Food & drink sector, to grow into new markets, and expand their presence in key traditional markets such as the EU and North America; encourages a more export-orientated focus across all businesses and sectors in Scotland; and creates the underlying conditions which continue to make Scotland a major destination for inward investment (Scottish Government, 2015). Policy makers are thereby concerned with potential macroeconomic impacts of successful export led strategies, and their knock-on effects on other policy areas, such as the skill strategy.

Figure 1.0.1: Four priorities in Scotland's Economic Strategy



Adapted from (Scottish Government, 2015)

Scotland's Economic Strategy thereby sets out a number of priorities for increasing long-term economic growth. These are underpinned by key policy initiatives such as increasing exports, making better use of skills in the workplace, and increasing the skilled workforce in a framework where these policies are intended to be 'mutually supportive' (Scottish Government, 2015). In order to achieve these objectives, policy makers require detailed data and modelling tools to assess potential system-wide impacts of policies set out within Scotland's Economic Strategy.

Currently, however, there are limited analytical tools available to assess the potential interactions and trade-offs between growth objectives set out by the Scottish Government. Moreover, there are no methods available to make system-wide and sectorally disaggregated assessments of policies that directly or indirectly affect labour market sub-categories, including workers with different educational attainments. This is despite the skill dimension being a crucial element within a number of key areas of the Economic Strategy. Multi-sectoral modelling tools that incorporate a disaggregated labour market can help to identify the potential macro-economic and distributional impacts of such policies.

This thesis constructs and applies multi-sectoral models with particular focus on analysing the skill-dimension. It also sheds light on: distributional aspect of policies across different household groups; sectoral impacts; how underlying characteristics of the Scottish economy influence policy outcomes; and whether policies within Scotland's Economic Strategy are 'mutually supportive'. This thesis contributes to the multi-sectoral policy analysis of the Scottish economy through building and extending the commonly used Social Accounting Matrix (SAM) framework and conducting policy relevant analyses within Input-Output (IO), SAM and Computable General Equilibrium (CGE) models.

IO and SAM based models are well established multi-sectoral models and are widely employed for policy analysis, but are predicated on the assumption of an entirely passive supply side. These models allow for a flexible degree of aggregation and capture the behaviour of key agents in the Scottish economy. CGE models extend the analysis by incorporating elements of agents' behavioural responses to shocks and incorporate the supply side. CGE models thereby capture the economy's interdependencies and feedback mechanisms on both the supply and demand side.

Scottish IO, SAM, and CGE models have predominantly treated labour as homogeneous where wage differentials between sectors only reflect industry premia. Disaggregating these data and models by skill thereby provides a framework allowing the identification of wage differentials by worker type, distinguished by highest qualification attained, as well as allowing system-wide, and sectoral analyses of the impacts of a wide range of possible policy relevant shocks. The following section gives an overview of the thesis structure.

1.1 Thesis structure

Chapter 2 constructs a SAM for Scotland for 2009, which details the flows of incomes and expenditures through the Scottish economy in that year. The SAM provides a highly disaggregated, comprehensive and consistent record of the interrelationships and characteristics of the Scottish economy at the level of individual industrial sectors, factors of production and institutions. These data provide considerable insights to policy makers without the need to employ complex modelling techniques. However, these data are also essential for both SAM and CGE models, which can simulate the responses of the economy to a variety of policy relevant shocks. SAMs for Scotland have been produced on a semi-regular basis over the past decade. However, thus far no consistent method for building a SAM for Scotland had been formalised. Chapter 2 develops a replicable method based around publicly available and robust data. The 2009 SAM for Scotland forms the building block for the subsequent chapters.

The Scottish SAM, as computed in Chapter 2, assumes a homogeneous labour force and only reports aggregate employment and wage income figures for each of the industries contained in the SAM. Under these circumstances, wage rate differentials between sectors are interpreted as reflecting industry premia. Chapter 3 develops and applies a method to disaggregate the wage payment entries in the SAM by skill categories, distinguished by highest qualification attained. The skill-disaggregated SAM thereby provides a framework allowing the identification of wage and employment differentials by worker type and industry, reflecting economic conditions within the labour market more precisely.

Chapter 4 compares methods for calculating IO Type II multipliers. These are formulations of the standard Leontief IO model which endogenise elements of household consumption. There are two basic IO Type II multiplier methods that are available in the literature and differences between the two do not appear to be explicitly acknowledged or understood. This chapter sets out to contrast the two principal methods for deriving Type II multipliers and to highlight the difference in computation and interpretation between them. An analytical comparison of the two IO Type II multiplier methods with a SAM multiplier identifies which Type II IO multiplier is more accurate if a SAM is not available. Additionally, this chapter test whether the IO Type II method employed by the Scottish Government in their policy analysis give the closest fit to the SAM multiplier.

Chapter 5 analyses the distributional effects of exogenous demand shocks within the Scottish economy. This is accomplished by employing a SAM model for Scotland that contains detailed information of the main transactors, as well as a disaggregated household account and two types of labour which are defined by their educational achievements. Also, any differential impacts on the two skill categories arising from the exogenous demand shock are used to identify whether that part of the Scottish economy reacting to the exogenous demand shock is more skilled or unskilled-intensive.

Chapter 6 outlines the theoretical framework underpinning CGE models. Technical specifications of the myopic AMOS model are given and the skill related modifications and extensions that this thesis introduces into the model are outlined. The skill-disaggregated AMOS model (AMOSKI) enhances the standard model with a more detailed treatment of the labour market, incorporating two types of labour which are distinguished by their education levels. The skill-disaggregated model specifies different migration, labour demand, and wage functions for the two skill categories. The AMOSKI model is then employed in the following chapters to analyse system-wide impacts of potential policy shocks relevant to Scotland's Economic Strategy.

Exports to both the Rest of the UK and the Rest of the World are a large contributor to Scotland's economic growth, and are a fundamental part in the Economic Strategy. Given the efforts to increase international exports, it is of policy relevance to simulate a variety of export demand shocks so as to identify likely impacts of successful export orientated policies. Chapter 7 employs the AMOSKI model to simulate a number of export shocks adopting different assumptions about the migration behaviour of skilled and unskilled labour. Using this model facilitates the separate identification of the disparate impacts on the skilled and unskilled, whilst also detailing policy relevant system-wide impacts in a multi sectoral modelling framework. The skill intensity of exports as assessed in the SAM model is revisited in a CGE modelling context in order to gain policy relevant insights into the export characteristics of the Scottish economy.

A key policy of the Scottish Government is 'to make better use of skills in the workplace'. This is interpreted here as encouraging a labour augmenting (Harrod-neutral) efficiency improvements where fewer workers are required to produce the same levels of output, with unchanged levels of other inputs. Given the importance of the skill dimension a range of alternative cases of labour-augmenting efficiency improvements are modelled in Chapter 8 using the AMOSKI model. That is, both skill-differentiated (a differential increase in skilled, as against unskilled, efficiency and vice versa), and skill-neutral (an equal increase in labour efficiency across all skill types) labour-augmenting improvements are introduced into the model and analysed.

Chapter 9 summarises each of the chapters and highlights their contribution to the relevant literature. This chapter concludes by identifying areas for future work.

Chapter 2

Chapter 2

Social Accounting Matrix for Scotland

2.1 Introduction

This chapter outlines the method used to construct the 2009 Social Accounting Matrix (SAM) for Scotland. A SAM is a set of accounts which identify the flow of goods, services and factor inputs, and the corresponding flow of funds between agents in an economic system for a given time period (Hosoe et al., 2010). Essentially, the SAM extends the Scottish Input-Output (IO) tables by incorporating Income and Expenditure (IncExp) Accounts. Thus, the IncExp Accounts contain information on institutional accounts that are not recorded within the IO tables. Therefore the SAM can be used to analyse the economy and the impact of social and economic policy in a more comprehensive way. The structure of a SAM and the main benefits of adopting this accounting framework are outlined in Section 2.2. Next, the computed IncExp Accounts and the 2009 Scottish IO tables are combined to complete the 2009 SAM for Scotland (Section 2.3). In the section 2.4 the IncExp Accounts and the methods used to compute these Accounts is described in detail. It must be noted that the fully disaggregated SAM is publicly available and can be assessed from Emonts-Holley and Ross (2016). The file also contains detailed descriptions of the calculations and data sources used for each entry of the IncExp Accounts.

2.2 Social Accounting Matrices

The SAM can be considered as an extended IO table which not only records macroeconomic-aggregates and their sectoral disaggregation but also the distribution and redistribution of income. The focus of a SAM therefore lies in recording interrelationships at the meso-level with emphasis on distributive aspects (Keuning & de Ruuter, 1988). It is concerned with the systematic organisation of information about the economic and social structure of a country, region, or city, in a particular time period - usually a year (King, 1981).

In contrast to IO tables, the SAM records flows from producing sectors to factors of production and then on to institutional accounts and finally back to the demand for goods (Adelman & Robinson, 1986). That is, IO tables show payments to factors of production (wages and Other Value Added) but do not show subsequent flows to institutions.

As such, a SAM is different from an IO table in that it contains complete information on institutional accounts (i.e. households, government and corporations), instead of solely tracing income and expenditure flows associated with the production of commodities (Breisinger et al., 2010). The main features of a SAM can be divided into three sections (Round, 2003).

First, the row sums in the SAM show the total receipts and the column sums show the total payments of funds in individual accounts. Importantly, each row sum must equal its corresponding column total. That is, the total revenue must equal total expenditure in each account (Hosoe et al., 2010). Each cell in the SAM represents a flow of funds from a column account to a row account, thereby documenting the interconnections between these accounts in an explicit way.

Second, the SAM is considered to be comprehensive as it shows economic activity in terms of consumption, production, accumulation and distribution (although not necessarily in equivalent detail).

Third, the SAM is considered to be flexible in the degree of disaggregation, whilst at the same time following a basic accounting framework (Breisinger et al., 2010). The degree of disaggregation generally depends on the motivation behind the construction of the SAM (e.g. depending on the location of the initial shock and the outcome variables) and more restrictively, the availability of data (Round, 2003).

There are many benefits from constructing a SAM. The additional information contained in the SAM, compared to IO tables, can be used to extend and improve the multiplier modelling capacity to include the behaviour of the non-production part of the economy. In particular, the more explicit link between activity and household income should improve the Type II multiplier (this is discussed in detail in Chapter 4)

Thus, a key benefit of extending the IO table to a SAM stems from the added ability of modelling households in more detail. When examining the income effects of an external policy shock on households, IO models allow for analysing different effects on household income. SAM-based multiplier models, however, can additionally detail distributional effects on households (Round, 2003).

Moreover, the SAM can incorporate a highly disaggregated social breakdown. This is particularly important as a large number of economic interactions happen within the household sector. That is, the household account can be further disaggregated to record income and expenditure flows of households determined by, for example, income and age-groups. This in turn allows for more accurate analysis of distributional effects of policy (Stuttard & Frogner, 2003b). This is illustrated in Chapter 5 of this thesis in more detail.

An important side-effect of the SAM compilation process is that data gaps and inconsistencies can be identified. This information can be used to improve and extend survey methods, definitions, classifications and the overall compatibility of data sources (Keuning & de Ruuter, 1988).

The main utility, however, of a SAM is that it provides a comprehensive and consistent record of the interrelationships of an economy at the level of individual production sectors, factors and institutions. Thereby, the SAM makes available an internally consistent statistical foundation, or benchmark, for the creation of plausible economic models (e.g. Computable General Equilibrium models) which simulate changes to the economy (Reinert & Roland-Holst, 1997).

2.3 Social Accounting Matrix for Scotland

The main components of the Scottish SAM are the 2009 IO tables for Scotland (Scottish Government, 2013a), and the IncExp accounts. Note that the 2009 data were the most up-to-date data available at the time of constructing the SAM. The IO table is a symmetric Industry by Industry (IxI) IO table with 104 industries defined at the SIC07. The IxI table presentation allows the interdependence of industries to be formally examined as each industry is shown as intermediate purchasers of their own and other industries' output. A detailed description of the methods and data sources used for the construction of the Scottish Government Supply and Use Tables and Analytical IO tables can be accessed from the Scottish Government (2011).

Table 2.3.1 is an aggregate version of the 2009 IxI table for Scotland. Focusing on the first row and column, the row gives the expenditure on Scottish goods/services, whilst the column details the cost breakdown of the Scottish production sectors. The IO tables define the production cost entries in the column as: intermediates, labour costs, Other Value Added (OVA), Government and Imports from the Rest of UK (RUK), and the Rest of the World (ROW). The production income entries are defined as: Capital, Household expenditure on Scottish goods/services, Government, and exports.

The first row total of £210,920m in the aggregated IxI Table 2.3.1 gives the total turnover of all production and service activity in the Scottish economy (total aggregate demand of gross outputs). It is labelled as 'Activities'. This includes private, public and voluntary sector production activity.

This total is broken down to show these interactions in more detail. That is, the largest flow of funds within Activities take place within sales and purchases of Scottish goods/services (intermediate demand) at £63,607m. This is followed by combined exports at £54,045m (with exports to the RUK comprising 68% of total exports), Household consumption expenditure on goods/services at £49,802m, Government payments (or grants) to Activities (such as Universities and public services) at £29,486m, and lastly Investment expenditure at £13,981m. The disaggregate version of the IxI table details these interactions at full 104 industry level.

The first column in the IO table can be read as expenditures made by productive Activities. It can also be interpreted as the full cost of generating these activities. These expenditures are again further broken down into expenditures to 'factors of production' (labour and OVA - including capital and land), Government, and imports. Payments to factors of production comprise 48% of total expenditures (costs) to Activities. The remaining payments go to Government and imports. Also note that, 75% of total imports to Activities stem from the RUK.

The IxI table 2.3.1 shows the destination of industry output, for example primary manufacturing products. The columns of the IxI Table show purchases made by industries and final demand from each Scottish industry's output arising from both principal production and intermediate demand. Conversely, the rows provide a breakdown of industry receipts by origin. This data on industry linkages can be used in conventional multiplier analysis to estimate knock-on effects throughout the Scottish economy of a change in final demand.

It must be noted, that the economic activity arising from resource extraction occurring in the North Sea is not directly included in these Scottish accounts. The Scottish 2009 IO tables therefore only include mainland activity. However, onshore activity servicing the extractive activities are identified in the Scottish IO tables as exports to the RUK.

The aggregate IxI Table 2.3.1 shows that Total Final Demand equals Total output at basic prices (see Scottish Government (2011) for a definition and discussion of 'basic prices') within the Activities account. That is, all expenditures are balanced by receipts within the Activities account (£210,920m - £210,920m = 0).

IO tables, however, do not attempt to link the elements of Value Added (Wages and OVA) with the elements of Final Demand (Consumers, Government and Investment). This is in contrast to a SAM where the "missing" data on transfers between these accounts are recorded. Recoding these flows is done by compiling IncExp Accounts and linking these together with the IxI table to generate a fully balanced square matrix.

Table 2.3.1: Aggregate Industry by Industry Table, 2009 basic prices (£million)

	1. Activities	2. Labour	3. Capital	4. OVA	5. Households	6. Government	7. RUK	8. ROW	Total
1. Activities	63,607	-	13,981	-	49,802	29,486	36,879	17,166	210,920
2. Labour	63,561	-	-	-	-	-	-	-	63,561
3. Capital	-	-	-	-	-	-	-	-	-
4. OVA	38,441	-	-	-	-	-	-	-	38,441
5. Households	-	-	-	-	-	-	-	-	-
6. Government	4,779	-	1,495	-	6,568	-	193	129	13,165
7. RUK	30,274	-	3,358	-	13,875	-	4,362	2,890	54,759
8. ROW	10,258	-	1,097	-	4,424	-	3,057	161	18,997
Total	210,920	-	19,930	-	74,669	29,486	44,491	20,346	

Source: Scottish Government (2013a)

Table 2.3.2 gives an aggregate version of the SAM that is derived by combining the IxI table and the IncExp Accounts. In order to record transfers between accounts a 'Corporations' account is added which does not feature in the IxI table. The Corporations account is outlined in detail in Section 2.4.2. For illustrative purposes disaggregation within accounts has been suppressed, as in Table 2.3.1. For example, the 104 industries contained in the SAM are aggregated to one industry (Activities). It must be emphasised that for modelling purposes a much more detailed SAM is used.

Table 2.3.2: Aggregated 2009 SAM for Scotland, 2009 basic prices (£million)

	1. Activities	2. Labour	3. Capital	4. OVA	5. Households	6. Corporations	7. Government	8. RUK	9. ROW	Total
1. Activities	63,607	-	13,981	-	49,802	-	29,486	36,879	17,166	210,920
2. Labour	63,561	-	-	-	-	-	-	-	-	63,561
3. Capital	-	-	-	-	5,070	24,828	119	- 5,217	- 4,871	19,930
4. OVA	38,441	-	-	-	-	-	-	-	-	38,441
5. Households	-	63,561	-	5,289	-	15,103	19,835	1,853	2,237	107,877
6. Corporations	-	-	-	29,456	6,401	-	5,722	5,964	5,964	53,507
7. Government	4,779	-	1,495	3,697	27,947	5,248	13,165	20,234	129	76,694
8. RUK	30,274	-	3,358	-	14,113	3,768	8,368	4,362	2,890	67,133
9. ROW	10,258	-	1,097	-	4,544	4,560	-	3,057	161	23,676
Total	210,920	63,561	19,930	38,441	107,877	53,507	76,694	67,133	23,676	

The fully disaggregated SAM can be assessed from: Emonts-Holley and Ross (2016)

The aggregated 2009 SAM for Scotland, as detailed in Table 2.3.2, is a square matrix with 9 column and 9 corresponding row accounts. This aggregated SAM contains the following main accounts: Activities, Labour, Capital, OVA (Profits), Households, Corporations, Government, the RUK, and the ROW.

The row and column entries in the SAM are considered to be receipts and expenditures receptively. The rows in the SAM show income sources for each Account in detail. For example, the Household account shows that total Household income is £107,877m, of which £63,561m (58%) comes from Labour income. Conversely, the columns in the SAM depict the expenditures of each account in detail. Again, total Household expenditure is £107,877m, of which £49,802m (46%) are payments to productive Activities i.e. Household consumption on goods/services produced in Scotland.

The first row and the first column of the SAM include all the aggregated information from the IxI IO tables, and thus balance. That is the £210,920m from the IxI table (see Table 2.3.1) are fully incorporated. Thus, IO tables provide key macroeconomic variables (GDP and total wage income) as well a breakdown of flows between Scottish industries.

Yet, the SAM links up these accounts and thereby presents a more comprehensive and consistent overview of economic activity. For instance, the Government account in the IO table (see Table 2.3.1) identifies only five sources of total Government income and only one source of its expenditures. Thus, in contrast to the SAM, only 17% (£13,165m/£76,694m) of total Government income is recorded in the IO table.

Similarly, only 38% (£29,486m/£76,694m) of total Government expenditure is recorded in the IO table. It must be noted that imports from RUK and ROW include 'Non-resident household expenditure in Scotland'. If this was not the case, imports to Government from RUK and ROW would be zero.

The additional information contained in the SAM is vital in improving the multiplier modelling capacity. As mentioned in Section 2.2, the additional information contained in the SAM, compared to the IO Tables, can be used to extend and improve the multiplier modelling capacity to include the behaviour of the non-production part of the economy as well. In particular, the more explicit link between activity and household income should improve the Type II multiplier.

The IxI table 2.3.1 gives a breakdown of total Household (£74,669m) consumption on Activities (domestic goods/services), Government and Imports. However, the IxI table does not detail other sources of expenditure, and more importantly, no explicit sources of Household income. In contrast, the SAM in Table 2.3.2 provides a more detailed breakdown of Household expenditure on savings, Corporations, Taxes, and Imports. Total Household expenditure is thereby estimated to be £107,877m. Thus, in comparison to the SAM, the IxI table only captures 69% of total Household expenditure.

The SAM also presents a detailed breakdown of Household income by Labour, OVA, Corporations, Government and Exports. The SAM thereby details additional sources of Household income that are not captured in the IxI table. The entries that were added to the IO Tables to compute the more detailed SAM are derived from the balanced IncExp Accounts. This approach assures that every expenditure total and its corresponding receipt total balance and therefore retain the integrity of the IO accounts when constructing the SAM.

The SAM thereby incorporates the information of sales and purchases of Scottish goods and services at 104 industry level, at both intermediate and final demand; and also income and transfers among the transactors. Thus, the SAM is meant to link together existing IO tables and other national statistics. Data necessary for the construction of the SAM that are not contained within the IO table are derived by computing the IncExp Accounts. These accounts record income and expenditure of households, corporations, government, capital and the external sector in detail.

2.4 The Income and Expenditure Accounts for 2009

The IncExp Accounts provide a detailed picture of flows of funds for the main local transactors (Households, Corporations and Government), as well as for the Capital and External sectors in Scotland. The IncExp Accounts are compiled by using publicly available data, sourced from both the UK and the Scottish Government, including the 2009 IO Tables for Scotland (Scottish Government, 2013a).

Section 2.3 outlined the role that the IncExp Accounts have in extending the 2009 IO Tables into the 2009 Scottish SAM. This section provides an overview of the IncExp Accounts and how these accounts are constructed. This includes a discussion of the data sources, an illustration of the layout and an overview of the calculations and the internal balancing of the Accounts. Emonts-Holley and Ross (2016) provide a detailed and replicable Excel file of how each of the entries in the Accounts is calculated.

2.4.1 Data

The data used in the construction of the IncExp Accounts are derived from either UK or Scottish Government sources and are all publicly available. The information presented in the Accounts is for the calendar year 2009. This is the format used for the IO Tables, which is carried forward to the SAM.

However, some data, for example those from the Government Expenditure and Revenue Scotland (GERS) publication (Scottish Government, 2013b), are given for financial years. This format is specified as starting from the beginning of April in one year to the end of March in the next year. Therefore the financial year 2008/09 covers the period from 01.04.08 to 31.03.09. In order to transform these data to the calendar year format for 2009, a one-quarter share of the data entry for the financial year 2008-09 is combined with a three-quarter share of the data entry for the financial year 2009-10 i.e. 2008-09*0.25 + 2009-10*0.75.

The main data sources used for the construction of the Accounts are identified in Figure 2.4.1. This figure gives an indication of the proportion of the required data that is taken from the main sources. The shares are calculated by de-constructing each entry in the Accounts and is calculated identifying the source of each component.

Figure 2.4.1 shows that the largest source of data for the IncExp Accounts originates from the 2009 IO Tables for Scotland with 29% (Scottish Government, 2013c). The other two major data sources are depicted as GERS with 24% (Scottish Government, 2013b) and the ONS Blue Book, i.e. the UK National Accounts, with 24% (ONS, 2013).

The majority of data used in the compilation of the IncExp Accounts thereby originates from Scottish data. Summing up the shares of the 2009 IO Tables, GERS and other Scottish Government sources shows that approximately 56% of data is of Scottish origin. The total amount based on UK data sources is calculated at 35%, which is the sum of the shares of the ONS Blue Book (24%), Other UK Government (6%), and PESA (5%).

Figure 2.4.1: Shares of data sources in Income and Expenditure Accounts

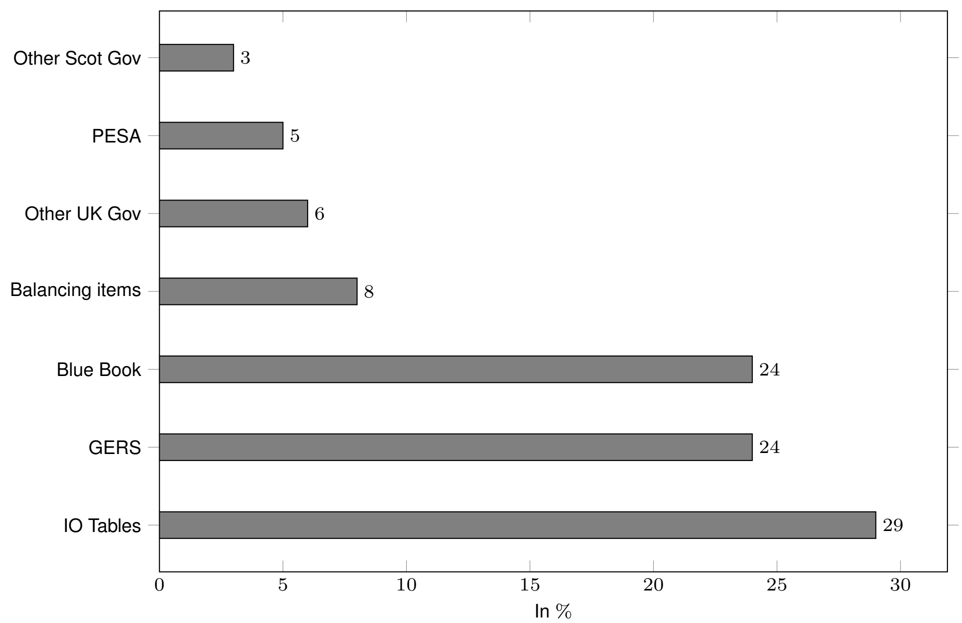


Figure 2.4.1 shows furthermore that Balancing Items account for 8% of total individual entries in the Accounts. Essentially, these are elements which are determined through the requirement that the expenditures and receipts in each account must balance (note that a full discussion on Balancing Items can be found in Section 2.4.3).

Data Sources

The largest data source for the calculation of the IncExp Accounts are the 2009 IxI (IO) Tables. The 2009 Tables are the latest IO Tables released by the Scottish Government at the time of this publication and henceforth they determine the year for which the Scottish SAM is built. The IO Tables furthermore determine the accounting period of the IncExp Accounts and the SAM, which is the calendar year format.

The Scottish IO Tables and thus the Scottish SAM represent the Scottish onshore economy only, and do not include revenue from North Sea oil and gas operations. It has to be noted that other data sources used in the compilation of the IncExp Accounts, for example the ONS Blue Book (ONS, 2013), include revenue from North Sea operations. This directly affects the Scottish GDP as a share of total UK GDP, which is derived by figures from the IO Tables and the ONS Blue Book respectively (Scottish Government, 2013c; ONS, 2013). The Scottish GDP is underestimated in this instance in relation to the UK GDP figure.

The second largest source for data used in the IncExp Accounts is GERS, which is an annual publication by the Scottish Government. GERS uses both UK and Scottish Government finance statistics in order to capture all public sector expenditures and receipts in Scotland. This source provides, inter alia, household and corporate tax payments as well as total public spending control totals for the IncExp Accounts (Total Government Expenditure). The data in GERS are presented in financial year format and have to be transformed to the calendar year format (as discussed above) for the IncExp Accounts (Scottish Government, 2013b).

The third largest data source used here is the ONS Blue Book, i.e. the UK National Accounts, which is an annual UK National Statistics Publication. The Blue Book is constructed using governmental financial statistics, both from the UK- as well as international government sources. It provides a detailed sectoral breakdown of the UK economy as well as its economic activities with the ROW. The Blue Book data are used for a wide variety of entries in the Accounts, for example, public and private dividend payments to households. The data are in the calendar year format and do not require transformation (ONS, 2013).

The fourth largest single source for the IncExp Accounts is the data from the annual HM Treasury (2012) Public Expenditure Statistical Analyses (PESA) publication. Here Local and Central Government spending is detailed, including the budgets of UK government department.

PESA is a major source for the GERS publication by the Scottish Government (Scottish Government, 2013b). The data used in the IncExp Accounts originating from PESA are public sector identifiable, non-identifiable and total spending (HM Treasury, 2012). The data are presented in financial year format and have to be transformed to the calendar year format for the IncExp Accounts.

Finally, there are other UK and Scottish Government sources. These include, for example, figures used for the derivation of Scottish households as a share of total UK households (Scottish Government, 2012a; ONS, 2012).

Shares

As mentioned above, several shares are used in order to transform UK data for the Scottish IncExp Accounts. These shares are essential as some data are only available on the UK level. For example, the Total Managed Public Sector Expenditure in PESA (HM Treasury, 2012), which is used to estimate the total public expenditure in Scotland. This is the Total Government Expenditure Balancing Total in the IncExp Accounts.

The various shares are used throughout the derivations of the individual cells of the IncExp Accounts. The three shares used for the majority of UK data transformation are given below. These are the GDP share at 8.22%, the Population share at 8.41%, and the Households share at 9%. Other shares, such as the Scottish share of Total UK Other Value Added at 8.31% are also used in the calculations. The excel file in which the SAM is compiled gives details on each of the shares (Emonts-Holley & Ross, 2016). These shares are all close in value. However, theoretical considerations favour different shares for specific UK data as outlined below.

First, the GDP share is applied when UK data is transformed for the Scottish jurisdiction. For example, Governmental and Corporate transfers payments (ONS, 2013) are multiplied by the GDP share following the framework set out by Turner (2002). Second, the Population share is used for public sector spending, which is allocated to the different jurisdictions within the UK through size estimates of the relevant region. This is in line with the methodology applied in GERS (Scottish Government, 2013b) for transforming PESA (HM Treasury, 2012) data for Scotland. Third, the Household share is applied to transform UK Dividend Payments to a Scottish figure, which follows UK calculations in transforming total dividend payments to the household level (ONS, 2013).

The majority of data used in the IncExp Accounts is derived from Scottish sources as outlined above. Nevertheless, some statistics are only available on the UK level and the Scottish figure has to be inferred as a share of that. Increasing the volume of entries calculated from direct Scottish data would result in more accurate IncExp Accounts.

2.4.2 Layout

The IncExp Accounts detailed in Table 2.4.1 are divided into five sectors (Households, Corporations, Government, Capital and External) as well as the Scottish Trade and External balance with both the RUK and the ROW. Each of those sectors is divided further into an income and an expenditure section (left-hand side and right-hand side respectively), hence the name for these Accounts.

Each numerical entry in the IncExp Accounts is referred to as a cell and is identified for convenience through the number code given to each entry. For example, (Cell 2) refers to the Income from Employment entry of the Households' account, and (Cell 19) refers to the Profit Income (OVA) of the Corporations' Income Account.

Every account has a Total Income and a Total Expenditure figure, which is a summation of the entries in each section (highlighted in bold). The total expenditure and the total income for each of the main transactors as well as for the Capital account are equal to each other. This is essential for the balancing of the SAM and is discussed in more detail in Section 2.4.3 under "Balancing Items".

In addition to the totals derived by summing up the individual entries in each of the main transactors' accounts, the Household and Government sector have additional Control Totals from external sources. For the Household Sector this is (Cell 1), which is the Total Household Income from the GDHI figures (ONS, 2011b). For the Government sector the Control Total is (Cell 43), which is the total public sector expenditure in Scotland derived from GERS and the PESA accounts (Scottish Government, 2013b; HM Treasury, 2012).

The main transactors (Households, Corporations and Government) have a similar cell breakdown. The largest share of entries in these accounts are Income from- and payments to the other main transactors as well as flows of funds to and from the External account.

Note that due to the accounting identity used in the IncExp Accounts, the receipt that, for example, sector A receives from sector B is equal to the payment made by sector B to sector A. This is discussed in more detail in Section 2.4.3 under "Corresponding Figures".

The External payments are comprised of goods & services payments and receipts to and from Scotland to both RUK and ROW. Additionally, they show the sums of the transfers to and from RUK and ROW by the main transactors. For example, (Cell 53) are the Transfers that Scotland pays to RUK, which is the sum of (Cells 14, 27, and 41). Furthermore, all main transactors have a Profit Income (OVA) entry and a Payments to Capital [1] entry on the Income and on the Expenditure side, respectively.

[1] These are equal to savings made by the individual sector and the Payments to Capital of each sector are used to derive the Capital account.

Table 2.4.1: Income-Expenditure Accounts for Scotland (in £million)

Households					
1. **Income**	**107,877**		10. **Expenditure**	**107,877**	
2. Income from Employment	63,561		11. IO Expenditure	74,669	
3. Profit Income (OVA)	5,289		12. Payments to Corporations	6,401	*
4. Income from Corporations	15,103		13. Payments to Government	21,379	
5. Income from Government	19,835		14. Transfers to RUK	238	
6. Transfers from RUK	1,853		15. Transfers to ROW	119	
7. Transfers from ROW	2,237		16. Payments to Capital (Savings)	5,070	
8. Mixed and Proport. Income Unalloc.	867	*			
9. **Total Household Income**	**107,877**		17. **Total Expenditure**	**107,877**	**
Corporations					
18. **Income**	**53,507**		24. **Expenditure**	**53,507**	
19. Profit Income (OVA)	29,456		25. Payments to Households	15,103	**
20. Income from Households	6,401	**	26. Payments to Government	5,248	
21. Income from Government	5,722	**	27. Transfers to RUK	3,768	
22. Income from RUK	5,964		28. Transfers to ROW	4,560	
23. Income from ROW	5,964		29. Payments to Capital (Savings)	24,828	*
Government					
30. **Income**	**63,530**		37. **Expenditure**	**63,530**	
31. Profit Income (OVA)	3,697		38. IO Expenditure	29,486	
32. Net Commodity Taxes	13,165		39. Payments to Corporations	5,722	*
33. Income from Households	21,379	**	40. Payments to Households	19,835	**
34. Income from Corporations	5,248	**	41. Transfers to RUK	8,368	
35. Income from RUK	20,041	*	42. Payments to Capital (Savings)	119	
36. **Total Gov Inc Balancing Total**	**63,530**	**	43. **Total Gov Exp Balancing Total**	**63,530**	
Capital					
44. **Income**	**19,930**		49. **Expenditure**	**19,930**	
45. Households	5,070	**	50. IO Expenditure	19,930	
46. Corporations	24,828	**			
47. Government	119	**			
48. RUK/ROW	-10,087	**			
External					
51. RUK Income from Scotland	67,133		58. RUK Expenditure in Scotland	70,597	
52. Goods & Services from RUK	54,759		59. Goods & Services to RUK	42,739	
53. Transfers to RUK	12,374		60. Transfers from RUK	27,858	
54. ROW Income from Scotland	23,676		61. ROW Expenditure in Scotland	27,378	
55. Goods & Services from ROW	18,997		62. Goods & Services to ROW	19,178	
56. Transfers to ROW	4,679		63. Transfers from ROW	8,201	
			64. Tourist Expenditure in Scotland	2,921	
57. **Total Income**	**90,808**		65. **Total Expenditure**	**100,896**	
			66. Surplus/Deficit	-10,087	
G&S trade balance			**Total balance of payments**		
67. RUK	-12,020		69. RUK	5,217	
68. ROW	181		70. ROW	4,871	
			71. Total Balance of Payments	10,087	
External balance			**Note:**		
72. Income from Employment	-3,464		* = Balancing item.		
73. Profit Income (OVA)	-3,703		** = Corresponding figure.		
74. Income from Corporations	-2,921				
75. Income from Government	-10,087		See Emonts-Holley and Ross (2016) for detailed calculations.		

2.4.3 Calculation Overview and Internal Balancing

The structure used for compiling the IncExp Accounts follows a framework set out by Turner (2002), which also used data from both the Scottish IO Tables as well as other external sources. As stated above, the largest share of data entries originates from the 2009 IO Tables for Scotland (Scottish Government, 2013c). The entries in the IncExp Accounts, which are calculated solely with data from the IO Tables, do not have to be transformed in order to fit these into the SAM framework. For example, (Cell 11) and (Cell 38) are summations of several IO entries.

Linking together the IncExp Accounts (see Table 2.4.1) and the IxI Table (see Table 2.3.1) is described in the following by the means of using the Government account as an example. Table 2.4.2 depicts the Government account in an aggregate 2009 Scottish SAM. In the parenthesis of the SAM figures the location within the IncExpAccounts or IO table is detailed. For example, the £29,486m Government expenditures on Activities stem from the IO table (Table 2.3.1). The £119m of Government expenditures on Capital stem from the IncExp Account and can be found in (Cell 42) in Table 2.4.1.

Due to the aggregation of the SAM (Table 2.4.2) it is necessary to combine IO and IncExp data for several entries. For example, the £27,947m Government income from Households is the sum of (Cell 33) 'Payments to Households to Government' and the IO entry 'Taxes on Expenditure'. Thus, it mus be stressed again, that this aggregation is for illustration purposes only and that the fully disaggregated table as given in Emonts-Holley and Ross (2016) should be consulted when evaluating the figures contained within the SAM.

Table 2.4.2: Linking together IO tables and the IncExp Accounts, 2009 basic prices (£million)

	1. Activities	2. Labour	3. Capital	4. OVA	5. Households	6. Corporations	7. Government	8. RUK	9. ROW
Government expenditures	29,486	-	119	-	19,835	5,722	13,165	8,368	-
(Column in SAM)	(IO)	-	(Cell 42)	-	(Cell 40)	(Cell 39)	(Cell 32)	(Cell 41)	-
Gov receipts	4,779	-	1,495	3,697	27,947	5,248	13,165	20,234	129
(Row in SAM)	(IO)	-	(IO)	(Cell 31)	(Cell 33+IO)	(Cell 34)	(Cell 32)	(Cell 35+IO)	(IO)

Note: The location of the figures in the IncExp Accounts and the IO Tables are detailed in the parenthesis.

Additional to the IO Tables and the other data sources discussed in the Section 2.4.1, the IncExp Accounts in Table 2.4.1 contain internally derived cells. These are denoted with a single star (*) for Balancing Items and with two stars (**) for Corresponding Figures.

Balancing Items

Balancing Items are used to balance the Total Income and the Total Expenditure of the main transactors. The method used for allocating Balancing items to the various accounts is as follows. The Household and Government accounts have control totals and in order to balance total income with total expenditure for these accounts, manual balancing is needed. Thus, there is a Balancing Item on the income and on the expenditure side for each one of these accounts.

The Corporate Account does not have control totals, however. Within the Corporate account, the income entries are more robust than the expenditure ones. The balancing is therefore imposed on the latter. Generally, Balancing Items are imposed on those cells, for which data availability or quality is least robust.

Balancing Items are calculated by summing up all figures of one sector on the relevant account side (apart from the cell used as a Balancing Item) and deducting the Total figure by that calculated sum. For example, Corporations' Payments to Capital (Cell 29) is calculated through deducting the sum of (Cell 25) to (Cell 28) from the total Expenditure (Cell 24): (£15,103m + £5,248m + £3,768m + £4,560m) - £53,507m = £28,828m.

Corresponding Figures

As outlined in the previous section, based on the accounting identity used for the IncExp Accounts, the income that sector A receives from sector B is equal to the payment that sector B makes to sector A. Thus there is a correspondence between payments of the main transactors to each other in the IncExp Accounts. For example, the Income from Corporations received by the Government (Cell 34) is equal to the Payments to Government made by Corporations (Cell 26).

It must be noted that the sequence of the Accounts determines the use and presence of Corresponding Figures. The sequence of the IncExp Accounts is set out to be: 1.Households, 2.Corporations, 3.Government, 4.Capital and 5.External. Corresponding Figures between the main transactors occur only in the accounts that follow the Household account. The Household account's Total Expenditure (Cell 17), is an 'account internal Corresponding Figure' referencing Total Household Income (Cell 9) and thus not an entry corresponding to another main transactor.

The use of Corresponding Figures is only then problematic when it corresponds to a cell that is calculated as a Balancing Item. For example, all income entries for the Capital account are Corresponding Figures, as these are equal to the Payments to Capital entries by each of the Primary Sectors (Cells 16, 29 & 42) as well as the net External balance (Cell 66).

The entry that could cause a 'compounded error' due to reusing a Balancing Item, here, is Capital Income from the Corporate account (Cell 46) which corresponds to the Corporations' Payments to Capital (Cell 29), which is a Balancing Item.

Table 2.4.3 provides details of the cells of the IncExp Accounts, which highlights, inter alia, whether cells are derived through external sources or through internal calculation. Cells noted as “Regular” are simply cells in the IncExp Accounts, which are marked as neither Balancing Items nor Corresponding Figures (see Table 2.4.1).

Table 2.4.3: Income and Expenditure cell details

	Internal	External	Total
1. Regular	29	28	57
2. Balancing Item	5	-	5
3. Corresponding Figure	4	9	13
Total	38	37	75

The slight majority of the “Regular ” cells is derived through internal calculations (with 29 internally calculated cells versus 28 externally calculated cells). For example, Total Household Income (Cell 9), which is the total of all cells in the Households’ income account, is internally calculated. The cells noted as being externally calculated are those, which were derived through figures external to the IncExp Accounts. For instance, the Households’ Payments to Government (Cell 13) is calculated through figures taken solely from GERS (Scottish Government, 2013b).

The second row of Table 2.4.3 shows that there are a total of 5 Balancing Items in the IncExp Accounts. These are all internally derived, following the method outlined above. Note that three of those Balancing Items are used within the Accounts as Corresponding Figures and could thereby be the source of a ‘compounding error’.

Cells noted as Corresponding Figures in the IncExp Accounts are detailed in row three of Table 2.4.3. Four of these cells are denoted as being derived from internally calculated cells. Three of those are the above-mentioned Balancing Items, which are also used as Corresponding Figures.

The fourth internally derived Corresponding Figure is the Household sector’s Total Expenditure (Cell 17). This cell is equal to Total Household Income (Cell 9), which is a summation of all income of the Household sector. All other Corresponding Figures are equal to externally calculated cells. For example, Government’s Payments to Households (Cell 40) is equal to Household’s Income from Government (Cell 5), which are derived through figures from both both GERS and the ONS Blue Book (Scottish Government, 2013a; ONS, 2013).

Note that although thirteen cells are identified as Corresponding Figures in the Accounts, in effect 26 cells have corresponding entries to other cells. If the ordering of the Accounts were different, for example the Household account would follow the Government account, then Household’s Income from Government (Cell 5) would be a Corresponding Figure of Government’s Payments to Households (Cell 40). Thus (Cell 5) would be noted as a Corresponding Figure, whilst (Cell 40) would not.

Table 2.4.3 highlights that in total 38 cells are calculated through internal sources, whilst 37 cells in the Accounts are derived through external calculation. The entries of the main transactors are mainly obtained through external sources whilst the majority of entries from the Capital account and below (see Table 2.4.1) are derived through internal calculations.

Concerning future work on the IncExp Accounts, the reliance on Balancing Items could be assessed further. As Figure 2.4.1 shows, these cells account for 8% of the total individual entries for the IncExp Accounts. Currently, the cells for which the least robust data available are chosen in order to balance the accounts of the main transactors. If robust estimates for these entries could also be obtained, then the balancing of the account could be distributed across a number of cells in an account. However, determining the balancing share of each entry might prove difficult and could result in a number of robust estimates to be skewed.

2.5 Summary

This chapter developed a method for the construction of the Scottish SAM. The method is replicable and utilises data that is publicly available. The way that the 2009 Scottish SAM is constructed in Excel allows for any of the raw data, that are used to compute the entries, to be updated. That is to say that the method presented in this chapter enables SAM's based on other base years, for example, to be built in a very short time span which was previously not possible. The framework and the SAM presented here is now used by the Scottish Government and other researchers as the basis for their modelling work. Also, the 2009 Scottish SAM provides the basis for several more highly disaggregated variants. The next chapter disaggregates the income from labour entries in the SAM by skill categories.

Chapter 3

Chapter 3

Skill-disaggregated Social Accounting Matrix

3.1 Introduction

When modelling workforce skill policy, such as the impact of skill-differentiated training initiatives, it is essential that the 'Income from Employment' entry in the Scottish Social Accounting Matrix (SAM) is disaggregated to reflect the skill composition, and corresponding income differentials of the Scottish economy. The Scottish SAM (as detailed in Chapter 2) does not detail characteristics of the workers who receive labour incomes and only reports aggregate employment and income figures for each of the 104 industries. That is, labour is homogeneous and wage differentials between sectors reflect industry premia. This chapter is concerned with disaggregating these entries by different skill categories, distinguished by highest qualification attained, in order to reflect economic conditions within the labour market more precisely [1]. The disaggregated SAM thereby provides a framework allowing the identification of wage differentials by worker type and industry. As there is no single data source readily available by which this type of disaggregation can be computed, this chapter details the method used to disaggregate income from employment. Sections 3.2 and 3.3 outline the method and the data used to disaggregate the labour income entries in the Scottish SAM by different types of skill categories. Section 3.4 describes each of the steps in detail. The final sections, 3.5 and 3.6, analyse the skill-disaggregated SAM and summarise the main results.

[1] It should be noted that the 2009 SAM for Scotland is also disaggregated by gender. This is not outlined here as it follows the same method that is used to disaggregate by skill. The gender and skill disaggregated SAM can be accessed from Ross (2016b).

3.2 Method

This section outlines the method used to disaggregate the 'Income from Employment' (labour income) entries in the SAM. The SAM, and the Input-Output (IO) tables contained within, give control totals for several variables necessary for the skill disaggregation. Available are: estimates for full time equivalent (FTE) employment in each industry, U, and thereby also total FTE employment, and the aggregate total wage by industry, V.

$$U = \begin{bmatrix} u_{1,1} & \cdots & u_{1,104} \end{bmatrix} \tag{3.1}$$

$$V = \begin{bmatrix} v_{1,1} & \cdots & v_{1,104} \end{bmatrix} \tag{3.2}$$

The 2009 SAM for Scotland, as detailed in Chapter 2, thereby shows how compensation of employees is paid by Scottish firms across industries and also provides aggregate details on the workforce which supplies the labour. The SAM has figures for wages and salaries by industry (104 industries) but it contains no information about the characteristics of the workers who receive the income.

The data required for disaggregating the labour income entry for each industry do not exist in the required form and have to be constructed from various sources. Here the 2009 SAM for Scotland is disaggregated by 50 skill categories, defined by highest attained qualification. The final product of the skill disaggregation, X, identifies wages and salaries by skill category and industry, whilst retaining the control totals on labour incomes by industry, V, as given in the SAM.

$$X = \begin{bmatrix} x_{1,1} & \cdots & x_{1,104} \\ \vdots & \ddots & \vdots \\ x_{50,1} & \cdots & x_{50,104} \end{bmatrix} \tag{3.3}$$

It must also be noted that the skill disaggregation is implemented at the highest possible level in the SAM (50 skill categories) to provide a framework that can be tailored specifically according to the policy to be analysed. That is, for policy analysis a more aggregate version is likely to be appropriate.

The disaggregation of labour incomes in the Scottish SAM is computed by following a bottom-up approach. This approach uses micro data sources, adding in factors (i.e. skills) that are not included within the SAM. The resulting estimates are then calibrated to match SAM control totals. The skill disaggregation process is illustrated in Figure 3.2.1. Estimates of labour incomes by skill category are produced for each industry. Shares of these estimates are computed, which are then multiplied with the control totals from the SAM in order to produce the final skill-disaggregated labour incomes by industry.

That is, the labour incomes for each skill and industry are estimated. This is done through several data sources, which identify the number of workers of each skill category in each industry; and the wage premia of each skill category. When the number of workers in each skill category and industry are multiplied with their corresponding wages, it can be expected to obtain estimates close to SAM wage income figures. The variables unknown are thereby: (1) FTE employment in each of the industries by skill category, and (2) the wage premia of each skill category.

It is, however, anticipated that estimates fall short, or overshoot SAM wage income at industry level due to, for example, excluding variables such as bonus payments, overtime payments and tax avoidance. Therefore, the estimated labour incomes by skill and industry are used to compute shares which are subsequently multiplied by the control totals from the SAM. Hence, results are calibrated to equal aggregate SAM labour income figures.

Figure 3.2.1: Skill disaggregation of labour incomes

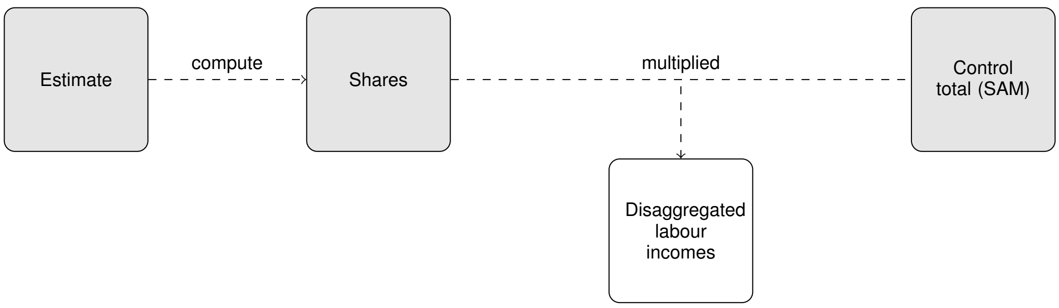


Table 3.2.1 provides a detailed overview and road map of the matrices and vectors used for the skill disaggregation of labour incomes. The columns give the name, dimension, description, and source for each the matrices/vectors. These are described in detail in Section 3.4. Section 3.4.1 outlines the computations required to derive employment by skill and industry. Section 3.4.2 outlines the process of estimating wage premia for each skill category. Section 3.4.3 estimates employment by skill and industry and then calibrates results to match SAM wage income control totals. Section 3.5 describes the data of skill-disaggregated SAM.

Table 3.2.1: Skill disaggregation of labour incomes - matrix overview

Variable	Description	Units	Product of / source
$V_{1\times104}$	Labour costs of each industry. In £m.	104 industries	SAM/IO
$W_{104\times104}$	Aggregation matrix. Elements are inverse of corresponding column total from V matrix. In £m.	Diagonal matrix	V
$X_{50\times104}$	Labour costs of each industry (V) disaggregated by 50 skill categories. In £m.	50 skills, 104 industries	$D * W$
Employment (see Section 3.4.1)			
$U_{1\times104}$	FTE employment for each industry.	104 industries	SAM/IO
$T_{104\times104}$	Aggregation matrix. Elements are the inverse of corresponding column totals from U matrix.	Diagonal matrix	U
$S_{50\times104}$	Share of employment by skill category and sector. In %.	50 skills, 104 industries	LFS (UK Data Service, 2013)
$R_{50\times104}$	FTE employment by skill category and sector.	50 skills, 104 industries	$S * T$
$Q_{50\times1}$	FTE employment by skill category.	50 skills	R
$P_{50\times50}$	Aggregation matrix. Elements are the inverse of corresponding row totals from Q matrix.	Diagonal matrix	Q
Wage premia (see Section 3.4.2)			
$O_{1\times9}$	Average wages by major occupation group. In £.	9 occupations	ASHE (ONS, 2009, 2010)
$N_{9\times9}$	Aggregation matrix. Elements are the inverse of corresponding column totals from O matrix. In £.	Diagonal matrix	O
$M_{50\times9}$	Share of employment by skill category and occupation. In %.	50 skills, 9 occupations	LFS (UK Data Service, 2013)
$L_{50\times9}$	FTE employment by skill category and occupation.	50 skills, 9 occupations	$P * M$
$K_{50\times9}$	Incomes by skill and occupation. In £.	50 skills, 9 occupations	$L * N$
$J_{50\times1}$	Total incomes by skill category. In £.	50 skills	K
$H_{50\times1}$	Average income by skill category. In £.	50 skills	$J \div Q$
$G_{50\times50}$	Aggregation matrix. Elements are the inverse of corresponding row totals from H matrix. In £.	Diagonal matrix	H
Labour incomes (see Section 3.4.3)			
$F_{50\times104}$	Estimate of income by skill and industry. In £.	50 skills, 104 industries	$G * R$
$E_{104\times104}$	Aggregation matrix. Elements are inverse of corresponding column totals from F matrix.	Diagonal matrix	F
$D_{50\times104}$	Share of labour incomes for each skill category and industry. In %.	50 skills, 104 industries	$F * E$
$X_{50\times104}$	Labour incomes of each industry disaggregated by 50 skill categories. In £m.	50 skills, 104 industries	$D * W$

3.3 Data

This section outlines the data used in the disaggregation of the labour income entries in the SAM. As detailed previously, the SAM, and the Input-Output (IO) tables contained within, give control totals for several variables necessary for the skill disaggregation. Available are: FTE employment in each industry, U, and thereby also total FTE employment, and the aggregate FTE total wage by industry, V. FTE employment numbers per industry are backed out from the IO tables following the approach set out by the Scottish Government (2011) in their IO Methodology Guide.

FTE employment numbers by industry, Ω_j, are identified by dividing the Type II Employment effect, $\sum_i \omega_i \Pi_{ij}$, by the Type II Employment multiplier, $\sum_i \omega_i \Pi_{ij}/\omega_j$, and multiplying the result by the Gross Output per Industry Λ_i, where Π is the Leontief Inverse Matrix.

$$\Omega_j = \frac{\sum_i \omega_i \Pi_{ij}}{\sum_i \omega_i \Pi_{ij}/\omega_j} \cdot \Lambda_i \tag{3.4}$$

The employment effect shows the direct plus indirect and induced impact upon employment throughout the Scottish economy arising from a change in final demand for industry $j's$ output. The employment multiplier is the ratio of direct plus indirect plus induced employment changes to the direct employment change, where ω is the equal to FTE per £ of total output for each industry. This gives the number of FTE employees in each of the 104 industries, U, in a 1×104 matrix.

$$U = \begin{bmatrix} u_{1,1} & \cdots & u_{1,104} \end{bmatrix} \tag{3.5}$$

Sources external to the SAM are used to estimate the remaining unknown variables: (1) FTE employment by skill category for each of the industries, and (2) wage premia by skill category. These variables are identified by using several data-sets which are made consistent with SAM control totals. Data from the Labour Force Survey (LFS) as given in UK Data Service (2013) and the ONS (2011a) are used to identify skill shares. The Annual Survey of Hours and Earnings (ASHE) as provided by the ONS (2009, 2010) is used to identify wage premia for each skill category. The LFS and the ASHE are selected as being the most relevant primary data source available for Scotland.

The annual LFS sample for Scotland (including the boost from the Annual Population Survey) is approximately 4000 households per quarter (ONS, 2011a). The LFS is a survey of households living at private addresses (including NHS accommodation and students in halls of residence) in the UK. The LFS excludes people living in communal establishments, for example conscripts, people in prison, military barracks, elderly people staying in rest home, regardless of the length of stay away from houses. Students living in halls of residence or boarding schools are covered by the LFS if their parents are resident in Great Britain, as information about them is collected by proxy at their parents' address (UK Data Service, 2013).

The LFS is based on an unclustered sample of addresses for the whole of Great Britain. For this approach improves the precision of estimates particularly when making regional analyses. In the case of Scotland a very small bias arises from partial coverage of the population north of the Caledonian Canal. This area contains about five percent of the total population of Scotland. A single stage sample of addresses with a random start and constant interval is drawn from the Postcode Address File (PAF) for Great Britain and south of the Scottish Caledonian Canal. The PAF is sorted by postcode so the sample is effectively stratified geographically (UK Data Service, 2013).

The LFS for the two year period 2009:Q1 to 2010:Q4 is used (UK Data Service, 2013) to disaggregate the 2009 SAM for Scotland by skill. These two years are selected for a number reasons. First, using data for only 2009 provides insufficient observations per skill and industry, requiring the use of an additional year. The two year period also reflects the restriction that the SAM shows economic activity for one specific year so that data sources must be of close time proximity to the 2009 base year of the SAM.

Second, due to changes in the Standard Industrial Classification (SIC) codes it is 'not possible' to use data before 2009. That is, a crucial variable in the 2008 LFS dataset that identifies employment by industry is at SIC92 4 digit which makes it impossible to be accurately mapped to SIC07 4 digit. The SIC07 4 digit industry classification is the standard used in the 2009 Scottish Government (2013a) IO tables and thereby also the 2009 SAM. Last, using a 'pool' of data covering several years is also consistent with methods set out for constructing a SAM (e.g. Keuning & de Ruuter, 1988).

The ASHE (ONS, 2009, 2010) is based on a one percent sample of employee jobs taken from HM Revenue and Customs PAYE records and does not cover self-employed nor does it cover employees not paid during the reference period. Full-time work within the ASHE is defined as employees working more than 30 paid hours per week or 25 hours or more for the teaching professions. The earnings information presented relates to gross pay before tax, National Insurance or other deductions, and excludes payments in kind. The results are restricted to earnings relating to the survey pay period and so exclude payments of arrears from another period made during the survey period; any payments due as a result of a pay settlement but not yet paid at the time of the survey are also excluded.

Legitimate concerns regarding statistical reliability of the two surveys can be raised given the relatively small Scottish sample. Yet, compared to other labour market related surveys, the LFS and the ASHE contain the largest sample for Scotland and, more importantly, the largest sample of data relevant for the skill disaggregation. Selecting the LFS and the ASHE as the main source for the skill disaggregation is also consistent with methods set out by other researchers (e.g. Stuttard & Frogner, 2003a/2003b and McNicoll et al., 2001).

It must be noted that whenever LFS and ASHE data are used that these are in FTE. That is, both full- and part-time observations are extracted from the surveys and converted into FTE's. These are computed by multiplying the full-time observations by 1.0 and the part-time observations by 0.5 and then summing them up. For consistency, this ratio is always applied when calculating FTE's. From here on employment and wage data are in FTEs unless indicated otherwise.

Table 3.3.1 details the 50 skill categories that are recorded in the LFS and by which the labour entries in the SAM are disaggregated. Even though the sample of the LFS is increased by using two years of pooled data, the coverage of skills in individual industries, at full skill (50) and industry (104) disaggregation, is very low in both absolute and in percentage terms. It must be stressed, however, that this problem is reduced when skills are aggregated up to, for example, Scottish Credit and Qualifications Framework (SCQF) skill levels and the number of industries aggregated to 25.

Importantly, depending on the needs of the researcher, the 50 skill categories can be mapped to the National Qualifications Framework (NQF), International Standard Classification of Education (ISCED), SCQF levels or, as in this thesis, to a binary distinction, skilled and unskilled. Table 3.3.1 gives the concordance matrix between the 50 skill categories given in the LFS and SCQF, NQF, and skilled/unskilled (The Data Service, 2013; ONS, 2009).

In the examples to follow, the data are aggregated up to skilled & unskilled at 25 industry level as done within the skill-disaggregated AMOS CGE model (see Chapter 6). The skilled labour force is defined here as the sum of SCQF levels 6 to 12; and the unskilled is defined as the sum of SCQF levels 5 and below (see Table 3.3.1 for details). The aggregation of the skill categories to skilled & unskilled is also in keeping with the SAM and CGE literature (e.g. Stuttard & Frogner, 2003a/2003b and Boeters & Savard, 2011) where the conventional cut-off point is analogous to completed degree.

Table 3.3.1: List of skill categories and concordance matrix between skill categorises and SCQF, NQF, Skilled & Unskilled

SCQF	Level 12-11	Level 10-7	Level 6	Level 5	Below 5	Other
NQF	Level 7-8	Level 4-6	Level 3	Level 2	Below 2	Other
	Skilled	Skilled	Skilled	Unskilled	Unskilled	Unskilled
1. Higher degree	1	-	-	-	-	-
2. NVQ level 5	1	-	-	-	-	-
3. First/Foundation degree	-	1	-	-	-	-
4. Other degree	-	1	-	-	-	-
5. NVQ level 4	-	1	-	-	-	-
6. Diploma in higher educ	-	1	-	-	-	-
7. HNC,HND,BTEC etc higher	-	1	-	-	-	-
8. Teaching, further educ	-	1	-	-	-	-
9. Teaching, secondary educ	-	1	-	-	-	-
10. Teaching, primary educ	-	1	-	-	-	-
11. Teaching foundation stage	-	1	-	-	-	-
12. Teaching, level not stated	-	1	-	-	-	-
13. Nursing etc	-	1	-	-	-	-
14. RSA higher diploma	-	1	-	-	-	-
15. Other higher educ below degree	-	1	-	-	-	-
16. NVQ level 3	-	-	1	-	-	-
17. Advanced Welsh Bac'te	-	-	1	-	-	-
18. International Bac'te	-	-	1	-	-	-
19. GNVQ/GSVQ advanced	-	-	1	-	-	-
20. A level or equivalent	-	-	0.6	0.3	0.1	-
21. RSA advanced diploma	-	-	1	-	-	-
22. OND,ONC,BTEC etc, national	-	-	1	-	-	-
23. City & Guilds advanced craft/part 1	-	-	1	-	-	-
24. Scottish CSYS	-	-	0.67	0.33	-	-
25. SCE Higher or equivalent	-	-	0.6	0.3	0.1	-
26. Access qualifications	-	-	1	-	-	-
27. A,S level or equivalent	-	-	0.6	0.3	0.1	-
28. Trade apprenticeship	-	-	0.5	0.5	-	-
29. NVQ level 2 or equivalent	-	-	-	1	-	-
30. Intermediate Welsh Bac'te	-	-	-	1	-	-
31. GNVQ/GSVQ intermediate	-	-	-	1	-	-
32. RSA diploma	-	-	-	1	-	-
33. City & Guilds craft/part 2	-	-	-	1	-	-
34. BTEC,SCOTVEC first/general diploma etc	-	-	-	1	-	-
35. O level, GCSE grade A-C or equivalent	-	-	-	1	-	-
36. NVQ level 1 or equivalent	-	-	-	-	1	-
37. Foundation Welsh Bac'te	-	-	-	-	1	-
38. GNVQ,GSVQ foundation level	-	-	-	-	1	-
39. CSE below grade1,GCSE below grade c	-	-	-	-	1	-
40. BTEC,SCOTVEC first/general certificate	-	-	-	-	1	-
41. SCOTVEC modules	-	-	-	-	1	-
42. RSA other	-	-	-	-	1	-
43. City & Guilds Foundation/Part 1	-	-	-	-	1	-
44. YT,YTP certificate	-	-	-	-	1	-
45. Key Skills Qualif	-	-	-	-	1	-
46. Basic Skills Qualif	-	-	-	-	1	-
47. Entry Level qualif	-	-	-	-	1	-
48. Other qualif	-	-	0.1	0.35	0.55	-
49. No qualif	-	-	-	-	-	1
50. Don't know	-	-	-	-	-	1

3.4 Disaggregating labour incomes

Section 3.2 outlined the method of the skill disaggregation in broad terms. This section details the steps required to disaggregate the labour income entries in the SAM by different skill categories. Sections 3.4.1 and 3.4.2 disaggregate the employment figures by skill categories, and estimate the wage premia for each of the skill categories respectively. Section 3.4.3 estimates labour income entries by skill and industry and then matches these to the control totals given in the SAM. To recall, Table 3.2.1 provides references for each of the matrices/vectors and the various computations.

3.4.1 Employment

The first step in disaggregating labour incomes by skill is to identify the number of workers in each skill category and industry. As detailed in Section 3.3, the total number of workers in each of the 104 industries is given as U. This is the control total for employment by industry that is to be disaggregated by skill. The T matrix is a diagonal matrix, where the elements are the inverse of corresponding column totals from U.

$$U = \begin{bmatrix} u_{1,1} & \cdots & u_{1,104} \end{bmatrix} \tag{3.6}$$

$$T = \begin{bmatrix} t_{1,1} & \cdots & t_{1,104} \\ \vdots & \ddots & \vdots \\ t_{104,1} & \cdots & t_{104,104} \end{bmatrix} \tag{3.7}$$

Data from the LFS (UK Data Service, 2013) give the percentage share of workers of each skill category in each industry, S, where the rows identify the 50 skill categories and the column identify the 104 industries. The sum of each column of S is equal to 1.00.

$$S = \begin{bmatrix} s_{1,1} & \cdots & s_{1,104} \\ \vdots & \ddots & \vdots \\ s_{50,1} & \cdots & s_{50,104} \end{bmatrix} \tag{3.8}$$

$$\sum_{i=1}^{50} s_{i,j} = 1.00 \qquad for\ each:\ _i \tag{3.9}$$

Multiplying the percentage share of workers of each skill category in each industry, S, with the total number of workers in each of the 104 industries, T, gives:

$$R = \begin{bmatrix} r_{1,1} & \cdots & r_{1,104} \\ \vdots & \ddots & \vdots \\ r_{50,1} & \cdots & r_{50,104} \end{bmatrix} \tag{3.10}$$

where R is a 50×104 matrix that identifies the number of workers in each skill category and industry. Total R is now total T, and employment per industry in R matches the totals in each industry in T, so that the employment control totals given in the SAM are preserved. The sum of each row of R gives the total number of employment by skill category, Q. The P matrix is a diagonal matrix, where the elements are the inverse of corresponding row totals from Q.

$$Q = \begin{bmatrix} q_{1,1} \\ \vdots \\ q_{50,1} \end{bmatrix} \tag{3.11}$$

$$P = \begin{bmatrix} p_{1,1} & \cdots & p_{1,50} \\ \vdots & \ddots & \vdots \\ p_{50,1} & \cdots & p_{50,50} \end{bmatrix} \tag{3.12}$$

Table 3.4.1 summarises total employment for the 25 major industries contained in the SAM. As discussed previously, the 50 skill categories are aggregated up to skilled & unskilled (see Table 3.3.1 for a detailed concordance matrix). Table 3.4.1 shows that, for example, there are 1,302,392 skilled (58%) workers and 927,540 unskilled workers and 2,229,931 workers in Scotland in total. These totals are broken down by industry. For example, sector 1, Agriculture, forestry & fishing employs 51,467 workers in total, of which 39% are skilled and 61% are unskilled. These results are discussed in more detail in Section 3.5.

Table 3.4.1: FTE employment by industry broken down by skill

	Skilled	%	Unskilled	%	Total
1. Agriculture, forestry and fishing	19,997	39	31,470	61	51,467
2. Mining	16,087	65	8,676	35	24,763
3. Food, drink and tobacco	19,154	42	26,925	58	46,079
4. Textile, leather, wood and paper	13,340	44	17,157	56	30,497
5. Chemicals	6,785	70	2,867	30	9,652
6. Rubber, plastic, cement and iron	5,840	37	10,140	63	15,979
7. Computer, electrical and transport eq.	55,746	59	38,005	41	93,751
8. Electricity, gas and water	18,427	56	14,603	44	33,030
9. Construction	93,815	55	76,712	45	170,528
10. Wholesale and retail	130,764	42	177,172	58	307,936
11. Land transport	18,999	37	32,644	63	51,642
12. Water transport	1,559	61	1,009	39	2,569
13. Air Transport	2,024	51	1,961	49	3,985
14. Post and support transport services	19,383	42	26,800	58	46,183
15. Accommodation	22,988	49	24,257	51	47,245
16. Food & beverage services	38,512	42	52,831	58	91,343
17. Telecommunication	24,415	69	11,224	31	35,639
18. Computer and information services	24,567	80	6,198	20	30,765
19. Financial services	55,961	65	30,327	35	86,289
20. Real estate	18,003	69	7,989	31	25,992
21. Professional services	193,556	63	111,662	37	305,218
22. Research and development	7,218	90	813	10	8,030
23. Public administration	434,886	71	175,769	29	610,655
24. Recreational services	30,634	57	23,285	43	53,918
25. Other services	29,732	64	17,042	36	46,774
Total	1,302,392	58	927,540	42	2,229,931

Note: see Appendix 3A for full set of results.

3.4.2 Wage premia

The core of the skill disaggregation is the derivation of a representative wage for each of the skill categories. Several different ways to approach this task were considered. The first was to use published figures on income differentials per skill. This, however, is not practicable as income differentials are only available for small sets of skills and industries and cover only a very small sample at UK level. The second was to extract hourly earnings from the LFS. But this is not considered to be feasible due to resource limitations imposed by the high level of skill and industry disaggregation required, and the rather small sample of Scottish data. Thus, a third method is developed and applied using official income figures per Standard Occupational Classification (SOC2010), henceforth referred to as ‘occupation’, and corresponding skill and occupation shares.

This method requires the use of several datasets. First, average pay by occupation is identified. This is done solely by using readily available ONS (2011a) data. Second, employment per occupation is obtained. This is done by extracting skill shares from the LFS (UK Data Service, 2013), and using these shares to disaggregate employment per occupation control totals given in Section 3.4.1. Last, employment per occupation, skill is multiplied by average pay per occupation. The resulting total income per skill is then divided by the employment per skill to obtain the average annual pay for each skill category. All necessary steps are detailed below and the results are summarised in Tables 3.4.2 and 3.4.3.

Data from the ASHE (ONS, 2009, 2010) are used to identify the mean annual pay for each of the 9 main occupation groups (see Table 3.4.2). It must be noted that 2009 ASHE data lack mean (and median) entries for 'Managers and Senior Officials' and 'Skilled Trades Occupations' for male part-time, and 'Skilled Trades Occupations' for female full-time. Thus, 2010 equivalent figures for these entries are used (ONS, 2010). O gives average wages across nine occupation groups. Transforming O into an diagonal matrix gives N:

$$O = \begin{bmatrix} o_{1,1} & \cdots & o_{1,9} \end{bmatrix} \tag{3.13}$$

$$N = \begin{bmatrix} n_{1,1} & \cdots & n_{1,9} \\ \vdots & \ddots & \vdots \\ n_{9,1} & \cdots & n_{9,9} \end{bmatrix} \tag{3.14}$$

The share of employees per occupation and skill category are given in the LFS (UK Data Service, 2013). M is a 50×9 diagonal matrix that gives the share of skill categories across nine occupation groups. Each row total of M is equal to 1.00 (see Appendix 3B for results given in M).

$$M = \begin{bmatrix} m_{1,1} & \cdots & m_{1,9} \\ \vdots & \ddots & \vdots \\ m_{50,1} & \cdots & m_{50,9} \end{bmatrix} \tag{3.15}$$

Multiplying the number of workers in each skill category, P, with the share of workers in each occupation, M, gives:

$$L = \begin{bmatrix} l_{1,1} & \cdots & l_{1,9} \\ \vdots & \ddots & \vdots \\ l_{50,1} & \cdots & l_{50,9} \end{bmatrix} \tag{3.16}$$

where L is a 50×9 matrix that gives employment per skill and occupation (see Table 3.4.2). Multiplying employment per skill and occupation, L, with the wage per occupation, N, gives:

$$K = \begin{bmatrix} k_{1,1} & \cdots & k_{1,9} \\ \vdots & \ddots & \vdots \\ k_{50,1} & \cdots & k_{50,9} \end{bmatrix} \tag{3.17}$$

where K is a 50×9 matrix that identifies the aggregate annual incomes by skill category and occupation. The sum of each row of K gives:

$$J = \begin{bmatrix} j_{1,1} \\ \vdots \\ j_{50,1} \end{bmatrix} \tag{3.18}$$

where each row of J identifies the aggregate annual incomes for each skill category. Each row of J is divided by the corresponding row of Q. That is, total income by skill is divided by the number of workers in that skill category. This gives the average income for each skill category, H, and G in diagonal matrix form:

$$H = \begin{bmatrix} h_{1,1} \\ \vdots \\ h_{50,1} \end{bmatrix} \tag{3.19}$$

$$G = \begin{bmatrix} g_{1,1} & \cdots & g_{1,50} \\ \vdots & \ddots & \vdots \\ g_{50,1} & \cdots & g_{50,50} \end{bmatrix} \tag{3.20}$$

Table 3.4.2 summarises the data in these steps. The first column, average wage, corresponds to the O (and N) matrix (ONS, 2009, 2010). The second column, FTE employment, corresponds to the L matrix. Note, employment totals per skill in Table 3.4.2 match the totals detailed in Table 3.4.1. The wage incomes column corresponds to the K matrix and is the result of multiplying the average wage in each occupation group with the number workers employed in each occupation group and skill category.

The estimated total income per skill category, £48.49m for the skilled and £26.90m, are divided by the corresponding FTE employment total in each skill category, 1,303,392 and 927,540, respectively. This gives the average wage for each skill category, £37 thousand for the skilled and £29 thousand for the unskilled. This process corresponds to the matrices J and H.

Table 3.4.2: Average wage, FTE employment, and estimated wage incomes per occupation and skill

	Average wage (£)	FTE employment		Wage income (£m)	
		Skilled	Unskilled	Skilled	Unskilled
1. Managers and Senior Officials	54,123	230,089	103,278	12.45	5.59
2. Professional occupations	48,645	264,040	22,003	12.84	1.07
3. Associate Professional and Technical	36,808	255,355	73,525	9.40	2.71
4. Administrative and Secretarial	25,921	127,227	122,588	3.30	3.18
5. Skilled Trades Occupations	28,867	142,147	131,096	4.10	3.78
6. Personal Service Occupations	23,874	101,078	88,398	2.41	2.11
7. Sales and Customer Service Occupations	20,224	61,563	92,511	1.25	1.87
8. Process, Plant and Machine Operatives	25,210	53,730	115,914	1.35	2.92
9. Elementary Occupations	20,566	67,162	178,228	1.38	3.67
Total		1,302,392	927,540	48.49	26.90

Average wage per SOC2010 occupation adapted from: ONS (2009, 2010)

Table 3.4.3 gives the estimated average Scottish FTE annual wage for each of the 50 skill categories, as given in the H (and G) matrix, and corresponding employment figures, as given in the Q (and P) matrix. Skill categories that are not covered within the Scottish sample of the LFS, such as 'Welsh Baccalaureate Qualification', are left blank as 'missing values'.

The estimates in Table 3.4.3 show that, on average, a worker in Scotland with a 'Higher degree' earns £45,950 per annum, and that there are 158,149 workers in Scotland who hold that degree. Similarly, on average, a FTE worker in Scotland with a 'no qualification' earns £28,368, and there are 162,217 FTE workers without qualification.

Table 3.4.3: Average wages and employment in each skill category

	Average FTE wages (£)	FTE Employment		Average FTE wages (£)	FTE Employment
1. Higher degree	45,950	158,149	26. Access qualifications	23,723	683
2. NVQ level 5	37,473	4,693	27. A,S level or equivalent	21,940	467
3. First/Foundation degree	42,848	337,937	28. Trade apprenticeship	35,610	142,126
4. Other degree	43,625	33,655	29. NVQ level 2 or equivalent	25,873	53,627
5. NVQ level 4	36,769	13,569	30. Intermediate Welsh Bac'te	-	-
6. Diploma in higher educ	40,995	30,384	31. GNVQ/GSVQ intermediate	22,508	1,487
7. HNC,HND,BTEC etc higher	35,533	230,007	32. RSA diploma	29,119	503
8. Teaching, further educ	43,953	2,272	33. City & Guilds craft/part 2	34,918	6,432
9. Teaching, secondary educ	43,190	1,086	34. BTEC,SCOTVEC first/general diploma etc	27,148	2,419
10. Teaching, primary educ	44,722	3,843	35. O level, GCSE grade A-C or equivalent	29,984	295,085
11. Teaching foundation stage	27,044	48	36. NVQ level 1 or equivalent	25,065	5,430
12. Teaching, level not stated	39,084	2,062	37. Foundation Welsh Bac'te	-	-
13. Nursing etc	33,047	38,430	38. GNVQ,GSVQ foundation level	-	-
14. RSA higher diploma	22,552	201	39. CSE below grade1,GCSE below grade c	27,349	22,205
15. Other higher educ below degree	33,862	8,122	40. BTEC,SCOTVEC first/general certificate	24,684	1,041
16. NVQ level 3	30,414	77,957	41. SCOTVEC modules	31,335	4,267
17. Advanced Welsh Bac'te	-	-	42. RSA other	27,157	2,969
18. International Bac'te	30,505	1,840	43. City & Guilds Foundation/Part 1	30,832	1,691
19. GNVQ/GSVQ advanced	36,455	1,847	44. YT,YTP certificate	27,617	771
20. A level or equivalent	32,927	34,300	45. Key Skills Qualif	31,560	3,685
21. RSA advanced diploma	28,897	1,025	46. Basic Skills Qualif	26,016	2,436
22. OND,ONC,BTEC etc, national	32,588	37,090	47. Entry Level qualif	38,719	1,140
23. City & Guilds advanced craft/part 1	37,526	70,012	48. Other qualif	30,208	163,585
24. Scottish CSYS	39,290	3,778	49. No qualif	28,386	182,217
25. SCE Higher or equivalent	32,735	227,777	50. Don't know	31,173	15,580

3.4.3 Estimating labour incomes

This section estimates labour incomes by skill category and industry. This is done by multiplying the number of employed in each skill category and industry (see Section 3.4.1) with the mean average gross pay of each skill category (see Section 3.4.2). This gives an estimate of labour incomes by skill category and industry. These estimates are expected to over/under estimate SAM labour income control totals and are thus calibrated to match the SAM.

The first step is to multiply employment per skill and industry, G, by the mean average gross pay per skill, R, that were derived in Sections 3.4.1 and 3.4.2 respectively. This yields estimates for total wages per industry and skill category, F.

$$F = \begin{bmatrix} f_{1,1} & \cdots & f_{1,104} \\ \vdots & \ddots & \vdots \\ f_{50,1} & \cdots & f_{50,104} \end{bmatrix} \tag{3.21}$$

Table 3.4.4 details the sectoral labour income estimates (as given in F), the SAM labour income entries (as given in T), and the difference between the estimate and the SAM. Total labour income is estimated to be £77,894m whilst actual is £63,561m. The estimate is thereby 122% of the SAM labour income control total.

Over and under estimation can occur for several reasons: First, a weakness of using the bottom-up approach is that the results are heavily dependent on the classification of industry in the LFS and the ASHE. The classification in these surveys is based on self reporting by survey respondents which can be a source of error. Respondents may report on the work that is carried out in their area rather than that done in the firm as a whole (Stuttard & Frogner, 2003a). In contrast, SAM/IO income figures are based on classification of firms.

Second, IO labour income figures could contain 'errors' that were introduced in the final rebalancing of the IO table through the RAS procedure. It is, however, not expected that this possible 'error' has generated significant variance of the actual to the estimate.

Third, the SAM includes some components of earnings, that are not captured in the LFS or the ASHE, such as earnings in cash and in kind. Earnings in kind include company cars, private health insurance and loans at preferred rates of interest (Stuttard & Frogner, 2003a). That is, only cash earnings are captured in the LFS and the ASHE, which is the source of the derived average wage. Researchers such as Stuttard and Frogner (2003a) estimated the labour income within the 1996 SAM for the UK and found that using the bottom-up approach led to a shortfall of £14bn (4% of the National Accounts), which they accounted to earnings in kind and tax evasion.

Given these possible sources of 'error' it is not unreasonable to manually adjust estimated Income figures to match actual SAM labour income figures whilst retaining the skill composition within each industry. This is also consistent with the approach taken by other researchers (e.g. Stuttard & Frogner, 2003a/2003b and McNicoll et al., 2001).

Table 3.4.4: Estimated labour income and difference to SAM control totals. In £m

	Estimated	SAM	Difference
1. Agriculture, forestry and fishing	1,823	368	1,454
2. Mining	943	655	288
3. Food, drink and tobacco	1,522	1,787	- 265
4. Textile, leather, wood and paper	1,036	847	188
5. Chemicals	365	501	- 137
6. Rubber, plastic, cement and iron	547	706	- 159
7. Computer, electrical and transport eq.	3,412	4,393	- 980
8. Electricity, gas and water	1,191	1,544	- 353
9. Construction	6,261	4,705	1,556
10. Wholesale and retail	10,070	6,892	3,178
11. Land transport	1,815	1,149	666
12. Water transport	94	100	- 6
13. Air Transport	149	202	- 52
14. Post and support transport services	1,611	1,481	130
15. Accommodation	1,531	809	722
16. Food & beverage services	2,907	1,419	1,487
17. Telecommunication	1,333	1,211	122
18. Computer and information services	1,298	941	358
19. Financial services	3,051	4,047	- 996
20. Real estate	898	362	536
21. Professional services	11,069	6,547	4,523
22. Research and development	327	320	7
23. Public administration	21,180	20,512	668
24. Recreational services	1,877	1,116	761
25. Other services	1,584	948	636
Total	77,894	63,561	14,333

To rebalance the estimates to match the SAM labour income control totals, the income estimate per industry is divided by the total income estimate of that industry. The result is a matrix that details the share of total income per industry and skill category. This yields the coefficients by which the SAM labour income control total is multiplied to generate the final disaggregation by skill category. This ensures that the data derived from the LFS and the ASHE are retained whilst matching SAM labour income control totals.

For this, the F matrix is pre-multiplied with the E matrix, which is a 104×104 diagonal matrix, where the elements are the inverse of the corresponding row totals from the F matrix. This matrix multiplication effectively divides each individual column entry of the F matrix by the corresponding column sum and yields the D matrix.

$$E = \begin{bmatrix} e_{1,1} & \cdots & e_{1,104} \\ \vdots & \ddots & \vdots \\ e_{104,1} & \cdots & e_{104,104} \end{bmatrix} \tag{3.22}$$

$$D = \begin{bmatrix} d_{1,1} & \cdots & d_{1,104} \\ \vdots & \ddots & \vdots \\ d_{50,1} & \cdots & d_{50,104} \end{bmatrix} \tag{3.23}$$

where D is a 50×104 matrix that identifies the skill categories in the rows and the 104 industries in the columns. Each scalar in the D matrix captures the share of labour incomes from the jth industry's to the ith skill category so that the columns of the B matrix sum up to 1.00.

Multiplying the share of labour incomes by industry and skill category, D, with the labour incomes by industry, W, gives the final matrix,

$$X = \begin{bmatrix} x_{1,1} & \cdots & x_{1,104} \\ \vdots & \ddots & \vdots \\ x_{50,1} & \cdots & x_{50,104} \end{bmatrix} \tag{3.24}$$

where X is a 50×104 matrix that identifies the labour incomes (in £m) by industry (104) for each skill category (50). The control totals of total labour income by industry, as given in the SAM, are thereby retained but disaggregated by 50 skill categories. These results are discussed in detail in Section 3.5.

3.5 Skill-disaggregated SAM

Table 3.5.1 summarises the results for employment, labour incomes, and wage rates for each skill category and for each of the 25 major industries contained in the SAM. Figures 3.5.1 to 3.5.3 summarise these results graphically by ranking the 25 industries according to employment, labour incomes, and wage rates. Average wage rates are total labour incomes by industry (the sum of the skilled + unskilled labour incomes) divided by the total number of workers (the sum of skilled + unskilled workers). Similarly, the (un)skilled wage rate is the (un)skilled labour income divided by the number of (un)skilled workers. Appendix 3A details these results at full 104 sector level.

Table 3.5.1: Sectoral employment and wage characteristics

	Labour income (£m)				FTE Employment (th)				Wage rate (£th)		
	Skilled	%	Unskilled	%	Skilled	%	Unskilled	%	Average	Skilled	Unskilled
1. Agriculture, forestry and fishing	162	44	207	56	20	39	31	61	7	8	7
2. Mining	451	69	203	31	16	65	9	35	26	28	23
3. Food, drink and tobacco	866	48	921	52	19	42	27	58	39	45	34
4. Textile, leather, wood and paper	406	48	441	52	13	44	17	56	28	30	26
5. Chemicals	371	74	131	26	7	70	3	30	52	55	46
6. Rubber, plastic, cement and iron	284	40	422	60	6	37	10	63	44	49	42
7. Computer, electrical and transport eq.	2,840	65	1,553	35	56	59	38	41	47	51	41
8. Electricity, gas and water	945	61	600	39	18	56	15	44	47	51	41
9. Construction	2,782	59	1,922	41	94	55	77	45	28	30	25
10. Wholesale and retail	3,241	47	3,651	53	131	42	177	58	22	25	21
11. Land transport	495	43	654	57	19	37	33	63	22	26	20
12. Water transport	64	64	36	36	2	61	1	39	39	41	36
13. Air Transport	112	56	90	44	2	51	2	49	51	55	46
14. Post and support transport ser.	697	47	785	53	19	42	27	58	32	36	29
15. Accommodation	442	55	367	45	23	49	24	51	17	19	15
16. Food & beverage services	665	47	755	53	39	42	53	58	16	17	14
17. Telecommunication	891	74	320	26	24	69	11	31	34	36	29
18. Computer and information ser.	797	85	144	15	25	80	6	20	31	32	23
19. Financial services	2,883	71	1,163	29	56	65	30	35	47	52	38
20. Real estate	268	74	94	26	18	69	8	31	14	15	12
21. Professional services	4,852	74	1,695	26	194	63	112	37	21	25	15
22. Research and development	297	93	23	7	7	90	1	10	40	41	28
23. Public administration	15,883	77	4,630	23	435	71	176	29	34	37	26
24. Recreational services	703	63	413	37	31	57	23	43	21	23	18
25. Other services	578	61	369	39	30	64	17	36	20	19	22
Total	41,974	66	21,587	34	1,302	58	928	42	29	32	23

Note: see Appendix 3A for full set of results.

To recall, only the skill components of these figures are estimated. The remaining data stem directly from the SAM/IO. That is, total labour incomes by industry, total employment by industry, and average wage rates are given by the SAM/IO. It must thus be stressed that the quality of the data for each skill category may thereby not only be limited by the robustness of the survey data used, but also by the quality of the data given in the SAM/IO.

Considering first labour incomes as shown in Table 3.5.1 and Figure 3.5.1 it can be seen that there are significant variations in both absolute and percentage terms across the two skill categories, and also across the 25 industries. On average 66% of total wages go to skilled, and 34% go to unskilled workers. The sector with the largest share of skilled wages is sector 22, Research & development, with 93%. In contrast, with only 40% of total wages going to skilled workers, sector 6, Rubber, plastic, cement & iron, has the smallest skilled wage share. In absolute terms the by far largest sector in terms of labour incomes is sector 23, Public administration with £20,512m (32% of total wage incomes). This is followed by sector 10, Wholesale & retail, with £6,892m. These sectors also employ a large percentage of the total workforce.

Table 3.5.1 and Figure 3.5.2 show that there is significant variation between the two skill categories in terms of employment. On average 58% of workers are skilled, and 42% are unskilled. As with labour incomes, sector 22, Research & development, has the highest share of skilled employment (90%) across the 25 sectors. This is closely followed by sector 18, Computer & information services, with 80%. Again, the sector with the smallest share of skilled workers is sector 6, Rubber, plastic, cement & iron, with 37%. The by far largest sector in terms of number of workers is sector 23, Public administration, with 610 thousand workers (27% of the total workforce). Sectors 23, Public administration, 21, Professional services, and 10, Wholesale and retail, provide a large share of skilled and unskilled employment.

Table 3.5.1 and Figure 3.5.3 show wage rates across sectors and skill categories. As noted previously, there is a large variation of average wages across sectors, as given by the SAM/IO, without taking into consideration wage premia of skill categories. The data in the SAM/IO suggest that the average wage in sector 1, Agriculture, forestry, & fishing, is £7 thousand. On average workers earn £29 thousand in annual wages, a skilled workers earns £32 thousand, and an unskilled workers earns £23 thousand. The sector with the lowest wage rate is sector 1, Agriculture, forestry, & fishing, irrespective of skill category. In contrast, the sectors with the highest wage rates are sectors 13 and 5, Air Transport and Chemicals, respectively.

Table 3.5.2 shows the aggregate 2009 Scottish SAM. The 104 industries are aggregated into Activities. The SAM shows that of the total £63,561m labour income generated, £41,974m is generated by skilled labour and £21,587m by unskilled labour. Again, it must be stressed that the skill-disaggregated SAM contains 50 skill categories (and gender classification) at full 104 industry level and can be accessed from Ross (2016b).

Figure 3.5.1: Labour incomes broken down by skill category and sector

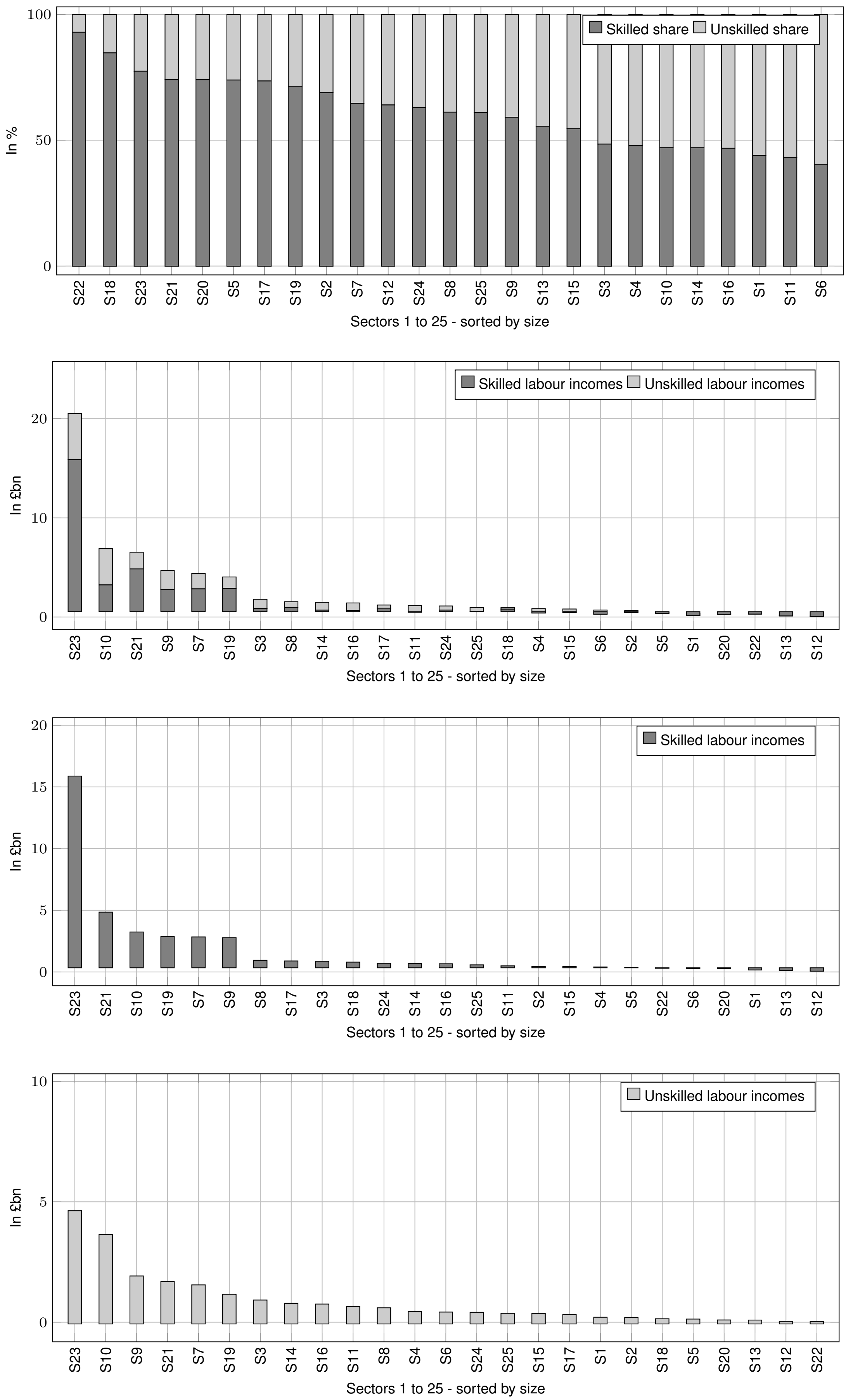


Figure 3.5.2: FTE employment broken down by skill category and sector

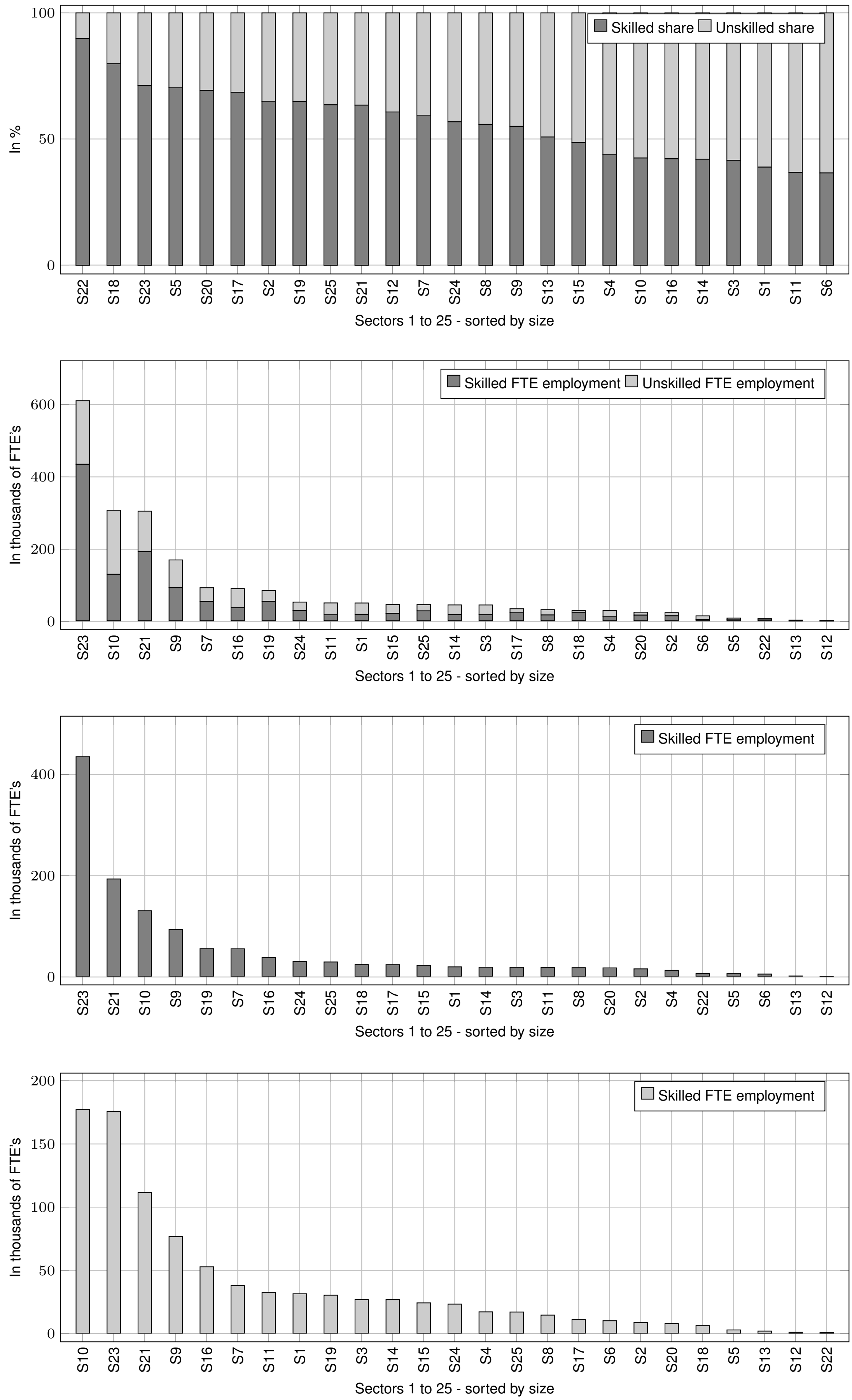
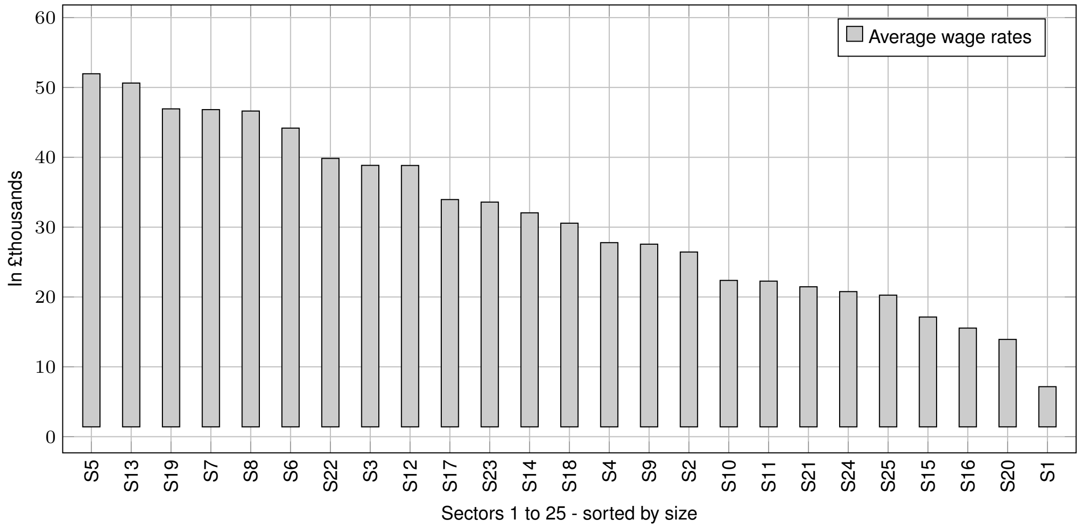
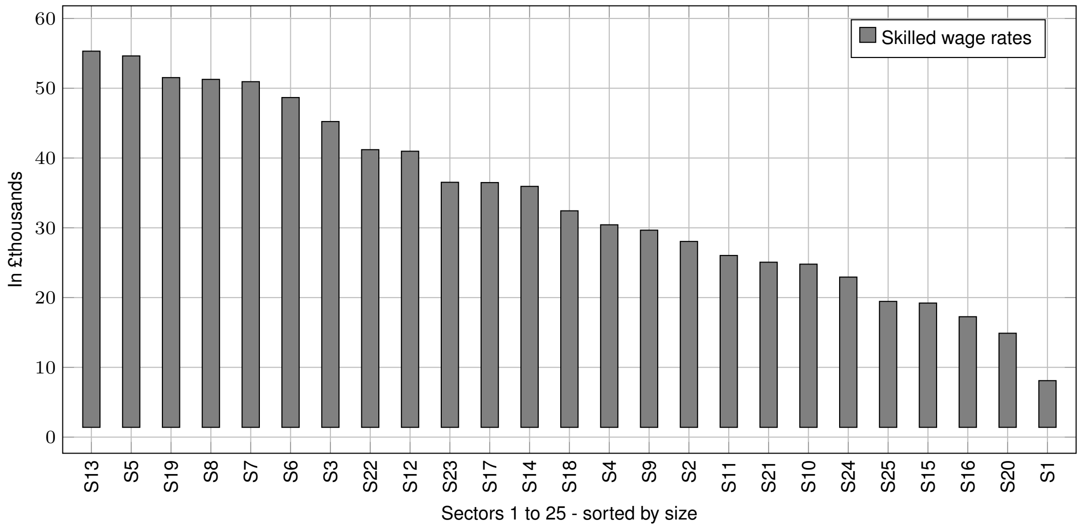


Figure 3.5.3: Wages rates broken down by skill category and industry





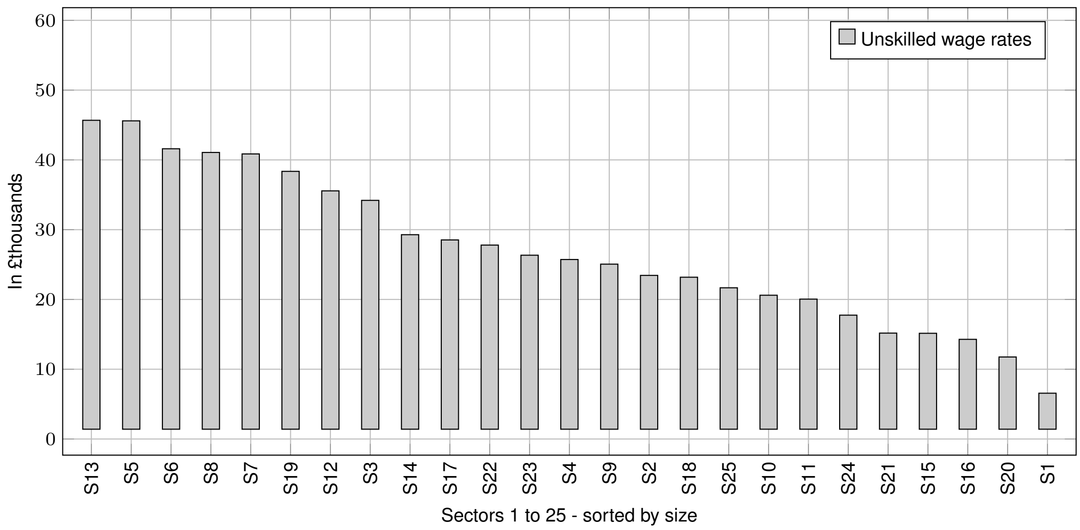


Table 3.5.2: Aggregated 2009 SAM for Scotland, 2009 basic prices (£million)

	1. Activities	2. Labour	3. Capital	4. OVA	5. Households	6. Corporations	7. Government	8. RUK	9. ROW	Total
1. Activities	63,607	-	13,981	-	49,802	-	29,486	36,879	17,166	210,920
2. Labour skilled	41,974	-	-	-	-	-	-	-	-	41,974
3. Labour unskilled	21,587	-	-	-	-	-	-	-	-	21,587
4. Capital	-	-	-	-	5,070	24,828	119	- 5,217	- 4,871	19,930
5. OVA	38,441	-	-	-	-	-	-	-	-	38,441
6. Households	-	63,561	-	5,289	-	15,103	19,835	1,853	2,237	107,877
7. Corporations	-	-	-	29,456	6,401	-	5,722	5,964	5,964	53,507
8. Government	4,779	-	1,495	3,697	27,947	5,248	13,165	20,234	129	76,694
9. RUK	30,274	-	3,358	-	14,113	3,768	8,368	4,362	2,890	67,133
10. ROW	10,258	-	1,097	-	4,544	4,560	-	3,057	161	23,676
Total	210,920	63,561	19,930	38,441	107,877	53,507	76,694	67,133	23,676	

Note: the fully disaggregated SAM can be accessed from Ross (2016b)

3.6 Summary

To summarise, the SAM shows how compensation of employees is paid by Scottish firms and also provides aggregate details on the workforce who supply the labour. The SAM has estimates for the wages and salaries by industry but it contains no information about the characteristics of the workforce who receive the income. Disaggregating the SAM by different skill categories, distinguished by highest qualification attained, sheds light on some socio-economic issues such as the return to education. It must be stressed that this information is not available from a single data source and cannot be derived from multiple sources on a consistent and coherent basis without the use of a SAM as a control total. The skill-disaggregated SAM can be used as the source for descriptive statistics, SAM and IO multiplier analysis, as done in Chapter 5, and as the main data foundation of CGE analysis, as detailed in Chapters 6 to 8.

Chapter 4

Chapter 4

Type II multiplier analysis

4.1 Introduction

Input-Output (IO) multipliers are widely used in order to simulate the impact of exogenous shocks to an economy. Most commonly demand shocks are modelled using IO Type I and Type II multipliers. Type I multipliers capture the linkage effects between industries with the household sector being treated as an exogenous expenditure sector. Type II multipliers aim at incorporating the impact on household consumption following the initial demand shock.

This chapter compares methods for calculating IO Type II multipliers. These are formulations of the standard Leontief demand-driven IO model which attempt to endogenise at least a part of household consumption. This is done essentially through a two-step process. First, a link is made between income generated in production and household income. Second, the endogenous change in household income then stimulates corresponding changes in household consumption.

There are two basic IO Type II multiplier methods that are available in the literature. The choice of the Type II method has a marked effect on the multiplier value. This lack of homogeneity in deriving the Type II multiplier is also problematic when multiplier values are compared across different economies. The discussion of these different methods also raises methodological issues such as the treatment of non-wage income. These differences across methods does not appear to be explicitly acknowledged or understood in the current literature.

In this discussion the standard IO assumptions that hold in production are assumed to be extended to the generation of household income and expenditure. These assumptions are that there are no supply constraints and that there are fixed coefficients in the linear production and consumption functions. This implies that all responses to changes in demand occur through changes in output, with no changes in prices, and that these responses are linear, with average and marginal values being identical.

This chapter sets out to contrast the two principal methods for deriving Type II multipliers and to highlight the difference in computation and interpretation between them. Section 4.2 summarises the underlying issues when endogenising household expenditure for the Type II multipliers, Section 4.3 outlines the different Type II multipliers in detail and Section 4.4 provides an introduction to Social Accounting Matrix multiplier. Section 4.5 analytically compares the Multiplier Values, 4.6 outlines the data used, 4.7 details the calculations and 4.8 analyses the results. Section 4.9 discusses the implications of the findings and concludes.

4.2 Endogenising Households in Type II Multipliers

Input-Output (IO) multipliers are widely used in order to simulate the impact of exogenous shocks to an economy, see for example Allan et al. (2007); McGregor et al. (2008); Wiedmann et al. (2007). Most commonly demand shocks are modelled using IO Type I and Type II multipliers, for example Fraser of Allander Institute (2014).

For an increase in final demand, in one sector, the Type I multiplier incorporate two distinct output effects. The direct effect is the increase in production required in that sector to satisfy the change in final demand. The Type I multiplier also incorporates the expansionary effect on the output of intermediate sectors, and how these sectors will in turn increase their demand for their own intermediate inputs, and so on. The activity that is generated by the sum of these demands for intermediate inputs is the indirect effect. The indirect effect thereby identifies the interdependencies of the various sectors to satisfy a final demand increase in one sector (Miller & Blair, 2009).

These multiplier effects occur because sectors buy / sell intermediate inputs to one another. Therefore an increase in sales in one sector increases output in others, generating a linear relationship between final demand and output.

IO analysis demonstrates that all output can be attributed to final demand, since all intermediate demand is endogenised, and that multipliers show how a change in final demand results in the change in vector of outputs. The sum of these changes gives the value of the respective output multiplier (Miller & Blair, 2009).

Type I multipliers treat household consumption as an exogenously determined final demand category. Type II multipliers aim at also capturing the impact on household consumption following the initial demand shock. This is done by endogenising household expenditure in the model. That is to say, households are now treated as an income sector.

By endogenising households, the Type II multiplier shows three levels of effect: the direct- and indirect effect (as seen in the Type I multiplier) and the induced effect. This effect shows induced changes in household consumption (Miller & Blair, 2009).

This change is due to the impact that the initial demand shock has on the income (wages and other income sources) for households and their change in spending compared to the base scenario. This approach is similar to that taken in the Keynesian multiplier where changes in output lead to changes in household income which in turn changes household expenditure (Raa, 2006).

IO tables have GDP determined in production which in turn is a primary source of household income. The Type II multiplier therefore attempts to link household consumption to income generated in production. The different methods used to endogenise household expenditure in the Type II multiplier focus on wages but use different methods to link wages to household expenditure. A secondary issue that must be acknowledged is that there are other income sources to households, such as Other Value Added (OVA).

A literature review reveals that Miller and Blair (1985) and Batey (1985) adopt alternative methods in calculating the Type II multiplier. These two methods are henceforth referred to as $Miller\&Blair$ and $Batey1$ respectively. The aim of both methods is to endogenise households by using information that is contained within the IO tables (the data used to compute the multipliers).

The Type II $Miller\&Blair$ uses the total of the "Compensation of Employee" (wages) as the denominator for the technical coefficients of the household sector. Thereby this method endogenises all of household consumption by linking it to wages. Yet, this method does not acknowledge that there are income flows (such as OVA), and thereby does not take into account expenditures driven by exogenous income. This method thereby tends to inflate multipliers (Miller & Blair, 1985).

The benefit, however, of using this method is that the data required to compute the Type II multipliers are available within the IO tables. This method would be correct in situations where there are no additional flows of income to households other than wages.

The $Batey1$ multiplier uses the total household expenditure as given in the IO table as the denominator. This method tries to counter the shortcomings of $Miller\&Blair$ by attempting to endogenise only that part of household consumption that is driven by wages which are linked to production. Yet, this method does not explicitly link transfers and other income sources generated in production to households. Thereby, the multipliers derived by this method may be 'too small' (Batey, 1985). Again, the benefit from using this method is that the data required to compute the Type II multiplier are available within the IO tables.

It is, however, anticipated that both $Miller\&Blair$ and $Batey1$ are not adequate in endogenising household expenditure flows, as IO tables, by design, do not capture all income and expenditure flows to households. $Batey1$ recognises that there are no explicit links within the IO data to capture the implied flows of funds. Moreover, the size of the multipliers is expected to vary significantly between these two models. Both methods have a weakness in appropriately endogenising factors of income and linking these to household consumption.

Given these shortcomings a third Type II model is used, which includes all known income flows to households from an external source, but compatible, to the IO tables. This method uses data from a Social Accounting Matrix (SAM) which captures all household income and expenditure flows in a explicit way. That is to say, it identifies 'all' income flows between production and domestic institutions (including households).

The SAM is an extension to the IO tables and incorporates these fully. Thereby the derived multipliers stem from comparable data. The third Type II model, henceforth referred to as $Batey2$, uses the total expenditure of the household sector from the SAM.

$Batey2$ is similar to $Batey1$ in that it does not treat all of household expenditure as endogenous but it includes income flows in addition to wages. Thereby, $Batey2$ is more inclusive in linking income to household expenditure. In order to measure which model has the closest approximation, a SAM multiplier is also computed.

The SAM multiplier offers the most inclusive study of the multipliers. As well as endogenising the household sector, the SAM multiplier also endogenises the corporate sector. The advantages of the SAM are that it fully identifies the sources of household income. It therefore has more scope in completely identifying linkages between production and income sources.

The SAM multiplier is used as a benchmark as it automatically includes the Compensation of Employees and household coefficients. The inter-industry flows and the Income from Compensation of Employees entries are the same for the IO and the SAM multiplier calculations. The variation of the multiplier values for the methods is due in part to the different totals used for endogenising the household sector. Thus the assumption is that the multipliers closest in value to the SAM multipliers are the most inclusive Type II multipliers. The detailed derivation of the different multipliers is given in the following section.

4.3 IO Multiplier

IO tables allow for the computation of various types of multipliers, including income, employment and output multipliers. The focus here is on the latter. The output multiplier is the most basic multiplier. Other multipliers, such as the employment multiplier, are built on the framework of the output multiplier. Therefore, both Type I and Type II income and employment multiplier, for example, can be analysed following the same procedure. Type II multipliers are extensions of Type I multiplier.

Section 4.3.1 outlines the derivation of the Type I multiplier. Section 4.3.2 derives the generic Type II. Section 4.3.3 details the $Miller\&Blair$ model. Building upon this, the following sections (4.3.4 and 4.3.5) outline $Batey1$ and $Batey2$.

4.3.1 Type I

The Type I multiplier quantifies the 'knock-on' effects throughout the economy of a change in final demand. It incorporates the direct and the indirect effect associated with the production for final demand (Miller & Blair, 2009). The data needed for the computation of Type I multiplier are the inter-industry flows documented in the IO tables, the relevant column totals as well as the "Total Output" for each industry. The derivation of the Type I multiplier is outlined below. A more detailed description of the Type I multiplier is presented in Appendix 4A. The Type I multiplier is the framework on which all other IO multipliers, including the Type II output multiplier, are based.

The Type I, as well as, the Type II multiplier in section 4.3.2 and the SAM multiplier in section 4.4 are based on Leontief production functions (Miller & Blair, 2009). An underlying assumption here is that quantities and thus technical input coefficients are fixed.

Practically this translates into assuming fixed prices for multipliers derived from the IO framework. That is prices for intermediate and final goods as well as the proportions of inputs needed for production remain constant and do not change following an exogenous shock to the IO or SAM system. This implies that only outputs of production factors adjust to clear markets whilst prices remain fixed. Furthermore the supply of non-produced inputs is assumed to be completely elastic at the existing price.

All IO multipliers are based on the Leontief Inverse (Leontief, 1986). Equation 4.1 details the first step in its derivation for an economy with n production sectors. The column totals of which are the output multiplier for the respective industry. The A-matrix is a $n \times n$-matrix of the technical coefficients, derived by dividing each sector column entry by its relevant column total. The x is a $n \times 1$-matrix of the total output of each sector i. f is a $n \times 1$-matrix and this is the Final Demand total of each sector, respectively.

$$Ax + f = x \tag{4.1}$$

Equation 4.2 shows the intermediate step in order to derive the equation for the total output of each sector x. Subtracting Ax from both sides of 4.1 gives

$$f = [I - A]x \tag{4.2}$$

Pre-multiplying both sides of 4.2 by $[I-A]^{-1}$ produces the familiar:

$$[I-A]^{-1}f = x \tag{4.3}$$

The total output of each sector x is given by Equation 4.3, which also shows the Leontief Inverse explicitly, $[I-A]^{-1}$. Equation 4.3 means that a unit increase in final demand for output i will generate increases in output in the jth industry that can be found as the jth element of the ith column of the $[I-A]^{-1}$. Summing the elements of column j gives the Type I multiplier for sector j, M_j^I. This is the total output across all sectors associated with a unit increase in exogenous demand for the output of sector j. If there are n sectors it is given as:

$$M_j^I = \sum_{i=1}^{n} a_{i,j} \tag{4.4}$$

Note that equation 4.3 can be interpreted as an accounting identity, in that any initial set of IO accounts can be manipulated in this way so that the actual vector of outputs is attributed to actual final demand. Imposing all the relevant assumptions results in equation 4.3 being interpreted as a model in which changes in final demand will drive, in a linear and deterministic manner, total output.

4.3.2 Type II Output Multiplier

The Type II output multiplier extends the Type I output multiplier by linking household consumption to income generated in production. In the Type I model, household consumption demand is included in (exogenous) final demand.

Type II multipliers seek to endogenise some or all of the household consumption. As noted earlier, this should be in principle linked to all income that is generated in production. In practice both Type II IO approaches link household consumption to wage income.

This task presents two central problems, both relating to the limited information available in the IO accounts. The first is that it is not possible to track fully all the income that is generated in production which goes, either directly or indirectly, to households. The second is that with the data given in the IO accounts, accurate household coefficients cannot be calculated.

Type II multipliers incorporate the induced changes in household consumption whilst retaining the direct and indirect effects, as outlined for the Type I multiplier (Miller & Blair, 2009). This induced change is a result of the impact of the demand shock on household income (both wages and other income sources) and thus their (induced) change in spending compared to the base scenario. Note that it is consistent with Keynesian multiplier analysis, which is driven solely by consumption demand (Raa, 2006).

To begin, although household income should be linked to all factor income that is generated in production, the conventional IO Type II approaches tie endogenous household consumption solely to wage income. The total wages, W, generated in production are straightforward to calculate. They are given as:

$$W = wx \tag{4.5}$$

In equation 4.5 w is the $1 \times n$ vector of wage coefficients, where the ith element is the wage payment in sector i divided by the total output of that sector. In the Type II multiplier, labour demand is therefore generated in the same way as the demand for any other intermediate input.

The key aspect of the Type II multiplier is that the household consumption demand vector given in the IO accounts, c, is divided into two $n \times 1$ vectors representing endogenous, c_N^Z, and exogenous, c_X^Z , household consumption expenditures. In principle, endogenous household consumption expenditure is expenditure funded by income generated in production, whereas exogenous household expenditure is financed through savings, transfers (pensions, welfare payments, etc.). Each of the three multiplier methods, identified by the superscript Z, does this breakdown in a different way.

But in all, these together with the matrix of technical coefficients A, do not vary across different Type II IO methods. However, the h^Z , the $n \times 1$ vector of household coefficients, does differ across the different approaches and this affects what is taken to be exogenous final demands. Therefore where equation 4.4 is taken as an accounting identity, the different methods will have different values for the level of (exogenous) final demand.

$$c = c_N^Z + c_X^Z \tag{4.6}$$

In the Type II IO context, the ith element of the c_N^Z vector is equal to the appropriate consumption coefficient, ϕ_N^Z, times what is taken to be the endogenous household income, Y_N^Z . Therefore:

$$c_N^Z = \phi_N^Z Y_N^Z \tag{4.7}$$

where ϕ_N^Z is the $n \times 1$ vector of endogenous household consumption coefficients. Combining equations 4.2, 4.5, 4.6 and 4.7 and presenting in matrix form gives:

$$B^Z j^Z + f^Z = j^Z \tag{4.8}$$

where B^Z is an $(n+2) \times (n+2)$ matrix, and where f^Z and j^Z are $n+2$ column vectors, given as

$$B^z = \begin{bmatrix} A & 0 & \phi_N^Z \\ w & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}, f^z = \begin{bmatrix} f - c_N^Z \\ 0 \\ 0 \end{bmatrix} \text{ and } j^z = \begin{bmatrix} x \\ W \\ Y_N^Z \end{bmatrix} \tag{4.9}$$

Using the familiar matrix inversion, the Type II accounting identity that corresponds to equation 4.3 in the Type I formulation:

$$[I - B^Z]^{-1} f^z = j^z \tag{4.10}$$

The matrices and vectors A, w and c do not vary across different IO Type II methods. However the ϕ_N^Z vector of endogenous household coefficients does and this will also imply variations across multiplier methods in the endogenous final household consumption demand vector, cN^Z. As with the Type I multipliers, if $\beta_{i,j}$ is the coefficient in the ith row and jth column, the multiplier value for sector j is the sum of the first n elements of the jth row. The impact on total output of a unit change in the exogenous final demand for the output of sector j is thereby given as:

$$M_j^Z = \sum_{i=1}^{n} \beta_{i,j} \tag{4.11}$$

4.3.3 Type II - Miller & Blair

Miller and Blair endogenise all household consumption. That is to say, $c_N^{MB} = c$ and total household income, Y, consists solely of wages, so that $Y = W$. The ith element of the endogenous household consumption vector, ϕ_N^{MB} , is therefore calculated as the ith element of the total domestic household consumption vector, c_i, divided by the total wage payment, W, so that:

$$\phi_N^{MB} = \left[\frac{c}{W}\right] \tag{4.12}$$

Also implicit in this approach is that when equation 4.4 is used as an accounting identity, the exogenous final demand vector includes no household consumption demand (Miller & Blair, 1985).

A major benefit of using the $Miller\&Blair$ multiplier is that the data needed for the computation of the multiplier are all contained in the IO tables. However, as discussed above, using the total of household wage income for endogenising the household sector excludes other income sources from being internalised in the model. Furthermore, this total results in an inflated multiplier.

The primary problem for the $Miller\&Blair$ method is that typically only around 60% of Scottish household income comes from wages (as detailed in Chapter 2), yet the whole of household expenditure is determined by wage income in this method. This means that typically the sum of the coefficients in the household consumption vector, c_i, is greater than one. Moreover, perhaps more critically, some elements of household consumption, such as pensions and some government transfers, are conventionally treated as being exogenous, independent of income generated in current production.

This issue is 'fudged' in the example given in Miller and Blair (1985) where the sum of household consumption is made to arbitrarily equal the total wage payment. This would be correct in a situation in which there is no flow of OVA or other transfer payments to household income. Or if other transfer payments were linked either directly or indirectly to wages.

One example that would make the $Miller\&Blair$ approach defensible would be if transfer payments to households would be proportionate to the population and the population would be proportionate to employment. This is a fairly restrictive assumption placed on the economy and one that does not correspond to any empirical evidence.

As discussed later, perhaps even more critical is the fact that there are elements of household consumption, such as pensions and some government transfers, that are not dependent on income generated in current production. Therefore it is expected that the $Miller\&Blair$ approach overestimates the true Type II multiplier values.

4.3.4 Type II - Batey 1

In the approach outlined in Batey (1985) the Type II multiplier captures the household consumption that comes through changes in wage income alone. In this case, the vector of household coefficients, $\phi_N^{B_1}$, is constructed by dividing the entries in the household consumption column in the IO accounts by total household consumption, C. This implies that the ith element of the vector of coefficients equals:

$$\phi_{N,i}^{B_1} = \left[\frac{c_i}{C}\right] \tag{4.13}$$

A benefit of the $Batey1$ multiplier approach is that is can be computed using data contained in the IO tables alone. However, a drawback to this approach is the obverse of the problem facing the $Miller\&Blair$ method. $Miller\&Blair$ is criticized above for assuming that all income to households comes from wages.

However, a criticism of $Batey1$ is that there are also sources of income generated in production, apart from wages, that make their way into household income. Income enters the household account directly from OVA and also indirectly through the elements of corporate income that are distributed to households. Therefore endogenising household expenditure by tying it strictly to the consumption directly funded by wage income will give a multiplier that is too big.

4.3.5 Type II - Batey 2

An alternative approach retains the spirit of $Batey1$ but uses external data to endogenise the household expenditure. It is labelled $Batey2$. In this case, the vector of household coefficients, $\phi_N^{B_2}$, is constructed by dividing the entries in the household consumption column in the IO accounts by a more comprehensive total for household consumption than is used for $Batey1$ (here the household total from the SAM is used), Y. This implies that the ith element of the vector of coefficients equals:

$$\phi_{N,i}^{B_2} = \left[\frac{c_i}{Y}\right] \tag{4.14}$$

Using the household total from the SAM for the derivation of this Type II multiplier addresses the lack of additional sources of household income that $Miller\&Blair$ and $Batey1$ encounter. However, there are four main problems in this case. The first is that, as with $Batey1$, the $Batey2$ method does not incorporate non-wage household income generated in current production. Secondly, it ignores all the household income not spent on domestic and imported goods and services. Therefore it does not take into account some taxes, savings and other transfers.

A third problem is that the total household income, Y, is not a figure that is given in the IO accounts. It needs to come from some other source. A fourth problem is that with this method it is not possible to determine directly the exogenous and endogenous household consumption from the IO accounts. This means that equation 4.4 cannot be used as a consistency to check to determine whether the model replicates base when applying the base value final demands. This is because the base level final demands are unknown.

In order to better endogenise household consumption a more complete set of national accounts is needed. This framework is provided by using the SAM and the more inclusive SAM multiplier instead of the IO multiplier.

4.4 SAM Multiplier

All of the Type II output multipliers discussed in section 4.3 are unable to map fully total income flowing to households. The SAM contains a more comprehensive set of accounts than the IO tables and therefore, the SAM multiplier captures all income flows to households. This includes household income stemming from the external sector. The SAM multiplier endogenises both the household and the corporate sector.

Therefore, the direct link between household income and OVA, as well as, the indirect flow of OVA through corporations to households is endogenised in the SAM multiplier. Thereby the previously discussed shortcomings of the Type II multipliers are taken into account. Traditionally, the government, capital, and external sector are treated as exogenous in the model (Round, 2003).

The IxI table used to compute the Type II multipliers is fully incorporated in the SAM. Additionally, other external data sources are used to extend the IO database to include the above-mentioned extensions in the SAM. Thereby the SAM uses a more comprehensive dataset and thus relies on additional assumptions than the Type I or Type II output multiplier.

Note that the basic assumption of fixed prices still holds. Thus, the modelled demand shock on the economy does not affect prices, but it is assumed that there is excess capacity and unemployment, which absorb the shock (Thorbecke, 2000). Therefore, any job gains or losses are treated as permanent and instantaneous.

In the SAM multiplier, total OVA, Π, is determined in exactly the same way as wages in the Type II IO:

$$\Pi = \pi x \tag{4.15}$$

where π is an $n \times 1$ vector whose ith value is the OVA in the ith sector divided by the total output of that sector. A share of value added, ρ^Y goes directly to households and a share ρ^R goes to corporations. Subsequently a share of corporate income, r^Y, is transferred to households. This means that in the SAM multiplier, corporate, R, and household income, Y, are given as:

$$R = \rho^R \Pi + T^R \tag{4.16}$$

$$Y = W + \rho^Y \Pi + r^Y R + T^Y \tag{4.17}$$

where T^R and T^Y are exogenous transfers to the corporate and household sector from the government and external sectors. Finally for household expenditure the appropriate coefficients are the $Batey2$ values. Combining equations 4.3, 4.5, 4.12, 4.13, 4.16 and 4.17 and expressing this in matrix form produces:

$$S \begin{bmatrix} x \\ v \end{bmatrix} + \begin{bmatrix} f - c \\ f_v \end{bmatrix} = \begin{bmatrix} x \\ v \end{bmatrix} \tag{4.18}$$

where the S is the $(n+4) \times (n+4)$ matrix:

$$S = \begin{vmatrix} A & 0 & 0 & \phi_N^{B_1} & 0 \\ w & 0 & 0 & 0 & 0 \\ \pi & 0 & 0 & 0 & 0 \\ 0 & 1 & \rho^Y & 0 & r^Y \\ 0 & 0 & \rho^R & 0 & 0 \end{vmatrix} \tag{4.19}$$

where f_V is the 4×1 vector of exogenous income transfers and v is the 4×1 vector of factor and institutional incomes, so that:

$$f_V = \begin{bmatrix} 0 \\ 0 \\ T^Y \\ Y^R \end{bmatrix}, v = \begin{bmatrix} W \\ \Pi \\ Y \\ R \end{bmatrix} \tag{4.20}$$

Through the standard matrix inversion:

$$[I - S]^{-1} \begin{bmatrix} f - c \\ f_V \end{bmatrix} = \begin{bmatrix} x \\ v \end{bmatrix} \tag{4.21}$$

The multiplier outlined here endogenises both the household and the corporate sector. Therefore, the direct link between household income and OVA, as well as the flow of OVA through corporations to households is endogenised in the SAM multiplier. As mentioned previously, government, capital, and external sector are traditionally treated as exogenous in the model (Round, 2003).

Again if the element in the ith row and the jth column of the SAM inverse is represented as $_{i,j}$ then the SAM multiplier value for sector j , M_j^S , is the sum of the first n elements j:

$$M_j^S = \sum_{i=1}^{n} \sigma_{i,j} \tag{4.22}$$

Thereby measuring the system-wide change in total output generated by a unit increase in exogenous final demand for the output of sector j.

Equation 4.21 identifies the characteristics of the SAM multiplier model. Expenditure in the government, capital and external accounts are wholly exogenous. Expenditures in all other accounts are endogenous. All wage and profits income generated in production go to domestic households.

Household and corporate expenditures are endogenised but in both cases there are exogenous transfers from government and the external sector, together with endogenous income indirectly from production. This means that all changes to wages and OVA generated in production, which is indirectly linked to households, are allocated to households in a way that is consistent with the standard demand-driven IO approach.

The SAM multiplier analysis is subject to the limitations imposed by the underlying IO framework, which are, inter alia, the fixed price assumption and permanent labour market adjustments, as outlined above. Furthermore, income elasticities of demand are assumed to equal 1. Thus, the impact of an increase in household income on the demand for luxury goods is understated whilst the model overstates the impact on demand for necessities (Golan et al., 2000). Nevertheless, SAM multiplier analysis overcomes the IO Type II limitations with regards to mapping household income flows comprehensively.

4.5 Analytical Comparison of Multiplier Values

If the SAM framework is accepted as the most appropriate way to endogenise household consumption in a manner consistent with the Input-Output approach, none of the standard IO Type II multiplier methods are correct. Equations 4.23 and 4.24 adjust the B^Z and S matrices shown in Equations 4.8 and 4.18 so that their structures are harmonised in order to better identify the differences.

$$\overline{B}^Z = \begin{vmatrix} A & 0 & 0 & \phi_N^{B_1} \\ w & 0 & 0 & 0 \\ \pi & 0 & 0 & 0 \\ 0 & \kappa^Z & 0 & 0 \end{vmatrix} \tag{4.23}$$

where $\kappa^{B1} = \frac{Y}{C}$, $\kappa^{B2} = 1$ and $\kappa^{MB} = \frac{Y}{W}$.

There is an argument for endogenising other elements of these disaggregated accounts. In the present context, it is sometimes argued that endogenising transfers, particularly those linked to population and employment status, increases the accuracy with which household consumption is modelled (Batey, 1985; Batey & Madden, 1983; Batey & Weeks, 1989).

$$\bar{S} = \begin{vmatrix} A & 0 & 0 & \phi_N^{B_1} \\ w & 0 & 0 & 0 \\ \pi & 0 & 0 & 0 \\ 0 & 1 & \rho^Y + \rho^R r^Y & 0 \end{vmatrix} \tag{4.24}$$

Each of the four rows and columns in the $\overline{B}^Z$ and $\overline{S}$ matrices represent receipts and expenditures of the industries, labour, OVA and household accounts. Note that the first three rows of these matrices are identical. They use the same A matrix and w, π and c_N^{B2} vectors of coefficients. The two matrices differ solely in the fourth row which identifies the sources of income entering the household account.

In the $\overline{B}^Z$ matrix one adjustment is the addition of the OVA account. However, its impact is trivial. Although the OVA generated in production can be identified, the destination of OVA expenditure is unknown in the IO accounts. Therefore the OVA column, column three in $\overline{B}^Z$, only has zero elements. The second change is more interesting.

In Equation 4.8 the different Type II multiplier formulations are identified by their different household consumption coefficients. However, it is straightforward to show that this can be translated to a differences in the level of wage income transferred to households, combined with the household consumption coefficients used in $Batey2$ and the SAM multipliers.

The consumption coefficient $\phi_{N,i}^{B_1}$ is defined in equation 4.13 and $\phi_{N,i}^{B_2}$ in equation 4.14. Using these equations, the coefficients $\phi_{N,i}^{B_2}$ can be expressed as:

$$\phi_{N,i}^{B_1} = \frac{c_i}{C} = \frac{c_i}{Y} \cdot \frac{Y}{C} = \phi_{N,i}^{B_2} \, \kappa^{B_1} \tag{4.25}$$

where $\kappa^{B1} = \frac{Y}{C}$. Applying a similar procedure to equations 4.12 and 4.13, where $\kappa^{MB} = \frac{Y}{W}$:

$$\phi_{N,i}^{MB} = \phi_{N,i}^{B_1} \, \kappa^{MB} \tag{4.26}$$

Equations 4.25 and 4.26 show that the $Miller\&Blair$ and $Batey1$ household consumption coefficients are simply scalar multiples of the $Batey2$ coefficients, which are the coefficients also used in the SAM multipliers. The different Type II IO multipliers can therefore solely be represented by differences in the relationship between the change in wage income and the subsequent change in effective household income.

Given that, in the Scottish data, $Y > C > W$, the relative values of values of κ^Z for Scotland are $\kappa^{MB} > \kappa^{B1} > \kappa^{B2}1$. Note that this implies the seemingly illogical position that in the $Batey2$ and $Miller\&Blair$ multiplier measures, more than 100% of the wage income is assumed to be transferred to household income. However, as has been remarked already, in the B^Z matrix there is no transfer of OVA to household income.

Therefore some overweighting of wage income could be justified on this basis. These observations have a number of implications. Begin with the IO Type II multipliers. For each industry, their values can be ranked in the same order as their κ^Z values. That is to say, for Scotland for any industrial sector, i; $M_i^{MB} > M_i^{B1} > M_i^{B2}$. However, a comparison between the IO Type II and the SAM multiplier values is a little more complex.

The $Batey2$ multiplier value is always lower than the SAM multiplier: for any sector, i, $M_i^S > M_i^{B2}$. This is apparent from a comparison of the $\overline{B}^{B1}$and the $\overline{S}$ matrices given in equations 4.23 and 4.24. The only difference in the two matrices is the additional elements in the SAM matrix, $\overline{S}$, linking household income positively to OVA. On the other hand, the value of the $Miller\&Blair$ multiplier will generally be higher than the corresponding SAM value. The sum of the M_i^{MB} values, weighted by their associated final demands, is greater than the corresponding weighted sum of the SAM multipliers.

This is because in the accounting identity (equation 4.8) the $Miller\&Blair$ multiplier endogenises all household income through directly linking all household income linearly to wage payments. But, in general, there are exogenous elements in household income, so that T^Y is positive in equation 4.18. This means that the $Miller\&Blair$ method typically overcompensates for not directly including the link between household income and OVA generated in production.

However, this does not mean that M_i^{MB} is necessarily greater than M_i^S for all industries. If an industry is very capital intensive and if a significant share of OVA is transferred to household income, the SAM multiplier can be higher than $Miller\&Blair$ for particular individual industries. Clearly the $Batey1$ multiplier takes an intermediate position, between the $Batey2$ and $Miller\&Blair$ figures. Its value relative to the SAM multiplier is wholly data dependent. The $Batey1$ average multiplier value and the value for individual sectors could be higher or lower than the corresponding SAM values, depending on the extent to which the impact of wages on household income under- or over-compensates for the missing income from OVA. This in itself might reflect the level of OVA income retained in the local economy.

4.6 Data

The data used to compute the IO and SAM multipliers are the 2009 Scottish IxI table (Scottish Government, 2013a) and the 2009 Scottish SAM, respectively. Both the IO tables and the SAM are outlined in detail in Chapter 2 but a summary is presented here. It should be noted from the start that the 2009 SAM is based on the 2009 Scottish IO tables. Thereby multipliers for both IO and SAM are consistent.

The IxI table used here is for the calendar year 2009 and is sourced from the Scottish Government (2013a). Table 4.6.1 is an aggregate version of the 2009 IxI table for Scotland. Focusing on the first row and column, the row gives the expenditure on Scottish goods/services, whilst the column details the cost breakdown of the Scottish production sectors.

The IO tables define the production cost entries in the column as: intermediates, labour costs, OVA, Government and intermediate Imports from the Rest of UK (RUK), and the Rest of the World (ROW). The production income entries are defined as: Capital, household expenditure on Scottish goods/services, Government, and exports to the RUK and ROW.

The first row total of £210,920m in the aggregated IxI table 4.6.1 gives the total turnover of all production and service activity in the Scottish economy (total aggregate demand of gross outputs). It is labelled as 'Activities'. This includes private, public and voluntary sector production activity. This total can be broken down to show the interactions between individual sectors in more detail. The disaggregate version of the IxI table details these interactions at full 104 industry level.

The IxI table 4.6.1 show the destination of industry output, for example primary manufacturing products. The columns of the IxI table show purchases made by industries and final demand from each Scottish industry's output arising from both principal production and intermediate demand. Conversely, the rows provide a breakdown of industry receipts by origin.

Note that the sum of all final demands across all sectors is equal to the sum of all value added (Scottish Government, 2011). The aggregate IxI table shows that Total Final Demand equals Total output at basic prices within the Activities account. That is, all expenditures are balanced by receipts within the Activities account (£210,920m - £210,920m = 0).

IO tables do not attempt to link the elements of Value Added (wages and OVA) with the elements of Final Demand (consumers, government, and investment). This is in contrast to a SAM where the "missing" data on transfers between these accounts is recorded.

Table 4.6.1: Aggregated Industry-by-Industry Table, 2009 basic prices (£million)

	1. Activities	2. Households	3. Government	4. Capital	5. RUK	6. ROW	Total
1 Activities	63,607	49,802	29,486	13,981	36,879	17,166	210,920
2. Labour	63,561	-	-	-	-	-	63,561
3. OVA	38,441	-	-	-	-	-	38,441
4. Government	4,779	6,568	-	1,495	193	129	13,165
5. RUK	30,274	13,875	-	3,358	4,362	2,890	54,759
6. ROW	10,258	4,424	-	1,097	3,057	161	18,997
Total	210,920	74,669	29,486	19,930	44,491	20,346	

Source: Scottish Government (2013a)

Table 4.6.2 depicts an aggregate version of the SAM that is derived by combining the IO Industry-by-Industry (IxI) table and the Income and Expenditure Accounts (details on this account can be found in Chapter 2). For illustrative purposes the disaggregation within accounts has been suppressed, as in Table 4.6.1. For example. the 104 industries contained in the SAM are aggregated to one industry (Activities).

Table 4.6.2: Aggregated 2009 Scottish SAM, 2009 basic prices (£million)

	1. Activities	2. Labour	3. OVA	4. Households	5. Corporations	6. Government	7. Capital	8. RUK	9. ROW	Total
1. Activities	63,607	-	-	49,802	-	29,486	13,981	36,879	17,166	210,920
2. Labour	63,561	-	-	-	-	-	-	-	-	63,561
3. OVA	38,441	-	-	-	-	-	-	-	-	38,441
4. Households	-	63,561	5,289	-	15,103	19,835	-	1,853	2,237	107,877
5. Corporations	-	-	29,456	6,401	-	5,722	-	5,964	5,964	53,507
6. Government	4,779	-	3,697	27,947	5,248	13,165	1,495	20,234	129	76,694
7. Capital	-	-	-	5,070	24,828	119	-	- 5,217	- 4,871	19,930
8. RUK	30,274	-	-	14,113	3,768	8,368	3,358	4,362	2,890	67,133
9. ROW	10,258	-	-	4,544	4,560	-	1,097	3,057	161	23,676
Total	210,920	63,561	38,441	107,877	53,507	76,694	19,930	67,133	23,676	

The fully disaggregated SAM can be assessed from: Emonts-Holley and Ross (2016)

It must be emphasised that for modelling purposes a much more detailed SAM is used. The aggregated 2009 SAM for Scotland is a square matrix with 9 column and 9 corresponding row accounts. This aggregated SAM contains the following main accounts: Activities, Labour, OVA (Profits), Households, Corporations, Government, Capital, RUK, and ROW.

The row and column entries in the SAM are considered to be receipts and expenditures receptively. The rows in the SAM show income sources for each Account in detail. For example, the household account shows that total household income is £107,877m, of which £63,561m (58 percent) comes from Labour income.

Conversely, the columns in the SAM depict the expenditures of each account in detail. Again, total household expenditure is £107,877m, of which £49,802m (46 percent) are payments to domestic productive Activities i.e. household consumption on goods/services produced in Scotland.

The first row and the first column of the SAM include all the aggregated information from the IxI table, and thus balance. That is the £210,920m from the IxI table (see Table 4.6.1) are fully incorporated. Thus, IO tables provide key macroeconomic variables (GDP and total wage income) as well a breakdown of flows between Scottish industries.

The IxI table 4.6.1 gives a breakdown of total household (£74,669m) consumption on Activities (domestic goods/services), Government and Imports. However, the IxI table does not detail other forms of expenditure, and more importantly, no explicit sources of household income.

In contrast, the SAM in Table 4.6.2 provides a more detailed breakdown of household expenditure on savings, corporations, taxes, and imports. Total household expenditure is thereby estimated to be £107,877m.

In comparison to the SAM, the IxI table only captures 69 percent of total household expenditure. The SAM also presents a detailed breakdown of household income by Labour, OVA, Corporations, Government and ROW. The SAM thereby contains additional sources of household income that are not captured in the IxI table.

The additional information contained in the SAM, compared to the IO tables, can be used to extend and improve the multiplier modelling capacity to include the behaviour of the non-production part of the economy. In particular, the more explicit link between activity and household income should improve the Type II multiplier.

4.7 Multiplier Calculations

The following two Sections discuss the computations of the three Type II multiplier methods and the SAM Multiplier using the 2009 Scottish IxI table and SAM. This section discusses the derivation of the multipliers. Section 4.8 analyses the computations using descriptive analysis.

4.7.1 Miller & Blair

The $Miller\&Blair$ method derived in section 4.3.3 uses the total of wages from employment received by household, W. That is the "Total Intermediate Demand" of the "Compensation of employees" row in the IxI table (see Table 4.6.1), at £63,561m.

Thereby, the data used to endogenise the household sector are, first, the "Income from Employment" row which gives the data on wage income from employment. And second, the "Households" column containing the entries of household expenditure on industry output.

$$h_k^{MB} = \left[\frac{H_k}{W}\right] \qquad Where: W = \pounds 63,561m \tag{4.27}$$

4.7.2 Batey 1

The $Batey1$ method derived in section 4.3.4 internalises exogenous household income alongside wage income in the model. Here the total used for endogenising the household sector is the total of household expenditure from the IO tables, C^H. This is the total household expenditure scalar given at £74,669m in Table 4.6.1.

$$h_k^{B_1} = \left[\frac{H_k}{C^H}\right] \qquad Where: C^H = \pounds 74,669m \tag{4.28}$$

4.7.3 Batey 2

The $Batey2$ method derived in section 4.3.5 uses a more comprehensive household Total, Y^H. This figure is derived by summing up the "Final Consumption Expenditure" of households and that of Non-Profit Organisations Serving households (NPISHs). Then the household expenditure on goods & services of the following sectors are added to the household Total: ROW, RUK, Corporate, Government and Capital. This figure amounts to £107,877m.

$$h_k^{B_2} = \left[\frac{H_k}{Y^H}\right] \qquad Where: Y^H = \pounds 107,877m \tag{4.29}$$

Note that there is an alternative figure in use, which follows the same theoretical foundation as the approach outlined here. This method uses the combined Compensation of Employees at £63,561m from the IxI table (Scottish Government, 2013a) and all 'Unearned Income' at £46,835m (Scottish Government, 2013d). The total for this method is £110,396m. This is the figure used for the official Scottish Government Leontief Inverse calculations.

4.7.4 SAM Multiplier

Equation 4.30 illustrates the calculation for the SAM multiplier. The inter-industry matrix of technical coefficients is given as S. Note that the household Total, h^{B2}, shown in equation 4.31 is the one used in $Batey2$. This figure amounts to £107,877m.

$$[I-S]^{-1}\left[\frac{F_x^S}{F_v^S}\right] = \left[\frac{x}{v}\right] \tag{4.30}$$

$$S = \begin{vmatrix} A & 0 & 0 & h^{B2} & 0 \\ w & 0 & 0 & 0 & 0 \\ \pi & 0 & 0 & 0 & 0 \\ 0 & 1 & \pi^h & 0 & c^h \\ 0 & 0 & \pi^c & h^c & 0 \end{vmatrix} \qquad Where: \quad h^{B2} = \pounds 107,877m. \tag{4.31}$$

4.8 Descriptive analysis

If the SAM multiplier value is accepted as the most appropriate method for endogenising household consumption in a manner consistent with the IO approach, then none of the standard Type II IO multiplier methods is ‘correct’. IO does not identify key income flows from production into (total) household income, therefore in attempting to endogenise household consumption there is, almost inevitably, some inaccuracy.

Appendix 4B provides a full breakdown of the Type I, the Type II ($Miller\&Blair$, $Batey1$, and, $Batey2$) and the SAM multiplier derived for 102 sectors of the 2009 Scottish IxI table and the 2009 Scottish SAM (sector 7, Oil & Gas Extraction, Metal Ores, and sector 20, Tobacco, do not contain data and are thereby omitted from the initial 104 sectors).

Table 4.8.1 also shows the mean, the minimum and the maximum values for each of the multipliers detailed in Appendix 4B. The Type I multiplier shows the lowest values. This is to be expected, since this multiplier is computed using only the inter-industry flow data from the IxI table.

The mean values for the $Miller\&Blair$, $Batey1$ and $Batey2$ variants of the IO Type II multipliers are 2.156, 2.017 and 1.810 respectively. This implies that the indirect and induced activity calculated using the $Miller\&Blair$ multiplier formulation is just less than 20% higher than the corresponding activity calculated using the $Batey1$ measure. Thus it clearly matters which formulation is used.

The mean SAM multiplier lies within the range of mean IO Type II values. The $Batey2$ value is systematically below the SAM multiplier and the $Miller\&Blair$ and $Batey1$ approaches systematically higher. The $Batey1$ approach gives the Type II IO mean that is closest to the SAM multiplier. The minimum and maximum multiplier values also reflect these analytics.

Table 4.8.1: Multiplier summary statistics

		Type II			
	Type I	Miller & Blair	Batey1	Batey2	SAM
Mean	1.465	2.156	2.017	1.810	1.910
Min	1.000	1.220	1.206	1.186	1.321
Max	2.780	3.343	3.230	3.061	3.214

When comparing the multipliers at sector level, there are some clear results. One is that for any sector the $Batey2$ multiplier, the multiplier reported by the Scottish Government, must always lie below the SAM multiplier value.

This is because the household coefficients are the same for the two measures but the SAM multiplier incorporates that part of profits income that indirectly enters household income. Also if household income, household consumption and total wages can be ranked so that $Y^H > C^H > W$, then for any sector k; $M_k^{MB} > M_k^{B_1} > M_k^{B_2}$. However, which is closest to the SAM multiplier is an empirical issue.

This hierarchy is also largely observed at individual sector level. It is always the case that the three IO values are in the same order, and when including the SAM multiplier, $Batey2$ always takes the lowest of all the multipliers. However, the position of the SAM multiplier value varies at sector level and is not always between $Batey1$ and $Batey2$. The $Miller\&Blair$ multiplier is below that of the SAM for sectors 27. Coke, petroleum & petrochemicals, 75. Real estate, and 76. Imputed rent.

The $Batey1$ multiplier is below that of the SAM in sectors: 1. Agriculture, 4. Fishing, 5. Aquaculture, 9. Mining Support, 17. Spirits & wines, 18. Beer & malt, 27. Coke, petroleum & petrochemicals, 47. Electricity, 49. Water and sewerage, 75. Real estate, and 76. Imputed rent. These are industries with high ratios of OVA to wages. This is because income from profits, which plays no role in any of the IO type II multipliers, is an important element of the SAM multiplier.

Figure 4.8.1 gives the difference between the SAM and the Type II multipliers. The horizontal axis here can be interpreted to represent the SAM multiplier value and thus the closer the lines are to this axis, the better the fit. This graph shows that the $Batey2$ method using the more comprehensive household figure gives the closest fit to the SAM multiplier.

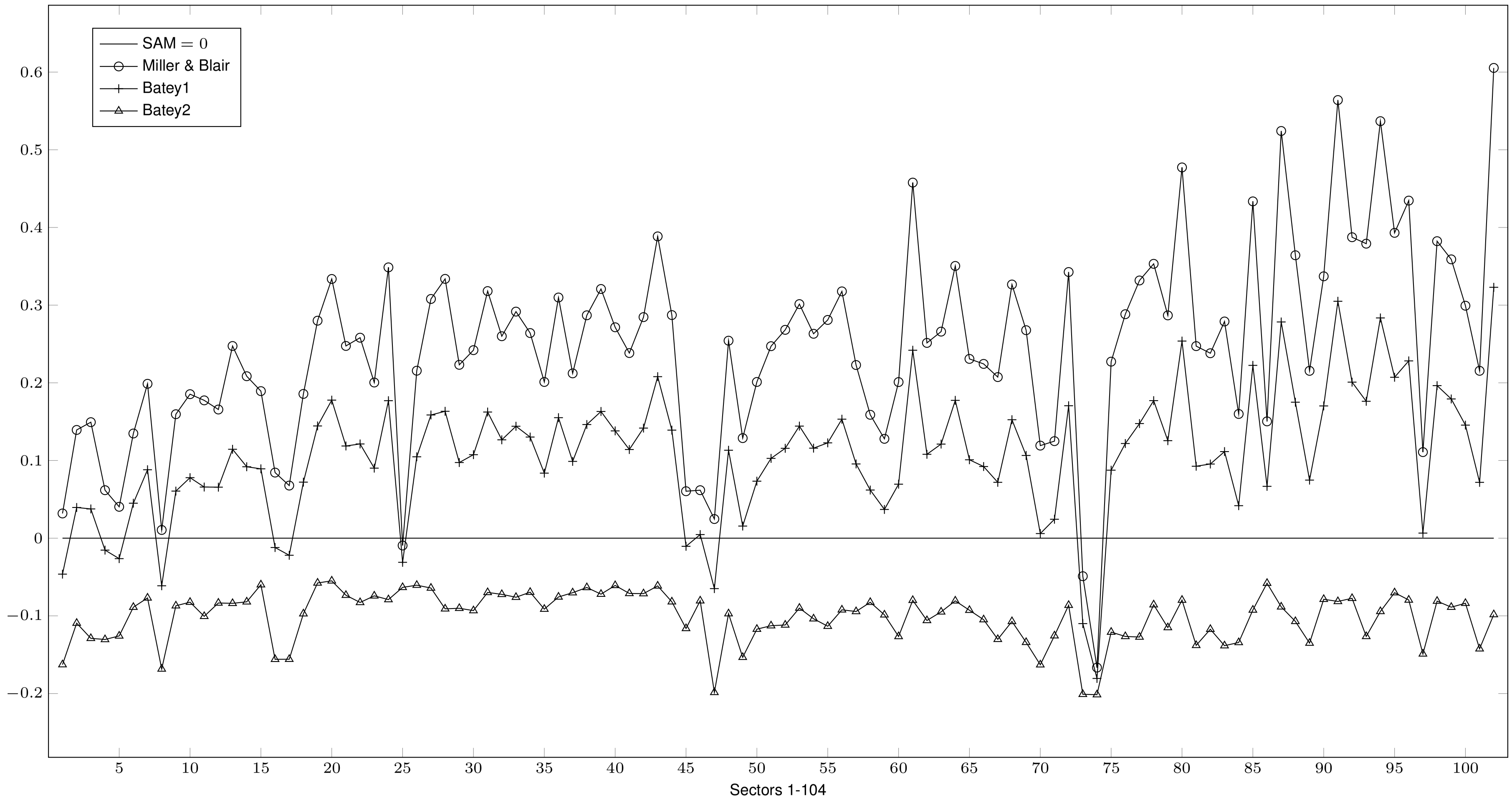
The graph also depicts that this method varies less in value compared to $Batey1$ and $Miller\&Blair$, because the coefficients are the same. The $Miller\&Blair$ method shows the overall biggest differences to the SAM. This confirms that endogenising the household sector using a more comprehensive figure (external to the IO table) results in the closest fit.

Furthermore, Figure 4.8.1 highlights that the difference between the methods varies substantially between the sectors. The methods using the $Batey2$ for endogenising the household sector show some variation compared to the SAM. However, there are some very pronounced spikes observable for the $Miller\&Blair$ and the $Batey1$ methods.

The three biggest differences are for sectors 93. Education, 89. Security & Investigation, and 96. Social Work. The multipliers for these sectors show large variation in comparison to the SAM multiplier. These differences seem to be due to a small gap between the values for Gross Value Added and Total Output.

Table 4.8.2 shows various error-computations of the three IO methods. This allows for detailed measurements of the differences between the methods compared to a benchmark, here the SAM multiplier. The error-measurements are the Root Mean Squared Error (RMSE) and the Mean Absolute Error (MAE). The smallest value indicates the best fit with respect to the SAM multiplier.

Figure 4.8.1: Difference between SAM and Type II multipliers



Note: see Appendix 4B for full set of results.

All measurements show that compared to endogenising the household sector using the SAM household total figure, $Batey2$, results in the closest fit. This method does not differ much in the error values. Also note that the methods shown can be classified into two groups. Both $Miller\&Blair$ and the $Batey1$ use purely data from the IO tables, $Batey2$ uses more comprehensive household expenditure figures which are not found purely in IO tables.

The values in Table 4.8.2 also confirm that the $Miller\&Blair$ method results in the least close fit compared to the SAM multiplier. In comparison, $Batey1$, which endogenises household expenditure using the IxI household expenditure total, results in a closer fit. The RMSE for the $Miller\&Blair$ method is given at 0.201 and the RMSE for $Batey1$ at 0.099.

Table 4.8.2: Error statistics

	Miller & Blair	Batey1	Batey2
RMSE	0.201	0.099	0.077
MAE	0.131	0.062	0.054

The results show that if IO multipliers are computed using only the Scottish IO tables, then $Batey1$ method results in more reliable computations as opposed to the $Miller\&Blair$ method. The overall smallest error values are computed by using the $Batey2$ method which uses the household total from the SAM. However, all three methods are not 'correct' as the IO table does not identify key income flows from production into (total) household income, therefore in attempting to endogenise household consumption there is, almost inevitably, some inaccuracy.

4.9 Discussion and conclusion

There is complete agreement about the method used to calculate IO Type I multipliers. These measure the direct and indirect output effects from a unit expansion in exogenous final demand in a particular sector. They incorporate the change in activity associated with the production of the intermediate goods that contribute directly or indirectly to the production of final demand.

Type II multipliers identify the direct and indirect effects. However, they also incorporate the impact of increased household income and subsequent consumption expenditure that accompanies any change in output. These are known as induced effects. Although this is a very common procedure, a number of different methods have been adopted in the literature.

A literature review has shown that the variation in methods is not widely recognised. This is potentially problematic for the interpretation of Type II multipliers, their use in modelling demand-side disturbances and the value for comparing the structural characteristics of different economies. Second, it would be valuable to standardise the Type II procedure, which requires choosing amongst the different formulations.

The first question is whether empirically this is a serious problem. The Scottish results suggest that it is. The range of Type II multiplier mean values is almost 40% of the most accurate measurement of additional multiplier effect. The second question is: which method is preferable? If the SAM multipliers embody the most complete linking of income generated in production and the subsequent distribution to households for Scotland, the mean value using the $Batey2$ method is closest to the mean SAM value and has the smallest mean error, even though the method systematically underestimates the SAM multiplier values. However, this method has the disadvantage that it requires information on household income that is typically not available from the IO accounts themselves.

This indicates that when using IO tables data exclusively the $Batey1$ multiplier will provide the 'best' estimates. When incorporating data external to IO tables for the computation of the Type II multiplier, the $Batey2$ provides the closest fit.

Despite some of the models coming close to SAM multipliers, it must be acknowledged that all three Type II methods have a fundamental weakness; they all explicitly endogenise wages, and link household expenditure to these. A SAM multiplier incorporates income from OVA into household income in a way completely consistent with the standard demand-driven IO approach. It is therefore the only wholly satisfactory means of endogenising household consumption in the application of such an approach.

Chapter 5

Chapter 5

Effects of exogenous demand shocks - a SAM modelling approach

5.1 Introduction

This chapter sets out to analyse distributional effects of exogenous demand shocks within the Scottish economy. This is done by employing a Social Accounting Matrix (SAM) for Scotland that contains detailed information of the main transactors, as well as a disaggregated household account, and two types of labour which are defined by their educational achievements. Also, any differential impacts on the two skill categories arising from the exogenous demand shock are used to identify whether that part of the Scottish economy reacting to the exogenous demand shock is more skilled or unskilled-intensive. Input-Output (IO) accounting methods have been used in the past to answer similar question. For example, Leontief (1953) used IO techniques methods to analyse the capital and labour intensity of US trade flows (Leontief's paradox). IO techniques are similarly used to analyse pollution embodied in trade flows (Turner et al., 2014; Minx et al., 2009). In keeping with this tradition, the exogenous demand shock within the SAM is not only used to analyse distributional effects, but also to analyse the structure of the Scottish economy in more detail. This chapter is organised as follows; Sections 5.2 and 5.3 outline the modelling strategy and the main features of the SAM. Section 5.4 discusses the main results in detail, Section 5.5 analyses the skill intensity of exogenous expenditures, and Section 5.6 gives a summary and policy implications.

5.2 Modelling strategy

The SAM can be considered as an extended IO table which not only records macroeconomic-aggregates and their sectoral disaggregation but also the distribution and redistribution of income. The focus of a SAM therefore lies in recording interrelationships at the meso-level with emphasis on distributive aspects (Keuning & de Ruuter, 1988). Round (2003, p.75) goes so far as to state that "an overriding feature of a SAM is that households and household groups are at the heart of the framework; only if there exists some detail on the distributional features of the household sector can the framework truly earn the label 'social' accounting matrix."

A strength of SAM modelling techniques is thereby to reveal structural components of income and expenditure linkages in the economy as these affect relative incomes (Roland-Holst & Sancho, 1992). SAM practitioners traditionally focus on questions of consumption, household income distribution, and demographics (Pyatt & Round, 1985, 1985; Roland-Holst, 1990). In a review of extended IO and SAM models Batey and Rose (1990), however, find that the main efforts in extending these models tends to be for labour market analysis and income distribution.

In keeping with this tradition the focus here is on quantifying the impacts of an exogenous demand shock across the Scottish economy in a skill- and household-disaggregated SAM modelling context. That is, the impacts on sectoral output, Gross Regional Product (GRP), labour incomes, household income distribution, and jobs are analysed. To allow for a systematic comparison across sectors, an exogenous demand shock of £500m is modelled for each of the 25 sectors contained in the SAM. This shock is motivated by the efforts of the Scottish Government to increase international exports (Scottish Government, 2015).

Addressing the heterogeneity of households and the labour market are argued to be important (Kim et al., 2016; Boeters & Savard, 2011). To closely analyse distribution effects of the demand shocks, the SAM contains extended labour and household accounts: labour is disaggregated by two skill types (skilled and unskilled) where skill is categorised in terms of the level of education; and households comprise five groups, which are defined by income bands (characteristics of the SAM are outlined in Section 5.3). The following gives a description of the SAM multiplier and the underlying assumptions important for this research.

As discussed in detail in Chapter 4, the SAM contains a comprehensive set of accounts capturing 'all' income flows to households. This includes household income stemming from the external sector. The SAM multiplier endogenises both the household and the corporate sector. Therefore, the direct link between household income and Other Value Added (OVA), as well as the indirect flow of OVA through corporations to households is endogenised in the SAM multiplier. Traditionally, the government, capital, and external sector are treated as exogenous in the model (Round, 2003). To recall from Chapter 4, total OVA, Π, is determined as:

$$\Pi = \pi x \tag{5.1}$$

where π is an $1 \times n$ vector whose ith value is the OVA in the ith sector divided by the total output of that sector, x. A share of value added, ρ^Y goes directly to households and a share ρ^R goes to corporations. Subsequently a share of corporate income, r^Y, is transferred to households. This means that in the SAM multiplier, corporate, R, and household income, Y, are given as:

$$R = \rho^R\,\Pi + T^R \tag{5.2}$$

$$Y = W + \rho^Y\,\Pi + r^Y R + T^Y \tag{5.3}$$

where T^R and T^Y are exogenous transfers to the corporate and household sector from the government and external sectors. Combining equations 4.3, 4.5, 4.12, and 4.13, from Chapter 4, with 5.2 and 5.3 and expressing this in matrix form produces:

$$S \begin{bmatrix} x \\ v \end{bmatrix} + \begin{bmatrix} f - c \\ f_v \end{bmatrix} = \begin{bmatrix} x \\ v \end{bmatrix} \tag{5.4}$$

where the S is the $(n+4) \times (n+4)$ matrix:

$$S = \begin{vmatrix} A & 0 & 0 & \phi_N & 0 \\ w & 0 & 0 & 0 & 0 \\ \pi & 0 & 0 & 0 & 0 \\ 0 & 1 & \rho^Y & 0 & r^Y \\ 0 & 0 & \rho^R & 0 & 0 \end{vmatrix} \tag{5.5}$$

where: f_V is the 4×1 vector of exogenous income transfers and v is the 4×1 vector of factor and institutional incomes; W, is the total wages generated in production; w is the $1 \times n$ vector of wage coefficients, where the ith element is the wage payment in sector i divided by the total output of that sector, and the A-matrix is a $n \times n$-matrix of the technical coefficients, derived by dividing each sector column entry by its relevant column total, so that:

$$f_V = \begin{bmatrix} 0 \\ 0 \\ T^Y \\ Y^R \end{bmatrix}, v = \begin{bmatrix} W \\ \Pi \\ Y \\ R \end{bmatrix} \tag{5.6}$$

Through the standard matrix inversion:

$$[I - S]^{-1} \begin{bmatrix} f - c \\ f_V \end{bmatrix} = \begin{bmatrix} x \\ v \end{bmatrix} \tag{5.7}$$

The multiplier outlined here endogenises both the household and the corporate sector. Therefore, the direct link between household income and OVA, as well as the flow of OVA through corporations to households is endogenised in the SAM multiplier. As mentioned previously, government, capital, and external sector are traditionally treated as exogenous in the model (Round, 2003).

Again if the element in the ith row and the jth column of the SAM inverse is represented as $_{i,j}$ then the SAM multiplier value for sector j , M_j^S , is the sum of the first n elements j, and thereby measures the system-wide change in total output generated by a unit increase in exogenous final demand for the output of sector j.

$$M_j^S = \sum_{i=1}^{n} \sigma_{i,j} \tag{5.8}$$

Equation 5.7 identifies the characteristics of the SAM multiplier model. Expenditure in the government, capital and external accounts are wholly exogenous. Expenditures in all other accounts are endogenous. All wage and profits income generated in production go to domestic households.

Household and corporate expenditures are endogenised and in both cases there are exogenous transfers from government and the external sector, together with endogenous income indirectly from production. This means that all changes to wages and OVA generated in production, which is indirectly linked to households, are allocated to households in a way that is consistent with the standard demand-driven IO approach.

The SAM multiplier analysis is subject to the limitations imposed by the underlying IO framework, which are, inter alia, fixed coefficient technologies, an absence of capacity constraints and an infinitely elastic supply of labour. In the regional context, as applicable for Scotland, the SAM system can be interpreted as describing the long-run response of activity to a permanent change in aggregate final demand (McGregor et al., 1996) [1]. Essentially, under these conditions, input and commodity prices do not vary with changes in final demand. Thus, the modelled demand shock on the economy does not affect prices, but it is assumed that there is excess capacity and unemployment, which absorb the shock (Thorbecke, 2000).

Furthermore, income elasticities of demand are assumed to equal one. Thus, the impact of an increase in household income on the demand for luxury goods is understated whilst the model overstates the impact on demand for necessities (Golan et al., 2000) [2]. Nevertheless, SAM multiplier analysis overcomes the IO Type II limitations with regards to mapping household income flows comprehensively, as discussed in Chapter 4, and is thereby used widely for analysis of distributional effects.

What is counted as exogenous and what is endogenous is a key issue in SAM modelling as the model operates so that exogenous expenditures drive endogenous ones. Endogenising, for example, a part of the Government sector in the SAM model would counter a criticism of this type of model, where changes in the system do not have an impact on the components that are treated as exogenous but may be endogenous under some fiscal arrangement. This, however, would require additional disaggregation of the SAM, as done by Emonts-Holley (2016) for example.

Empirical observations suggest that geographic mobility within the UK differs by skill, where the unskilled are less geographically mobile as compared to the skilled (Dixon, 2003). A potential limitation of the skill- and household-disaggregated SAM model may thereby be the assumption that both skilled and unskilled workers are available at an infinitely elastic supply. There are extended IO and SAM models that take into account migration behaviour, see for example, Batey and Rose (1990). However, this is addressed in this thesis in Chapters 6 to 8 where a Computable General Equilibrium (CGE) model is employed that allows for skill-differentiated migration responses. The next section outlines the main features of the skill- and household-disaggregated 2009 SAM for Scotland.

[1] McGregor et al. (1996) endogenise investment in order to generate these results - as done in their CGE model.

[2] It must be noted that this could be modelled more precisely be applying a utility function, such as a Stone-Geary (1954) utility function, which differentiates household consumption expenditures between inferior and normal goods.

5.3 Main features of the Social Accounting Matrix

The skill- and household-disaggregated 2009 SAM for Scotland given in Ross (2016a) is used in this chapter. The SAM outlined in Chapter 2 forms the basis of this SAM. The income from labour entries are disaggregated as outlined in Chapter 3. Ross (2016a) disaggregates the household entries by income bands and connects these to the disaggregated labour entries. Table 5.3.1 gives an aggregate version of the 2009 SAM table for Scotland, and Appendix 5A gives the underlying Household Income-Expenditure Account.

Each row of the SAM gives the receipts of an account, whilst the column give the expenditures. The first row and column thereby gives the receipts and expenditures of the Scottish production sectors. The first row total of £210,920m in the aggregated SAM in Table 5.3.1 gives the total turnover of all production and service activity in the Scottish economy (total aggregate demand for gross outputs). It is labelled as 'Activities'. This includes private, public and voluntary sector production activity. This total can be disaggregated to show the interactions between individual sectors in more detail. The disaggregated version of the SAM details these interactions at full 104 industry level (results in sections to follow are given at 25 sector level).

The SAM in Table 5.3.1 shows the destination of industry output. The columns of the SAM show purchases made by industries and final demand from each Scottish industry's output arising from both principal production and intermediate demand. Conversely, the rows provide a breakdown of industry receipts by origin.

The SAM contains two labour categories (skilled and unskilled) where skill is categorised in terms of the level of education. Skilled labour are defined here as workers holding a degree; and unskilled are defined as anything below that. This skilled/unskilled disaggregation has been used previously in the SAM/CGE literature by Stuttard and Frogner (2003a, 2003b), and Boeters and Savard (2011) where the cut-off point is typically a completed degree. To recall, Chapter 3 gives a comprehensive overview of skill types and the construction of the skill-disaggregated SAM.

The SAM contains five household groups, which are defined by income bands. Household income bands are given as: 0 to £16,640 for Household 1; £16,641 to £21,320 for Household 2; £21,321 to £27,040 for Household 3; £27,041 to £35,880 for Household 4; and £35,881+ for Household 5. This household categorisation is given by the Intra-Governmental Tax and Benefit Model (IGOTM) from the HM Treasury, a data set used by Ross (2016a) to disaggregate the SAM.

Table 5.3.1: Aggregated 2009 SAM for Scotland with disaggregated labour and household accounts

	1. Production activities	2. Labour skilled	3. Labour unskilled	4. Other Value Added	5. Net Commodity Taxes	6. Household 1	7. Household 2	8. Household 3	9. Household 4	10. Household 5	11. Corporate	12. Government	13. Capital	14. Stocks	15. Tourist expenditure	16. RUK	17. ROW	Total
1. Activities	63,607	-	-	-	-	8,615	4,043	5,759	7,825	23,560	-	29,486	14,332	- 352	1,851	35,768	16,426	210,920
2. Labour skilled	41,974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41,974
3. Labour unskilled	21,587	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21,587
4. Other Value Added	38,441	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38,441
5. Taxes on expenditures	4,779	-	-	-	-	769	972	1,305	1,571	1,951	-	-	1,495	-	322	-	-	13,165
6. Household 1	-	1,150	2,016	423	-	-	-	-	-	-	102	9,810	-	-	-	117	141	13,759
7. Household 2	-	1,239	2,323	354	-	-	-	-	-	-	387	3,603	-	-	-	141	170	8,216
8. Household 3	-	3,443	4,029	573	-	-	-	-	-	-	1,281	2,861	-	-	-	218	263	12,668
9. Household 4	-	7,404	5,268	584	-	-	-	-	-	-	2,632	2,047	-	-	-	264	318	18,517
10. Household 5	-	28,738	7,952	3,355	-	-	-	-	-	-	10,701	1,514	-	-	-	1,114	1,344	54,718
11. Corporate	-	-	-	29,456	-	248	228	383	905	4,637	-	5,722	-	-	-	2,196	1,404	45,179
12. Government	-	-	-	3,697	13,165	636	1,356	2,654	4,547	12,185	5,248	-	-	-	-	11,673	-	55,162
13. Capital	-	-	-	-	-	346	117	322	652	3,633	24,828	119	-	-	-	- 5,216	- 4,871	19,930
14. Stocks	-	-	-	-	-	-	-	-	-	-	-	-	- 500	-	-	-	-	- 500
15. RUK	30,274	-	-	-	-	2,381	1,137	1,698	2,283	6,614	-	-	3,467	- 109	507	-	-	48,252
16. ROW	10,258	-	-	-	-	764	363	547	732	2,138	-	-	1,136	- 39	240	-	-	16,139
Total	210,920	41,974	21,587	38,441	13,165	13,759	8,216	12,668	18,517	54,718	45,179	55,162	19,930	- 500	2,921	46,274	15,196	

Household 1: 0 to £16,640

Household 2: £16,641 to £21,320

Household 3: £21,321 to £27,040

Household 4: £27,041 to £35,880

Household 5: £35,881 +

Considering first household incomes, the following main characteristics can be observed. The data in the SAM show that £41,974m of labour incomes go to skilled, and £21,587m go to unskilled workers. These labour incomes are then linked to their respective household income groups. Household 1 receives 23% of incomes from employment, whilst Households 2 to 5 receive 43%, 59%, 68%, and 68% of their incomes from employment respectively. Households in the lower income bands tend to be less skilled and vice versa for higher income households.

Similar observations can be made for OVA, corporate, and transfers from out with Scotland, where households in the higher income bands tend to receive more of these types of incomes. Government incomes, however, are significantly concentrated in the lowest income household. Household 1 receives 71% of incomes from the Government, whilst Households 2 and 3 receive 44% and 23% respectively.

Considering household expenditures it can be seen that higher income household tend to spend less of their total expenditures on domestic goods/services, and more on payments to corporations, the Government, and to Capital, as compared to lower income households. For example, Household 1 spends 91% of total expenditures on domestic goods/services, whilst Households 2 to 5 spend 79%, 73%, 67%, and 62% on domestic goods/services receptively. The propensity to spend on domestic goods/services is thereby extremely high in the lowest household income band, and the incomes for this spending stems predominately from the Government. It must be noted that the survey data used by Ross (2016a) to disaggregate these entries comes from the Living Costs and Food Survey, a long standing and robust data source.

To recall from Chapter 3, there are significant differences across sectors which are of key importance when interpreting sector specific results. Table 5.3.2 summarises sector characteristics by selected income and expenditure components as found in the skill- and household-disaggregated 2009 SAM for Scotland. This table is called to mind when outlining sector specific impacts of the exogenous demand shocks.

The first three columns in Table 5.3.2 give labour costs of output broken down by skill category. Skill, and labour intensity of output varies significantly across sectors. There are a number of sectors that are high-skill intensive. For example, the Research & development, and the Public administration sector have a skilled wage share of output of 50% and 40% respectively. In contrast, the Wholesale & retail, the Food & beverage services, and the Rubber, plastic, cement & iron sector sector are more low-skill intensive with a unskilled wage share of output of 19%.

There are a number of sectors with very low wage shares of output. For example, the Real estate sector, and the Chemicals sector have a wage share of output of 3% and 8% receptively. In contrast, the Research & development, and the Public administration sector have the high wage shares of output with 54% and 51% respectively.

Table 5.3.2: Sector characteristics by key income and expenditure components

	% share of costs (expenditures)								% share of incomes (receipts)											
	S labour	U labour	Total labour	OVA	Tax on expen.	RUK imports	ROW imports	Total imports	Household 1	Household 2	Household 3	Household 4	Household 5	Households	Government	Capital	Tourism	RUK exports	ROW exports	Total exports
1. Agriculture, forestry and fishing	5	6	11	32	- 16	27	4	31	5	2	3	4	10	23	0	3	0	17	11	27
2. Mining	7	3	10	38	2	13	4	17	0	0	0	0	1	1	-	1	0	72	9	81
3. Food, drink and tobacco	10	11	21	19	2	17	6	23	5	2	3	4	9	23	-	0	0	24	31	55
4. Textile, leather, wood and paper	13	14	27	6	2	19	7	26	2	1	2	2	8	15	0	1	1	24	13	37
5. Chemicals	6	2	8	15	2	40	20	60	2	1	1	2	7	13	-	0	1	39	22	62
6. Rubber, plastic, cement and iron	13	19	33	7	4	17	6	23	1	0	1	1	3	6	-	1	0	13	15	29
7. Computer, electrical and transport eq.	19	10	29	7	1	17	12	29	1	1	1	1	4	8	-	11	0	16	23	39
8. Electricity, gas and water	7	5	12	20	3	12	8	20	8	3	4	4	9	28	3	0	0	18	2	20
9. Construction	14	10	24	17	1	12	3	15	1	0	0	0	1	2	0	53	0	8	1	9
10. Wholesale and retail	17	19	37	16	4	13	3	16	10	5	7	10	29	62	0	3	2	9	7	16
11. Land transport	13	17	30	12	5	15	4	19	3	2	3	4	14	27	-	0	1	10	5	15
12. Water transport	10	5	15	9	6	20	6	27	3	2	3	4	12	23	-	4	1	6	40	46
13. Air Transport	9	8	17	17	8	18	6	24	5	4	5	8	24	46	-	0	0	23	4	27
14. Post and support transport services	15	17	32	18	1	13	3	15	1	0	0	0	1	3	0	1	0	12	9	21
15. Accommodation	19	16	35	17	7	11	5	16	6	4	5	8	26	50	0	0	29	0	0	0
16. Food & beverage services	17	19	36	13	9	10	7	17	10	6	9	14	42	81	-	-	10	-	-	-
17. Telecommunication	23	8	32	22	2	13	4	17	7	3	5	6	16	37	1	3	0	10	7	17
18. Computer and information services	38	7	45	19	2	14	3	17	0	0	0	0	1	1	1	17	0	32	16	48
19. Financial services	15	6	21	29	4	11	2	13	2	1	2	3	8	16	-	0	0	47	8	55
20. Real estate	2	1	3	55	- 0	20	1	21	16	7	10	13	34	81	-	3	0	2	0	2
21. Professional services	28	10	38	18	1	14	2	16	0	0	0	1	2	4	0	3	0	29	10	39
22. Research and development	50	4	54	3	- 10	18	4	22	0	0	0	0	0	1	0	2	0	23	34	57
23. Public administration	40	12	51	7	3	11	4	15	2	1	1	2	8	14	72	0	0	1	1	2
24. Recreational services	25	14	39	12	4	13	3	16	6	4	6	9	28	53	15	1	4	4	2	7
25. Other services	26	17	43	22	3	10	3	12	10	5	8	11	33	66	0	1	1	4	1	5

Imports and exports broken down by their RUK and ROW components in Table 5.3.2 show that the majority of industries have stronger import linkages with the RUK as compared to the ROW. Imports are a significant part of total costs for some sectors. For example, 40% of the total costs for the Chemical sector arise from RUK imports. There are a number of sectors which are highly export orientated. For example, the Financial services, the Mining, the Food & drink, and the Research & development sectors all have an export share of output of above 50%.

It must be noted, that the economic activity arising from resource extraction occurring in the North Sea is not directly included in these Scottish accounts. The Scottish 2009 IO tables therefore only include mainland activity. However, onshore activity servicing the extractive activities are identified in the Scottish IO tables as exports to the RUK.

There are a number of sectors that mainly serve the domestic market. For example, 81% of incomes in the Food & beverages services, and the Real estate sector stem from domestic households. 72% of incomes in the Public administration sector comes from the public sector. The Accommodation sector, and the Food & beverages services sector have a relatively large share of incomes coming from Tourism (i.e. expenditure by non-residents) with 29% and 10% respectively.

The Construction sector receives 53% of total incomes from providing investment goods. This is by far the largest capital share of output across all sectors. The second largest capital provider, in terms of share of output, is the Computer & information services sector with 17%.

To recall from Chapter 3, there are 2,229,931 full time equivalent (FTE) workers, of which 1,302,392 (58%) are skilled and 927,540 (42%) are unskilled. Sector 23, Public administration, is the largest employment sector with 610,655 workers. This is followed by sector 10, Wholesale and retail with 307,936 workers, sector 21, Professional services with 305,218 workers, and sector 9, Construction with 170,528 workers.

5.4 Effects of exogenous demand shocks

Table 5.4.1 details the full set of results for the £500m exogenous demand shocks to each of the sectors contained in the SAM. Figures 5.4.1 to 5.4.6 detail the effects on GRP, OVA, labour incomes, employment, wage rates, and households in more detail.

The results can be interpreted as follows. The first column, for example, shows the results of the demand shock to sector 1 (S1) which is Agriculture, forestry & fishing, and column two shows the results for the demand stimulus to sector 2 (S2), the Mining sector.

The very last column of Table 5.4.1, denoted as 'All sectors' details the results for a £500m exogenous demand shock, where the £500m are distributed to each of the 25 sectors simultaneously so that exogenous demand is increased by £20m in each sector.

Rows 1-25 show the direct, indirect, and induced SAM output effects in in £millions on the other sectors in the Scottish economy i.e. the demand linkages between sectors. For example, the £500m demand stimulus to the Agriculture, forestry & fishing sector generates an increase in output of £584m in that sector, an increase of £3m in the Mining sector, £27m increase in output in Food, drink & tobacco sector, and so on. The row denoted as Total output is the sum of these.

The rows denoted as skilled and unskilled labour give the income from labour in £millions to each of the skill categories generated by the shock. For example, the £500m demand stimulus to the Agriculture, forestry & fishing sector generates £92m and £79m in wage income for the skilled and unskilled respectively when taking into account the direct, indirect, and induced effects of the shock.

The OVA, Taxes on expenditure, and the Households rows are interpreted in similar manner. The GRP row gives the effect in £millions of the demand shock (the sum of skilled and unskilled labour, and OVA) on Gross Regional Product. Wage rates are in £(incomes over FTE employment).

It must be noted that there are two sectors that give negative numbers for Taxes on expenditures. The Agriculture, forestry & fishing sector, and the Research & development sector receive net subsidies in the base year, as recorded in the Scottish IO tables. The fixed coefficients in the SAM system thereby increases this subsidy as output increases.

The last three rows give the FTE employment effects. For example the £500m demand stimulus to the Agriculture, forestry & fishing sector generates 12,853 FTE direct, indirect, and induced jobs throughout the Scottish economy. Of these 5,551 jobs are skilled, and 7,301 jobs are unskilled.

The results show that there are a number of sectors that have very strong domestic demand linkages. For example, the £500m demand stimulus to sector 8, Electricity, gas & water (S8), yields a £765m increase in output in that sector, and a increase of £1,036m in total output. Similarly, the demand stimulus to sector 9, Construction (S9), increases output in that sector by £658m and increases total output by £1,064m.

In contrast, there are sectors where the stimulus to demand has limited linkages to other Scottish sectors. For example, the stimulus to sector 5, Chemicals (S5), yields a £517m increase in that sector, and a £694m increase in output across all sectors. This is because the majority of the transactions of the Chemicals sector are with the external sector. As detailed in Table 5.4.1 60% of costs are from imports, and 62% of incomes are from exports. This is also reflected in the impact on GRP of the exogenous demand shock to that sector.

Figure 5.4.1 details the aggregate GRP effects of the £500m demand stimulus to each sector by its components i.e. OVA and Labour income. On average, the £500m demand stimulus generates £438m in GRP. The main components of GRP are on average 40% OVA, and 60% wages.

Table 5.4.1: Effects of a £500m exogenous demand stimulus

£500m demand stimulus to Sector ->	S1	S2	S3	S4	S5	S6	S7	S8	S9
1. Agriculture, forestry and fishing	584	4	72	24	2	8	4	4	6
2. Mining	3	522	3	4	20	19	3	13	8
3. Food, drink and tobacco	27	8	549	11	4	10	9	7	10
4. Textile, leather, wood and paper	10	4	12	603	3	13	8	4	13
5. Chemicals	27	11	12	17	517	26	10	9	9
6. Rubber, plastic, cement and iron	7	5	12	6	3	538	14	3	21
7. Computer, electrical and transport eq.	28	32	26	30	16	56	624	32	49
8. Electricity, gas and water	35	47	32	48	13	42	30	765	25
9. Construction	14	50	10	15	6	12	11	18	658
10. Wholesale and retail	64	40	56	58	36	67	65	42	58
11. Land transport	20	17	17	23	5	18	11	8	12
12. Water transport	1	6	1	1	1	1	1	1	1
13. Air Transport	2	5	2	2	1	3	3	2	3
14. Post and support transport services	11	11	11	12	5	11	10	9	10
15. Accommodation	5	5	4	4	2	5	4	4	5
16. Food & beverage services	9	10	10	10	4	11	11	8	11
17. Telecommunication	11	7	8	9	3	8	8	7	10
18. Computer and information services	1	2	2	2	1	2	2	2	2
19. Financial services	28	20	21	23	9	22	21	18	24
20. Real estate	30	24	27	29	12	30	29	23	35
21. Professional services	36	58	30	26	14	24	33	25	52
22. Research and development	0	2	1	1	1	1	1	1	1
23. Public administration	22	24	23	24	11	24	25	21	30
24. Recreational services	6	8	6	6	3	6	6	6	7
25. Other services	6	6	5	5	2	6	6	5	6
Total output	987	926	951	994	694	962	953	1,036	1,064
Labour skilled	92	107	116	140	58	137	174	105	167
Labour unskilled	79	59	102	127	30	149	102	66	111
Other value added	265	272	192	116	113	118	112	205	187
Taxes on expenditure	- 64	34	27	37	22	53	36	43	35
Corporate	221	227	166	109	96	112	107	174	167
Total Households	282	280	300	319	135	339	327	258	360
Household 1	13	12	15	17	6	19	16	12	17
Household 2	16	14	18	20	7	22	18	14	20
Household 3	33	30	36	40	15	44	38	29	42
Household 4	52	51	58	64	25	69	64	48	69
Household 5	168	173	173	178	83	185	192	156	211
GDP effect	436	438	409	383	200	403	388	377	466
Wage rate skilled (£)	16,637	29,212	32,811	29,878	38,399	37,936	40,818	38,590	29,945
Wage rate unskilled (£)	10,828	22,512	25,020	24,022	27,017	33,335	30,812	29,573	24,069
Total FTE Employment	12,853	6,285	7,603	9,955	2,596	8,067	7,579	4,965	10,205
FTE employment skilled	5,551	3,675	3,530	4,674	1,502	3,608	4,254	2,725	5,578
FTE employment unskilled	7,301	2,610	4,074	5,281	1,094	4,458	3,325	2,239	4,627

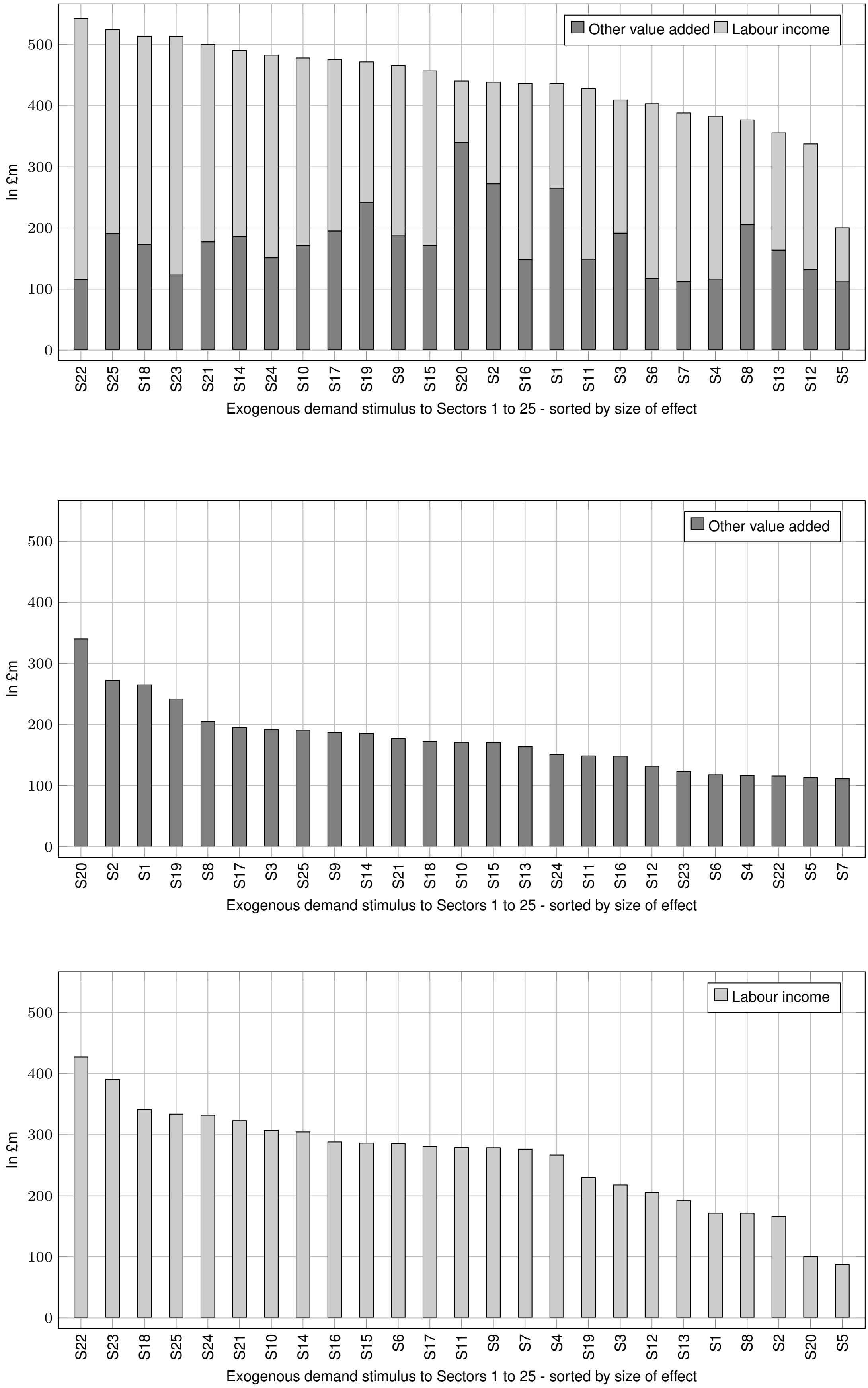
Table 5.4.1 continued: Effects of a £500m exogenous demand stimulus

£500m demand stimulus to Sector ->	S10	S11	S12	S13	S14	S15	S16	S17	S18
1. Agriculture, forestry and fishing	6	5	6	4	5	14	20	5	5
2. Mining	3	3	3	3	2	2	2	2	2
3. Food, drink and tobacco	17	10	9	9	11	53	73	10	11
4. Textile, leather, wood and paper	6	4	3	3	4	6	6	9	5
5. Chemicals	9	33	34	42	8	10	8	8	7
6. Rubber, plastic, cement and iron	5	6	3	2	3	3	3	7	3
7. Computer, electrical and transport eq.	18	21	37	27	17	13	13	23	18
8. Electricity, gas and water	27	26	18	19	24	28	26	24	24
9. Construction	23	13	16	15	21	15	13	24	10
10. Wholesale and retail	555	54	37	37	49	50	52	50	53
11. Land transport	29	516	8	7	17	12	11	11	9
12. Water transport	1	1	544	1	3	1	1	1	1
13. Air Transport	4	3	5	514	8	3	3	3	3
14. Post and support transport services	41	70	111	43	617	12	13	17	12
15. Accommodation	7	5	4	5	5	510	5	5	6
16. Food & beverage services	14	11	8	11	12	12	512	12	13
17. Telecommunication	13	12	10	10	14	13	11	551	12
18. Computer and information services	4	5	5	10	7	4	3	5	508
19. Financial services	28	22	19	23	24	24	23	24	24
20. Real estate	47	32	28	30	35	35	34	36	36
21. Professional services	44	46	40	38	45	38	33	37	72
22. Research and development	1	1	1	1	1	1	0	1	1
23. Public administration	29	41	23	26	32	29	27	31	33
24. Recreational services	7	6	5	6	7	8	7	12	9
25. Other services	7	6	7	8	8	8	8	10	7
Total output	945	953	985	893	981	903	909	919	884
Labour skilled	160	143	125	114	160	163	149	194	265
Labour unskilled	147	136	80	78	144	123	139	87	76
Other value added	171	149	132	164	186	171	148	195	173
Taxes on expenditure	54	56	56	66	41	64	75	41	40
Corporate	155	136	118	142	167	154	136	174	160
Total Households	383	345	263	262	386	361	354	366	418
Household 1	20	19	13	13	20	18	19	16	17
Household 2	23	21	15	14	23	21	22	18	19
Household 3	48	43	31	30	48	43	44	40	43
Household 4	76	69	51	50	76	70	70	69	77
Household 5	216	193	155	155	219	208	198	223	263
GDP effect	478	428	337	355	490	457	437	476	514
Wage rate skilled (£)	26,681	28,348	34,781	37,727	32,765	22,288	20,975	33,622	31,285
Wage rate unskilled (£)	21,053	21,066	27,440	30,405	26,602	16,901	16,013	24,998	21,773
Total FTE Employment	12,984	11,497	6,521	5,582	10,314	14,610	15,800	9,247	11,955
FTE employment skilled	6,011	5,051	3,607	3,016	4,884	7,307	7,088	5,761	8,477
FTE employment unskilled	6,973	6,446	2,914	2,566	5,430	7,304	8,711	3,486	3,479

Table 5.4.1 continued: Effects of a £500m exogenous demand stimulus

£500m demand stimulus to Sector ->	S19	S20	S21	S22	S23	S24	S25	All sectors
1. Agriculture, forestry and fishing	4	3	5	7	6	6	6	33
2. Mining	2	1	2	3	2	2	2	25
3. Food, drink and tobacco	10	6	12	14	13	14	13	37
4. Textile, leather, wood and paper	5	3	5	7	7	7	6	30
5. Chemicals	6	4	7	15	12	8	9	34
6. Rubber, plastic, cement and iron	2	2	3	3	3	4	3	27
7. Computer, electrical and transport eq.	12	9	14	18	27	17	18	48
8. Electricity, gas and water	21	13	26	38	33	33	28	58
9. Construction	17	44	14	17	16	18	13	43
10. Wholesale and retail	42	29	51	61	58	51	53	71
11. Land transport	9	5	11	13	14	11	10	33
12. Water transport	1	1	1	1	1	1	1	23
13. Air Transport	5	2	4	7	3	4	3	24
14. Post and support transport services	24	7	13	15	12	11	11	45
15. Accommodation	7	3	6	7	8	6	6	25
16. Food & beverage services	11	8	13	16	16	13	14	31
17. Telecommunication	17	7	13	13	13	15	12	32
18. Computer and information services	6	2	4	5	3	4	4	24
19. Financial services	611	63	24	29	28	24	25	48
20. Real estate	36	523	36	44	42	36	39	52
21. Professional services	48	25	599	91	38	70	46	64
22. Research and development	1	0	1	509	2	1	1	21
23. Public administration	30	31	52	64	571	33	38	52
24. Recreational services	7	4	9	10	9	538	15	29
25. Other services	7	4	9	11	10	26	521	28
Total output	938	801	933	1,016	944	952	897	937
Labour skilled	155	66	228	354	284	209	206	163
Labour unskilled	75	34	95	73	106	122	128	99
Other value added	242	340	177	116	123	151	191	176
Taxes on expenditure	51	20	40	- 11	52	53	49	39
Corporate	207	277	162	121	124	142	173	157
Total Households	332	239	401	483	449	400	418	338
Household 1	14	9	17	18	19	19	20	16
Household 2	17	11	20	20	22	22	23	18
Household 3	36	25	44	48	48	46	48	39
Household 4	61	41	76	89	85	77	80	65
Household 5	204	153	245	308	274	235	246	200
GDP effect	472	440	500	543	513	483	524	438
Wage rate skilled (£)	39,131	26,197	26,358	36,922	34,412	24,605	21,905	29,679
Wage rate unskilled (£)	27,464	20,551	17,382	22,458	24,149	18,862	21,532	21,996
Total FTE Employment	6,683	4,183	14,112	12,841	12,648	14,999	15,327	9,976
FTE employment skilled	3,970	2,518	8,637	9,583	8,258	8,506	9,387	5,486
FTE employment unskilled	2,714	1,664	5,475	3,258	4,390	6,492	5,940	4,490

Figure 5.4.1: Aggregate GRP effects by component for a £500m exogenous demand stimulus to each sector



Note: see Table 5.4.1 for full set of results.

Figure 5.4.1 shows that the demand stimulus to the Research & development sector, S22, yields the largest increase in GRP, followed by the Other services sector. The £513m in GRP generated by the stimulus to the Research & development sector is driven mainly by wages (80% of GRP) - this sector itself is the most wage intensive sector in the Scottish economy.

Due to its weak demand linkages to other Scottish sectors, the stimulus to the Chemicals sector generates a very modest increase in GRP (£200m) of which 60% are generated by OVA and 40% are generated by wages. Sector 20, Real estate, is the most capital intensive sector, and has relatively low wage costs, so that the overall overall GRP effect of £440m is mainly driven by OVA (80%). The demand stimulus to sector 19, Financial services, generate a relatively even increase in OVA and wages, where the GRP effect is £472m, of which £242m are OVA, and £230m are wages.

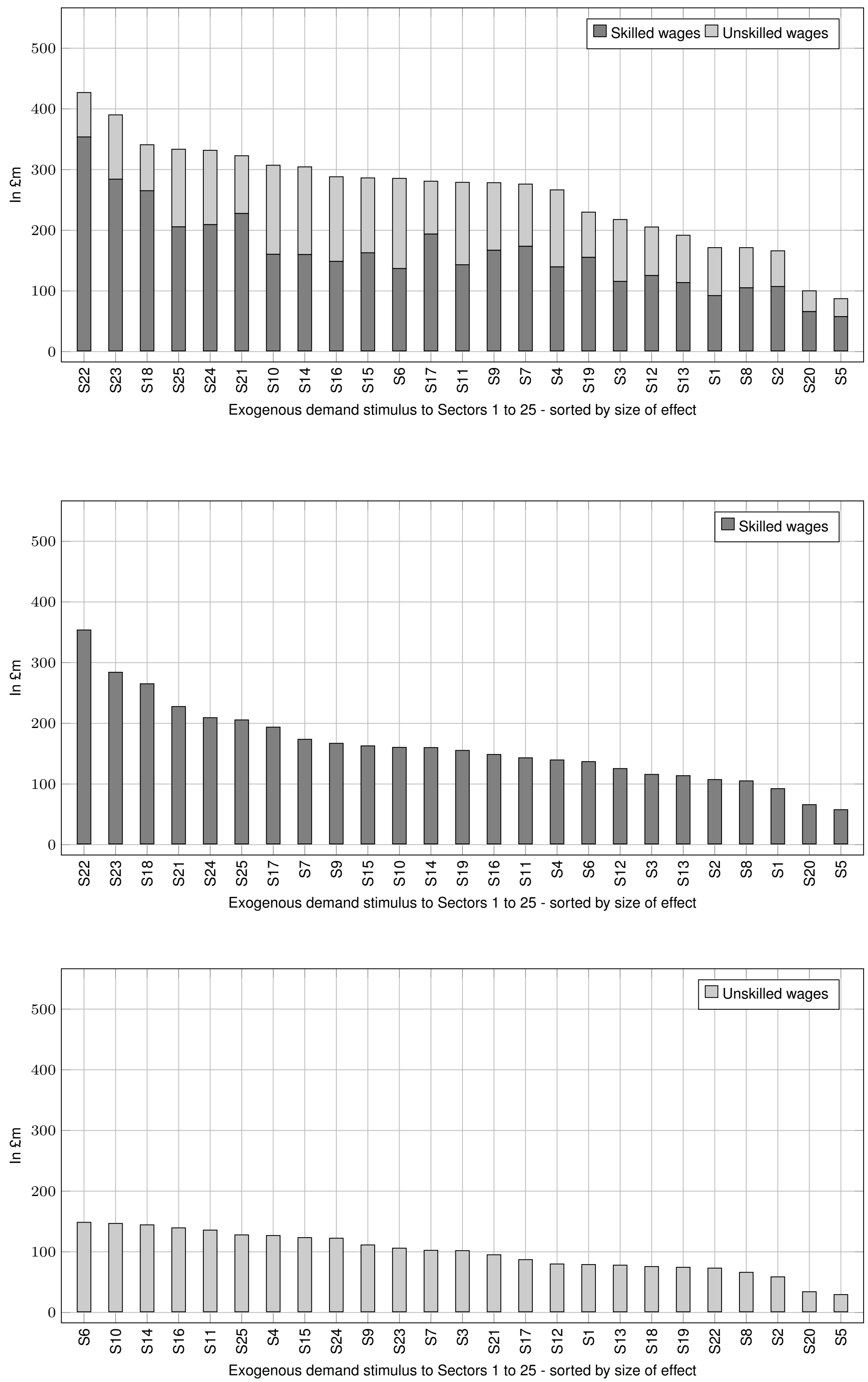
Figure 5.4.2 details the aggregate wage effects of the £500m demand stimulus to each sector by skill category. Taking into account the direct, indirect, and induced effects shows that there are a number of sectors that generate very modest wage effects. As detailed previously, the stimulus to sector 5, Chemicals, is again ranked lowest with a total wage effect of £87m. This is followed by sector 20, Real estate, with £100m, sector 2, Mining, with £166m, and sector 1, Agriculture, forestry & fishing, with £171m. In contrast, the stimulus to sector 22, Research & development, generates by far the largest wage effect of £427m.

Figure 5.4.3 details the aggregate FTE employment effects of the £500m demand stimulus to each sector by skill category. On average there are 9,976 jobs created throughout the Scottish economy as a result of the £500m demand stimulus. This is on average 5,486 skilled FTE jobs, and 4,490 unskilled FTE jobs.

There are a number of sectors that generate a significant amount of FTE jobs. For example, the stimulus to sector 16, Food & beverage services, generates 15,800 FTE jobs. Large FTE employment effects are also seen in sector 25, Other services, with 15,327 FTE jobs, and sector 24, Recreational services, with 14,999 FTE jobs. There are, however, some sectors where where the effect on employment is rather weak. As detailed previously, sector 5, Chemicals, generates little demand effects due to it structural composition and thereby only generates 2,596 FTE jobs.

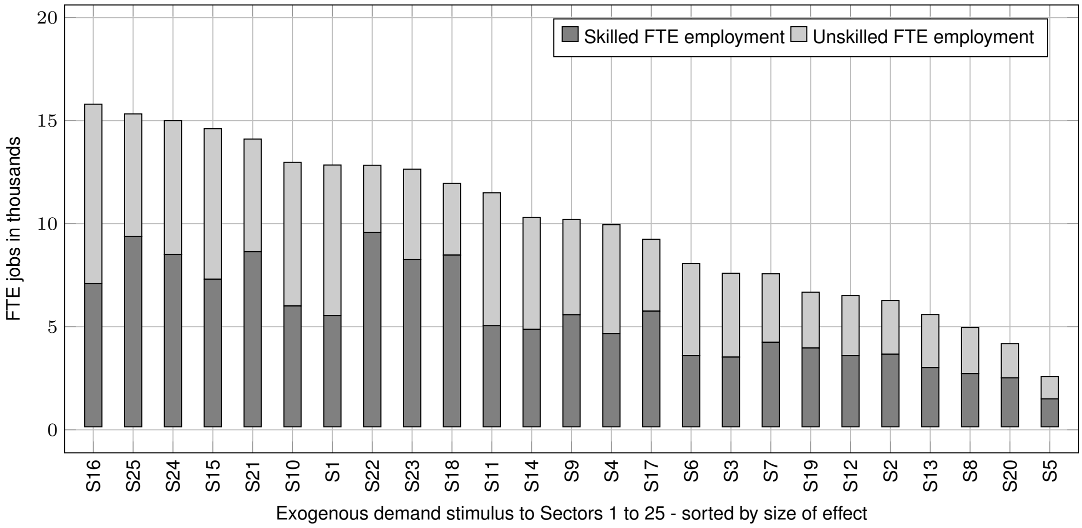
A somewhat surprising results is the skill intensity of the effects on FTE employment. To recall, there are 2,229,931 full time equivalent (FTE) workers, of which 1,302,392 (58%) are skilled and 927,540 (42%) are unskilled. The £500m exogenous stimulus generates 9,976 FTE jobs, 5,486 of which are skilled, and 4,490 are unskilled (see very last column in Table 5.4.1). This represents a 0.42% increase in skilled, and 0.48% increase in unskilled FTE jobs from their base. This poses the question whether components of exogenous expenditures follow the same pattern. This is discussed in more detail in Section 5.5.

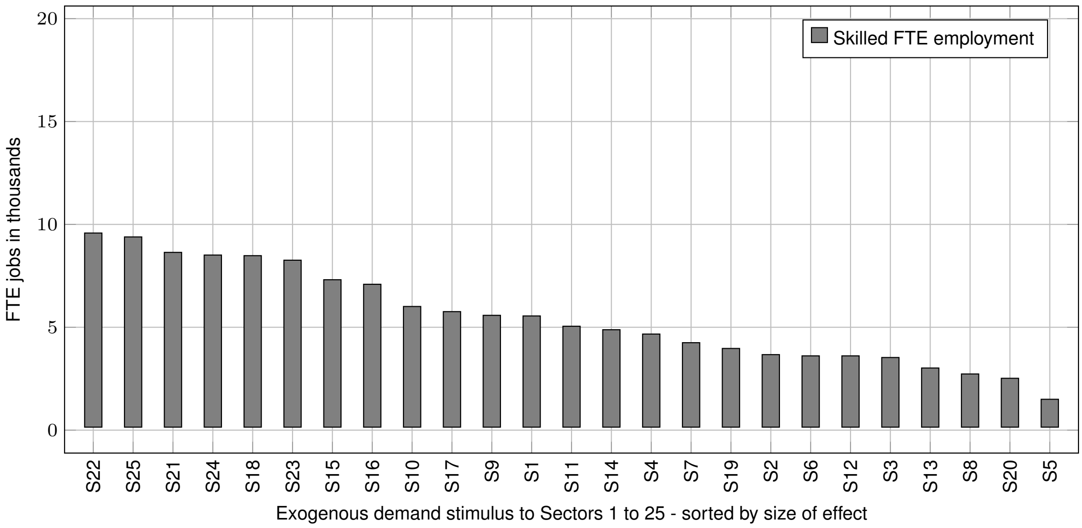
Figure 5.4.2: Aggregate labour income effects by skill category for a £500m exogenous demand stimulus to each sector

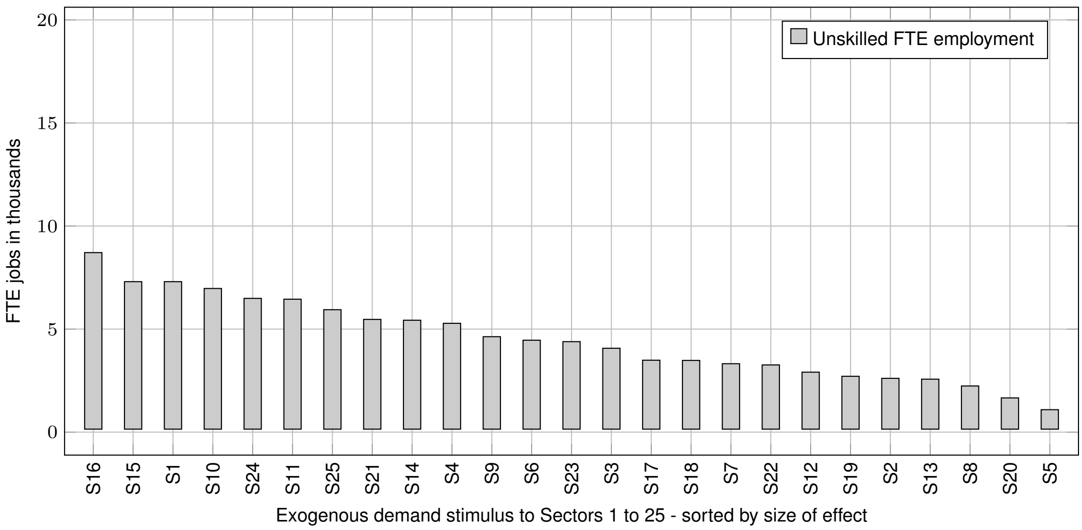


Note: see Table 5.4.1 for full set of results.

Figure 5.4.3: Aggregate employment effects by skill category for a £500m exogenous demand stimulus to each sector



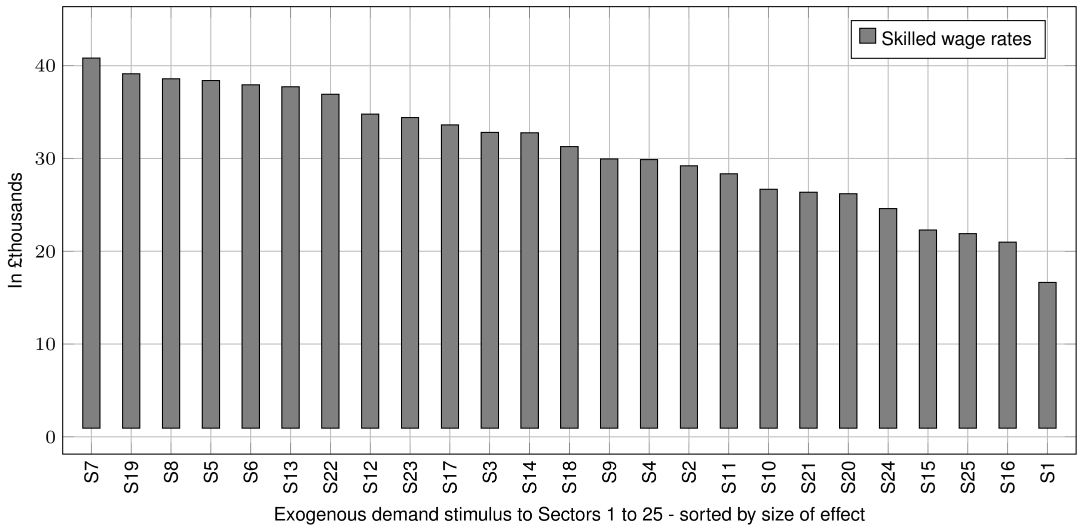


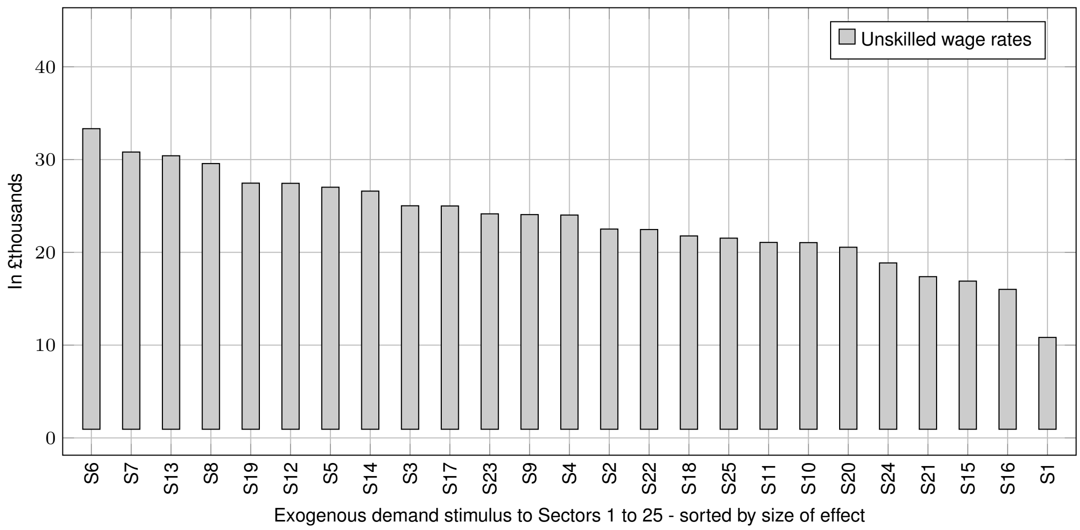


Note: see Table 5.4.1 for full set of results.

Taking into consideration the ratio between the additional wages, and the additional FTE jobs generated by the stimulus the 'quality' of these jobs can be assessed. Figure 5.4.4 gives the skilled and unskilled wage rates for a £500m exogenous demand stimulus to each sector. On average, total wage rates are £26,221 per average FTE job. This is £29,679 on average for a skilled FTE job, and £21,996 for a unskilled FTE job.

Figure 5.4.4: Aggregate effects on wage rates for a £500m exogenous demand stimulus to each sector





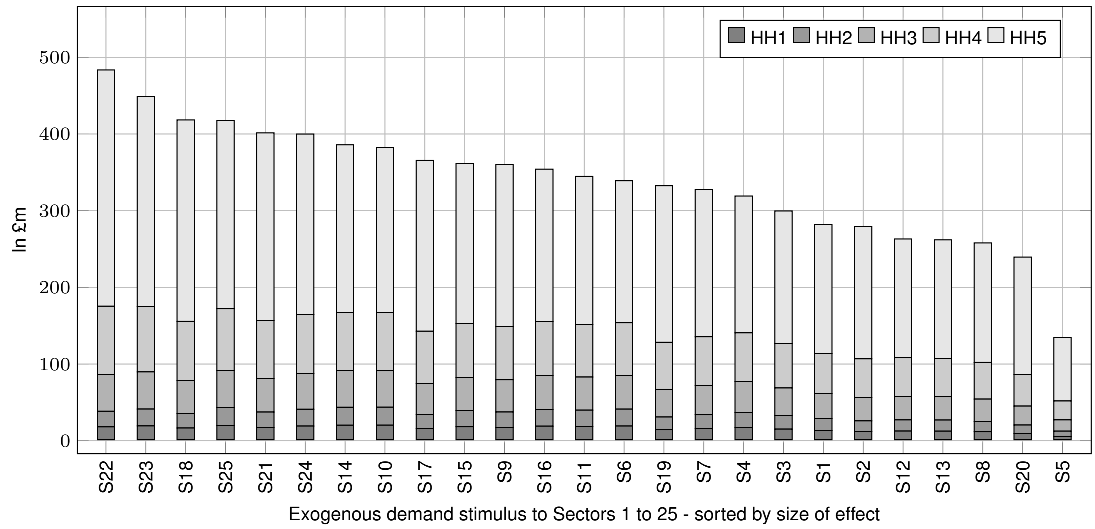
Note: see Table 5.4.1 for full set of results.

On aggregate (total wages over total FTE jobs) the lowest paying jobs are seen when sector 1, Agriculture, forestry & fishing, is stimulated with £13,337 per FTE job, followed by the stimulus to sector 16, Food & beverages services, with £18,239 per FTE job, and sector 15, Accommodation, with £19,595 per FTE job. In contrast, the highest paying jobs are seen when sector 7, Computer, electrical & transport equipment, is stimulated with £36,428 per FTE job.

The lowest paying skilled FTE jobs are seen when sector 1, Agriculture, forestry & fishing, is stimulated (£16,637), and the highest paying when sector 7, Computer, electrical & transport equipment, is stimulated (£40,818). Again, the lowest paying unskilled FTE jobs are seen when the Agriculture, forestry & fishing is stimulated (£10,828), and the highest when sector 6, Rubber, plastic, cement & iron, is stimulated (£33,335).

Figure 5.4.5 details the aggregate Household income effects of the £500m demand stimulus to each sector across each of the five household groups. On average total Household income increases by £338m as a result of the £500m demand stimulus. On average the demand stimulus increase the incomes of Households 1 to 5 by £16m, £18m, £39m, £65m, and £200m respectively. Given the fixed coefficient assumptions, the demand stimulus thereby disproportionally benefits the highest household income group, Household 5, on aggregate.

Figure 5.4.5: Aggregate Household income effects for a £500m exogenous demand stimulus to each sector

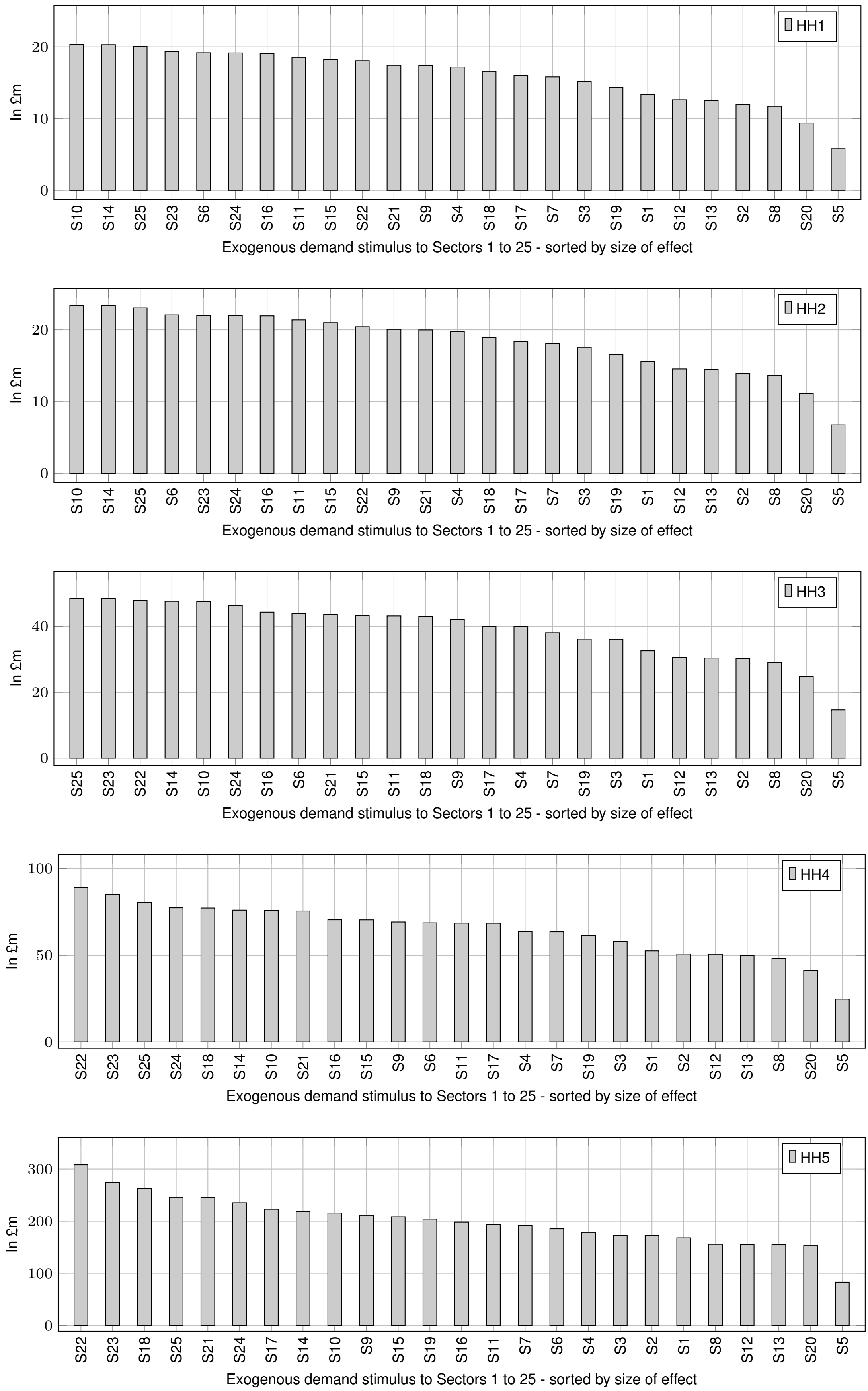


Note: see Table 5.4.1 for full set of results.

Figure 5.4.5 shows that the sector with the weakest impact on household incomes is sector 5, Chemicals, which is due to its demand linkages to the external sector. Sector 20, Real estate, also ranks low as it has by far the lowest labour costs as share of output with only 3%. In contrast, sectors 22 and 23, Research & development, and Public administration, both have strong income linkages to households with very large labour costs of output shares, 54% and 51% respectively.

Figure 5.4.6 ranks the size of the impact across each of the five household groups for the £500m exogenous demand stimulus to each sector. The results show that there are sizeable differences between the five household groups depending on the sector that experiences the direct stimulus.

Figure 5.4.6: Aggregate income effects by household group for a £500m exogenous demand stimulus to each sector



Note: see Table 5.4.1 for full set of results.

Figure 5.4.6 shows that sectors 5, Chemicals, and 20, Real estate, are ranked lowest irrespective of the household income group. Also, sectors 13, Air transport, 2, Mining, 8, Electricity, gas & water, and 12, Water transport are always within the lowest five irrespective of the household income group (even though the ranking can differ across households).

When considering only the top five sectors with the largest impacts on each household group it can be seen that the demand stimulus to sector 25, Other services, and 23, Public administration, has significant positive income effects across all household groups (even though the ranking varies across households). Although the five household groups have these sectors in common, there are significant differences within the top five.

Figure 5.4.6 shows Households 1-2 benefit largely from the demand stimulus to sectors 10, 14, and 6, Wholesale & retail, Post & support transport services, and Rubber, plastic, cement and iron respectively. Households 3-4 have sector 22, Research & development in common, but Household 3 also sees strong income linkages with the stimulus to sectors 14, Post & support transport services, and 10, Wholesale & retail. The stimulus to sector 24, Recreational services generates a large amount of incomes to Household 4. Sector 18, Computer & information services, is strongly connected to Households 4 and 5. The stimulus to sector 21, Professional services, seems to generate large incomes to Household 5. The following section disaggregates the exogenous expenditures to identify the skill intensity of these components.

5.5 Skill intensity of exogenous expenditures

The results of the exogenous demand shock, as detailed in Section 5.4, show that production and activity accounts tend to be more unskill intensive, where skilled employment increases by 0.42% and unskilled employment by 0.48%. The percentage increase thereby gives the skill intensity as compared to the average, as the weighted sum of all exogenous expenditure impacts are skill neutral in the sense that they replicate existing skill disaggregation. The skill intensity of exogenous expenditures may, however, differ from this. The skill composition of direct and indirect effects of Government, Investment, Tourism, and RUK & ROW export expenditures are analysed using the SAM model employed in Section 5.4. This is implemented by using the actual figures of exogenous expenditures by sector as the values for exogenous demand shock.

For example, when identifying the skill intensity of the exogenous Government expenditures a £29,486m demand shock is modelled (see aggregate SAM in Table 5.3.1). Similarly, for RUK export a value of £35,768m is used for the demand shock. The percentage changes of skilled and unskilled employment from the SAM model then give the skill intensity of these exogenous expenditures, as summarised in Table 5.5.1.

When using Government expenditures for the values of the exogenous demand shock the results show that skilled employment increases by 37%, and unskilled employment increases by 28%. The results thereby show that Government expenditures are more skill intensive. In contrast, the results for Capital, Tourism, and export expenditures show that these components of final demand expenditures are more unskill intensive.

Table 5.5.1: Skill intensities of exogenous final demand expenditures. In % changes

	Government	Capital	Tourism	RUK exports	ROW exports
Skilled employment	37	12	2	26	12
Unskilled employment	28	14	3	28	14

The skill intensity of the Government expenditures comes as no surprise since the sector that mainly serves public sector consumption, Public administration, is highly skill intensive. To recall from Chapter 2, the Public administration sector is by far the largest sector in terms of employment. It employs 27% of the total workforce with 610 thousand workers, and 71% of these are skilled. It is also the largest sector in terms of labour incomes. 32% of total wage incomes (£20,512m) are generated in that sector.

However, a somewhat surprising results is that tourism and exports to the RUK and the ROW are more unskill intensive. To recall, the Scottish Government (2015) has set out an over-arching economic growth strategy to achieve a more productive, cohesive and fairer Scotland. Scotland's Economic Strategy focuses on the two mutually 'supportive goals' of increasing competitiveness and tackling inequality and this is underpinned by four growth priorities. One of the priorities focuses on making better use of skills in the workplace, increasing the skilled workforce, and providing jobs that are highly skilled. Moreover, the skill dimension is also a key avenue for tackling a range of issues from poverty and income inequality to health and life expectancy, as addressed by the objective of inclusive growth. This strategy aims to, at least in part, to tackle poverty and get people back into work (Scottish Government, 2015). The remaining key policy areas are focused on promoting Scotland on the international stage to boost trade and investment. Given this, it was expected that an export led growth strategy would bring about a significant stimulus to the skilled labour market.

The skill intensity of Scottish exports is reconsidered in Chapter 7 where a CGE model is employed for a similar set of simulations. The CGE model, however, takes into account different assumptions about the supply of skilled and unskilled labour which in turn may generate results that do not follow the structural pattern identified in the SAM model.

5.6 Summary and policy implications

The SAM can be considered as an extended IO table which not only records macroeconomic-aggregates and their sectoral disaggregation but also the distribution and redistribution of income. A strength of SAM modelling techniques is thereby to reveal structural components of income and expenditure linkages in the economy as these affect relative and absolute incomes. The SAM is use in this analysis to quantify the impacts of an exogenous demand shock across the Scottish economy in a skill- and household-disaggregated SAM modelling context. To allow for a systematic comparison across sectors, an exogenous demand shock of £500m is modelled for each of the 25 sectors contained in the SAM. This shock is motivated by the efforts of the Scottish Government to increase international exports (Scottish Government, 2015) and the assessment of potential trade-offs between other growth policies.

The £500m exogenous demand stimulus yields a £937m increase in total output, and a £438m GRP effect on average. The results show that there are a number of sectors that have strong domestic demand linkages. For example, the stimuli to the Electricity, gas & water sector and the Construction sector generate relative large increases in total output, £1,036m and £1,064m respectively. In contrast, the stimulus to the Chemicals sector yields limited output effects of £694m as it has few linkages to other Scottish sectors. This is because the majority of the transactions of the Chemicals sector are with the external sector. This is also reflected in the GRP effect, £200m, of the exogenous demand shock to that sector.

There are sectors which yield relatively large increases in GRP. For example, the stimulus to the Research & development sector generates a large effect on GRP, £543m, driven mainly by a stimulus to wages. A stimulus to the most capital intensive sector, Real estate, generates a relatively large increase in GRP, £440m, which is in turn mainly driven by OVA. Sectoral characteristics are therefore crucial in determining the effects on output and GRP.

These differences across sectors are also reflected in the skilled and unskilled labour markets. The exogenous stimulus to each sector generates direct, indirect, and induced wage effects. On average the £500m exogenous demand stimulus generates £163m in wages for the skilled, and £99m in wages for the unskilled. There are a number of sectors where the demand stimulus generates very modest wage effects. The Chemicals sector is again ranked lowest in terms of the generated wage effect with £87m, followed by the Real estate sector, with £100m. In contrast, the stimulus to the Research & development generates by far the largest wage effect with £427m.

There are a number of sectors that generate a significant positive impact on FTE jobs when stimulated. For example, the stimulus to the Food & beverage services sector, the Other services sector, and the Recreational services sector generate relatively large FTE employment effects with 15,800, 15,327, and 14,999 FTE jobs respectively. In contrast, a stimulus to the Chemicals sector generates little employment demand due to it structural composition and so only generates 2,596 FTE jobs. On average there are 9,976 jobs created throughout the Scottish economy as a result of the £500m demand stimulus. This is on average 5,486 skilled FTE jobs, and 4,490 unskilled FTE jobs, a 0.42% increase in skilled employment, and a 0.48% increase in unskilled employment. The results of the exogenous demand shock thereby show that the production and activity accounts tend to be more unskill intensive in response to an exogenous demand shock. This poses the question whether components of exogenous expenditures follow the same pattern.

Taking into consideration the ratio between the additional wages, and the additional FTE jobs generated by the stimulus the 'quality' of these jobs can be assessed. On average, total wage rates are £26,221 per average additional FTE job. This is £29,679 on average for a skilled FTE job, and £21,996 for a unskilled FTE job. The lowest paying skilled FTE jobs are seen when the Agriculture, forestry & fishing sector is stimulated, £16,637, and the highest paying when the Computer, electrical & transport equipment sector is stimulated, £40,818. Similarly, the lowest paying unskilled FTE jobs are seen when the Agriculture, forestry & fishing is stimulated, £10,828, and the highest when the Rubber, plastic, cement & iron, is stimulated, £33,335.

Total Household income increase on average by £338m as a result of the £500m demand stimulus. On average the demand stimulus increases the incomes of Households 1 to 5 by £16m, £18m, £39m, £65m, and £200m respectively. This indicates that over 59% goes to the top 20% of households and only 5% to the bottom 20%. The exogenous demand shock thereby does not benefit the lowest household income bands much due to their weak links with the labour market.

This ability to assess potential impacts on individual household income groups is of particular importance to the Scottish Government as the policy of inclusive growth aims to tackle a range of issues from poverty and income inequality to health and life expectancy. Results presented here show that these exogenous demand shocks would have negative effects on income equality.

There are a number of sectors that the Scottish Government (2014) deem vital for their economic growth strategy. A subset of the sectors with particular policy attention are: Food & drink, Accommodation - due to its tourism linkages, and the Financial services sector. It must be noted that it is problematic to disentangle precisely the 'key growth sectors' from the sectoral aggregation provided in the IO tables. The exogenous demand stimulus to these three key growth sectors, however, tends to generate only modest effects on GRP, skilled and unskilled FTE employment, and wage rates. The rationale for key sector status, as defined by the Scottish Government (2014) [3], may thereby not be reflected within the SAM modelling results. This is discussed in more detail in Chapter 7 where a CGE model is employed to analyse export demand shocks to key growth sectors.

[3]The rationale for key sector status is given as: "Scotland has distinctive capabilities and businesses with the potential to be internationally successful in areas of global demand; they currently account for a significant part of the Scottish economy and reflect the contribution of all areas of Scotland; and government intervention can make a significant difference to future success by facilitating or accelerating development in areas where the market alone cannot deliver the best outcome" (Scottish Government, 2014).

A large part of Scottish Government (2014) growth policies focuses on stimulating exports. These economic growth policies are in turn linked with objectives to tackle inequality, increase the skilled workforce, and to provide jobs that are highly skilled. Results presented here, however, suggest that exports (to both the RUK and the ROW) tend to be more unskilled intensive than the average. An export led growth strategy would thereby bring about a stimulus to the labour market which is biased towards the unskilled. This is reconsidered in Chapter 7 where a CGE model is employed for a similar set of simulations.

The results presented here emphasise the importance of detailing results at meso-level with emphasis on analysing the distribution and redistribution of incomes. Moreover, the analysis presented here brings to attention key structural characteristics at sectoral and aggregate level. More detailed information on structural characteristics of the Scottish economy is of importance to policy makers in order to achieve and/or maximise their economic growth objectives.

The SAM multiplier analysis is subject to the limitations imposed by the underlying IO framework, which are, inter alia, fixed coefficient technologies, an absence of capacity constraints and an infinitely elastic supply of labour. A potential limitation of the skill-disaggregated SAM model is the assumption that both skilled and unskilled workers are available with an infinitely elastic supply. This is addressed in this thesis in Chapters 6 to 8 where a CGE is employed that allows for skill-differentiated migration responses.

Chapter 6

Chapter 6

The skill-disaggregated AMOS model

6.1 Introduction

A review of innovations in regional computable general equilibrium (CGE) modelling concluded that "more work needs to account for the interaction of skilled worker migration and agglomeration economies, as well as any resulting spillover effects" (McGregor et al., 2010, p.1309). Model extensions presented here develop a better understanding of a skill-disaggregated labour market and the impact of skill-differentiated migration responses. The skill-disaggregated AMOS model (A Micro-Macro Model for Scotland) builds upon and expands the 'standard' AMOS model (Harrigan et al., 1991). The AMOS model is a computable general equilibrium modelling framework which provides a great deal of flexibility in functional form, parameter values and behavioural assumptions concerning the operation of different markets. The AMOS model, and various extensions, have been used as the basis for a wide array of academic and policy-driven research. The skill-disaggregated AMOS model enhances the standard model with a more detailed treatment of the labour market. This extension focuses on incorporating two types of labour which are distinguished by their education levels. Section 6.2 gives a general description of theoretical principles underlying CGE modelling and a description of its central components and characteristics (whilst acknowledging that the structure and key features of CGE models now vary widely). Section 6.3 provides a general overview of skill disaggregation relevant to this research. Section 6.4 details the technical specifications of the AMOS model and the skill related modifications and extensions introduced into the model.

6.2 Theoretical background

This section aims to briefly outline the core concepts of a Computable General Equilibrium (CGE) model and to identify its strengths and weaknesses for policy analysis. CGE models have their roots in 'general equilibrium' concepts introduced by Walras (1874). These were further developed by a number of researchers, such as Arrow and Debreu (1954); McKenzie (1960); Debreu (1959), and Leontief (1986), which ultimately resulted in modelling approaches that still stand today.

General equilibrium (GE) concepts are summarised in Shoven and Whalley (1992) to be: a system of simultaneous equations which represent market equilibrium conditions, where an equilibrium is characterised by a set of prices levels of production in each industry such that demand equals supply for all commodities simultaneously. This definition is based on work by Debreu (1959), and others, who specified the necessary conditions for a competitive equilibrium to exist.

Johansen (1960) research is considered to be a forerunner of modern CGE models. Johansen (1960) produced one of the first attempts to analytically solve a multi-sectoral economic model in a linearised equilibrium system in his work on 'A Multi-Sectoral Study of Economic Growth' (Dixon & Parmenter, 1996). A 'fixed output stochastic model' is employed around a benchmark data set for Norway for 1950. The data set takes a matrix form of the national accounts data of that year, in the spirit of an Input-Output model. Johansen (1960) is thereby accredited with the development of CGE models in that his research linked an input-output database with national accounts data and a series of macro balancing equations (Mitra-Kahn, 2008).

Research by Scarf (1967a, 1967b) is considered to be central in the transformation from the GE model to the AGE approach i.e. from a purely theoretical framework to an operational model that could aid policy decision-making. Scarf (1967a, 1967b) developed an algorithm to compute a Walrasian general equilibrium. This algorithm was employed by Shoven and Whalley (1984) to construct and solve a CGE model based explicitly on a Walrasian general equilibrium framework.

Today the AGE and CGE approaches initiated by Johansen (1960), Scarf (1967a, 1967b), and others are summarised as: calibrating and benchmarking observed data on economies into an initial equilibrium data set to allow for counterfactual policy analysis (Kehoe et al., 2005).

Even though the application of policy-orientated CGE models for national economies increased drastically following publications by authors such as Miller and Spencer (1977), and Shoven and Whalley (1972), applications to regional economies are more recent. One possible reason for the slow start to regional CGE modelling is that the required data are more likely to be available at national rather than regional levels (Partridge & Rickman, 1998).

Regional CGE models generally follow in the tradition of national patterns. That is, regional CGE models tend to use convenient expressions for production and consumption, make simplifying assumptions regarding market behaviour, and use similar methods of parameterisation and solution. The openness of the regional economy, however, suggests some desired structural divergences between the national and the regional CGE models (Partridge & Rickman, 1998).

Despite the relative slow initial adoption, recent surveys of the literature show that regional CGE models are now widely adopted as standard tools for regional economic development analysis (Partridge & Rickman, 2010; McGregor et al., 2010; Giesecke & Madden, 2013).

The adoption of CGE models has been primarily driven by policy makers and their need for a flexible tool which can accommodate both demand- and supply-side impacts. However, the structure and key features can vary significantly depending on their application and origin. The following gives a stylised overview of basic features of CGE models.

CGE models comprise a detailed database of actual economy-wide income and expenditure flows at a particular point in time which can capture interdependencies across sectors in the economy, and a set of equations capturing behavioural and technical relationships (Shoven & Whalley, 1992).

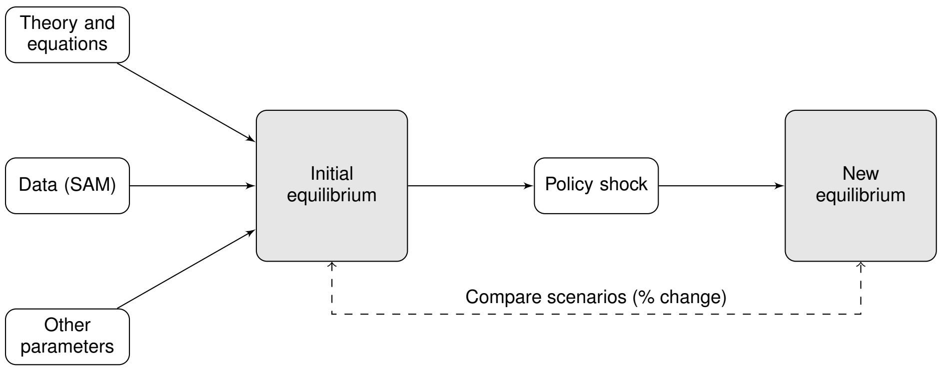
The equations in the model tend to be neoclassical in spirit where households maximise their utility subject to a budget constraint, and firms maximise their profits (minimise costs) under competition. This gives rise to demand and supply functions which are derived in accordance with consumption and production theories (Shoven & Whalley, 1992).

There are some characteristics in which CGE models are similar (even though these are by no means the defining characteristics of a CGE model). Many CGE models tend to: "be static, have two factors of production (labour, which may be disaggregated by skill level, and capital); have a limited number of commodities; model inter-industry linkages using IO fixed coefficients from an accompanying SAM database; and may assume constant returns to scale for production technologies to facilitate an equilibrium concept upon which to base the analysis" (Gilmartin, 2010, p.17).

There are, however, a number of factors that influence the structure and key features of the model, including the availability of data and solution techniques, but the precise structure of a CGE model is determined largely by the intended use of the model.

Figure 6.2.1 gives the schema of CGE modelling. The economic impacts of a policy or shock are estimated by comparing the economy before and after the shock. The 'pre-policy' baseline is generated by calibrating the model equations and the behavioural parameters to the base-year-data. The base-year-data reflect the current structure of the economy.

Figure 6.2.1: Schema of Computable General Equilibrium modelling



CGE models provide a framework to simulate policy changes and are able to trace the impact on key economic variables, including income and expenditure flows. CGE models do so by calibrating economic data to a set of equations which aim to capture the structure of the economy, and the behavioural responses of transactors. The model specifications are chosen by the modeller, and could therefore be seen as the reflection of the modeller's 'view of the world' (Greenaway et al., 1993).

The dataset which forms the backbone of the CGE model is the Social Accounting Matrix (SAM). The SAM records interrelationships at the meso-level with emphasis on distributive aspects (Keuning & de Ruuter, 1988). It is concerned with the systematic organisation of information about the economic and social structure of a country, region, or city, in a particular time period - usually a year (King, 1981).

The equations capture behavioural and technical relationships in a way that is consistent with the SAM. Actual values for some of the model's parameters, such as relative size and import intensity of sectors, are ascribed from the structural data embedded in the SAM. Key behavioural and technical parameters, such as parameters in the migration and wage setting functions and price elasticities of demand and substitution, are determined exogenously. A final set of parameter values are determined through calibration of the model. These model parameters take the form of constant terms in the relevant equations and are determined in the calibration in such a way that the model replicates the base-year-equilibrium in the absence of any shocks. This requires the assumption that the chosen benchmark data set represents an initial equilibrium (Hosoe et al., 2010; Gilmartin, 2010).

When a policy or shock is introduced to the system, the economy converges to a new equilibrium, governed by the economic relationships specified in the system of equations. The model derives a solution by finding a new set of prices and allocation of goods and factors such that the economy is in an equilibrium again. The model allows the impacts of policies and shocks to be traced through time to their new steady state (Scottish Government, 2016a).

The analysis of simulation results is primarily focused on the difference between the initial and the new equilibrium. Results are generally presented as percentage changes comparing the system before the shock to its new short/long-run equilibrium (Hosoe et al., 2010).

CGE models capture the economy's interdependencies and feedback mechanisms on both the supply and demand side and therefore allow for an adjustment in both quantities and prices following a policy or shock (Hosoe et al., 2010). CGE models are thereby suited to model demand and/or supply shocks. IO and SAM models, such as the ones used in Chapters 4 and 5, identify a subset of these mechanisms, specifically, they capture demand-side interdependences through IO linkages. These models are thereby traditionally used for demand side shocks only, and when applied to supply-side disturbances require off-model exogenous demand adjustments (Hosoe et al., 2010).

Since CGE models are grounded in economic theory, results can be explained using economic intuition, with the advantage that the economic impact can also be quantified using real data. Thus, one of the main strengths of the CGE framework is that its foundations lie within (micro)economic theory (Greenaway et al., 1993).

The following gives an overview of final demand components. It must be noted, however, that the level and nature of aggregation of a CGE model is determined by the research objective as well as data constraints. The focus in this research is on differential impacts across skill categories. The model (and the underlying data) must thereby be complex enough to identify these skill categories.

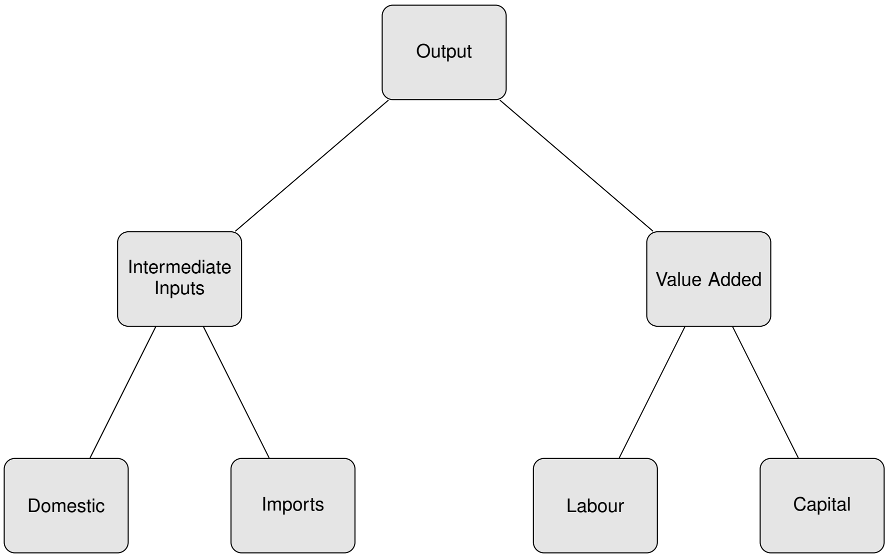
Households receive income from factor payments in the form of rent on capital and wages. This income is used to pay for households' consumption of goods and services which generates utility for households. Households then decide how much of their income is allocated across goods and services with the objective of maximizing utility subject to their budget constraint (Gilmartin, 2010). Households thereby attempt to maximise their utility from the consumption of goods and services under a budget constraint which is given as the sum of incomes - plus transfers, minus taxes depending on the model specification (Hosoe et al., 2010).

There is a set of inputs, a designated production technology, and a set of outputs to the production sector. Firms are profit maximising (cost minimising) and make supply decisions using the prices of goods and factors of production as market signals (Hosoe et al., 2010). Primary factors are purchased from households; intermediate goods from other firms. These are then used to produce outputs, which are, in turn, purchased by households. Sales revenues are used to pay the owners of factors of production and the suppliers of intermediate inputs (Gilmartin, 2010).

Figure 6.2.2 gives an example of a nested two-level production technology structure. The production technology is divided into intermediate and final goods. Depending on the model structure the inputs to production at the intermediate level can be further disaggregated into domestic- and foreign intermediate goods and services.

Primary factors of production, labour and capital, are used to produce value added. The intermediate and value added are combined to produce final outputs at the top level of the production hierarchy (Hosoe et al., 2010; Gilmartin, 2010).

Figure 6.2.2: Nested two-level production technology structure



In a CGE model with a government sector, "the role of the government is to receive income in the form of taxes and tariffs, to redistribute income in the form of subsidies and benefits, and to purchase goods and services" (Gilmartin, 2010, p.19). This again depends on the model structure. Government activities are often used to impose exogenous changes (policy shocks) on the model. An example is Emonts-Holley (2016).

The behaviour of agents in the model are predominantly determined by either Cobb-Douglas, Constant Elasticity of Substitution (CES) or Leontief functional forms. The level of produce differentiation between the domestic and the external sector is usually given by an elasticity of substitution e.g. Armington (1969).

It must be noted that the Armington assumption has implications for the decisions of both producers and consumers. The choice over imported or domestic inputs for firms depends on their relative prices, as well as the Armington elasticity. Similarly, consumers choose over imported and domestic goods depending on relative prices and the Armington value (Lecca et al., 2013; Gilmartin, 2010).

CGE models have recognised strengths and weaknesses. An extensive discussion is given in Greenaway et al. (1993); Partridge and Rickman (1998); Kehoe and Kehoe (1994); and Kehoe et al. (2005). McGregor et al. (2010); Partridge and Rickman (1998 & 2010); and West (1995) discuss regional CGE models. The following gives a brief summary of some of the main arguments.

As outlined previously in the calibration process, CGE models typically take 'key' parameter values from empirical studies. The issue there is that these values may relate to countries and/or time-periods different to the ones used in the CGE model. This is generally addressed through sensitivity analysis, as illustrated in Chapters 7 and 8 of this dissertation.

As detailed in Scottish Government (2008), the majority of CGE models represent production behaviour by using 'well-behaved' but relatively restrictive functional forms. These are typically Cobb-Douglas, CES or Leontief functional forms, and there may be limited facility for testing their appropriateness (Greenaway et al., 1993).

Another criticism is that CGE models generally assume that firms minimise costs, that consumers maximise utility and often that the source and direction of technical change is exogenous. Each is partly inconsistent with empirical evidence (Scottish Government, 2008). Also, factor inputs are often assumed to be perfectly mobile and markets to be perfectly competitive, although neither is a necessary feature of CGE models.

Some criticism is also made where modellers "assert a degree of precision over the results, which perhaps cannot be justified by the quality of information that is inputted to the model, or the extent of sensitivity of the results to assumptions that are often necessarily imposed, together with various data constraints, mean that the outcomes of CGE models must often be interpreted as 'insights' rather than absolute truths" (Gilmartin, 2010, p.55).

CGE techniques provide invaluable guidance for policy-making and enable analysts to consider the consequence of major policy changes despite these limitations. Moreover, modellers can adopt a number of approaches to attempt to minimise limitations associated with CGE models.

As detailed previously, the structure and the core elements of CGE models mainly depend on the policies to be analysed. The focus here is on labour market policies directed at (directly or indirectly) different labour market sub-groups. Given this, the next section outlines some general considerations and key distinctions CGE models must make in order to incorporate a more detailed labour market.

6.3 Labour market disaggregation

The transmission mechanism whereby government policies or macroeconomic shocks affect the labour market operates through several channels, such as changes in unemployment, labour force participation, wages, and migration. When modelling labour market related policies it is thus essential to identify precisely how the disturbance impacts on the system.

Shocks can be broadly classified into two categories. First, a shock that directly impacts the supply, demand, or price for labour (relative to capital and other intermediates). An example would be a policy that targets the supply of low-skilled workers by means of changes in the benefit system. Second, a shock that does not directly impact the labour market, yet has an indirect impact on the supply or demand for labour. This encompasses trade liberalisation, capital taxation, and would be consumption taxes (Boeters & Savard, 2011).

For example, Sørensen et al. (1997) analyse a tax cut for low incomes and consumption tax relief on low-skilled intensive services in order to stimulate low skilled employment in a model calibrated to the Danish economy. De Melo and Tarr (1992) introduce wage bargaining in the auto-mobile sector as a specific labour market feature in their analysis of trade liberalisation.

Whether policies/shocks shift the demand for labour directly or indirectly does not change the key questions. That is, to what extent the labour market is affected in terms of changes in employment, unemployment rates, real wages, and the migration responses. The model must thereby be detailed enough to separately identify these in the disaggregated labour market.

The research in this dissertation is focused on a labour market disaggregated by education levels (henceforth referred to as skills). This skilled/unskilled disaggregation has been used previously in the SAM/CGE literature by Stuttard and Frogner (2003a, 2003b), and Boeters and Savard (2011) where the cut-off point is typically a completed degree. Other studies present a labour market disaggregated by, for example, occupation (Giesecke et al., 2011), full-time and part-time labour (Hutton & Ruocco, 1999), rural and urban labour (Hendy & Zaki, 2013), age (Kim et al., 2015), or ethnicity (Maisonnave et al., 2009). The choice of aggregation again depends on the policies or shocks to be modelled.

Even though it is a given that the two skill categories require separate demand and supply functions in the CGE model whilst employing appropriate functional forms, there are some general issues that must be considered when disaggregating the labour market by skill. It must be assessed whether it is necessary to separately identify economic migration responses of the two skill categories, and whether there are differences in the way wages are determined. The following sections consider these in turn.

6.3.1 Wage determination

In the standard AMOS model, the labour market is characterised as a single (Scottish) labour market with perfect sectoral mobility. The model incorporates three wage setting closures (see Equation 6.1). This reflects an exogenous nominal wage (this can also be thought of in a regional context as national wage bargaining), fixed real wage, and regional bargaining (Lecca et al., 2013).

$$
Wage setting \begin{cases} w_t = w_{t=0} & -National\, Bargaining \\ w_t/cpi_t = w_{t=0}/cpi_{t=0} & -Fixed\, Real\, Wage \\ ln[w_t/cpi_t] = \beta - \epsilon\, ln(un_t) & -Regional\, Bargaining \end{cases} \tag{6.1}
$$

where w is the after tax nominal wage rate, cpi is the Consumer Price Index, un is the regional unemployment rate, ϵ is unemployment rate elasticity which is set to -0.133 (Layard et al., 1991), β is a calibrated parameter.

In the national bargaining (Keynesian) closure the nominal wage is set exogenously, assuming that prices in the rest of the UK are also fixed, and the aggregate labour supply function is suspended, with labour supply being infinitely elastic up to the point of full employment. Harrigan et al. (1991) suggests that this may 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).

The purchasing power of wages remains unchanged in the fixed real wage closure. This can be interpreted as a real-wage-resistance hypothesis (Lecca et al., 2013). That is to say, the nominal wage is a markup on the consumer price index. Harrigan et al. (1991) suggest that this may push real wages above a market clearing level, triggering unemployment, which could be considered involuntary from the individual's perspective. Harrigan et al. (1991) point out that this may be consistent with real wage resistance type models, but only under fairly extreme conditions such as government maintenance of full employment. This closure is currently only used as a benchmark but was employed in the past to illustrate ineffectiveness of devaluation to stimulate the economy.

The bargained real wage (BRW) closure directly relates the regional real consumption wage to workers bargaining power within the region, and therefore inversely to the regional unemployment rate. This empirical relationship between wages and the local unemployment rate is based on the 'wage curve' (Blanchflower & Oswald, 1995, Minford et al., 1994).

The BRW closure is considered the most appropriate representation of the Scottish labour market and has thereby become the de facto default closure for AMOS (Scottish Government, 2008; Hermannsson, 2012; Emonts-Holley, 2016). Other closures are often used forensically to investigate the role of the labour market in generating a particular outcome in the model. The BRW closure is also the closure most relevant for skill disaggregation. Given this, it is necessary to determine whether the two skill categories are expected to have different parameter values in the BRW function.

There are a number of possible explanations for the negative relationship between unemployment and wages as stipulated by the BRW (Card, 1995). The two crucial explanations for the skill disaggregation are the 'efficiency wage model' and the 'bargaining model'.

The efficiency wage theory builds on the model by Sharpio and Stiglitz (1984) where firms pay higher wages to workers so as to discourage them from shirking. That is, firms must pay a net wage such that losses involved in the possibility of being unemployed is just greater than the benefit from shirking. The expected penalty for shirking increases as it becomes harder to find a job. Thereby firms offer a lower wage premium during times of high unemployment (Card, 1995).

One of the fundamental properties of the efficiency wage model is that wages of labour market sub-groups are related solely to the group-specific (un)employment rates. For example, higher unemployment for unskilled workers, should have no effect on the wages of skilled workers, once their own unemployment is taken into account (Card, 1995).

In the (union) bargaining wage model a bargaining power parameter is introduced (De Menil, 1971). Here the bargaining power over the negotiated wage decreases with increasing unemployment. Moreover, union members are expected to have more bargaining power over their wages as compared to non-union members.

The efficiency wage-, and the bargaining wage models thereby give some empirical explanation as to the observed differences in unemployment rate elasticities of labour market sub-groups. Card (1995) finds that the unemployment elasticity of pay is "greater for males than for females, for the lower rather than the higher educated, among the young rather than old, for non-union members rather than union members, and in the private rather than the public sector" (Nijkam & Poot, 2005, p.5).

This is, however, not observed across all countries/regions. For example, female earnings are shown to be more responsive to the unemployment rate than male earnings in Australia (Kennedy & Borland, 2000). Despite these country/regional differences, it can be expected that labour market sub-groups, for example, the young, the unskilled, foreigners, and those outside unions, have different responses to changes in the unemployment rate.

The empirical studies outlined suggest that the BRW closure seems appropriate, and that it is necessary to identify key parameter values (i.e. the unemployment rate elasticity) of the skill categories by which the model is disaggregated.

6.3.2 Economic migration

Migration research based on the Census and the Labour Force Survey for the years from 1991 to 2000 suggest that around 10% of the total population of Great Britain move to a new home each year (Dixon, 2003). Gregg et al. (2004) estimate that residential mobility rates have varied between 10% and 13% between 1977 and 1999. The fraction of working-age individuals who moved between regions has thereby been relative stable over time.

Research based on the British Household Panel Survey (BHPS) published by the ONS (Dixon, 2003) suggests that around 13% of inter-regional migration within Britain between 1991 and 2000 is job related. This number, however, refers to respondents' employment only, and is not intended to include moves arising from the employment of a spouse, partner or parent. The total number of job related migrations is thereby expected to be higher.

The BHPS data suggest that shorter distance moves are most likely to be associated with relationship formation and break-ups, changes in housing, or the decision to move to a better area (Dixon, 2003). Interregional moves are most often motivated by labour market factors or by the start or completion of college or university study, although other motives such as housing changes also make a significant contribution (Dixon, 2003).

Table 6.3.1 gives rates of job-related migration between regions by skill level. The figures in the first column show variations in the total rate of residential mobility for employment reasons by highest qualification. Figures in the second column give the rate of interregional migration for employment reasons by highest qualification. The final column shows shows job-motivated moves as a proportion of all the interregional moves reported by the members of each skill group (Dixon, 2003). it must be noted that the percentage distributions do not add to 100 because more than one reason for moving could be given.

Table 6.3.1: Job-related migration between regions by skill. Great Britain 1991 to 2000

	All job related mobility (in % rates)	Between regions (in % rates)	% of total migration
Degree	3.4	2.1	45.4
Post-school qualifications	1.5	0.7	32.3
School qualifications	1.3	0.7	26.9
No qualifications	0.2	0.1	10.5

Adapted from (Dixon, 2003)

Data in Table 6.3.1 show that "each year an estimated 3.4% of those with degree-level qualifications moved home for employment reasons, compared with only 0.2% of those with no formal qualifications. The rate of interregional migration for people with degrees, at 2.1%, was several times higher than the rate for those with lower levels of education" (Dixon, 2003, p.7). Job factors were the motivating cause for the qualified migrants than those with less education. The data also show that the proportion of interregional migration that is job related is significantly higher for those with a degree, 45.4%, as compared to the proportion of those with no qualifications, 10.5% (Dixon, 2003).

Research by Gregg et al. (2004) suggests that there is significantly less persistence over time in the regional unemployment rates for skilled than in the regional unemployment rates for the unskilled.

This implies that regional disparities in the supply of, or demand for, skills (reflected in the unemployment rate disparities) are more quickly eliminated in graduate labour markets (Dixon, 2003). Migration in Great Britain has been shown to respond to differences in employment opportunities. Migrants tend to move towards regions with higher than average rates of employment growth (Czaika & Hein, 2011; Millington, 2000). Migration is thereby strongly driven by economic incentives, which appear to be higher for better educated workers (Gregg et al., 2004).

The UK regional labour markets are characterised by the following 'stylised facts': unemployment rates are higher for unskilled than for skilled workers both within the UK as a whole and within its constituent regions (Nomis, 2011). Inter-regional variations in unemployment rates are larger for unskilled than for skilled (Dixon, 2003, and Nomis, 2011). High unemployment regions have relatively large proportions of unskilled unemployment (Elliott & Lindley, 2006). Low skilled workers are less geographically mobile compared to the highly skilled (Dixon, 2003, Nomis, 2011, Brown and Sessions, 1997, and McGregor et al., 2000).

Given the variation in geographic mobility between the skilled and the unskilled, the AMOS model is extended to reflect these differences. In a stylised default setting, the migration closure takes the form of modelling skilled labour as geographically mobile, whilst the unskilled are taken to be immobile. But for comparative purposes it is useful to be able to adjust one skill category at a time. This is done with three closures. In the first closure both skilled and unskilled are geographically immobile. In the second closure the unskilled are immobile, whilst the skilled are geographically mobile. In the third closure both the skilled and the unskilled are geographically mobile.

6.4 Skill-disaggregated AMOS model: AMOSKI

The AMOS model is based on work by Harrigan et al. (1991), with subsequent extensions and updating. For example, Lecca et al. (2013) incorporates forward looking agents, and Emonts-Holley (2016) introduces more detailed Government accounts to the model. This section presents an overview of the 'standard' AMOS model as given in Lecca et al. (2013), outlining some of the main characteristics, and the additions made to the model to incorporate the skill disaggregation.

The description given here is largely based on the AMOS model details found in Harrigan et al. (1991); McGregor et al. (1991) & Lecca et al. (2013), but is summarised here as adapted for Scotland, as a region of the UK, and is characterized by myopic agents. The Scottish Government (2016a), in collaboration with the Fraser of Allander Institute, produced a document outlining the AMOS model, and its importance to policy makers. The document also details future extensions to the model. The work presented here is one of these extensions. The following introduction to AMOS model borrows from and builds upon this document.

Here the AMOS model is extended to include two skill types (skilled and unskilled) where skill is categorised in terms of the level of education. Skilled labour are defined here as workers holding a degree (the sum of SCQF levels 6 to 12); and unskilled are defined as anything below that (the sum of SCQF levels 5 and below). This skill disaggregation has been used previously in the SAM & CGE literature by Stuttard and Frogner (2003a, 2003b), and Boeters and Savard (2011) where the cut-off point is typically a completed degree. To recall, Chapter 3 gives a comprehensive overview of skill types and the construction of the skill-disaggregated SAM.

It must be noted that the model could be extended to incorporate the fully disaggregated SAM containing 48 different skill groups. However, this would require the incorporation of 48 distinct labour demand, wage curves, and labour migration functions. Moreover, the more skill groups the more challenging it is to identify the empirically plausible elasticities that are needed in the model i.e. unemployment rate elasticities, the elasticity of substitution between these skill groups, and their migration behaviour. More importantly, the implicit claim that skill is an unchangeable attribute, that is individuals cannot move between skills without investment in human capital, becomes less plausible as the number of skill groups is increased (Boeters & Savard, 2011).

This work builds on previous attempts to extend the AMOS model by two labour market varieties. McGregor et al. (2000) attempt to incorporate two types of occupations into the model. Yin (2002) builds upon the work by McGregor et al. (2000) and incorporates manual and non-manual workers (rather than occupation) into the model.

The AMOS model has two main sets of micro- and macroeconomic components. The macroeconomic components are the main wage setting and migration closures employed. The microeconomic components are within the commodity supplies, factor demands and trade flows, and are based on, and calibrated to, a base year SAM. Within the CGE model these are solved simultaneously so that all markets are simultaneously in equilibrium (Scottish Government, 2016a).

The multi-sectoral AMOS model has some well-established strengths. For example, the model gives time adjustment paths which provide policy relevant insights into how the economy adjusts to its new equilibrium. These adjustments over time are not just given for macroeconomic variables, but also for key variables at the individual industry level.

As detailed previously, CGE models have some weaknesses, some of which also hold true for the AMOS model. The selection of key parameters, for example, may be seen as critical. This research, however, conducts a sensitivity analysis around selected key parameters when the skill-disaggregated AMOS (AMOSKI) is employed. A full discussion around some of the strengths and weaknesses of the AMOS model are given in Scottish Government (2008), Hermannsson (2012), and Scottish Parliament (2013).

The standard AMOS model has three domestic transactors, namely households, firms and government, 25 commodities (markets and activities), and two external transactors (RUK and ROW) which are taken to be exogenous. The elements of final demand are consumption, investment, government, tourism, and export expenditure.

Production takes place in the model with assumed 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 (Lecca et al., 2013). 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. CES technology is adopted with elasticities of substitution of 0.3 (Lecca et al., 2013).

AMOSKI extends the production structure of the 'standard' AMOS model to incorporate skill and unskilled labour in nested CES functions. In each industry, the labour input is therefore a composite of skilled and unskilled workers. The skill-disaggregated model also differentiates the migration, labour demand, and wage functions between the two skill groups. Each of these aspects of the skilled and unskilled labour markets are considered in turn in Sections 6.4.1 to 6.4.3.

Intermediate purchases in each industry 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 (Lecca et al., 2013; Hermannsson, 2012).

Figure 6.4.1 details the production structure of the model. The production technology is divided into two levels - intermediate and final goods. Intermediates are further disaggregated into domestic- and foreign intermediate goods and services. The intermediate and value added are combined to produce final outputs at the top level of the production hierarchy. Primary factors of production, labour (skilled and unskilled) and capital, are used to produce value added.

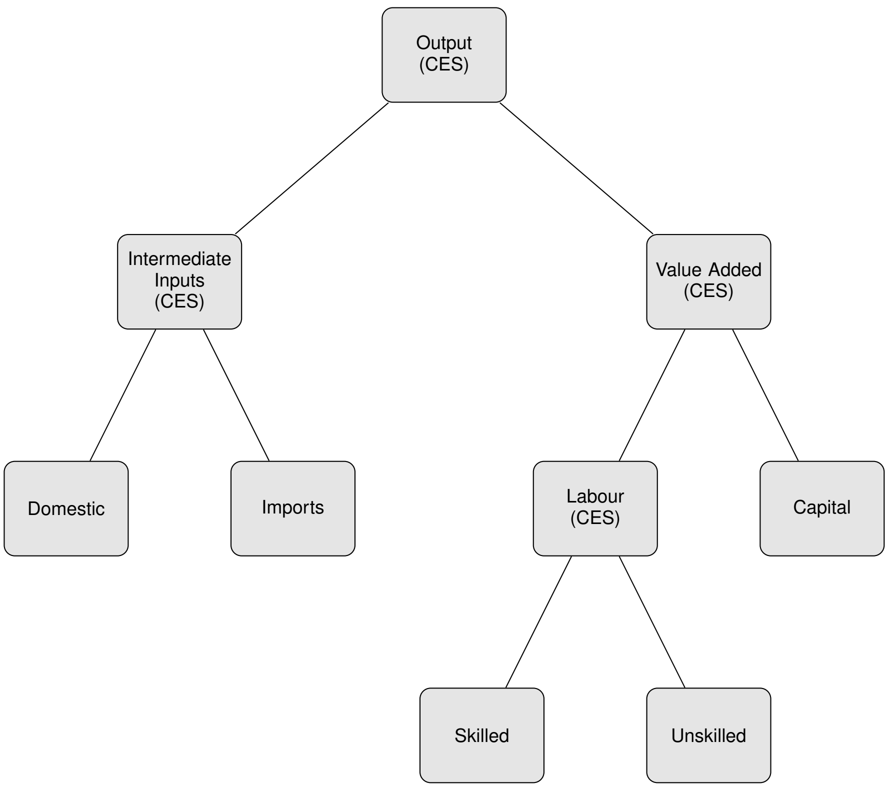
It is assumed that any change in government expenditure does not change the composition of that expenditure (Lecca et al., 2013). This assumption is also made for Tourism expenditures. That is, both Tourism and Government expenditures are treated as exogenous. It must be noted that there are versions of the AMOS model in which these assumptions are relaxed.

In this dissertation the model is run under the multi period variant, where capital stocks are updated between each period according to a simple capital stock adjustment mechanism. The model can, however, also be solved with forward looking agents. Lecca et al. (2013) compare the myopic and forward-looking models, highlighting the divergences among the main adjustment equations and the resulting simulation outcomes. Lecca et al. (2013) show that comparable regional myopic and forward-looking CGE models produce equivalent results in the long run.

Investment in each period is equal to depreciation, plus some fraction of the difference between the actual and the desired capital stock, where the desired capital stock is a function of commodity output, the nominal wage and the user cost of capital. Desired capital stocks are driven by cost-minimisation criteria, and actual stocks reflect last period's stocks, adjusted for depreciation and gross investment. Capital stocks are progressively updated between periods so that in every period the investment in period t affects the capital stock of period $t+1$. This capital accumulation process corresponds with a simple theory of optimal firm behaviour given the assumption of quadratic adjustment costs (Lecca et al., 2013).

The capital stock adjustment mechanism can also be analysed in terms of the relationship between the capital rental rate and the user cost of capital (Turner, 2002). The capital rental rate is the rental rate that would have to be paid in a competitive market for the (sector specific) capital, and the user cost is the annualised total cost to the firm of producing an additional unit of capital. The capital price index is the only endogenous component of the user cost (the interest rate, depreciation rate and tax rates are set exogenously). When 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 (Lecca et al., 2013; Turner, 2002; Hermannsson, 2012).

Figure 6.4.1: Production structure of the skill-disaggregated AMOS model



The two external transactors in AMSOKI are the RUK and ROW. Imported and locally produced intermediate goods are considered imperfect substitutes and are combined under a CES function (Armington, 1969). Each industry produces goods and services that can be exported or sold locally (as stipulated by the SAM). The foreign demand for goods depends on the ratio between the external price and the domestic price of output (Lecca et al., 2013).

To recall from Section 6.3.1, the labour market is characterised in the standard AMOS model as a single (Scottish) labour market with perfect sectoral mobility. The model incorporates three wage setting closures: National Bargaining, Fixed Real Wage, Regional Bargaining. The AMOSKI extends the standard model by identifying separate Regional Bargaining functions for the skilled and the unskilled. This is detailed in Section 6.4.1.

The standard AMOS model endogenises migration, where in-migration is positively related to the real wage differential, and negatively related to the unemployment rate differential, between regional and national unemployment rates. The labour force is fixed in the short run, but employment is variable over time, the unemployment rate can change, also labour is mobile across sectors. The total labour force is then adjusted from period to period through migration. Long-run equilibrium in the labour market implies zero net-migration.

The labour force can vary through inter-regional migration. Population and labour force change in response to the net effect of migration into and out of the region. There are assumed to be no natural demographic changes. The migration function (see equation 6.2) follows the flow equilibrium model outlined by Harris and Todaro (1970) and Hall (1970 & 1972), where m is the net-inmigration rate (as a proportion of the labour force), and superscript ^{N} is the indicator for a national variable.

$$m_t = \beta - \mu\left(un_t - un^N\right) + \nu\left(w_t - w^N\right) \tag{6.2}$$

The migration function is in accordance with the econometrically estimated model reported in Layard et al. (1991) where $\mu = 0.08$ and $\nu = 0.06$. The Scottish rate of in-migration is thereby positively related to the Scottish/RUK ratio of the real consumption wage and negatively related to the Scottish/RUK ratio of unemployment rates. The skill disaggregated migration functions are detailed in Section 6.4.2.

The net-migration flows in each period update the population at the beginning of the next period to establish the new labour force (LF) equilibrium in the following period, as detailed in equation 6.3). The population in time-period one is equal to the population in time-period zero $(LF_{t=1} = LF_{t=0})$ where time-period zero is represented by the calibrated SAM.

$$LF_{t+1} = (1 + m_t) \cdot LF_t \tag{6.3}$$

AMOSKI model is calibrated here on a 2009 SAM for Scotland, containing 25 commodities and activities, labour (skilled and unskilled), capital, other value added, households, corporations, government, and the external sector which is the rest of the UK (RUK), and the rest of the world (ROW). The model is subsequently parameterised using the annual data from the SAM, implying that each period in the period-by-period simulations is interpreted as a year.

Appendix 6A gives the sector aggregation. It must be noted that the industry aggregation is flexible, and can be varied as required as the data are aggregated from the initial 104 industries given in the SAM. To recall, the Scottish SAM captures the flow of all (onshore) economic activity at a detailed industry level which take place in the economy in a single year. Chapters 2 and 3 detail the data sources and procedures employed to construct the skill-disaggregated SAM for Scotland.

Appendix 6B gives the mathematical summary of the price setting equations, technology in production, trade interactions, the behaviour of households and other institutions, the government sector, the trade balance, private, and foreign and public assets. The elasticities of substitution and other behavioural parameters, for example, are based on econometric estimation or 'best guesses'. For all factors, trade elasticities are set equal to 2, whilst production elasticities are equal to 0.3 (Lecca et al., 2013). Model parameters are obtained through the usual calibration process.

The following sections detail the specific extensions made to the AMOS model to incorporate skill disaggregation. That is, wage determination, economic migration, and the demand and supply functions for each of the two skill categorises are considered in turn.

6.4.1 AMOSKI: Wage determination

Based on work by Layard et al. (1991) and Nickell and Bell (1995) a regional bargained real wage (BRW) function is implemented for regional wage setting (see equation 6.4), where z is skill (skilled & unskilled). The BRW directly relates the regional real consumption wage to workers bargaining power, and therefore inversely to the regional unemployment rate.

$$ln(w_{z,t}/cpi_t) = \beta - \epsilon_z \, ln(un_{z,t}) \tag{6.4}$$

The unemployment rate elasticities in the AMOSKI model are set to 0.120, and 0.112, for the skilled, s, and the unskilled, u, respectively (Nickell & Bell, 1995). Scottish specific estimates for these elasticities are dated and scarce. More up-to-date estimates of long-run unemployment rate elasticities (e.g. Galvez, 2014 and Fingleton & Palombi, 2013), however, produce values close to the ones found by Nickell and Bell (1995) and Galvez (2014) i.e. 0.113 and 0.112 respectively. Given this lack of empirical estimates for Scotland, and for skills in general, a sensitivity analysis is conducted in Chapter 7 using a variety of skilled and unskilled unemployment rate elasticities.

6.4.2 AMOSKI: Economic migration

This difference in geographical mobility of skilled as compared to unskilled workers is encompassed in the migration function of the model. Net-migration of (un)skilled workers is taken to be positively related to the real wage differential and negatively to the unemployment rate differential between Scottish and RUK (un)skilled workers. Therefore, skilled and unskilled workers migrate between regions in response to regional differentials in real wages and unemployment rates (depending on the model closure used).

The AMOSKI model differentiates skill migration by employing three closures of the migration function, whilst retaining the parameter values specified in the migration function of the standard AMOS model as detailed in equation 6.2. In the first closure both skilled and unskilled labour are geographically immobile and the labour force remains fixed as given in equation 6.5).

$$m_{z,t} = 0 \ and \ LF_{z,t+1} = LF_{z,t} = LF_{z,0} \tag{6.5}$$

In the second migration closure skilled are geographically mobile whilst unskilled are immobile. Thereby the skilled take the form of equation 6.6, whilst the unskilled take that of 6.7.

$$m_{s,t} = \beta - \mu \left(un_{s,t} - un_s^N\right) + \nu \left(w_{s,t} - w_s^N\right) \ and \ LF_{s,t+1} = (1 + m_{s,t}) \cdot LF_{s,t} \tag{6.6}$$

$$m_{u,t} = 0 \ and \ LF_{u,t+1} = LF_{u,t} = LF_{u,0} \tag{6.7}$$

In the third closure both skilled and unskilled are geographically mobile, each taking the form of equation 6.8.

$$m_{z,t} = \beta - \mu\left(un_{z,t} - un_z^N\right) + \nu\left(w_{z,t} - w_z^N\right)\ and\ LF_{z,t+1} = (1 + m_{z,t}) \cdot LF_{z,t} \tag{6.8}$$

Workers are fully mobile between industries, but there is no mobility of workers between skill groups. That is, changes in the skilled and unskilled labour force due to education and/or training are not considered in this model. Also, it is assumed that natives and immigrants are perfect substitutes within each skill group.

6.4.3 AMOSKI: Labour demand and supply

Skilled and unskilled labour are introduced into the demand side of the model by creating another level in the production hierarchy. To yield the aggregate labour input, skilled and unskilled labour are combined through a CES aggregation function, as indicated in Figure 6.4.1. The CES total labour demand, L, in the value-added production function for activity j is given as:

$$L_j = \phi_j^{\rho_j} \cdot [\delta_j^l \cdot (PY_j / w_j^p)]^{\rho_j} \cdot Y_j \tag{6.9}$$

where ϕ is a exogenous efficiency parameter (Hicks-neutral), δ is the labour share parameter in the value added function, PY is the price of value added, w^p the nominal price to producers of the composite labour input, ρ the elasticity of substitution between capital and composite labour, and Y is value added.

The price of the composite labour input is given in Equation 6.10, where $w_{s,u}$ is the nominal price of labour, including income and payroll taxes.

$$w_j^p = [\delta_{sj}^{\rho_{zj}} \cdot w_{sj}^{(1-\rho_{zj})} + \delta_{uj}^{\rho_{zj}} \cdot w_{uj}^{(1-\rho_{zj})}]^{1/1-\rho_{zj}} \tag{6.10}$$

The CES skill composite total demand function, L_z, is given as:

$$L_{zj} = \xi_j \cdot [\delta_s^l \cdot L_s^{\sigma_{ij}} + \delta_u^l \cdot L_u^{\sigma_{ij}}]^{\sigma_{ij}} \tag{6.11}$$

where ξ is a labour augmenting technology efficiency parameter, σ is the elasticity of substitution between skilled and unskilled labour i.e. the percentage change in demand for low (high) skill workers for a percentage change in the price of high (low) skill workers, is taken to be 1.01 in the AMOSKI model (Arpaia et al., 2009).

Estimates of the elasticity of substitution between skilled and unskilled labour, σ , range from 0.6 to 1000 in the literature (Freeman, 1999). Researchers, however, have converged around a consensus value of 1.5 (Katz & Murphy, 1992). The elasticity of substitution between skilled and unskilled labour in developing countries is taken to be around 2 (Behar, 2010). The majority of empirical work is based, however, on US data and estimates for the UK are sparse.

For example, estimates for the UK based on the substitution between blue- and white-collar workers in manufacturing is estimated to be around 3 (Hamermesh, 1993). This estimate has been criticised as being too high. Manacorda and Petrogolo (1999) estimate that the elasticity of substitution between skills is not significantly different from 1.

The latest and most robust data, however, are provided by the European Commission (Arpaia et al., 2009) who estimate a value of 1 for the elasticity of substitution between skilled and unskilled labour within the UK. A similar value is found by Edwards and Whalley (2002) who use 1.25 as their central estimate. A sensitivity analysis is conducted when employing the AMOSKI model in Chapters 7 and 8.

The labour demand function of each skill category is given as:

$$L_{sj} = \xi_j^{\sigma_{sj}} \cdot [\delta_{sj}^l \cdot (w_j^p / w_{sj}^p)]^{\sigma_{sj}} \cdot L_j \tag{6.12}$$

$$L_{uj} = \xi_j^{\sigma_{uj}} \cdot [\delta_{uj}^l \cdot (w_j^p / w_{uj}^p)]^{\sigma_{uj}} \cdot L_j \tag{6.13}$$

where $\xi_j^{\sigma_{sj}}$ and $\xi_j^{\sigma_{uj}}$ are labour augmenting technology efficiency parameters.

Labour supply (or rather labour force) is given as:

$$LF_{z,t+1} = (1 + (\zeta - \upsilon^{un}[ln(un_{z,t}) - ln(un_z^N)] + \upsilon^w[ln(w_{z,t}/cpi_t) - ln(w_z^N/cpi^N)])) \cdot LF_{z,t} \quad (6.14)$$

where ζ is a calibrated parameter, υ^{un} and υ^w are elasticities that measure the impact of the gap between the logs of regional and national unemployment and real wage rates, and cpi^N is the non time-varying national CPI. Total labour supply, at time, t, is multiplied by the fraction of the labour force employed (i.e. 1 minus the unemployment rate) equals labour demand at time t:

$$LF_t \cdot (1 - un_t) = \sum_j L_{j,t} \quad (6.15)$$

6.5 Summary

The skill-disaggregated AMOS (AMOSKI) model builds upon and extends the 'standard' AMOS model (Harrigan et al., 1991). The AMOS model structure is flexible and provides a range of model closures corresponding to different time periods of analysis, and labour market options. The AMOS model, and various extensions, have been employed in a wide array of policy relevant research.

AMOSKI extends the standard model with a more detailed treatment of the labour market. This comprises the incorporation of two types of labour which are distinguished by their education levels. This skilled and unskilled labour is introduced into the model by nested CES functions.

The skill-disaggregated model also differentiates migration, labour demand, and wage functions between the two skill groups. These options are highly flexible, as the skill categories can be, aggregated to different skill classifications, depending on the needs of the researcher.

The AMOSKI model is calibrated here on a 2009 SAM for Scotland, containing 25 commodities and activities, skilled and unskilled labour, capital, other value added, households, corporations, government, and the external sector (RUK/ROW).

The AMOSKI model is employed in Chapter 7 to analyse export demand shocks to key sectors of the Scottish economy. In Chapter 8 the model is used to analyse skill-neutral and skill-biased labour augmenting technical change.

Chapter 7

Chapter 7

Export demand shocks in the skill-disaggregated AMOS model

7.1 Introduction

Exports to both the Rest of the UK and the Rest of the World are a large contributor to Scotland's economic growth, and are a pillar in the Scottish Governments Economic Strategy. The push to improve internationalisation is also seen as a vital part in rebalancing the Scottish economy after the 2008 financial crisis. The Scottish Government (2015) Economic Strategy sets a rather ambitious target for Scottish businesses to deliver a 50% increase in the value of international exports by 2017. The Scottish Government is planning to increase exports by, for example, enabling small and medium-sized enterprises with international ambitions to access finance from the Scottish Investment Bank (Scottish Government, 2015). Given the efforts to increase international exports, it is of policy relevance to simulate a variety of export demand shocks as to identify likely impacts of successful export orientated policies. In cases where policies have disproportionate impacts on different skill levels the labour market model must be detailed enough to separately identify these. Here the skill-disaggregated AMOS model is used. It contains two skill types (skilled and unskilled) where skill is defined in terms of the level of education. Using this model facilitates the separate identification of the disparate impacts on the skilled and unskilled, whilst also detailing policy relevant system-wide impacts in a multi sectoral modelling framework. This chapter is organised as follows; Sections 7.2 and 7.3 outline the modelling strategy and describes the labour market adjustment mechanisms following a export demand stimulus in a simplified partial equilibrium framework. Section 7.4 details the CGE simulation results, Section 7.5 details the results for the sensitivity analysis, and Section 7.6 gives a summary and policy implications.

7.2 Simulation strategy

The focus is here on modelling policy relevant demand shocks and to analyse the differential impacts of these shocks on labour market sub-groups i.e. skilled and unskilled labour. For this two policy relevant sectors are selected. This provides analytical insights into the distinctive differences between the skilled and unskilled, whilst detailing policy relevant system-wide impacts in a multi sectoral modelling framework.

The two sectors selected are the Food & drink sector and the Financial Services sector. These sectors are key growth sectors of the Scottish economy. Also, specific policy targets are in place for the Food & drink sector, where the Scottish Government and Scottish Enterprise (2014) are aiming to increase exports to the Rest of the World (ROW).

The two modelled alternative demand shocks are a £500m increase in exports to the ROW for each of the Food & drink sector and the Financial Services sector. This shock is motivated by targets sets out by the Scottish Enterprise (2014) for the Food & drink sector. Using the same shock for the two sectors allows for a systematic comparison of the simulation results.

It must be noted that disentangling the 'key growth sectors' from the sectoral aggregation provided in the Input-Output (IO) tables is problematic. That is, even though the sectors with particular policy attention are defined within the Scottish Government (2014) Economic Strategy it is a challenging task to clearly identify these within the IO tables (see Appendix 6A for a detailed aggregation matrix).

Here the skill-disaggregated AMOS model (AMOSKI), as outlined in Chapter 6, is employed. It contains two skill types (skilled and unskilled) where skill is defined in terms of the level of education. Skilled labour are defined here as workers holding a degree. Using this model facilitates the separate identification of the distinctive impacts on the skilled and unskilled, whilst also detailing policy relevant system-wide impacts in a multi sectoral modelling framework.

Three variants of the myopic AMOSKI model are used for each of the export demand shocks, incorporating different flow migration closures. To recall, migration flows in one period update the population stock in the next period (depending on the closure used). The Scottish rate of in-migration is positively related to the Scottish/RUK ratio of the real consumption wage and negatively related to the Scottish/RUK ratio of unemployment rates.

The three migration closures used are: both skilled and unskilled labour are geographically mobile (free migration), only skilled labour is geographically mobile (skilled migration), both skilled and unskilled are geographically immobile (no migration).

Workers are thereby restricted/free to migrate between regions in response to regional differentials in real wages and unemployment rates. These three migration scenarios are chosen as empirical research shows that geographical mobility is strongly correlated with level of skill (as detailed in Chapter 6), where the skilled are more likely to migrate between regions than the unskilled.

The analysis of the simulations is conducted in three main sections. First, the basic theory of stylised adjustment mechanisms in the labour market are outlined for each of the simulations. This is done in a partial equilibrium framework in Section 7.3.

These labour market adjustment mechanisms are then explored through simulations of the skill-disaggregated AMOSKI model in Section 7.4. This allows for analysis of system-wide adjustments of the different shocks, and the distinctive impacts on each of the skill groups in a general equilibrium framework. Section 7.5 conducts a sensitivity analysis around key assumptions of the model. Section 7.6 summarises key findings of the export demand shock simulations.

The AMOSKI model is calibrated on a 2009 Social Accounting Matrix (SAM) for Scotland (as outlined in Chapters 2 and 3), containing 25 commodities and activities, labour (skilled and unskilled), capital, other value added, households, corporations, government, and the external sector (RUK/ROW). The model is subsequently parameterised using the annual data from the SAM, implying that each period in the period-by-period simulations is interpreted as a year.

To recall from Chapter 3, there are significant differences across sectors which are of key importance when interpreting sector specific simulation results. Table 7.2.1 summarises sector characteristics by selected income and expenditure components as found in the 2009 SAM. This table is called to mind when analysing sector specific impacts of the export demand shocks.

The first three columns in Table 7.2.1 give labour costs of output broken down by skill category. Skill, and labour intensity of output varies significantly across sectors. There are a number of sectors that are high-skill intensive. For example, the Research & development, and the Public administration sector have a skilled wage share of output of 50% and 40% respectively. In contrast, the Wholesale & retail, the Food & beverage services, and the Rubber, plastic, cement & iron sector are more low-skill intensive with a unskilled wage share of output of 19%.

There are a number of sectors with very low wage shares of output. For example, the Real estate sector, and the Chemicals sector have a wage share of output of 3% and 8% receptively. In contrast, the Research & development, and the Public administration sector have the high wage shares of output with 54% and 51% respectively.

Labour intensity in terms of the wage share of gross output in the two target sectors is similar. However, the skilled/unskilled ratio is very different. 21% of output of the Financial Services sector goes to wages (15% to skilled and 6% to unskilled). Similarly, 21% of output of the Food & drink sector goes to wages (10% to skilled and 11% to unskilled).

Table 7.2.1: Sector characteristics by key income and expenditure components

	% share of costs (expenditures)								% share of incomes (receipts)						
	S labour	U labour	Total labour	OVA	Taxes on exp.	RUK imports	ROW imports	Total imports	Households	Government	Capital	Tourism	RUK exports	ROW exports	Total exports
1. Agriculture, forestry and fishing	5	6	11	32	- 16	27	4	31	23	0	3	0	17	11	27
2. Mining	7	3	10	38	2	13	4	17	1	-	1	0	72	9	81
3. Food, drink and tobacco	10	11	21	19	2	17	6	23	23	-	0	0	24	31	55
4. Textile, leather, wood and paper	13	14	27	6	2	19	7	26	15	0	1	1	24	13	37
5. Chemicals	6	2	8	15	2	40	20	60	13	-	0	1	39	22	62
6. Rubber, plastic, cement and iron	13	19	33	7	4	17	6	23	6	-	1	0	13	15	29
7. Computer, electrical and transport eq.	19	10	29	7	1	17	12	29	8	-	11	0	16	23	39
8. Electricity, gas and water	7	5	12	20	3	12	8	20	28	3	0	0	18	2	20
9. Construction	14	10	24	17	1	12	3	15	2	0	53	0	8	1	9
10. Wholesale and retail	17	19	37	16	4	13	3	16	62	0	3	2	9	7	16
11. Land transport	13	17	30	12	5	15	4	19	27	-	0	1	10	5	15
12. Water transport	10	5	15	9	6	20	6	27	23	-	4	1	6	40	46
13. Air Transport	9	8	17	17	8	18	6	24	46	-	0	0	23	4	27
14. Post and support transport services	15	17	32	18	1	13	3	15	3	0	1	0	12	9	21
15. Accommodation	19	16	35	17	7	11	5	16	50	0	0	29	0	0	0
16. Food & beverage services	17	19	36	13	9	10	7	17	81	-	-	10	-	-	-
17. Telecommunication	23	8	32	22	2	13	4	17	37	1	3	0	10	7	17
18. Computer and information services	38	7	45	19	2	14	3	17	1	1	17	0	32	16	48
19. Financial services	15	6	21	29	4	11	2	13	16	-	0	0	47	8	55
20. Real estate	2	1	3	55	- 0	20	1	21	81	-	3	0	2	0	2
21. Professional services	28	10	38	18	1	14	2	16	4	0	3	0	29	10	39
22. Research and development	50	4	54	3	- 10	18	4	22	1	0	2	0	23	34	57
23. Public administration	40	12	51	7	3	11	4	15	14	72	0	0	1	1	2
24. Recreational services	25	14	39	12	4	13	3	16	53	15	1	4	4	2	7
25. Other services	26	17	43	22	3	10	3	12	66	0	1	1	4	1	5

Imports and exports broken down by their RUK and ROW components in Table 7.2.1 show that the majority of industries have stronger import linkages with the RUK as compared to the ROW. Imports are a significant part of total costs for some sectors. For example, 40% of the total costs for the Chemical sector arise from RUK imports. There are a number of sectors which are highly export orientated. For example, the Financial services, the Mining, the Food & drink, and the Research & development sectors all have an export share of output of above 50%.

There are a number of sectors that mainly serve the domestic market. For example, 81% of incomes in the Food & beverages services, and the Real estate sector stem from domestic households. 72% of incomes in the Public administration sector comes from the public sector. The Accommodation sector, and the Food & beverages services sector have a relatively large share of incomes coming from Tourism (i.e. expenditure by non-residents) with 29% and 10% respectively.

The Construction sector receives 53% of total incomes from providing investment goods. This is by far the largest capital share of output across all sectors. The second largest capital provider, in terms of share of output, is the Computer & information services sector with 17%.

To recall from Chapter 3, there are 2,229,931 FTE workers, of which 1,302,392 (58%) are skilled and 927,540 (42%) are unskilled. Sector 23, Public administration, is the largest employment sector with 610,655 workers. The Food & drink sector employs 46,079 FTE workers (42% are skilled and 58% are unskilled) whilst the Financial services sector employs 86,289 FTE workers (65% are skilled and 35% are unskilled).

The expenditures of the Food & drink sector are mainly on intermediate consumption (34%) and labour (10% on skilled and 11% on unskilled). Likewise, the expenditures of the Financial services sector are predominantly on intermediate consumption (32%), other value added (29%), and labour (15 % on skilled and 6% on unskilled). The intermediate consumption of the two sectors is very similar (34% and 32%). Both sectors have strong export linkages to the RUK and the ROW but the Financial services sector, in particular, is focused on RUK.

The incomes of the Food & drink sector stem mainly from ROW/RUK exports (24% and 31%), households (23%) and intermediate demand (21%). The incomes of the Financial services sector come mainly from the exports to the ROW/RUK (47% and 8%) and intermediate demand (29%).

The absolute size of the two industries stimulated differs significantly. Total output of the Financial services sector is £18,592m, and that of the Food & drink sector is £8,456m. The scale effect of the £500m stimulus to ROW exports constitutes an aggregate 3.04% increase in total ROW exports. This represents a 34.35% increase in ROW exports in the Financial services sector, and a 18.94% increase in ROW exports in the Food & drink sector in the unrestricted case.

The key similarities of the two sectors are in terms of their labour intensity (but with a different skill mix), and both sectors export the same share of output. A key difference here is that the Financial services sector is more capital intensive.

7.3 Ex-ante labour market analysis of demand shocks

This section outlines the labour market adjustment mechanisms following a export demand stimulus in a simplified partial equilibrium framework. A two sector economy is assumed, where these sectors are structurally different. That is, one sector is assumed to be high skill intensive whilst the other sector is assumed to be a low skill intensive sector.

The assumed export demand stimulus is equally and simultaneously imposed in both sectors. Some of the assumptions of the AMOS model (as detailed in Chapter 6), such as short run factor constraints (depending on the closure), are also applied in the partial equilibrium context. The partial equilibrium analysis is of the demand shock is done using three migration closures to reflect different levels of mobility across skill groups.

In the first closure, no migration, the supply side is fully constrained so that both skilled and unskilled workers are geographically immobile. In the second closure the constraints on the skilled are loosened so that the skilled can migrate between regions in response to regional differentials in real wages and unemployment rates. In the third closure, free migration, the supply side is unconstrained i.e. both skilled and unskilled workers migrate between regions.

The partial equilibrium set up outlined here is ill-equipped in dealing with issues such as identifying the demand for a skill type. In the AMOS CGE model the demand for a skill type is a function of the price of the composite labour, and then the substitution between the two, and also the demand for value added, and the substitution between capital and labour.

Thus, it must be stressed that this analysis is only theoretical and is focused solely on the labour market interactions in a simplified partial equilibrium setting. In contrast, the skill-disaggregated AMOS model takes into account all system-wide effects in a multi-sectoral general equilibrium. The partial equilibrium analysis is, however, instrumental in providing the basis to analyse more complex CGE modelling results.

7.3.1 Partial equilibrium: No migration

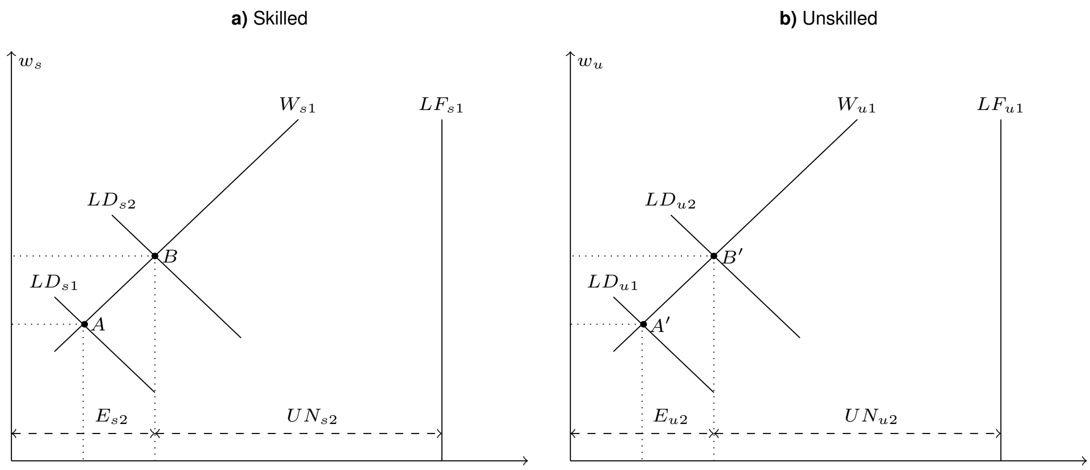
The mechanism following a demand shock where both skilled and unskilled are geographically immobile is outlined here. The labour demand for workers of different skill groups is derived from competitive firms' optimising behaviour which produces output using different types of labour distinguished by skill. The supply side of the labour market for each skill category is summarised by a bargaining real wage function, relating the real wage to the unemployment rate and to 'wage push' factors.

Together, the labour demand function and the bargaining real wage function determine the (un)-employment rate and wage for each of the skill groups. The bargaining real wage curve shifts in response to changes in the labour force, which in turn is only affected by net migration (natural demographic changes and domestic retraining are not taken into consideration here).

Figure 7.3.1 shows the bargaining real wage function, W, and labour demand, LD, for skilled, s, and unskilled, u, labour for a given real wage, w. The skilled and unskilled labour labour force is shown as a vertical line ($LF_{s,u}$). Since both skilled and unskilled workers are geographically immobile the adjustment mechanisms are the same for both skill groups in this case.

Points A and A' in Figure 7.3.1 show the initial equilibrium. Employment, E, and the unemployment level, UN, are read from the x-axis, and the y-axis gives the real wage, w. The unemployment level is shown as the distance between the equilibrium level of employment and the vertical labour force line (the greater the distance the greater the unemployment level). Employment is shown as the distance between the labour market equilibrium and the y-axis (w).

Figure 7.3.1: Labour market demand stimulus: short-run



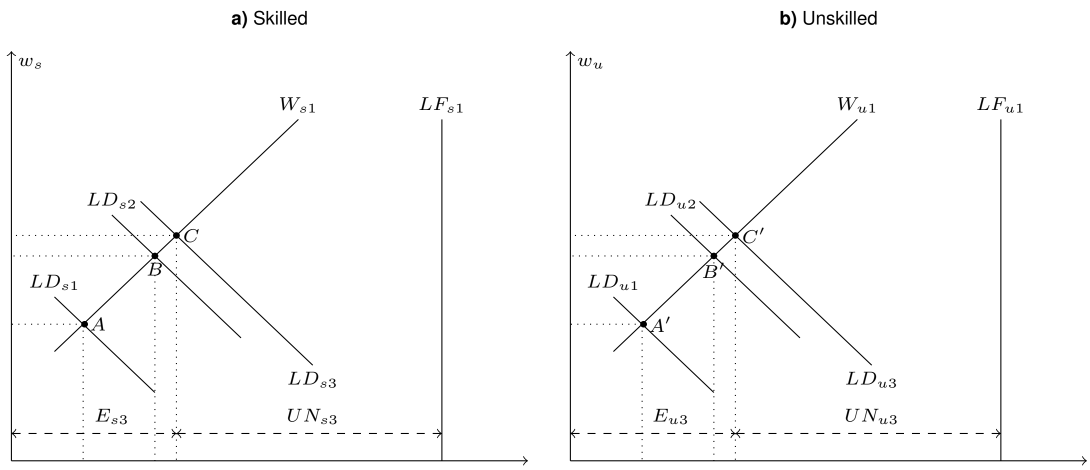
Points B and B' depict the new labour market equilibrium following the demand shock i.e. a rightward shift of the demand curve from $LD_{s,u,1}$ to $LD_{s,u,2}$. The increase in demand for labour exerts upward pressure on the real wage which in turn decreases unemployment, restoring the labour market equilibrium. Points B and B' in Figure 7.3.1 thereby show the short-run equilibrium in the skilled and the unskilled labour markets respectively.

The wage bargaining curve remains fixed for both the skilled and unskilled in the long run as there is no migration. They do, however, have different coefficients in the CGE model. Capital stocks are fixed in the short run. Following the demand stimulus there is an increase in prices, quantities, revenues, and profits. Over the long run this stimulates capital stocks and net-investment.

This increase in investment in the long run in turn further increases the demand for labour $LD_{s,u,2}$ to $LD_{s,u,3}$, decreasing unemployment, and exerting further pressure on real wages. Thereby the additional demand for labour, and the immobility of labour allows workers to permanently increases real wages above the short-run equilibrium.

Points C and C' in Figure 7.3.2 depict the long-run equilibrium for the skilled and unskilled labour markets where the real wage is now above its initial (and short-run) equilibrium and the supply of labour only marginally increases by reducing local unemployment and increasing local aggregate employment. Adverse competitiveness effect can be observed here in the short- and long run as real wages remain elevated.

Figure 7.3.2: Labour market demand stimulus: long-run, no migration



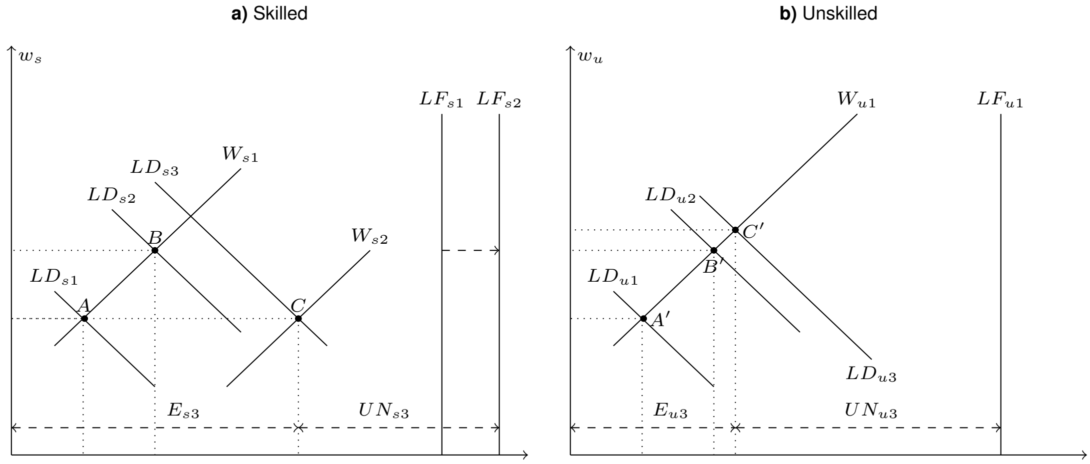
7.3.2 Partial equilibrium: Skilled migration

The mechanism following a demand shock where only skilled labour is mobile is outlined in Figure 7.3.3. The initial equilibrium and the short run outcome (i.e. the shift from A/A' to B/B') are the same as outlined in Section 7.3 for the no migration case.

Points A and A' in Figure 7.3.3 show the initial equilibrium. Points B and B' depict the new labour market equilibrium following the demand shock. As real wages have increased in the short run and unemployment rates have fallen, there is an incentive for skilled workers to migrate into the labour market (unskilled are immobile).

That is, there is a net-inflow of skilled workers from outside Scotland. This inflow of skilled workers gradually shifts the skilled workforce curve from $LFs1$ to $LFs2$ and thereby also the bargaining real wage function from W_{s1} to W_{s2} until it reaches its new equilibrium point where the real wage reverts back to its initial equilibrium at point C.

Figure 7.3.3: Labour market demand stimulus: long-run, skilled migration



In the long run the change in the skilled unemployment rate is zero and total skilled employment increases due to the inflow of skilled workers. Real wages for skilled workers revert back to the initial equilibrium state - but at a higher level of skilled employment.

In the long run, the wage bargaining curve remains fixed for unskilled labour as there is no unskilled migration. As seen previously, following the demand stimulus there is an increase in prices, quantities, revenues, and profits and thereby also an increase in the capital stock and investment.

This increase in investment and output in the long run and the demand for labour increases from LD_{u2} to LD_{u3}, decreasing unemployment, and exerting further pressure on real wages. Thereby the additional demand for labour, and the migration restriction allows workers to increases real wages above the short-run equilibrium. Point C' depicts the long-run equilibrium for the unskilled labour market where employment, the nominal wage, and real wages lie above their initial equilibrium values.

That is, the skilled real wage returns to its initial equilibrium but the real wage for unskilled workers remains above the initial equilibrium in the long run. Similarly to the no migration case, adverse competitiveness effect can be observed as the aggregate real wage does not revert back to its initial equilibrium. The adverse competitiveness effects, however, are dampened due to the adjustment of the skilled real wage.

7.3.3 Partial equilibrium: Free migration

Figure 7.3.4 shows the mechanism following a demand shock where both skilled and unskilled labour are free to migrate. It must be noted that since both skilled and unskilled workers are free to migrate the adjustment mechanisms are the same for both skill groups.

Points A and A' show the initial equilibrium, and points B and B' depict the new labour market equilibrium following the demand shock (as outlined in the previous sections).

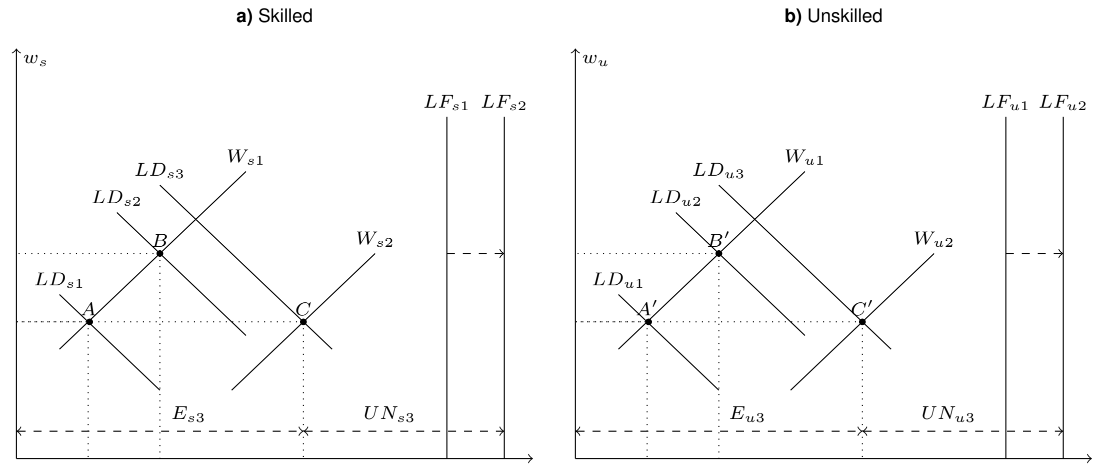
As real wages have increased in the short run and unemployment rates have fallen, there is an incentive for workers to migrate into the labour market. That is, there is a net-inflow of skilled and unskilled workers from outside Scotland.

This inflow of both skilled and unskilled workers gradually shifts the workforce curve from $LFs,u,1$ to $LFs,u,2$ and thereby also the bargaining real wage function from $W_{s,u,1}$ to $W_{s,u,2}$ until it reaches its new equilibrium point where nominal and real wages revert back to their initial equilibrium at points C and C'.

In the long run aggregate employment increases and there is no change in the unemployment rate, reflecting the migration response. Real wages and unemployment rates revert back to the initial equilibrium state - but at a higher supply of labour.

In contrast to the model version where labour is restricted from migrating, there are no competitiveness effects in the long run as real wages revert back to their initial equilibrium. This adjustment is akin to the long-run results found in IO where prices remain unchanged in the long run (even though capital stocks increase here) as no supply restrictions are imposed.

Figure 7.3.4: Labour market demand stimulus: long-run, free migration



The following sections in this Chapter employ the more complex AMOSKI CGE model. The simplified ex-ante analysis outlined in this section, however, is referred to when interpreting the CGE results as it provides the basic interpretation to analyse the more complex CGE modelling results.

7.4 Export demand shock CGE simulation results

This section presents the results for a permanent increase in exports to the Rest of the World (ROW) for two key sectors of the Scottish economy. The two demand shocks modelled are a £500m increase in exports to the ROW for each of the Financial services sector, and the Food & drink sector.

Sections 7.4.1, 7.4.2, and 7.4.3 detail the long-run results for the free migration closure, the skilled migration closure, and the no migration closures respectively. Section 7.4.4 gives the short-run results. Section 7.5 presents the results for the sensitivity analysis and Section 7.6 summarises the main findings.

To recall, the short-run results are the same for all three migration closures since there is no migration in the first period irrespective of the assumptions about labour mobility, and myopic investment decisions made in period one are unaffected by future migration decisions.

The labour force is fixed in the short run, but the unemployment rate can change and labour is mobile across sectors. The aggregate labour force is potentially adjusted from period to period through migration (depending on the migration closure used). Capital stock is fixed in the short run both in total and in its distribution across sectors. Capital stocks in individual production sectors vary through period by period flows of net investment.

The capital markets fully adjust in the long run models. All sectors earn the same return in the base period. In the short run and during the adjustment periods, capital rental rates can vary across sectors. Where the capital rental rate is greater than the user cost of capital, there is net investment. Conversely, there is disinvestment where the capital rental rate is less than the user cost of capital.

In the long run all sectors have the same capital rental rate which is then equal to the user cost of capital. The user cost of capital is driven by the capital price index, interest rate, together with the exogenous subsidies and relevant taxes, and depreciation rates. This is discussed in more detail when outlining the simulation results.

7.4.1 Long-run: Free migration

The adjustments seen in the long-run free migration case are akin to the long-run results found in IO modelling. With free migration no supply restrictions apply and prices remain unchanged in the long run (McGregor et al., 1996). Even though capital stocks change in these CGE results, the real wage is fixed in this long-run model closure. These results also reaffirm that the AMOSKI model follows expected and well established long run adjustment principles.

This closure of the AMOS model ties down long-run unemployment rates and real wages to their initial equilibrium through the combination of regional bargained real wage and flow migration. Any change in the real wage and the unemployment rate entail a migration response which in turn limits and ultimately reverse real wages changes until the labour market is again in a zero net-migration equilibrium.

To recall, migration responds here to any gap between the unemployment rate and/or real wages between Scotland the RUK. The regional bargained real wage negatively relates the regional unemployment rate to the regional real wage. Results presented here thereby mimic these found in an IO system by effectively imposing perfectly elastic supply of inputs.

Table 7.4.1 details the key macroeconomic long run free migration results, in percentage changes, for a £500m increase in exports to the ROW for each of the Financial services sector (FIN), and the Food & drink sector (F&D).

Figure 7.4.1 details the aggregate transition paths of GRP, employment, CPI, real wages, labour force, unemployment rates, investment, capital stocks, and exports. These figures report the percentage change from base year values.

There are a number of effects that can be observed irrespective of which of the two sectors is stimulated. Following the export demand stimulus there is an increase in prices, quantities, revenues, and profits and thereby also an increase in net investment and capital stocks. This increase in investment in the long run in turn further increases the demand for labour, decreasing unemployment. Real wages and unemployment rates are, however, ultimately pushed back down to the national levels.

As wages initially increase in the short run due to the stimulus to exports, and unemployment rates fall, there is an incentive for workers to in-migrate. That is, there is an inflow of workers from outside Scotland. This in turn exerts downward pressure on wages as workers see their bargaining power decreased. The real wage decreases until it returns to its initial equilibrium value in the long run.

Figure 7.4.1 shows that the unemployment rates initially fall and then gradually return to their base. Similarly, real wages initially rise and then gradually fall towards the long run. Employment rises above base throughout the simulation. Here the proportionate change in employment is equal to the proportionate change in labour force.

The initial increase in prices reflects some negative competitiveness effects. Figure 7.4.1 shows that exports to the Rest of the UK (RUK) initially fall. There are no changes the prices of domestically produced goods in the long run, and exports to the RUK gradually return to their base. Exports to the ROW rise in the long run by the full amount of the initial stimulus.

Capital stocks rise in the long run driven by net investment, which is affected by the gap between the capital rental rate and the user cost of capital that opens in the short run. The increase in investment further reinforces the output effect (and the impact on employment). The new steady-state equilibrium is reached by adjustments in the factors of production, notably the expansion of capital and labour.

The capital rental rate is what sectors earn for the actual capital stock in existence in this period (it indicates profitability), if it is rented out in this period for one period. i.e. the return on the fixed capital stock in a sector. The capital rental depends on the demand for capital and the capital stock. As demand for capital increases in that sector, the capital rental rate increases.

The replacement cost of capital is the annualised cost of producing one unit of new capital for the user. A price signal is given to increase capital by investing, if the capital rental rate is higher than the user cost of capital. Thereby capital can be rented out at a higher rate than it costs to produce. The investment function can thus be viewed as responding to the difference between the two.

Prices, the unemployment rate, real wages, and the replacement costs of capital return to their base levels in the long run. As there are no competitiveness effects, exports to the RUK also return to their base, whilst those to the ROW increase by 3.04%, the scale of the initial stimulus. GRP increases due to the stimulus to exports and investment.

Even though these general aggregate effects can be observed there are significant differences between the stimulus to the Financial services sector and the Food & drink sector. Moreover, the skilled and the unskilled experience rather different impacts depending on the sector that is stimulated.

The stimulus to GRP is significantly larger when the Financial services sector is stimulated, compared to the case when the Food & drink sector is stimulated. The capital intensity of the Financial services sector results in a relatively large increase in investment and also output. Figure 7.4.1 shows that investment time path adjustments follow similar patterns for the two cases, but the impact on investment is significantly larger when the Financial services sector is stimulated.

When the Financial services sector is stimulated the impact on employment of the two skill categories is equiproportional i.e. skilled, unskilled, and aggregate employment increases by 0.51% in the long run. There are little to no gaps in the skilled and unskilled adjustment paths of employment, real wages, and unemployment rates as detailed in Figure 7.4.1. The export stimulus to the Financial services sector thereby yields skill-neutral labour market impacts.

Figure 7.4.1 shows that real wages are above their base up to period 45 and see the largest increase from base in period one when the Financial services sector is stimulated. Similarly, the unemployment rates see their largest fall below base in period one and then gradually returns to their steady-state in period 45.

The impact of the stimulus to the Food & drink sector results in more disproportionate labour market impacts for the two skill categories. The unskilled see a larger percentage increase in employment in the long run, as compared to these seen by the skilled, 0.57% and 0.34% respectively. As the relative wage of the two skill categories is ultimately unaffected, the differences in skilled and unskilled employment are driven by sectoral impacts.

Figure 7.4.1 shows that adjustment paths for the two skill categories follow different patterns when the Food & drink sector is stimulated as compared to these seen when the Financial services sector is stimulated. The unskilled real wage sees a stronger increase, as compared to the skilled real wage, before it returns to its base in period. This is also reflected in time path adjustments of the unemployment rate.

The results show that even though the same stimulus is applied to two sectors separately, there are significant differences in aggregate, and more importantly, labour market outcomes of the two skill categories. These differences are driven mainly by sectoral characteristics.

Table 7.4.1: Long-run, free migration, effects: £500m ROW export demand stimulus to FIN and F&D. In % changes

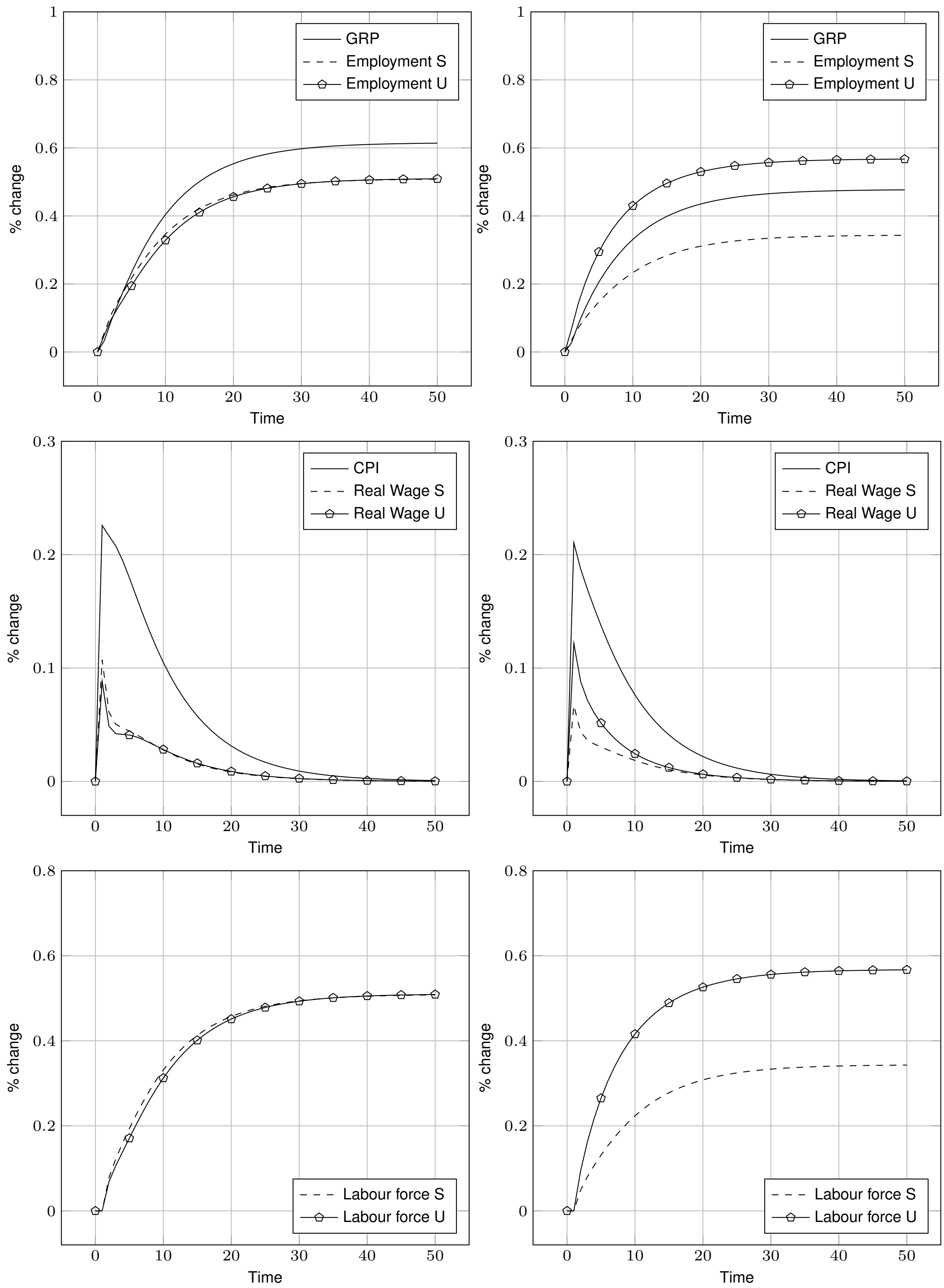
	LR - Free mig.	
	FIN	F&D
GRP Income measure	0.62	0.48
Consumer Price Index	0.00	0.00
Unemployment Rate	- 0.00	- 0.00
Unemployment Rate S	- 0.00	- 0.00
Unemployment Rate U	- 0.00	- 0.00
Total Employment	0.51	0.42
Total Employment S	0.51	0.34
Total Employment U	0.51	0.57
Nominal Gross Wage	0.00	0.00
Nominal Gross Wage S	0.00	0.00
Nominal Gross Wage U	0.00	0.00
Real Gross Wage	0.00	0.00
Real Gross Wage S	0.00	0.00
Real Gross Wage U	0.00	0.00
Labour force	0.51	0.42
Labour force S	0.51	0.34
Labour force U	0.51	0.57
Households Consumption	0.32	0.26
Investment	0.79	0.57
Capital Stock	0.79	0.57
Replacement cost of capital	0.00	0.00
Export RUK	- 0.00	- 0.00
Export ROW	3.04	3.04

FIN = Financial services; F&D = Food, drink & tobacco.
LR = long-run. S = Skilled; U = Unskilled.

Figure 7.4.1: Aggregate transition paths - £500m ROW export demand stimulus to FIN and F&D - long-run - free migration

a) Stimulus to Financial services

b) Stimulus to Food & drink



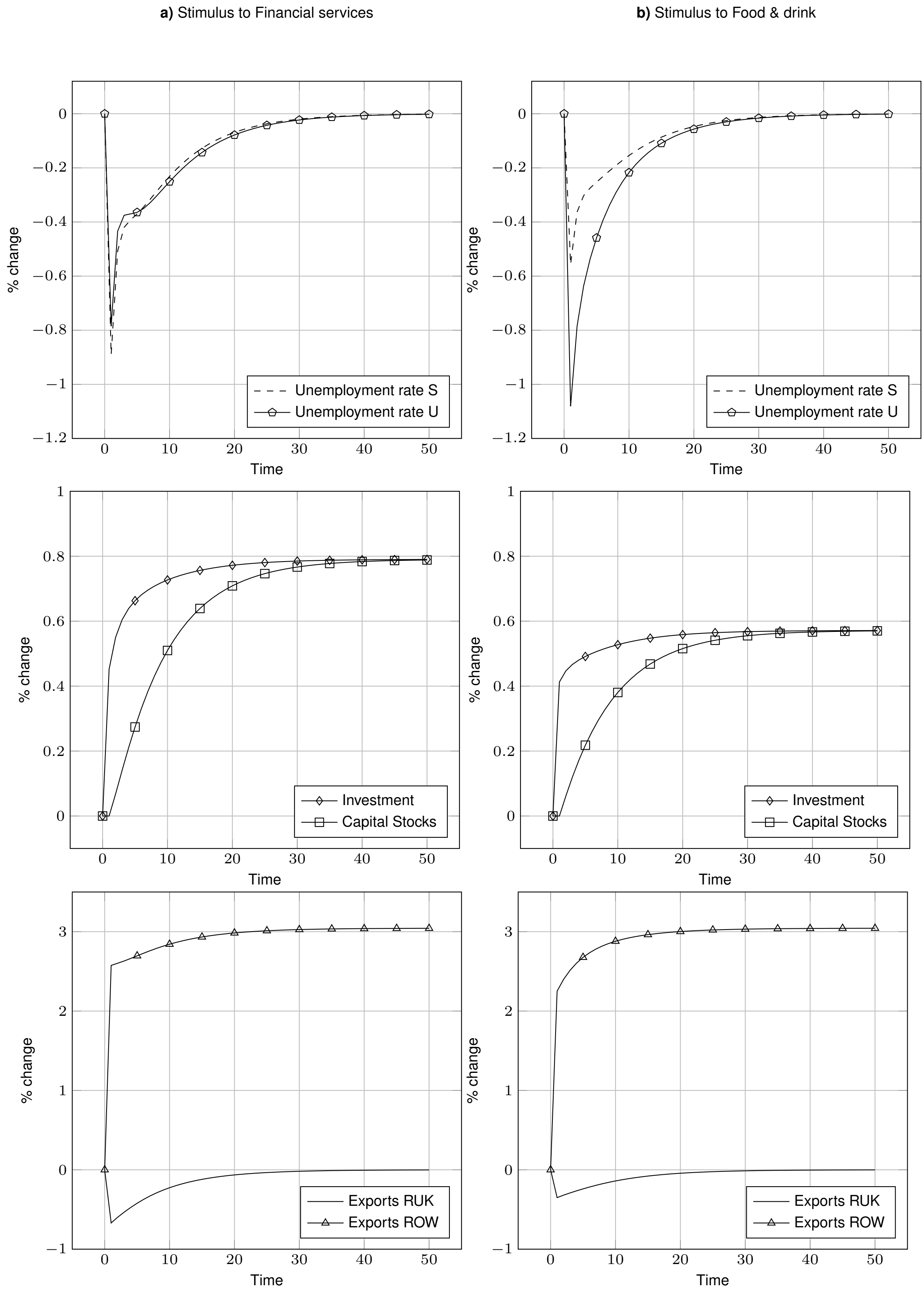

a) Stimulus to Financial services
b) Stimulus to Food & drink
% change
Time
Unemployment rate S
Unemployment rate U
Investment
Capital Stocks
Exports RUK
Exports ROW

Table 7.4.2 and Figure 7.4.2 detail the long-run results at the individual sector level for a £500m ROW export demand stimulus to the Financial services sector, and to the Food & drink sector. The results show that there are some general effects that can be observed irrespective of which of the two sectors is stimulated.

The stimulus to exports can be characterised at sectoral level to result in an increase in investments and total output. The stimulated demand increases employment. Notably, the percentage change in skilled and unskilled employment is equiproportional within each sector as the relative wage remains the same.

Prices in all sectors return to their base due to the flow migration and bargained real wage assumptions. As prices do not change there are no competitiveness effects and exports both to the RUK and the ROW return to their base. The exception from this are ROW exports which increase in the sectors that experience the stimulus.

Even though these main results can be observed at sectoral level, demand linkages of the stimulated sectors, and other sectoral characteristics, drive the overall results of the two simulations. Sectors that are not directly simulated thereby also experience significant differences depending on the sector that experiences the stimulus.

For example, when considering the impact on the Construction sector across the two simulations there are significant differences. The Construction sees a 0.90% increase in output, and a 0.91% increase in investment in the long run when the Financial services sector is stimulated. This stimulated impact to the Construction sector is smaller when the Food & drink sector is stimulated, 0.51% and 0.52% receptively.

To recall, the Construction sector is one of the main suppliers of investment goods, and the Financial services sector is capital intensive and thereby requires these investment goods to expand. The stimulus to the Financial services sector thus generates a larger stimulated impact on the Construction sector, as compared to the impact seen when the Food & drink sector is stimulated.

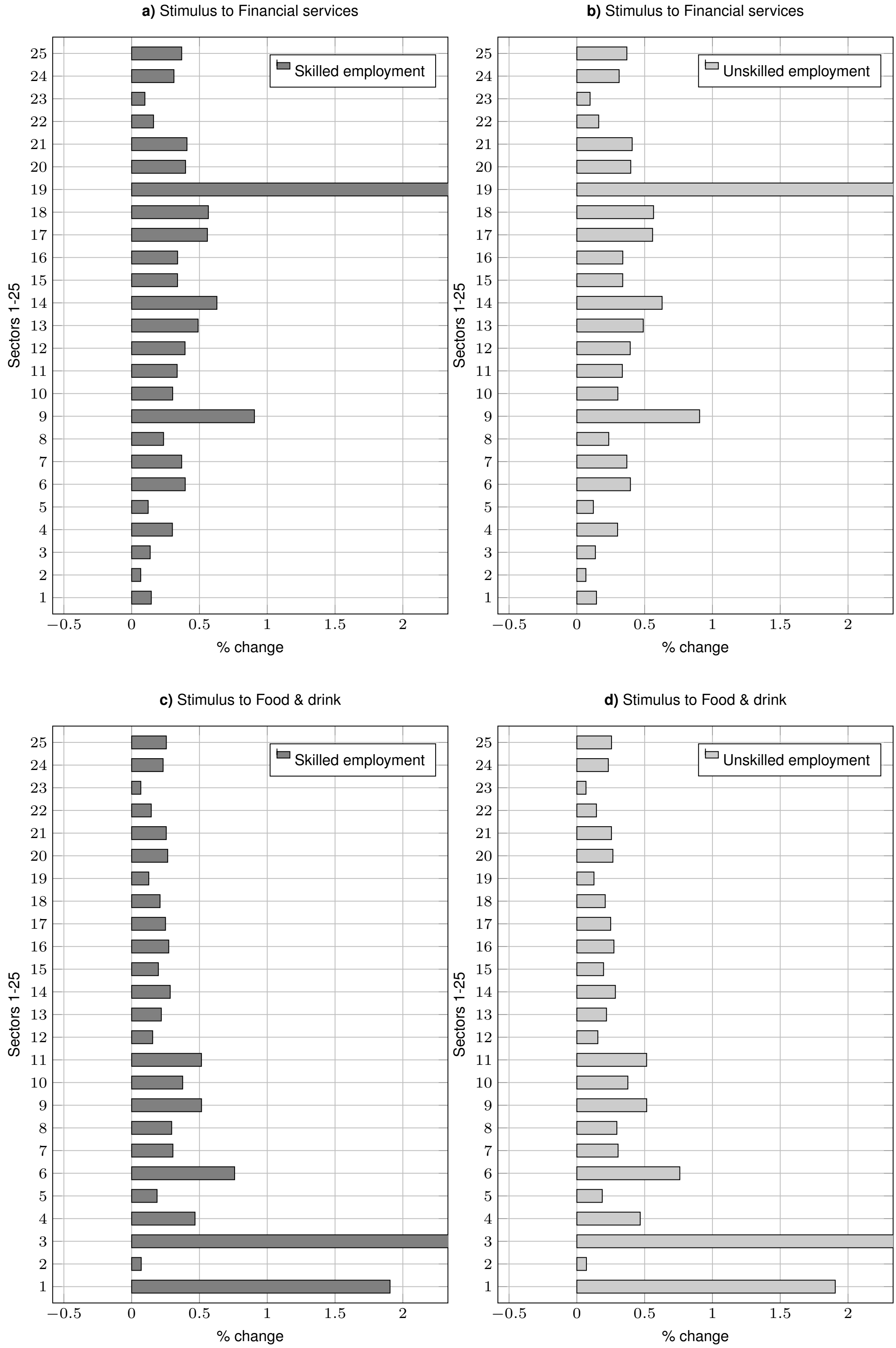
The Agriculture, forestry and fishing sector has strong demand linkages with the Food & drink sector. Thus, it sees a relatively large stimulus to output when the Food & drink sector is stimulated, as compared to the stimulus seen when the Financial services sector is stimulated.

These differences in the stimulated impacts can be observed across all sectors and are driven by sectoral consumption and sales characteristics. Notably, the Mining sector sees the same aggregate long run impacts irrespective of whether the Financial services, or the Food & drink sector is stimulated (adjustment paths, however, may differ).

Table 7.4.2: Long-run, free migration, results: £500m ROW export demand stimulus to FIN and F&D. In % changes

	Export demand stimulus to Financial services									Export demand stimulus to Food & drink								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	0.17	0.00	0.14	0.14	0.00	0.00	0.14	0.14	0.00	2.20	0.00	1.91	1.91	0.00	0.00	1.91	1.91	0.00
2. Mining	0.07	0.00	0.07	0.07	0.00	0.00	0.07	0.07	0.00	0.07	0.00	0.07	0.07	0.00	0.00	0.07	0.07	0.00
3. Food, drink and tobacco	0.13	0.00	0.14	0.14	0.00	0.00	0.14	0.14	0.00	6.50	0.00	6.63	6.63	0.00	18.94	6.63	6.63	0.00
4. Textile, leather, wood and paper	0.29	0.00	0.30	0.30	0.00	0.00	0.30	0.30	0.00	0.46	0.00	0.47	0.47	0.00	0.00	0.47	0.47	0.00
5. Chemicals	0.12	0.00	0.12	0.12	0.00	0.00	0.12	0.12	0.00	0.18	0.00	0.19	0.19	0.00	0.00	0.19	0.19	0.00
6. Rubber, plastic, cement and iron	0.38	0.00	0.39	0.39	0.00	0.00	0.39	0.39	0.00	0.73	0.00	0.76	0.76	0.00	0.00	0.76	0.76	0.00
7. Computer, electrical and transport eq.	0.36	0.00	0.37	0.37	0.00	0.00	0.37	0.37	0.00	0.30	0.00	0.30	0.30	0.00	0.00	0.30	0.30	0.00
8. Electricity, gas and water	0.23	0.00	0.24	0.24	0.00	0.00	0.24	0.24	0.00	0.29	0.00	0.30	0.30	0.00	0.00	0.30	0.30	0.00
9. Construction	0.90	0.00	0.91	0.91	0.00	0.00	0.91	0.91	0.00	0.51	0.00	0.52	0.52	0.00	0.00	0.52	0.52	0.00
10. Wholesale and retail	0.29	0.00	0.30	0.30	0.00	0.00	0.30	0.30	0.00	0.36	0.00	0.38	0.38	0.00	0.00	0.38	0.38	0.00
11. Land transport	0.32	0.00	0.34	0.34	0.00	0.00	0.34	0.34	0.00	0.49	0.00	0.51	0.51	0.00	0.00	0.51	0.51	0.00
12. Water transport	0.37	0.00	0.39	0.39	0.00	0.00	0.39	0.39	0.00	0.15	0.00	0.15	0.15	0.00	0.00	0.15	0.15	0.00
13. Air Transport	0.45	0.00	0.49	0.49	0.00	0.00	0.49	0.49	0.00	0.20	0.00	0.22	0.22	0.00	0.00	0.22	0.22	0.00
14. Post and support transport services	0.62	0.00	0.63	0.63	0.00	0.00	0.63	0.63	0.00	0.28	0.00	0.28	0.28	0.00	0.00	0.28	0.28	0.00
15. Accommodation	0.32	0.00	0.34	0.34	0.00	0.00	0.34	0.34	0.00	0.18	0.00	0.20	0.20	0.00	0.00	0.20	0.20	0.00
16. Food & beverage services	0.31	0.00	0.34	0.34	0.00	0.00	0.34	0.34	0.00	0.25	0.00	0.27	0.27	0.00	0.00	0.27	0.27	0.00
17. Telecommunication	0.55	0.00	0.56	0.56	0.00	0.00	0.56	0.56	0.00	0.24	0.00	0.25	0.25	0.00	0.00	0.25	0.25	0.00
18. Computer and information services	0.56	0.00	0.57	0.57	0.00	0.00	0.57	0.57	0.00	0.21	0.00	0.21	0.21	0.00	0.00	0.21	0.21	0.00
19. Financial services	3.36	0.00	3.50	3.50	0.00	34.36	3.50	3.50	0.00	0.12	0.00	0.13	0.13	0.00	0.00	0.13	0.13	0.00
20. Real estate	0.40	0.00	0.40	0.40	0.00	0.00	0.40	0.40	0.00	0.27	0.00	0.27	0.27	0.00	0.00	0.27	0.27	0.00
21. Professional services	0.40	0.00	0.41	0.41	0.00	0.00	0.41	0.41	0.00	0.25	0.00	0.26	0.26	0.00	0.00	0.26	0.26	0.00
22. Research and development	0.18	0.00	0.16	0.16	0.00	0.00	0.16	0.16	0.00	0.16	0.00	0.14	0.14	0.00	0.00	0.14	0.14	0.00
23. Public administration	0.09	0.00	0.10	0.10	0.00	0.00	0.10	0.10	0.00	0.07	0.00	0.07	0.07	0.00	0.00	0.07	0.07	0.00
24. Recreational services	0.30	0.00	0.31	0.31	0.00	0.00	0.31	0.31	0.00	0.22	0.00	0.23	0.23	0.00	0.00	0.23	0.23	0.00
25. Other services	0.36	0.00	0.37	0.37	0.00	0.00	0.37	0.37	0.00	0.25	0.00	0.26	0.26	0.00	0.00	0.26	0.26	0.00

Figure 7.4.2: Long-run, free migration, sectoral results: £500m ROW export demand stimulus to FIN and F&D



Note: see Table 7.4.2 for full set of results.

7.4.2 Long-run: Skilled migration

Table 7.4.3 details the key macroeconomic long-run results, in percentage changes, for a £500m increase in exports to the ROW for each of the Financial services sector (FIN), and the Food & drink sector (F&D), and for the free- and skilled migration closures.

Figure 7.4.3 details the aggregate transition paths of GRP, employment, CPI, real wages, labour force, unemployment rates, investment, capital stocks, and exports for the skilled migration case. These figures report the percentage change from base year values.

As detailed in the free migration case, following the demand stimulus there is an increase in prices, quantities, revenues, and profits and thereby also an increase in net investment and capital stocks. There are, however, some significant differences to the free migration closure.

In the free migration closure both the skilled and unskilled long-run unemployment rates, and the skilled and unskilled real wages are tied down to their initial equilibrium values through the combination of regional bargained real wage and flow migration. Both the skilled and unskilled labour force is available in the long run with an infinitely elastic supply at the base year real wage

In contrast to the free migration closure, the unskilled labour force is fixed in the skilled migration closure. This means that in response to changes in the demand for unskilled labour, the unskilled real wage and unemployment rate will adjust. If demand for unskilled labour rises, unskilled real wages will rise and their unemployment rate falls. The unskilled unemployment rate falls towards the long-run by 2.64% and 2.93%, and the unskilled real wage rises by 0.30% and 0.33%.

The skilled labour force is available 'as if' with infinitely elastic supply, which ultimately ties down the skilled unemployment rate and the skilled real wage to their initial equilibrium. Skilled labour thereby experience the same adjustment mechanisms seen in the free migration closure, as detailed in Section 7.4.1, where the skilled unemployment rate, and the skilled real wage revert back to their initial equilibrium.

Neither the aggregate unemployment rate nor aggregate real wages revert back to their initial equilibrium levels in the skilled migration closure. The aggregate unemployment rate falls by 0.91% and 1.01%, and the aggregate real wage rises by 0.10% and 0.12% receptively when the stimulus is to the Financial services sector and the Food & drink sector. CPI increases by 0.07% and 0.08% in the skilled migration closure. Nominal wages fall by 0.17% and 0.19% in the long run under the skilled migration closure.

The increase in prices in the long run has some negative competitiveness effects. The stimulus to output is thereby affected by the restriction of the supply of unskilled workers. Competitiveness effects reduce exports to the RUK by 0.12% and 0.13%. Also, exports to the ROW are below these seen in the free migration case. GPR growth is thereby dampened and sees a 0.49% and 0.38% increase, as compared to the 0.62% and 0.48% increase seen in the free migration closure.

Figure 7.4.3 shows that exports to the RUK see a significant initial fall, and then gradually increase towards period ten. In contrast to the free migration closure, these exports, however, remain below their base in the long run. This reflects adjustments of domestic prices, which are driven by wages.

The key here is that the bargaining power of unskilled workers is increased as demand for unskilled labour rises together with a fixed unskilled labour force. That is, unskilled workers are able to achieve an increase in their real wage in the skilled migration closure as compared to the free migration closure. These long run wage adjustments, however, generate negative competitiveness effects. Also, the adjustment differences between the free and the skilled migration closures imply that disparate impacts between the two skill groups are more visible.

Table 7.4.3: Long-run, skilled migration, effects: £500m ROW export demand stimulus to FIN and F&D. In % changes

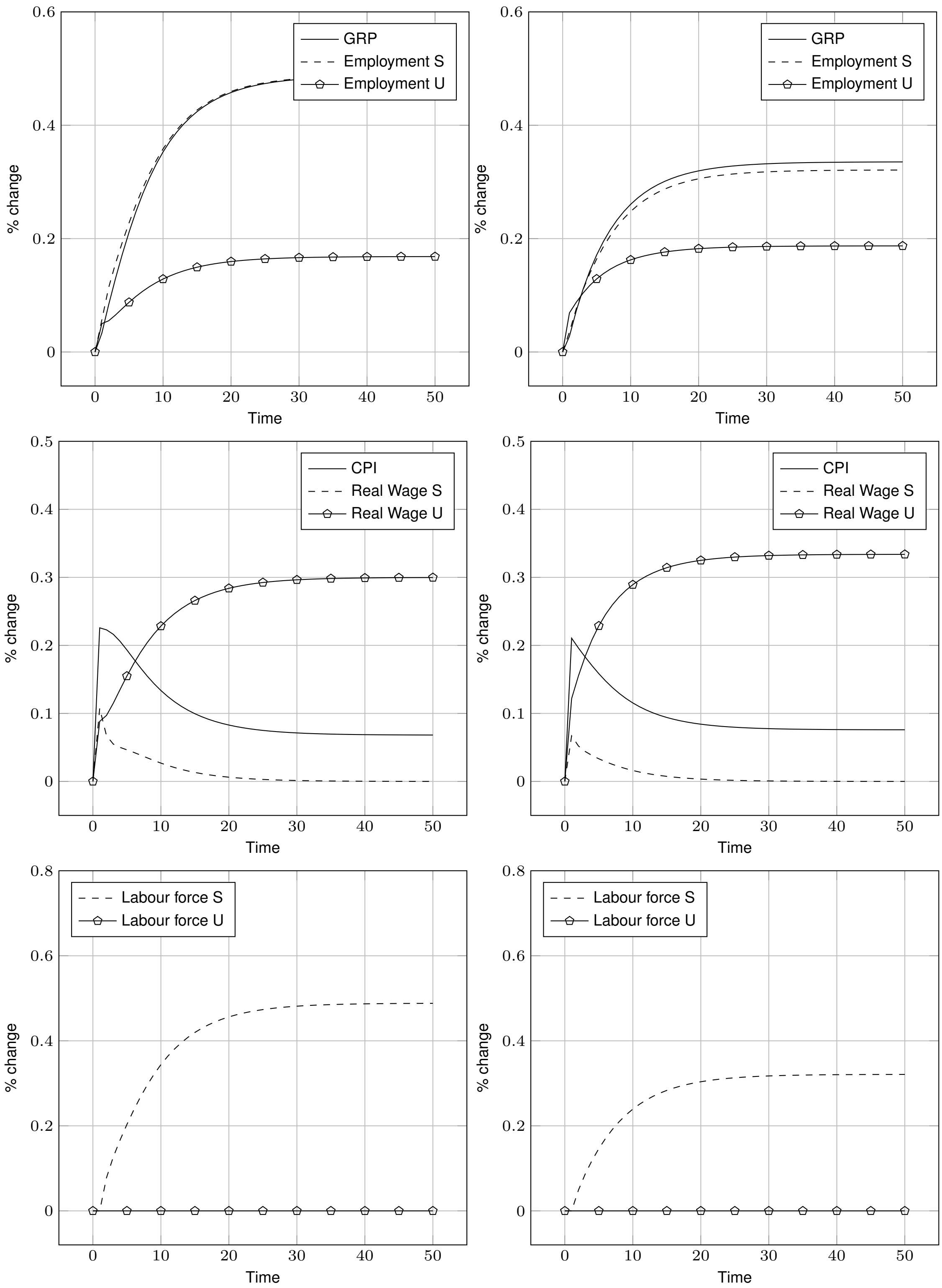
	LR - Free mig.		LR - Skilled mig.	
	FIN	F&D	FIN	F&D
GRP Income measure	0.62	0.48	0.49	0.34
Consumer Price Index	0.00	0.00	0.07	0.08
Unemployment Rate	- 0.00	- 0.00	- 0.91	- 1.01
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00
Unemployment Rate U	- 0.00	- 0.00	- 2.64	- 2.93
Total Employment	0.51	0.42	0.38	0.27
Total Employment S	0.51	0.34	0.49	0.32
Total Employment U	0.51	0.57	0.17	0.19
Nominal Gross Wage	0.00	0.00	0.17	0.19
Nominal Gross Wage S	0.00	0.00	0.07	0.08
Nominal Gross Wage U	0.00	0.00	0.37	0.41
Real Gross Wage	0.00	0.00	0.10	0.12
Real Gross Wage S	0.00	0.00	0.00	0.00
Real Gross Wage U	0.00	0.00	0.30	0.33
Labour force	0.51	0.42	0.32	0.21
Labour force S	0.51	0.34	0.49	0.32
Labour force U	0.51	0.57	-	-
Households Consumption	0.32	0.26	0.30	0.23
Investment	0.79	0.57	0.67	0.44
Capital Stock	0.79	0.57	0.67	0.44
Replacement cost of capital	0.00	0.00	0.07	0.07
Export RUK	- 0.00	- 0.00	- 0.12	- 0.13
Export ROW	3.04	3.04	2.92	2.91

FIN = Financial services; F&D = Food, drink & tobacco.
LR = long-run. S = Skilled; U = Unskilled.

Figure 7.4.3: Aggregate transition paths - £500m ROW export demand stimulus to FIN and F&D - long-run - skilled migration

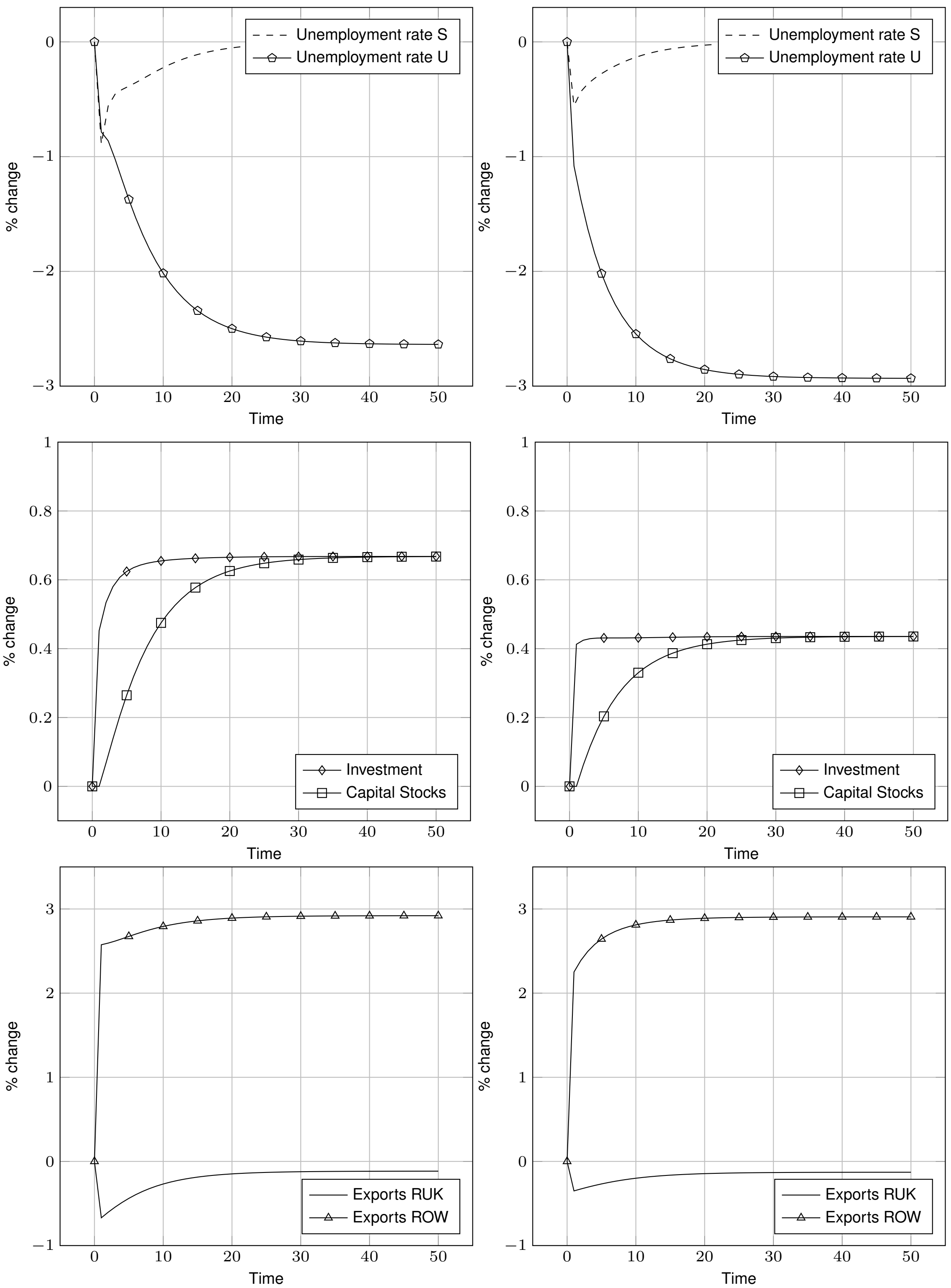
a) Stimulus to Financial services

b) Stimulus to Food & drink



a) Stimulus to Financial services

b) Stimulus to Food & drink



Given the adjustment mechanisms outlined, the skilled real wage and the skilled unemployment rate revert back to their base level values in the skilled migration closure. In contrast, the unskilled real wage and the unskilled unemployment rate, vary from their base in the long run, as shown in Figure 7.4.3.

This implies that unskilled workers are 'more expensive' in the long run as compared to skilled workers. Thus, there is a substitution effect between skilled and unskilled labour, and other inputs, as the price of skilled labour rises by less than the price of unskilled labour. Sectors thereby experience a competitiveness penalty from the supply restriction of unskilled workers.

This substitution effect is particularly visible when considering the impact on employment. Skilled employment increases by significantly more than unskilled employment in the skilled migration closure, irrespective of which of the two sectors experiences the stimulus.

When the Financial services sector is stimulated there are equiproportionate labour market impacts on the two skill categories in the free migration closure. In the skilled migration closure the differential impact on the two skill categories is marked, and is driven by the migration assumption.

Figure 7.4.3 shows that skilled employment increases significantly above its base, leaving a large gap between the increase seen in unskilled employment when the Financial services sector is stimulated. When the Food & drink sector is stimulated adjustment paths are similar, but the impact on skilled employment is less marked.

Employment changes are reflected by adjustments seen in the unemployment rate and the real wage of the two skill categories. Figure 7.4.3 shows that unskilled unemployment rate falls across all of the simulated periods. The skilled unemployment rate falls initially and then returns to its long run steady-state in period 45. Similar but inverse adjustments are seen in the real wage.

Even though the labour market adjustments are relatively similar when the Financial services sector and the Food & drink sector are stimulated, there are significant differences when considering the impact on skilled employment. That is, real wages and unemployment rate changes are relatively similar but yield significantly different impacts on employment. Sectoral effects thereby again play a significant part in determining overall labour market outcomes.

Table 7.4.4 and Figure 7.4.4 detail the long-run results at the individual sector level for a £500m ROW export demand stimulus to the Financial services sector, and to the Food & drink sector. The results show that there are some general effects that can be observed irrespective of which of the two sectors is stimulated.

The majority of the sectors see an increase in output, prices, employment, investment, rental rates, and a fall in exports (the stimulated sectors see increases in exports to the ROW). There are, however, some sectors that do not follow this general adjustment, and there are also significant differences across sectors depending on which sector is stimulated.

Table 7.4.4 shows that there is one sector that experiences a fall in output when the Financial services sector is stimulated. Similarly, there are five sectors that see a fall in output when the Food & drink sector is stimulated. These sectors experience crowding out of output due to the increase in prices and the corresponding fall in exports, and disinvestment.

Sectors with strong demand linkages to the stimulated sectors experience some positive output effects. Sectors that provide investment goods also benefit from the increased demand for capital. For example, the Agriculture, forestry, and fishing sector experiences a relatively large stimulus to output when the Food & drink sector is stimulated. The Construction sector, a sector providing investment goods, also sees some stimulus to output.

Sectors that experience a stimulus to output through demand linkages, and/or increases in investment demand, also see increases in skilled and unskilled employment. Unskilled employment experiences a fall in sectors where this stimulus to output is muted. This disparate impact is mainly due to substitution effects of the two skill categories as the price of skilled labour rises by less than the price of unskilled labour.

The substitution effect of skilled for unskilled workers is best illustrated when considering the employment impacts of a low skill intensive sector. To recall, the Rubber, plastic, cement & iron sector has the lowest share of skilled FTE workers (36%) across all of the sectors. In all of the skilled migration closure results, skilled employment increases significantly in the Rubber, plastic, cement & iron sector, whilst unskilled employment falls.

The differential impact on the two skill categories is more marked in the skilled migration closure as compared to the impact seen in the free migration closure. Both skill categories benefit relatively even in terms of labour market outcomes in the free migration closure.

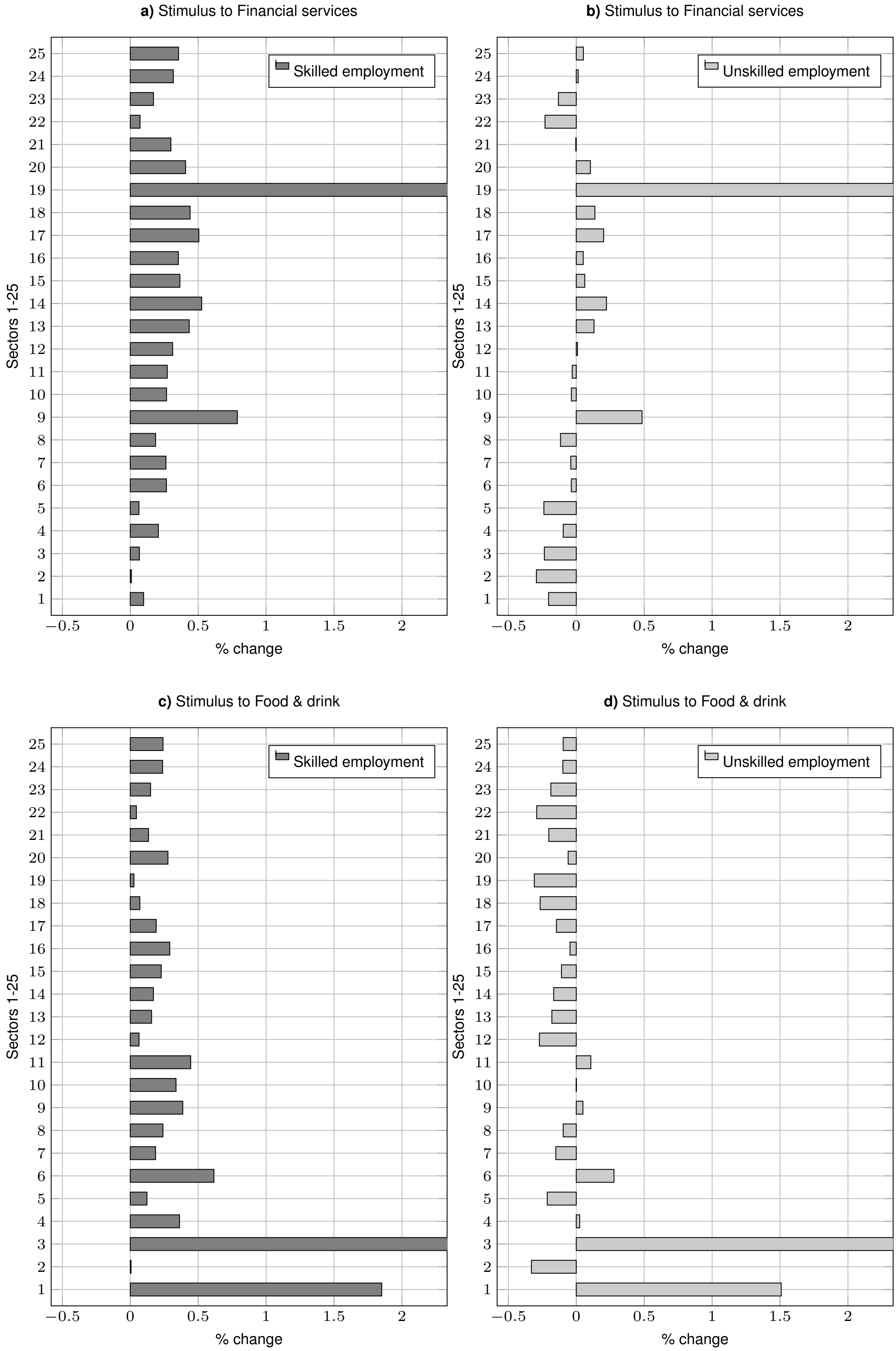
In the skilled migration closure, however, the skilled benefit from relatively large increases in employment as skilled real wages and skilled unemployment rates revert to their base. In contrast, the unskilled benefit from increases in the real wage and falling unemployment rates, but experience a relatively small stimulus to employment.

The main drivers of the differences seen between the stimulus to the Financial services sector, and the Food & drink sector are, however, sectoral characteristics. As seen in the free migration closure, the results show that even though the same stimulus is applied to two sectors separately, there are significant differences in aggregate, and more importantly, labour market outcomes of the two skill categories.

Table 7.4.4: Long-run, skilled migration, results: £500m ROW export demand stimulus to FIN and F&D. In % changes

	Export demand stimulus to Financial services									Export demand stimulus to Food & drink								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	0.04	0.05	0.10	-0.20	-0.10	-0.10	0.03	0.03	0.07	2.05	0.05	1.85	1.51	-0.11	-0.11	1.77	1.77	0.07
2. Mining	-0.05	0.04	0.01	-0.29	-0.07	-0.07	-0.06	-0.06	0.07	-0.06	0.04	0.01	-0.33	-0.08	-0.08	-0.08	-0.08	0.07
3. Food, drink and tobacco	0.00	0.06	0.07	-0.24	-0.12	-0.12	-0.01	-0.01	0.07	6.34	0.07	6.55	6.19	-0.13	18.78	6.46	6.46	0.07
4. Textile, leather, wood and paper	0.13	0.06	0.21	-0.10	-0.12	-0.12	0.13	0.13	0.07	0.28	0.07	0.36	0.03	-0.13	-0.13	0.28	0.28	0.07
5. Chemicals	0.00	0.04	0.06	-0.24	-0.08	-0.08	-0.01	-0.01	0.07	0.05	0.05	0.12	-0.21	-0.09	-0.09	0.04	0.04	0.07
6. Rubber, plastic, cement and iron	0.19	0.06	0.27	-0.04	-0.13	-0.13	0.19	0.19	0.07	0.51	0.07	0.62	0.28	-0.14	-0.14	0.53	0.53	0.07
7. Computer, electrical and transport eq.	0.19	0.06	0.26	-0.04	-0.12	-0.12	0.19	0.19	0.07	0.11	0.07	0.19	-0.15	-0.13	-0.13	0.11	0.11	0.07
8. Electricity, gas and water	0.11	0.05	0.19	-0.12	-0.11	-0.11	0.11	0.11	0.07	0.16	0.06	0.24	-0.10	-0.12	-0.12	0.16	0.16	0.07
9. Construction	0.71	0.07	0.79	0.48	-0.13	-0.13	0.72	0.72	0.07	0.30	0.07	0.39	0.05	-0.15	-0.15	0.31	0.31	0.07
10. Wholesale and retail	0.18	0.07	0.27	-0.04	-0.14	-0.14	0.19	0.19	0.07	0.24	0.08	0.34	0.00	-0.16	-0.16	0.26	0.26	0.07
11. Land transport	0.19	0.06	0.27	-0.03	-0.13	-0.13	0.20	0.20	0.07	0.35	0.07	0.44	0.11	-0.14	-0.14	0.36	0.36	0.07
12. Water transport	0.23	0.06	0.31	0.01	-0.11	-0.11	0.24	0.24	0.07	-0.01	0.06	0.06	-0.27	-0.12	-0.12	-0.02	-0.02	0.07
13. Air Transport	0.33	0.06	0.43	0.13	-0.12	-0.12	0.36	0.36	0.07	0.07	0.07	0.16	-0.18	-0.13	-0.13	0.08	0.08	0.07
14. Post and support transport services	0.45	0.06	0.53	0.22	-0.13	-0.13	0.45	0.45	0.07	0.09	0.07	0.17	-0.17	-0.14	-0.14	0.09	0.09	0.07
15. Accommodation	0.27	0.07	0.37	0.06	-0.15	-0.15	0.29	0.29	0.07	0.13	0.08	0.23	-0.11	-0.17	-0.17	0.15	0.15	0.07
16. Food & beverage services	0.25	0.08	0.35	0.05	0.00	0.00	0.28	0.28	0.07	0.19	0.09	0.29	-0.05	0.00	0.00	0.21	0.21	0.07
17. Telecommunication	0.42	0.07	0.51	0.20	-0.13	-0.13	0.43	0.43	0.07	0.11	0.08	0.19	-0.15	-0.15	-0.15	0.11	0.11	0.07
18. Computer and information services	0.36	0.08	0.44	0.14	-0.15	-0.15	0.37	0.37	0.07	-0.01	0.08	0.07	-0.27	-0.17	-0.17	-0.01	-0.01	0.07
19. Financial services	3.20	0.06	3.40	3.09	-0.12	34.20	3.33	3.33	0.07	-0.05	0.07	0.03	-0.31	-0.13	-0.13	-0.05	-0.05	0.07
20. Real estate	0.34	0.05	0.41	0.10	-0.10	-0.10	0.33	0.33	0.07	0.20	0.06	0.28	-0.06	-0.11	-0.11	0.20	0.20	0.07
21. Professional services	0.22	0.07	0.30	0.00	-0.13	-0.13	0.23	0.23	0.07	0.05	0.07	0.13	-0.20	-0.15	-0.15	0.05	0.05	0.07
22. Research and development	0.00	0.07	0.07	-0.23	-0.14	-0.14	0.00	0.00	0.07	-0.04	0.08	0.05	-0.29	-0.16	-0.16	-0.04	-0.04	0.07
23. Public administration	0.08	0.11	0.17	-0.13	-0.21	-0.21	0.10	0.10	0.07	0.05	0.12	0.15	-0.19	-0.24	-0.24	0.07	0.07	0.07
24. Recreational services	0.23	0.08	0.32	0.01	-0.16	-0.16	0.24	0.24	0.07	0.15	0.09	0.24	-0.10	-0.18	-0.18	0.16	0.16	0.07
25. Other services	0.27	0.08	0.36	0.05	-0.16	-0.16	0.28	0.28	0.07	0.15	0.09	0.24	-0.10	-0.18	-0.18	0.16	0.16	0.07

Figure 7.4.4: Long-run, skilled migration, sectoral results: £500m ROW export demand stimulus to FIN and F&D



Note: see Table 7.4.4 for full set of results.

7.4.3 Long-run: No migration

Table 7.4.5 details the key macroeconomic long-run results, in percentage changes, for a £500m increase in exports to the ROW for each of the Financial services sector (FIN), and the Food & drink sector (F&D), and for the free-, skilled-, and no migration closures.

Figure 7.4.5 details the aggregate transition paths of GRP, employment, CPI, real wages, labour force, unemployment rates, investment, capital stocks, and exports. These figures report the percentage change from base year values.

In the no migration closure neither skilled nor unskilled migrate between regions in response to changes in real wage and unemployment rates. That is, the total workforce remains fixed throughout the simulation, the skilled and unskilled unemployment rate and real wage vary in the long run in response to changes in labour demand.

The main adjustment mechanism seen in the free- and the skilled migration closures are also seen here, where the demand stimulus causes an increase in prices, quantities, revenues, and profits and thereby also an increase in the capital stock and investment. This increases the demand for labour, decreasing unemployment. The unemployment rate and the real wage, however, do not revert back to their initial equilibrium as the skilled and unskilled labour force remains fixed.

The most direct impact, as compared to the other migration closures, is that the skilled real wage increases in the long run in the no migration closure. The bargaining power of skilled and unskilled workers is increased as demand for labour rises together with a fixed labour force. That is, both skill categories are able to achieve an increase in their real wage.

Prices thereby rise by more than in the skilled migration closure. This in turn reduces the stimulus to exports and thereby the stimulated demand for labour. All sectors experience a competitiveness penalty in the no migration closure as the supply of both skilled and unskilled workers is restricted. This in turn causes some crowding out of output.

The impact on the skilled and the unskilled is very similar when the Financial services sector is stimulated. Skilled and unskilled employment increases by 0.15% and 0.14% respectively. The skilled unemployment rate falls by 2.43% and that of the unskilled by 2.27%. This close similarly is also reflected in the skilled and unskilled real wage adjustments.

Figure 7.4.5 shows that employment, unemployment rate, and real wage time-path adjustments of the two skill categories are similar when the Financial services sector is stimulated. These close to equiproportionate adjustments are similar to these seen in the free migration closure. The stimulus to the Financial services sector thereby yields comparatively balanced labour market impacts for the two skill categories in two of the three migration closures

The impact on the skilled and unskilled labour markets is more marked when the Food & drink sector is stimulated. The unskilled see a larger fall in the unemployment rate, and a larger increase in employment and the real wage as compared to that seen by the skilled. This is also apparent in the time path adjustments in Figure 7.4.5.

The crowding out of exports also mutes the stimulus to investment. Figure 7.4.5 shows that there is some overshooting of investment in the first periods. Investment, however, adjusts relatively rapid to its steady-state in period 25.

Notably, there are relatively large differences in GRP increases across the three migration cases. This indicates that the impact of freeing up labour is relatively large. Competitiveness effects reduce exports to the RUK by 0.31% and 0.26%. Also, exports to the ROW fall from 3.04%, as in the free migration case, to 2.71% and 2.77% in the no migration closure. GPR growth is thereby dampened and sees a 0.27% and 0.19% increase, as compared to the 0.62% and 0.48% increase seen in the free migration closure.

Table 7.4.5: Long-run, no migration, effects: £500m ROW export demand stimulus to FIN and F&D. In % changes

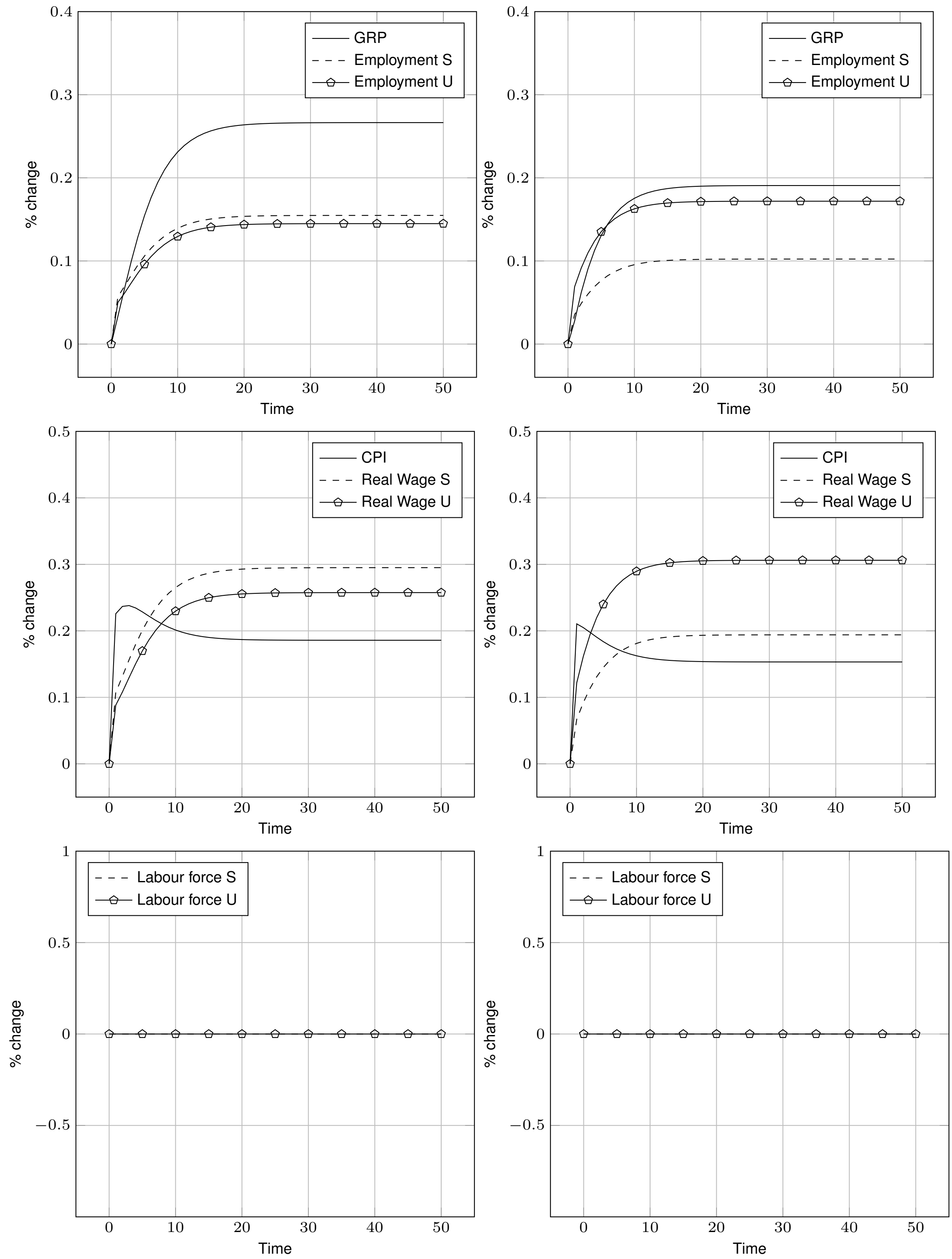
	LR - Free mig.		LR - Skilled mig.		LR - No mig.	
	FIN	F&D	FIN	F&D	FIN	F&D
GRP Income measure	0.62	0.48	0.49	0.34	0.27	0.19
Consumer Price Index	0.00	0.00	0.07	0.08	0.19	0.15
Unemployment Rate	- 0.00	- 0.00	- 0.91	- 1.01	- 2.37	- 1.98
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.43	- 1.60
Unemployment Rate U	- 0.00	- 0.00	- 2.64	- 2.93	- 2.27	- 2.69
Total Employment	0.51	0.42	0.38	0.27	0.15	0.13
Total Employment S	0.51	0.34	0.49	0.32	0.15	0.10
Total Employment U	0.51	0.57	0.17	0.19	0.14	0.17
Nominal Gross Wage	0.00	0.00	0.17	0.19	0.47	0.39
Nominal Gross Wage S	0.00	0.00	0.07	0.08	0.48	0.35
Nominal Gross Wage U	0.00	0.00	0.37	0.41	0.44	0.46
Real Gross Wage	0.00	0.00	0.10	0.12	0.28	0.23
Real Gross Wage S	0.00	0.00	0.00	0.00	0.30	0.19
Real Gross Wage U	0.00	0.00	0.30	0.33	0.26	0.31
Labour force	0.51	0.42	0.32	0.21	-	-
Labour force S	0.51	0.34	0.49	0.32	-	-
Labour force U	0.51	0.57	-	-	-	-
Households Consumption	0.32	0.26	0.30	0.23	0.25	0.20
Investment	0.79	0.57	0.67	0.44	0.46	0.30
Capital Stock	0.79	0.57	0.67	0.44	0.46	0.30
Replacement cost of capital	0.00	0.00	0.07	0.07	0.18	0.15
Export RUK	- 0.00	- 0.00	- 0.12	- 0.13	- 0.31	- 0.26
Export ROW	3.04	3.04	2.92	2.91	2.71	2.77

FIN = Financial services; F&D = Food, drink & tobacco.
LR = long-run. S = Skilled; U = Unskilled.

Figure 7.4.5: Aggregate transition paths - £500m ROW export demand stimulus to FIN and F&D - long-run - no migration

a) Stimulus to Financial services

b) Stimulus to Food & drink



a) Stimulus to Financial services

b) Stimulus to Food & drink

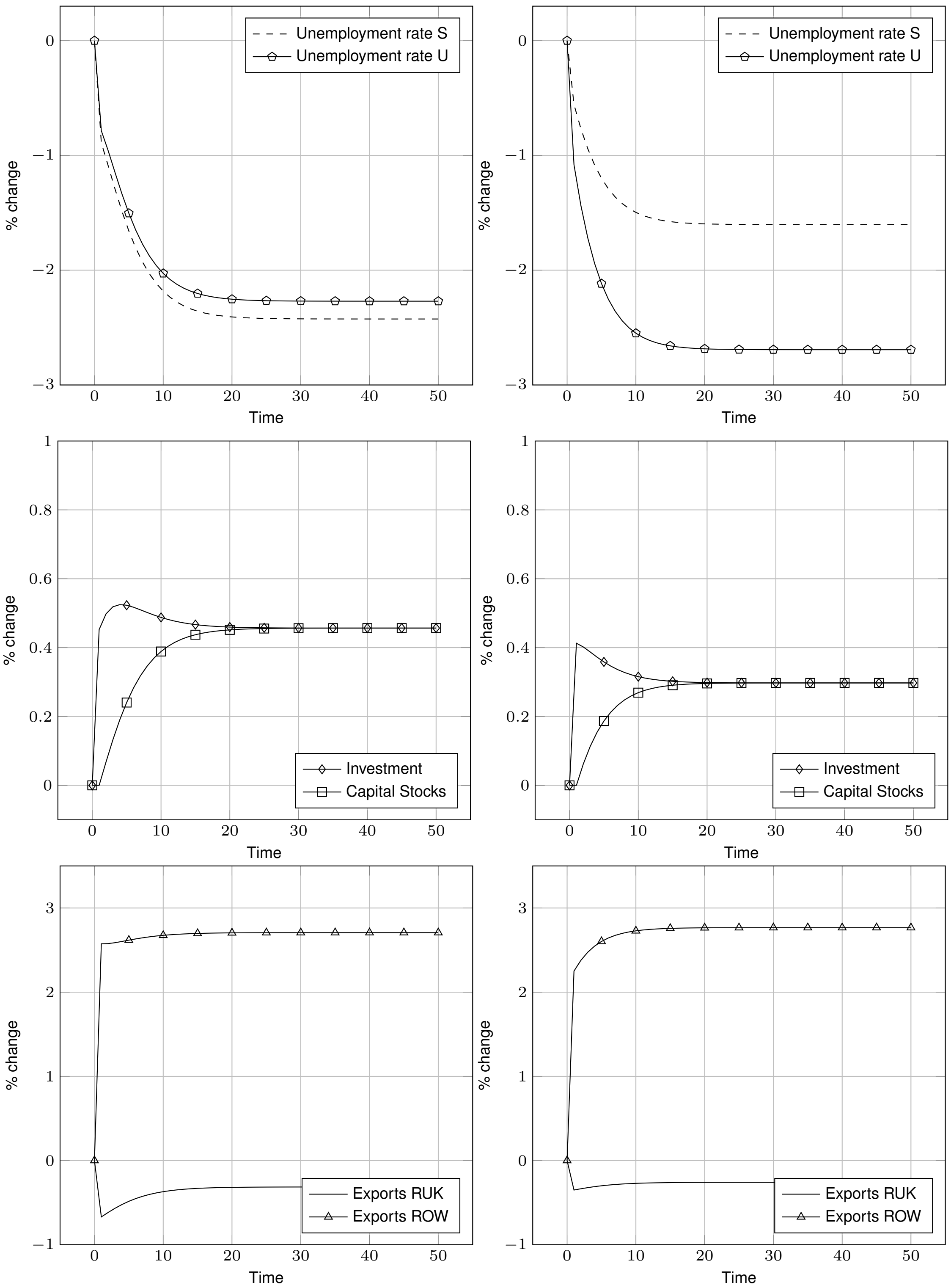
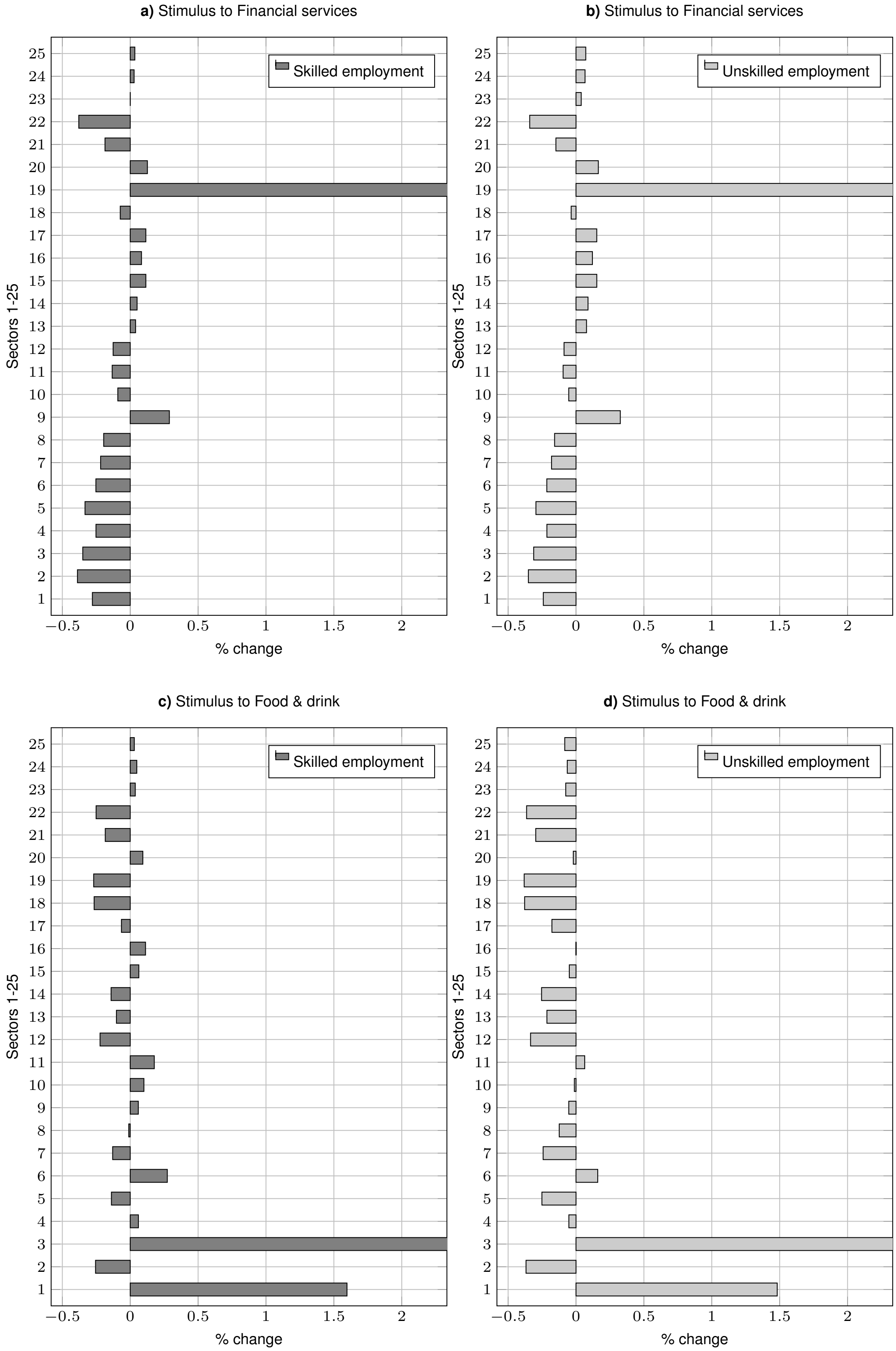


Table 7.4.6: Long-run, no migration, results: £500m ROW export demand stimulus to FIN and F&D. In % changes

	Export demand stimulus to Financial services									Export demand stimulus to Food & drink								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	-0.19	0.13	-0.28	-0.24	-0.26	-0.26	-0.18	-0.18	0.18	1.90	0.11	1.60	1.48	-0.21	-0.21	1.63	1.63	0.15
2. Mining	-0.26	0.10	-0.39	-0.35	-0.19	-0.19	-0.29	-0.29	0.18	-0.20	0.08	-0.26	-0.37	-0.16	-0.16	-0.22	-0.22	0.15
3. Food, drink and tobacco	-0.24	0.16	-0.35	-0.31	-0.32	-0.32	-0.25	-0.25	0.18	6.17	0.13	6.25	6.13	-0.26	18.63	6.29	6.29	0.15
4. Textile, leather, wood and paper	-0.15	0.16	-0.25	-0.21	-0.33	-0.33	-0.15	-0.15	0.18	0.09	0.13	0.06	-0.05	-0.27	-0.27	0.09	0.09	0.15
5. Chemicals	-0.21	0.11	-0.33	-0.30	-0.22	-0.22	-0.23	-0.23	0.18	-0.09	0.09	-0.14	-0.25	-0.19	-0.19	-0.11	-0.11	0.15
6. Rubber, plastic, cement and iron	-0.15	0.17	-0.25	-0.22	-0.34	-0.34	-0.15	-0.15	0.18	0.29	0.14	0.27	0.16	-0.28	-0.28	0.31	0.31	0.15
7. Computer, electrical and transport eq.	-0.11	0.16	-0.22	-0.18	-0.33	-0.33	-0.12	-0.12	0.18	-0.09	0.13	-0.13	-0.24	-0.27	-0.27	-0.10	-0.10	0.15
8. Electricity, gas and water	-0.08	0.15	-0.20	-0.16	-0.30	-0.30	-0.10	-0.10	0.18	0.03	0.12	-0.01	-0.12	-0.24	-0.24	0.02	0.02	0.15
9. Construction	0.39	0.18	0.29	0.33	-0.36	-0.36	0.39	0.39	0.18	0.09	0.15	0.06	-0.05	-0.30	-0.30	0.09	0.09	0.15
10. Wholesale and retail	0.00	0.20	-0.09	-0.05	-0.39	-0.39	0.01	0.01	0.18	0.12	0.16	0.10	-0.01	-0.32	-0.32	0.13	0.13	0.15
11. Land transport	-0.03	0.18	-0.13	-0.10	-0.35	-0.35	-0.03	-0.03	0.18	0.20	0.15	0.18	0.06	-0.29	-0.29	0.21	0.21	0.15
12. Water transport	-0.02	0.15	-0.13	-0.09	-0.31	-0.31	-0.03	-0.03	0.18	-0.17	0.13	-0.22	-0.33	-0.25	-0.25	-0.19	-0.19	0.15
13. Air Transport	0.13	0.16	0.04	0.08	-0.32	-0.32	0.14	0.14	0.18	-0.06	0.13	-0.10	-0.21	-0.27	-0.27	-0.07	-0.07	0.15
14. Post and support transport services	0.15	0.18	0.05	0.09	-0.35	-0.35	0.15	0.15	0.18	-0.11	0.15	-0.14	-0.25	-0.29	-0.29	-0.11	-0.11	0.15
15. Accommodation	0.19	0.20	0.12	0.15	-0.40	-0.40	0.21	0.21	0.18	0.08	0.17	0.06	-0.05	-0.33	-0.33	0.10	0.10	0.15
16. Food & beverage services	0.16	0.21	0.08	0.12	0.00	0.00	0.18	0.18	0.18	0.12	0.17	0.11	0.00	0.00	0.00	0.14	0.14	0.15
17. Telecommunication	0.21	0.18	0.12	0.15	-0.37	-0.37	0.21	0.21	0.18	-0.03	0.15	-0.06	-0.18	-0.30	-0.30	-0.03	-0.03	0.15
18. Computer and information services	0.02	0.21	-0.07	-0.04	-0.41	-0.41	0.03	0.03	0.18	-0.24	0.17	-0.27	-0.38	-0.34	-0.34	-0.23	-0.23	0.15
19. Financial services	2.92	0.16	2.94	2.98	-0.32	33.92	3.04	3.04	0.18	-0.22	0.13	-0.27	-0.38	-0.27	-0.27	-0.24	-0.24	0.15
20. Real estate	0.24	0.14	0.13	0.16	-0.27	-0.27	0.23	0.23	0.18	0.14	0.11	0.09	-0.02	-0.22	-0.22	0.13	0.13	0.15
21. Professional services	-0.09	0.18	-0.19	-0.15	-0.37	-0.37	-0.09	-0.09	0.18	-0.15	0.15	-0.18	-0.30	-0.30	-0.30	-0.15	-0.15	0.15
22. Research and development	-0.31	0.19	-0.38	-0.34	-0.39	-0.39	-0.28	-0.28	0.18	-0.24	0.16	-0.25	-0.36	-0.32	-0.32	-0.22	-0.22	0.15
23. Public administration	0.07	0.29	0.00	0.04	-0.58	-0.58	0.10	0.10	0.18	0.04	0.24	0.04	-0.08	-0.48	-0.48	0.07	0.07	0.15
24. Recreational services	0.11	0.22	0.03	0.07	-0.43	-0.43	0.13	0.13	0.18	0.07	0.18	0.05	-0.06	-0.36	-0.36	0.08	0.08	0.15
25. Other services	0.12	0.21	0.03	0.07	-0.43	-0.43	0.13	0.13	0.18	0.05	0.18	0.03	-0.08	-0.35	-0.35	0.06	0.06	0.15

Figure 7.4.6: Long-run, no migration, sectoral results: £500m ROW export demand stimulus to FIN and F&D



Note: see Table 7.4.6 for full set of results.

Table 7.4.6 and Figure 7.4.6 detail the long-run results at the individual sector level for a £500m ROW export demand stimulus to the Financial services sector, and to the Food & drink sector. There are some general effects that can be observed. The stimulated sectors experience a rise in output, prices, employment, exports to the ROW, and investments. Exports to the RUK fall due to the increase in prices.

Non stimulated sectors generally see an increase in output, prices, employment, and investment, and a fall in exports (both to the RUK and the ROW). These impacts, however, are not as unambiguous across sectors as observed in the other migration closures.

In contrast to the other migration closures there are a significant number of 'non stimulated' sectors that experience crowding out of output due to the increase in prices, and the corresponding fall in exports and investment demand.

This means that the demand for workers is subdued. Thereby there are sectors where skilled and/or unskilled employment falls. As given in the aggregate employment results, the impact on skilled and unskilled employment is comparatively balanced across all of the sectors when the Financial services sector is stimulated. This is because the wage for the skilled and unskilled workers sees similar percentage increases. This means that in each sector the changes in skilled and unskilled employment are also similar.

As seen in previous simulations, there are a number of sectors with strong demand linkages to the stimulated sectors that experience a rise in employment. For example, the Construction sector benefits strongly from the stimulus to the Financial sector. The Agriculture, forestry & fishing sector benefits significantly from the stimulus to the Food & drink sector.

7.4.4 Short-run

To recall, the short-run results are the same for all three migration closures since there is no migration in the first period irrespective of the assumptions about labour mobility, and myopic investment decisions made in period one are unaffected by future migration decisions. That is, the labour force is fixed in the short run, but the skilled and unskilled unemployment rate can change and labour is mobile across sectors. The capital stock is fixed in the short run in both total and its distribution across sectors. Following the demand stimulus there is an increase in prices, quantities, revenues, profits, desired capital stock, and investment.

As prices have increased, there is some crowding out in the first period (when the labour force is fixed) as the expansion in demand raises wages and the price of intermediate inputs for all sectors. This in turn results in a reduction in exports to the RUK and some crowding out can also be observed in exports to the ROW at individual sector level.

Table 7.4.7 details the key macroeconomic short- and long-run results, in percentage changes, for a £500m increase in exports to the ROW for each of the Financial services sector (FIN), and the Food & drink sector (F&D).

Table 7.4.7: Short- and long-run effects: £500m ROW export demand stimulus to FIN and F&D. In % changes

	LR - Free mig.		LR - Skilled mig.		LR - No mig.		SR	
	FIN	F&D	FIN	F&D	FIN	F&D	FIN	F&D
GRP Income measure	0.62	0.48	0.49	0.34	0.27	0.19	0.03	0.03
Consumer Price Index	0.00	0.00	0.07	0.08	0.19	0.15	0.23	0.21
Unemployment Rate	- 0.00	- 0.00	- 0.91	- 1.01	- 2.37	- 1.98	- 0.85	- 0.74
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.43	- 1.60	- 0.89	- 0.56
Unemployment Rate U	- 0.00	- 0.00	- 2.64	- 2.93	- 2.27	- 2.69	- 0.79	- 1.08
Total Employment	0.51	0.42	0.38	0.27	0.15	0.13	0.05	0.05
Total Employment S	0.51	0.34	0.49	0.32	0.15	0.10	0.06	0.04
Total Employment U	0.51	0.57	0.17	0.19	0.14	0.17	0.05	0.07
Nominal Gross Wage	0.00	0.00	0.17	0.19	0.47	0.39	0.33	0.30
Nominal Gross Wage S	0.00	0.00	0.07	0.08	0.48	0.35	0.33	0.28
Nominal Gross Wage U	0.00	0.00	0.37	0.41	0.44	0.46	0.31	0.33
Real Gross Wage	0.00	0.00	0.10	0.12	0.28	0.23	0.10	0.09
Real Gross Wage S	0.00	0.00	0.00	0.00	0.30	0.19	0.11	0.07
Real Gross Wage U	0.00	0.00	0.30	0.33	0.26	0.31	0.09	0.12
Labour force	0.51	0.42	0.32	0.21	-	-	-	-
Labour force S	0.51	0.34	0.49	0.32	-	-	-	-
Labour force U	0.51	0.57	-	-	-	-	-	-
Households Consumption	0.32	0.26	0.30	0.23	0.25	0.20	0.11	0.09
Investment	0.79	0.57	0.67	0.44	0.46	0.30	0.45	0.41
Capital Stock	0.79	0.57	0.67	0.44	0.46	0.30	-	-
Replacement cost of capital	0.00	0.00	0.07	0.07	0.18	0.15	0.33	0.18
Export RUK	- 0.00	- 0.00	- 0.12	- 0.13	- 0.31	- 0.26	- 0.67	- 0.35
Export ROW	3.04	3.04	2.92	2.91	2.71	2.77	2.58	2.25

FIN = Financial services; F&D = Food, drink & tobacco.
LR = long-run. S = Skilled; U = Unskilled.

The short run aggregate impacts of the stimulus to export demand in the two sectors are very similar. GRP increases by 0.03% in both cases. The increased demand for labour is met in the short run by a decrease in the unemployment rate and increasing aggregate employment. aggregate employment rises by 0.05%, the unemployment rate falls by 0.85% and 0.74%, and the real wage rises by 0.10% and 0.09%.

When the Financial services sector is stimulated there is a larger fall in the skilled unemployment rate, a larger increase in skilled employment, and a larger increase in skilled real wage, as compared to the changes seen by the unskilled. The opposite is seen when the Food & drink sector is stimulated. It must be noted that labour market impacts on the two skill categories are less marked as compared to the impacts seen in the long run.

These differences in skilled and unskilled employment changes reflect changes in real wages. Therefore, some substitution can be seen between the two skill categorises. These employment effects are, however, driven mainly by sectoral characteristics.

When moving from the short run to long run free migration case, by removing the restrictions on labour and capital, GRP increases from 0.03% to 0.62% and 0.48. When only removing the restrictions on capital whilst restricting labour, as is done in the no migration closure, GRP increases from 0.03% in the short run to 0.27% and 0.19% in the long run. This shows that the impact of freeing up capital and labour is significant for both the stimulus to the Food & drink sector and the Financial sector.

Table 7.4.8 and Figure 7.4.7 detail the short-run results at the individual sector level for a £500m ROW export demand stimulus to the Financial services sector, and to the Food & drink sector. In contrast to the long-run results there are a significant amount of non stimulated sectors that experience crowding out of output due to the more severe restrictions on labour and capital supplies over this period.

The stimulated sectors experience a rise in output, prices, employment, exports to the ROW, and investments. Exports to the RUK fall due to the increase in prices. Non stimulated sectors generally see a fall in output, employment, exports and investment and an increase in prices.

The initial stimulus to investment provided by the export stimulus can be seen in its impact on rental rates and user cost of capital. Capital rental rates fall, however, in some sectors so that investment initially falls in these sectors. Rental rates reflect the changes which are required to ensure that the demand for capital equals the fixed capital stock in a competitive market.

In the short run the user cost of capital rises because the capital price index rises. The capital price index rises because there is only a fixed amount of capital in each sector. The increase in the capital rental rate in, for example Construction, increases the user cost to other sectors. The user cost (the replacement cost of capital) increases in each sector by 0.33% and 0.18% (see Table 7.4.7).

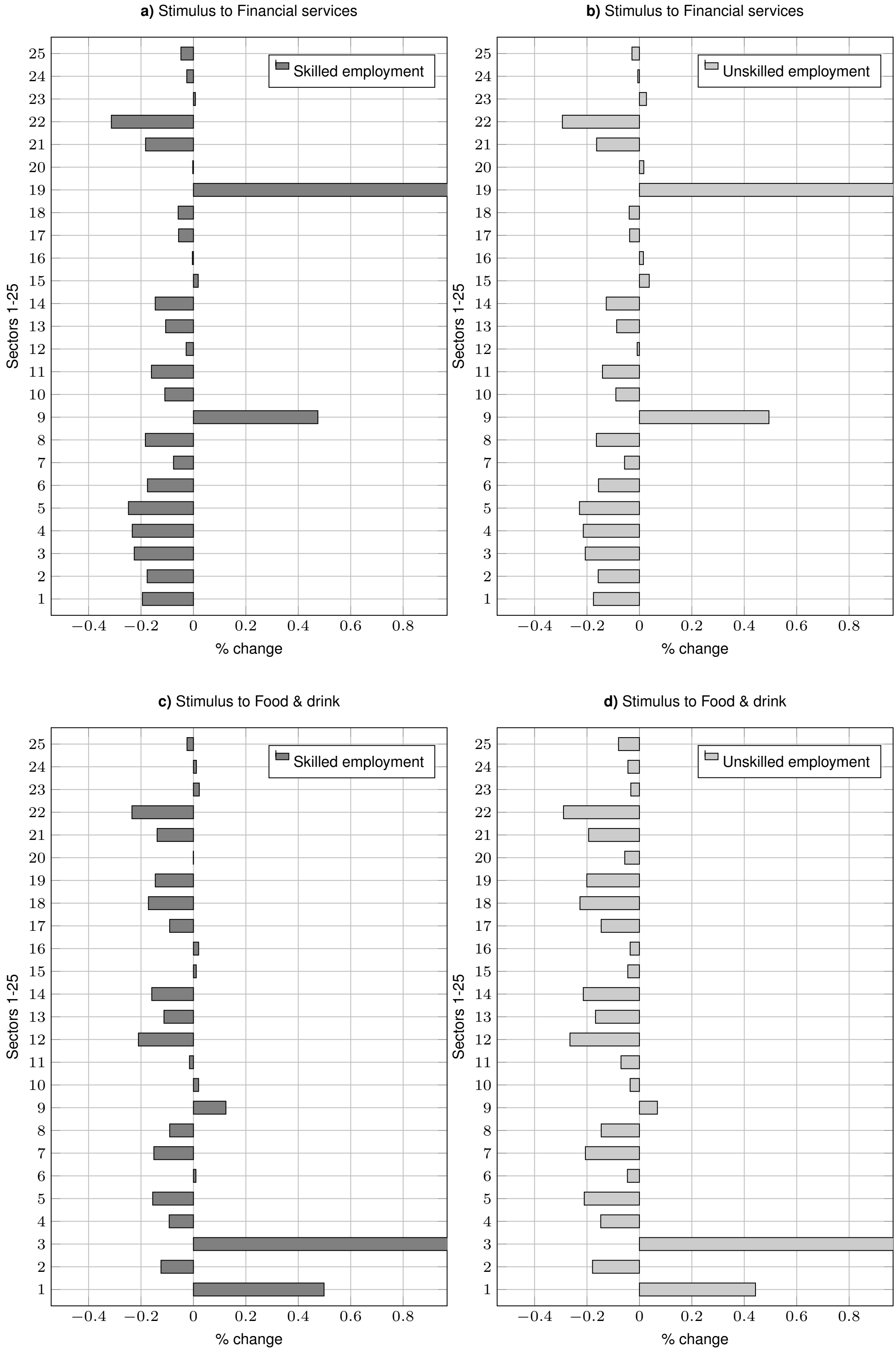
The fall in output at sector level and the increase in wages, however, leave a large amount of sectors with negative capital rental rates and thereby also negative investment. The combination of the investment intensity and the high labour intensity of the two stimulated sectors are the main contributing factors of the disinvestment seen in some of the sectors.

The falling capital rental rate at sector level, however, tends to mitigate crowding out in the affected sectors. The fixed capital stocks may limit the amount by which sectors can expand, but it cushions sectoral crowding out at the same time by making sectors less uncompetitive than they could otherwise be.

Table 7.4.8: Short-run: £500m ROW export demand stimulus to FIN and F&D. In % changes

	Export demand stimulus to Financial services									Export demand stimulus to Food & drink								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	-0.13	0.06	-0.19	-0.18	-0.12	-0.12	0.00	-0.63	-0.30	0.51	0.42	0.50	0.44	-0.84	-0.84	0.00	1.71	1.91
2. Mining	-0.08	0.03	-0.18	-0.16	-0.06	-0.06	0.00	-0.57	-0.24	-0.06	0.02	-0.12	-0.18	-0.05	-0.05	0.00	-0.36	-0.18
3. Food, drink and tobacco	-0.14	0.09	-0.23	-0.21	-0.17	-0.17	0.00	-0.73	-0.40	2.86	1.64	3.35	3.29	-3.19	15.14	0.00	11.22	11.87
4. Textile, leather, wood and paper	-0.17	0.14	-0.23	-0.21	-0.28	-0.28	0.00	-0.76	-0.43	-0.06	0.12	-0.09	-0.15	-0.24	-0.24	0.00	-0.26	-0.08
5. Chemicals	-0.16	0.08	-0.25	-0.23	-0.15	-0.15	0.00	-0.81	-0.48	-0.10	0.06	-0.16	-0.21	-0.13	-0.13	0.00	-0.47	-0.29
6. Rubber, plastic, cement and iron	-0.11	0.15	-0.18	-0.16	-0.29	-0.29	0.00	-0.57	-0.24	0.04	0.14	0.01	-0.05	-0.28	-0.28	0.00	0.08	0.26
7. Computer, electrical and transport eq.	-0.02	0.16	-0.08	-0.06	-0.31	-0.31	0.00	-0.24	0.10	-0.11	0.11	-0.15	-0.21	-0.22	-0.22	0.00	-0.45	-0.27
8. Electricity, gas and water	-0.11	0.10	-0.18	-0.16	-0.20	-0.20	0.00	-0.59	-0.26	-0.05	0.10	-0.09	-0.15	-0.19	-0.19	0.00	-0.25	-0.07
9. Construction	0.46	0.40	0.47	0.49	-0.79	-0.79	0.00	1.60	1.94	0.13	0.20	0.12	0.07	-0.41	-0.41	0.00	0.46	0.65
10. Wholesale and retail	-0.05	0.16	-0.11	-0.09	-0.31	-0.31	0.00	-0.35	-0.02	0.04	0.16	0.02	-0.04	-0.33	-0.33	0.00	0.12	0.30
11. Land transport	-0.09	0.14	-0.16	-0.14	-0.28	-0.28	0.00	-0.52	-0.19	0.01	0.14	-0.02	-0.07	-0.28	-0.28	0.00	0.00	0.18
12. Water transport	0.02	0.17	-0.03	-0.01	-0.35	-0.35	0.00	-0.07	0.26	-0.16	0.09	-0.21	-0.27	-0.18	-0.18	0.00	-0.65	-0.47
13. Air Transport	-0.04	0.15	-0.11	-0.09	-0.29	-0.29	0.00	-0.33	0.00	-0.07	0.10	-0.11	-0.17	-0.19	-0.19	0.00	-0.32	-0.14
14. Post and support transport services	-0.08	0.13	-0.15	-0.13	-0.26	-0.26	0.00	-0.47	-0.14	-0.11	0.08	-0.16	-0.21	-0.16	-0.16	0.00	-0.48	-0.30
15. Accommodation	0.05	0.21	0.02	0.04	-0.43	-0.43	0.00	0.08	0.41	0.03	0.17	0.01	-0.04	-0.33	-0.33	0.00	0.09	0.27
16. Food & beverage services	0.03	0.21	0.00	0.02	0.00	0.00	0.00	0.00	0.34	0.03	0.17	0.02	-0.04	0.00	0.00	0.00	0.12	0.30
17. Telecommunication	0.00	0.17	-0.06	-0.04	-0.34	-0.34	0.00	-0.17	0.16	-0.05	0.11	-0.09	-0.15	-0.21	-0.21	0.00	-0.25	-0.07
18. Computer and information services	-0.01	0.17	-0.06	-0.04	-0.35	-0.35	0.00	-0.18	0.15	-0.13	0.09	-0.17	-0.23	-0.17	-0.17	0.00	-0.52	-0.34
19. Financial services	0.99	1.01	1.23	1.25	-1.98	31.69	0.00	4.11	4.51	-0.09	0.05	-0.15	-0.20	-0.10	-0.10	0.00	-0.44	-0.25
20. Real estate	0.04	0.21	0.00	0.02	-0.43	-0.43	0.00	0.01	0.34	0.02	0.15	0.00	-0.06	-0.30	-0.30	0.00	0.05	0.23
21. Professional services	-0.11	0.11	-0.18	-0.16	-0.23	-0.23	0.00	-0.59	-0.26	-0.10	0.09	-0.14	-0.19	-0.18	-0.18	0.00	-0.41	-0.23
22. Research and development	-0.28	0.16	-0.31	-0.29	-0.31	-0.31	0.00	-1.03	-0.69	-0.22	0.13	-0.23	-0.29	-0.26	-0.26	0.00	-0.73	-0.55
23. Public administration	0.03	0.26	0.01	0.03	-0.51	-0.51	0.00	0.04	0.37	0.03	0.22	0.02	-0.03	-0.43	-0.43	0.00	0.12	0.31
24. Recreational services	0.02	0.20	-0.03	-0.01	-0.41	-0.41	0.00	-0.07	0.26	0.03	0.17	0.01	-0.04	-0.35	-0.35	0.00	0.09	0.27
25. Other services	0.00	0.19	-0.05	-0.03	-0.37	-0.37	0.00	-0.14	0.19	0.00	0.16	-0.02	-0.08	-0.31	-0.31	0.00	-0.03	0.15

Figure 7.4.7: Short-run, sectoral results: £500m ROW export demand stimulus to FIN and F&D



Note: see Table 7.4.8 for full set of results.

7.5 Sensitivity analysis

The following gives the results of the sensitivity analysis conducted around the elasticity of substitution between skilled and unskilled labour; the Armington trade elasticities for imports and exports; and the unemployment rate elasticity in the bargained real wage function. To recall, details on each function and the elasticities used in the model are outlined in Chapter 6. The sensitivity analysis separately varies values of these key elasticities whilst rerunning the export demand stimulus for the Financial services, and the Food & drink sectors.

Table 7.5.1 details a summary of the results (Appendix 7A gives the full set of results) for the sensitivity analysis conducted around the elasticity of substitution between skilled and unskilled labour, σ_S, which indicates the percentage change in demand for low (high) skill workers in response to a given percentage change in the price of high (low) skill workers. This elasticity is varied between: 0.6, 1.01, and 1.25, where 1.01 is the central elasticity used in AMOSKI.

The economic intuition is that the skilled and the unskilled become closer substitutes and thereby experience greater competition over employment gains as the elasticity of substitution is increased. That is, as firms try to minimise their labour costs there is a shift in demand towards the skill category with the lowest wage costs. As the elasticity of substitution is increased it becomes easier for firms to substitute away from the skill category with the higher wage. It must be noted that the long-run free migration results are not affected by changes in the elasticity of substitution between skilled and unskilled as prices remain unchanged in the long run.

The results in Table 7.5.1 show that changes in the substitution between skilled and unskilled only have relatively small (or no) effects on GRP (and other aggregate variables) in the skilled- and no migration long-run closures. There are, however, relatively large variations when considering long-run employment and real wage changes of the two skill categories. Even though aggregate real wages, employment, and unemployment rates remain unchanged in the no migration closure, when the elasticity of substitution is increased, there is significant variation within the two skill categories.

Considering the case where the Financial services sector is stimulated in the skilled migration closure the skilled real wage is at initial equilibrium level and the unskilled real wage is at 0.36% when σ_S is at 0.6. Unskilled workers are thereby comparatively more expensive. As σ_S is increased to 1.01 there is a shift away from unskilled workers, as they are more expensive, so that unskilled employment rises by less, and conversely skilled employment rises by more. With less demand for unskilled labour, due to the substitution away from the skilled, skilled real wage rises by less as compared to the case where σ_S is at 0.6. This mechanism can be observed across the migration closures.

Table 7.5.1: Sensitivity analysis. ROW export demand stimulus. Elasticity of substitution between skilled and unskilled.

	LR - Free migration	LR - Skilled migration			LR - No migration			SR		
		$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$
Export demand stimulus to the Financial services sector:										
GRP Income measure	0.62	0.46	0.49	0.50	0.27	0.27	0.27	0.03	0.03	0.03
Consumer Price Index	0.00	0.08	0.07	0.06	0.19	0.19	0.19	0.23	0.23	0.23
Unemployment Rate	- 0.00	- 1.07	- 0.91	- 0.83	- 2.37	- 2.37	- 2.37	- 0.85	- 0.85	- 0.85
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.46	- 2.43	- 2.41	- 0.91	- 0.89	- 0.88
Unemployment Rate U	- 0.00	- 3.13	- 2.64	- 2.42	- 2.19	- 2.27	- 2.30	- 0.75	- 0.79	- 0.80
Total Employment	0.51	0.35	0.38	0.39	0.15	0.15	0.15	0.05	0.05	0.05
Total Employment S	0.51	0.43	0.49	0.51	0.16	0.15	0.15	0.06	0.06	0.06
Total Employment U	0.51	0.20	0.17	0.15	0.14	0.14	0.15	0.05	0.05	0.05
Real Gross Wage	0.00	0.12	0.10	0.09	0.28	0.28	0.28	0.10	0.10	0.10
Real Gross Wage S	0.00	0.00	0.00	0.00	0.30	0.30	0.29	0.11	0.11	0.11
Real Gross Wage U	0.00	0.36	0.30	0.27	0.25	0.26	0.26	0.08	0.09	0.09
Export demand stimulus to the Food & drink sector:										
GRP Income measure	0.48	0.31	0.34	0.35	0.19	0.19	0.19	0.03	0.03	0.03
Consumer Price Index	0.00	0.09	0.08	0.07	0.15	0.15	0.15	0.21	0.21	0.21
Unemployment Rate	- 0.00	- 1.19	- 1.01	- 0.92	- 1.98	- 1.98	- 1.98	- 0.74	- 0.74	- 0.74
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 1.49	- 1.60	- 1.65	- 0.50	- 0.56	- 0.58
Unemployment Rate U	- 0.00	- 3.48	- 2.93	- 2.69	- 2.92	- 2.69	- 2.61	- 1.19	- 1.08	- 1.04
Total Employment	0.42	0.25	0.27	0.29	0.13	0.13	0.13	0.05	0.05	0.05
Total Employment S	0.34	0.26	0.32	0.35	0.09	0.10	0.11	0.03	0.04	0.04
Total Employment U	0.57	0.22	0.19	0.17	0.19	0.17	0.17	0.08	0.07	0.07
Real Gross Wage	0.00	0.14	0.12	0.11	0.23	0.23	0.23	0.09	0.09	0.09
Real Gross Wage S	0.00	0.00	0.00	0.00	0.18	0.19	0.20	0.06	0.07	0.07
Real Gross Wage U	0.00	0.40	0.33	0.31	0.33	0.31	0.30	0.13	0.12	0.12

LR = long-run; SR = short-run. S = Skilled; U = Unskilled.

σ_S = Elasticity of substitution between skilled and unskilled.

Skill-disaggregated AMOS σ_S = 1.01.

See Appendix 7A for full set of results.

Table 7.5.2 details a summary of the results for the sensitivity analysis conducted around the Armington trade elasticities for imports and exports, σ_V. Appendix 7A details the full set of results. This elasticity is changed to, 1.00, 2.00, and 3.00, where 2.00 is the central elasticity used in AMOSKI. Again, it must be noted that the long-run free migration results are not affected by changes in the Armington trade elasticities as prices remain unchanged in the long run.

As the degree of substitutability is increased from 1.00 to 3.00 the system becomes more sensitive to competitiveness changes. To recall, the demands for Scottish goods are determined via an export demand function according to which the quantity of goods exported is related to the relative regional price, given constant prices and income for the RUK and the ROW. Domestic and imported inputs are obtained in the AMSOKI model via an Armington (1969) link and are relative-price sensitive. The Armington trade elasticities thereby measure the extent to which a relative price change in the domestic market, compared to the price in the foreign market, affects the relative amount of imports to domestically produced goods sold in the domestic market (Turner et al., 2012).

The long-run results are best outlined when considering results of the no migration long-run closure as price effects are most prominent there. That is, the higher the trade elasticity the greater the sensitivity to relative price changes i.e. adverse competitiveness effects are enhanced and these occur in the same direction for both skill categories. The Armington trade elasticity changes the substitutability between domestic produced goods and imported goods. The higher the Armington elasticity the more imported goods are consumed, with a corresponding smaller domestic demand for domestic produced goods. With less domestic demand for domestic goods there is less stimulus to consumption, output, and stimulated demand for labour. As the Armington elasticity is increased there are more imports and the domestic market sees a smaller stimulus. In the labour market there is less upward pressure of wages. As exports become more price sensitive there is less crowding out of exports. However, the smaller stimulus to domestic goods means that there is a smaller stimulus seen from an export demand shock when the Armington trade elasticity is increased from 1.00 to 3.00.

Tables 7.5.3 and 7.5.4 detail a summary of the results for the sensitivity analysis conducted around the unemployment rate elasticity in the bargained real wage function ($\epsilon_{s/u}$). Appendix 7A details the full set of results. This is the elasticity of wages related to the level of unemployment rate and can also be interpreted as an index of wage flexibility. Essentially, the higher this elasticity, the greater the bargaining power workers have over wages. Again, it must be noted that the long-run free migration results are not affected by changes in this elasticity as prices remain unchanged in the long run. In Table 7.5.3 the unemployment rate elasticity of the unskilled is varied between 0.090, 0.112, and 0.134 (where the central estimate used in AMOSKI is 0.112) whilst the elasticity of the skilled remains fixed at 0.120. Conversely, in Table 7.5.4 the skilled unemployment rate elasticity is varied between 0.096, 0.120, and 0.144 (where the central estimate used in AMOSKI is 0.120) whilst the unskilled unemployment rate elasticity remains fixed at 0.112.

Results in Table 7.5.3 show that, as the bargaining power of the unskilled is increased, unskilled workers are able to establish a higher real wage. However, as real wages (and prices) are higher, there is a smaller stimulus to exports, output, and thereby also stimulated demand for labour. Unskilled employment thereby increases by less when the unemployment rate elasticity of the unskilled is increased. In contrast, Table 7.5.3 shows that as the bargaining power of the skilled is increased, skilled workers are able to establish a higher real wage. Again, as real wages (and prices) are higher, there is a smaller stimulus to exports, output, and thereby also stimulated demand for labour.

To summarise the sensitivity analysis, the results show that some of the results of the demand shocks modelled in AMOSKI are sensitive to the underlying elasticities. The sensitivity analysis conducted around the substitution between skilled and unskilled shows that changes to this elasticity has relatively small (or no) effects on GRP (and other aggregate variables). There are, however, relatively large variations when considering long-run employment and real wage changes of the two skill categories.

Changes to the Armingon trade elasticities show that the assumptions of the degree of substitutability between domestic produced goods and imported goods generate relatively large aggregate changes. Essentially, there is a smaller stimulus seen from an export demand shock when the Armington trade elasticity is increased as there is less stimulus coming though domestic demand linkages. In contrast, changes to the Armingon trade elasticities show relatively small impacts on the labour markets of the two skill categories, and these impacts affect both skill categories in the same direction.

Relatively small changes to the skilled and unskilled unemployment rate elasticity in the bargained real wage function show little to no impact on macroeconomic variables such as GRP. However, as the bargaining power of one skill category is increased, there are some differences in the magnitude of the impacts in the skilled and unskilled labour markets.

These results emphasise that the degree of openness of the Scottish economy to trade flows is significantly important in influencing the overall results. The results also draw out the importance of a more disaggregated labour market as results experienced can significantly vary across different sub categories of the labour market. Given that there is some uncertainty concerning the robustness of some of the elasticities used there is a clear need for more up to date econometric analysis.

Table 7.5.2: Sensitivity analysis. ROW export demand stimulus. Armington trade elasticity.

		LR - Skilled migration			LR - No migration			SR		
	LR - Free migration	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$
Export demand stimulus to the Financial services sector:										
GRP Income measure	0.62	0.52	0.49	0.46	0.31	0.27	0.24	0.05	0.03	0.02
Consumer Price Index	0.00	0.07	0.07	0.06	0.23	0.19	0.15	0.37	0.23	0.16
Unemployment Rate	- 0.00	- 0.99	- 0.91	- 0.84	- 2.97	- 2.37	- 1.97	- 1.27	- 0.85	- 0.63
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.98	- 2.43	- 2.05	- 1.28	- 0.89	- 0.67
Unemployment Rate U	- 0.00	- 2.88	- 2.64	- 2.43	- 2.94	- 2.27	- 1.82	- 1.25	- 0.79	- 0.54
Total Employment	0.51	0.41	0.38	0.35	0.19	0.15	0.13	0.08	0.05	0.04
Total Employment S	0.51	0.52	0.49	0.46	0.19	0.15	0.13	0.08	0.06	0.04
Total Employment U	0.51	0.18	0.17	0.16	0.19	0.14	0.12	0.08	0.05	0.03
Real Gross Wage	0.00	0.11	0.10	0.10	0.35	0.28	0.23	0.15	0.10	0.07
Real Gross Wage S	0.00	0.00	0.00	0.00	0.36	0.30	0.25	0.15	0.11	0.08
Real Gross Wage U	0.00	0.33	0.30	0.28	0.33	0.26	0.21	0.14	0.09	0.06
Export RUK	- 0.00	- 0.13	- 0.12	- 0.11	- 0.39	- 0.31	- 0.26	- 0.85	- 0.67	- 0.57
Export ROW	3.04	2.91	2.92	2.93	2.62	2.71	2.76	2.40	2.58	2.66
Export demand stimulus to the Food & drink sector:										
GRP Income measure	0.48	0.37	0.34	0.31	0.23	0.19	0.17	0.04	0.03	0.02
Consumer Price Index	0.00	0.08	0.08	0.07	0.19	0.15	0.13	0.32	0.21	0.16
Unemployment Rate	- 0.00	- 1.10	- 1.01	- 0.93	- 2.47	- 1.98	- 1.65	- 1.03	- 0.74	- 0.57
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.06	- 1.60	- 1.29	- 0.81	- 0.56	- 0.42
Unemployment Rate U	- 0.00	- 3.20	- 2.93	- 2.70	- 3.24	- 2.69	- 2.32	- 1.44	- 1.08	- 0.88
Total Employment	0.42	0.31	0.27	0.25	0.16	0.13	0.11	0.07	0.05	0.04
Total Employment S	0.34	0.36	0.32	0.29	0.13	0.10	0.08	0.05	0.04	0.03
Total Employment U	0.57	0.20	0.19	0.17	0.21	0.17	0.15	0.09	0.07	0.06
Real Gross Wage	0.00	0.13	0.12	0.11	0.29	0.23	0.19	0.12	0.09	0.07
Real Gross Wage S	0.00	0.00	0.00	0.00	0.25	0.19	0.16	0.10	0.07	0.05
Real Gross Wage U	0.00	0.36	0.33	0.31	0.37	0.31	0.26	0.16	0.12	0.10
Export RUK	- 0.00	- 0.14	- 0.13	- 0.12	- 0.32	- 0.26	- 0.21	- 0.47	- 0.35	- 0.29
Export ROW	3.04	2.89	2.91	2.92	2.70	2.77	2.81	2.09	2.25	2.35

LR = long-run; SR = short-run. S = Skilled; U = Unskilled.

σ_V = Elasticity of substitution between imports and domestic output in domestic demand.

Skill-disaggregated AMOS σ_V = 2.00.

See Appendix 7A for full set of results.

Table 7.5.3: Sensitivity analysis. ROW export demand stimulus. Unemployment rate elasticity (unskilled).

		LR - Skilled migration			LR - No migration			SR		
	LR - Free migration	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$
Export demand stimulus to the Financial services sector:										
GRP Income measure	0.62	0.50	0.49	0.48	0.27	0.27	0.26	0.03	0.03	0.03
Consumer Price Index	0.00	0.06	0.07	0.07	0.18	0.19	0.19	0.22	0.23	0.23
Unemployment Rate	- 0.00	- 1.04	- 0.91	- 0.80	- 2.49	- 2.37	- 2.28	- 0.88	- 0.85	- 0.83
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.43	- 2.43	- 2.42	- 0.88	- 0.89	- 0.90
Unemployment Rate U	- 0.00	- 3.03	- 2.64	- 2.33	- 2.61	- 2.27	- 2.01	- 0.89	- 0.79	- 0.70
Total Employment	0.51	0.39	0.38	0.37	0.16	0.15	0.15	0.06	0.05	0.05
Total Employment S	0.51	0.49	0.49	0.49	0.16	0.15	0.15	0.06	0.06	0.06
Total Employment U	0.51	0.19	0.17	0.15	0.17	0.14	0.13	0.06	0.05	0.04
Real Gross Wage	0.00	0.10	0.10	0.11	0.28	0.28	0.29	0.10	0.10	0.10
Real Gross Wage S	0.00	0.00	0.00	0.00	0.30	0.30	0.29	0.11	0.11	0.11
Real Gross Wage U	0.00	0.28	0.30	0.32	0.24	0.26	0.27	0.08	0.09	0.09
Export demand stimulus to the Food & drink sector:										
GRP Income measure	0.48	0.35	0.34	0.33	0.20	0.19	0.18	0.03	0.03	0.03
Consumer Price Index	0.00	0.07	0.08	0.08	0.15	0.15	0.16	0.21	0.21	0.21
Unemployment Rate	- 0.00	- 1.16	- 1.01	- 0.89	- 2.12	- 1.98	- 1.87	- 0.78	- 0.74	- 0.70
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 1.61	- 1.60	- 1.60	- 0.55	- 0.56	- 0.57
Unemployment Rate U	- 0.00	- 3.37	- 2.93	- 2.59	- 3.09	- 2.69	- 2.38	- 1.22	- 1.08	- 0.97
Total Employment	0.42	0.29	0.27	0.27	0.14	0.13	0.12	0.05	0.05	0.04
Total Employment S	0.34	0.32	0.32	0.32	0.10	0.10	0.10	0.03	0.04	0.04
Total Employment U	0.57	0.22	0.19	0.17	0.20	0.17	0.15	0.08	0.07	0.06
Real Gross Wage	0.00	0.11	0.12	0.12	0.23	0.23	0.24	0.08	0.09	0.09
Real Gross Wage S	0.00	0.00	0.00	0.00	0.19	0.19	0.19	0.07	0.07	0.07
Real Gross Wage U	0.00	0.31	0.33	0.35	0.28	0.31	0.32	0.11	0.12	0.13

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

ϵ = Unemployment rate elasticity in the bargained real wage function.

Skill-disaggregated AMOS ϵ_s = 0.120 and ϵ_u = 0.112.

See Appendix 7A for full set of results.

Table 7.5.4: Sensitivity analysis. ROW export demand stimulus. Unemployment rate elasticity (skilled).

	LR - Free migration	LR - Skilled migration			LR - No migration			SR		
		$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$
Export demand stimulus to the Financial services sector:										
GRP Income measure	0.62	0.49	0.49	0.49	0.28	0.27	0.25	0.04	0.03	0.03
Consumer Price Index	0.00	0.07	0.07	0.07	0.18	0.19	0.19	0.22	0.23	0.23
Unemployment Rate	- 0.00	- 0.91	- 0.91	- 0.91	- 2.63	- 2.37	- 2.18	- 0.92	- 0.85	- 0.80
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.80	- 2.43	- 2.14	- 1.00	- 0.89	- 0.80
Unemployment Rate U	- 0.00	- 2.64	- 2.64	- 2.64	- 2.30	- 2.27	- 2.25	- 0.77	- 0.79	- 0.80
Total Employment	0.51	0.38	0.38	0.38	0.17	0.15	0.14	0.06	0.05	0.05
Total Employment S	0.51	0.49	0.49	0.49	0.18	0.15	0.14	0.06	0.06	0.05
Total Employment U	0.51	0.17	0.17	0.17	0.15	0.14	0.14	0.05	0.05	0.05
Real Gross Wage	0.00	0.10	0.10	0.10	0.27	0.28	0.29	0.09	0.10	0.11
Real Gross Wage S	0.00	0.00	0.00	0.00	0.27	0.30	0.31	0.10	0.11	0.12
Real Gross Wage U	0.00	0.30	0.30	0.30	0.26	0.26	0.26	0.09	0.09	0.09
Export demand stimulus to the Food & drink sector:										
GRP Income measure	0.48	0.34	0.34	0.34	0.20	0.19	0.18	0.03	0.03	0.03
Consumer Price Index	0.00	0.08	0.08	0.08	0.15	0.15	0.16	0.21	0.21	0.21
Unemployment Rate	- 0.00	- 1.01	- 1.01	- 1.01	- 2.15	- 1.98	- 1.85	- 0.78	- 0.74	- 0.70
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 1.85	- 1.60	- 1.41	- 0.63	- 0.56	- 0.50
Unemployment Rate U	- 0.00	- 2.93	- 2.93	- 2.93	- 2.71	- 2.69	- 2.68	- 1.07	- 1.08	- 1.09
Total Employment	0.42	0.27	0.27	0.27	0.14	0.13	0.12	0.05	0.05	0.04
Total Employment S	0.34	0.32	0.32	0.32	0.12	0.10	0.09	0.04	0.04	0.03
Total Employment U	0.57	0.19	0.19	0.19	0.17	0.17	0.17	0.07	0.07	0.07
Real Gross Wage	0.00	0.12	0.12	0.12	0.22	0.23	0.24	0.08	0.09	0.09
Real Gross Wage S	0.00	0.00	0.00	0.00	0.18	0.19	0.20	0.06	0.07	0.07
Real Gross Wage U	0.00	0.33	0.33	0.33	0.31	0.31	0.30	0.12	0.12	0.12

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

ϵ = Unemployment rate elasticity in the bargained real wage function.

Skill-disaggregated AMOS ϵ_s = 0.120 and ϵ_u = 0.112.

See Appendix 7A for full set of results.

7.6 Summary and policy implications

This section summarises the long-run results for the export demand shocks to the Financial services sector, and to the Food & drink sector. To recall, Table 7.4.7 in Section 7.4.4 details the key macroeconomic short- and long-run results, in percentage changes, for a £500m increase in exports to the ROW for the Financial services and Food & drink sectors. The following outlines the key long-run results by summarised first results of the free migration closure, then the skilled migration closure, and finally the no migration closure.

Recall that in the Food & drink sector and the Financial services sector skilled labour makes up 42% and 65% respectively of the labour force. Labour intensity in terms of the wage share of gross output in these two sectors, however, is similar. 21% of gross output of the Financial Services sector goes to wages, 15% to skilled and 6% to unskilled. Similarly, 21% of gross output of the Food & drink sector goes to wages, 10% to skilled and 11% to unskilled. However, a key difference here is that the Financial services sector is more capital intensive.

There are a number of effects that can be observed irrespective of which of the two sectors is stimulated, and irrespective of the long-run closure. Following the export demand stimulus there is an increase in prices, quantities, revenues, and profits and thereby also an increase in net investment and capital stocks. This increase in investment in the long run in turn generates further increases the demand for labour so that employment increases. Despite these similarities across the long-run closures there are nevertheless some significant differences, especially within the labour markets of the two skill categories.

The free migration closure of the AMOSKI model ties down long-run unemployment rates and real wages to their initial equilibrium values through the combination of regional bargained real wage and flow migration. Any change in the real wage and the unemployment rate entail a migration response which in turn limits and ultimately reverse real wages changes until the labour market is in long-run equilibrium with unchanged real wages and unemployment rates. Prices, unemployment rates, and real wages thereby remain unchanged from base in the long run.

The £500m stimulus to ROW exports represents an aggregate increase in ROW exports of 3.04%. This represents a 34.35% increase in ROW exports in the Financial services sector, and a 18.94% increase in ROW exports in the Food & drink sector. Exports to the RUK see no change from base in the long run in the free migration closure. The stimulus to GRP is significantly larger in the long run when the Financial services sector is stimulated (+0.62%), compared to the case when the Food & drink sector is stimulated (+0.48%). The capital intensity of the Financial services sector results in a relatively large increase in investment and also output (this holds irrespective of the migration closure).

An unexpected result in the free migration long-run closure is that the employment impact on the two skill categories is equiproportionate i.e. the outcome is skill neutral when the Financial services sector is stimulated. When the Food & drink sector is stimulated the unskilled experience a larger percentage increase in employment as compared to that seen by the unskilled.

In contrast to the free migration closure, in the skilled migration closure the unskilled labour force is fixed. This means that in response to changes in the demand for unskilled labour, the unskilled real wage and unemployment rate will adjust. The skilled labour force, however, is available in the long run with an infinitely elastic supply at the base year real wage. The skilled labour force therefore experience the same adjustment mechanisms seen in the free migration closure. Given this differential treatment of the skilled and unskilled labour force, neither the aggregate unemployment rate nor aggregate real wages revert back to their initial equilibrium levels in the skilled migration closure.

The increase in prices in the long run in the skilled migration closure has some negative competitiveness effects. The stimulus to output is thereby adversely affected by the restriction of the supply of unskilled workers. The key here is that the bargaining power of unskilled workers is increased as demand for unskilled labour rises together with a fixed unskilled labour force. That is, unskilled workers are able to achieve an increase in their real wage in the skilled migration closure as compared to the free migration closure.

The adjustment differences between the free and the skilled migration closures imply that disparate impacts between the two skill groups are amplified. In the skilled migration closure the unskilled are better off in terms of the reduction in the unskilled unemployment rate and the accompanying increase in the unskilled real wage. The skilled benefit in terms of employment changes, as compared to the unskilled. By assumption this migration closure leads to a relatively large increase in the skilled labour force.

Competitiveness effects arising from the increase in prices reduce exports to the RUK by 0.12% and 0.13% in the skilled migration closure. Also, the increase in exports to the ROW is reduced from 3.04%, as in the free migration case, to 2.92% and 2.91% respectively. GPR growth is thereby dampened and sees a 0.49% and 0.38% increase, as compared to the 0.62% and 0.48% increase achieved in the free migration closure.

In the no migration closure neither skilled nor unskilled migrate between regions in response to changes in real wage and unemployment rates. That is, the total workforce remains fixed throughout the simulation, the skilled and unskilled unemployment rate and real wage vary in the long run in response to changes in labour demand. The most direct impact, as compared to the other migration closures, is that the skilled real wage increases in the long run in the no migration closure. The bargaining power of skilled and unskilled workers is thereby increased as demand for labour rises together with a fixed labour force. That is, both skill categories are able to achieve an increase in their real wage in the long run.

Prices thereby rise by more than in the skilled migration closure. This in turn reduces the stimulus to exports and thereby the stimulated demand for labour. Exports to the RUK fall by 0.31% and 0.26% respectively when the Financial services and the Food & drink sector are stimulated. The rise in exports to the ROW falls from 3.04%, as seen in the free migration closure, to 2.71% and 2.77%. GRP increases by 0.27% and 0.19% in the no migration closure, as compared to the 0.62% and 0.48% increase seen in the free migration case. The labour market stimulus is greatest for the skilled when the Financial services sector is stimulated, and greatest for the unskilled when the Food & drink sector is stimulated.

The disparate impacts on the two skill categories arising from the export demand shock serve to emphasize that sectoral characteristics play a significant role in determining aggregate and also skill-specific labour market outcomes. This poses the question whether Scottish exports are more skilled or unskilled-intensive than the workforce as a whole (as done in Chapter 5 in a SAM model). IO accounting methods have been used in the past to answer similar question. For example, Leontief (1953) used IO techniques methods to analyse the capital and labour intensity of US trade flows (Leontief's paradox). Similarly, IO techniques are used to analyse pollution embodied in trade flows (Turner et al., 2014; Minx et al., 2009). In keeping with this, the AMSOKI model is employed to analyse the skill intensity of exports.

Table 7.6.1 details the effects of a £500m demand stimulus to exports. Results show the impact on employment in percentage changes for the three long-run closures. In terms of pure demand effects, in the spirit of an extended IO model, the free migration long-run results suggest that Scottish exports are more unskill intensive. This is in line with the results outlined in Chapter 5 using a SAM model. However, depending on supply-side responses the ranking of changes in employment by skill category can differ from this. The long-run results of the skilled migration closure show that exports are more skill intensive, and more unskill intensive in the no-migration closure.

Table 7.6.1: Effects on employment of a £500m demand stimulus to exports. In % changes

	LR - Free migration	LR - Skilled migration	LR - No migration
Total Employment S	0.83	0.79	0.25
Total Employment U	0.97	0.32	0.28

LR = long-run. S = Skilled; U = Unskilled.
See Appendix 7B for full set of results.

The Scottish Government (2016b, p.27) suggest that: "rebalancing the economy will require a stronger role for exporting companies and sectors to increase sales in products and services." "Increasing the scale of the manufacturing [exporting] sector can help with wider equality objectives in terms of addressing regional imbalances through local spillovers, while providing jobs that are typically high skilled and well paid". Also, "attracting skilled workers to Scotland is key to boosting our skills base and tackling the challenges of demographic change" (Scottish Government, 2016b, p.70).

This is encompassed in Scotland's Economic Strategy, which sets a number of 'mutually supportive goals' which aim to: "invest in our people and our infrastructure in a sustainable way; foster a culture of innovation and research and development; promote inclusive growth and create opportunity through a fair and inclusive jobs market and regional cohesion; promote Scotland on the international stage to boost our trade and investment, influence and networks" (Scottish Government, 2015).

Results in Table 7.6.1 suggest that exports tend to be biased towards the unskilled. That is, exports require more unskilled workers than skilled workers in the free and the no-migration closures. Stimulating Scottish exports may therefore not necessarily support the goal of increasing the skilled workforce, and providing jobs that are highly skilled. On the other hand, however, it could be suggested that an export led growth strategy may be used as a tool to indirectly stimulate the labour market, even though the skilled labour market is stimulated to a lesser extent.

The Economic Strategy seems to suggest that the policies set out within are 'mutually supportive', which may be misleading. Simulation results presented here emphasise the importance of identifying outcome variables. That is, policy makers engaged in Scotland's Economic Strategy must be clear on whether the export growth strategy is solely geared towards increasing economic output; or whether the policy is also designed towards being 'mutually supportive' towards other goals within the Economic Strategy, such as increasing the skilled workforce.

When the outcome variables are identified, it can then be decided on which sector to focus the policy efforts. Results presented here show that the aggregate impacts, and the impacts on the two skill categories, vary significantly depending on the sector that experiences the direct stimulus. For example, when comparing the stimulus between the two sectors stimulated, it could be suggested to pursue export growth policies in the Financial services sector, rather than the Food & drink sector, when wanting to maximise the impact of the stimulus to GRP and total employment.

The simulations have also shown that the openness of the Scottish economy to migration is crucial in determining the local labour market outcomes. Sectoral characteristics, such as the skill intensity of exports, however, also significantly drive the disparate impacts between the two skill categories. This is investigated in more detail in the following chapter where skill-neutral and skill-biased technical progress is modelled.

Chapter 8

Chapter 8

Technical progress in the skill-disaggregated AMOS model

8.1 Introduction

A key policy of the Scottish Government (2012b) is 'to make better use of skills in the workplace'. This implies an improvement in labour efficiency where a given output can be produced with the initial levels of capital and intermediates and less labour. Labour-augmenting (Harrod-neutral) efficiency improvements thereby mean that fewer workers are required to produce the same output. Technical change is modelled here as an exogenous labour-augmenting improvement in the production technology. Labour-augmenting technological change has been suggested to play a significant role in widening of skill wage and/or unemployment differentials. That is, the demand-shift hypothesis argues that technological change has led to substantial shifts in the demand for skilled and unskilled workers (Machin, 1995). This tends to be observed as a shift towards skilled workers to the detriment of unskilled workers (Sanders, 2005). Given the importance of the skill dimension alternative cases of labour-augmenting efficiency improvements are modelled. Both skill-differentiated (a differential increase in skilled, as against unskilled, efficiency and vice versa), and skill-neutral (an equal increase in labour efficiency across all skill types) labour-augmenting improvements are introduced and analysed. This research employs the multi-sectoral AMOSKI CGE model of Scottish economy. The AMOSKI model details the distinct impacts on the skilled and unskilled labour markets, whilst taking into account system-wide impacts of the efficiency shock. This chapter is organised as follows; Section 8.2 outlines the modelling strategy. Sections 8.4 and 8.5 details the CGE simulation results for the skill-neutral and skill biased technological progress, Section 8.6 details the results for the sensitivity analysis, and Section 8.7 gives a summary and policy implications.

8.2 Technological progress

Scotland's Economic Strategy sets out an over-arching framework for how the Scottish Government aims to achieve a more productive, cohesive and fairer Scotland. Within the Economic Strategy the Scottish Government (2012b) cites technological progress to be a key driver of economic growth due to its impact on the country's economic performance, employment and tax revenue.

The focus here is on analysing the impact of technical change on the regional labour market, and more specifically, the impact on skilled and unskilled workers. Empirical research suggests that the impact of technical change has significant disproportionate effects on the skilled and the unskilled.

For example, Acemoglu (2002) reviewed the implications of technical change for US the labour market. Findings suggest that technical change has been skill-biased (increasing the demand for skilled labour) during the past sixty years; and that this skill-bias has has accelerated over the past few decades.

The prevailing view is that technological changes have been predominantly skill-biased, where workers with higher skills see large increases in demand and pay while those with low skills experience reduced demand for their labour and lower earnings. During the 1990's and 2000's, however, technical progress seems less robust in explaining changes in relative wage differences (Bell & Eiser, 2013).

Levy and Murnane (2003) suggests a nuanced view whereby it is suggested that technology replaces routinised jobs predominantly held by semi-skilled workers. A hollowing out of the labour market is expected in this 'routinisation' hypothesis i.e a declining share of middle-wage, middle-skill jobs being replaced by an increasing share of both the highest and lowest wage jobs (Bell & Eiser, 2013).

Empirical evidence suggests that recent hollowing out of the labour market (or 'job polarisation') can be observed in, for example, the US (Autor, 2010), the UK (Goos & Manning, 2007), and to a certain extent in Scotland (Rogers & Richmond, 2015). The consensus is, however, that the impact of labour-augmenting technological progress on the skilled and the unskilled is significantly disparate.

Given this, labour-augmenting technical progress is modelled here for two reasons. First, a more comprehensive understanding of system-wide (and sector specific) impacts of technological change are of key importance to Scottish policy makers. Second, it is expected that technological change has disparate impacts on the skilled and unskilled, and this issues is not well documented and quantified by current Scottish policy analysis.

8.2.1 Partial equilibrium analysis

Labour-augmenting technical progress is introduced as a labour-saving. That is, the productivity or efficiency of workers is increased by, for example, an improvement in working practices. Essentially, the improvement in efficiency reduces the cost of labour in efficiency units so that the cost of a given effective labour supply is reduced. A given output can then be produced with initial levels of capital and intermediates but with less labour as measured in natural units. The analysis presented here follows closely that of Yin (2002) and McGregor et al. (2000).

Let ξ denote an exogenous labour augmenting technical progress, L^e the demand for labour in efficiency units, L the demand for labour in numbers (i.e. $L = L^e/\xi$), W the wage rate, and W^e the efficiency wage rate (defined to be W/ξ), e is the level of efficiency and takes a value of 1 initially. Then,

$$L^e = L^e(W^e) \tag{8.1}$$

Differentiating equation 8.1 with respect to ξ gives:

$$\delta L/\delta\xi = -(L^e(\epsilon + 1)/\xi^2) \tag{8.2}$$

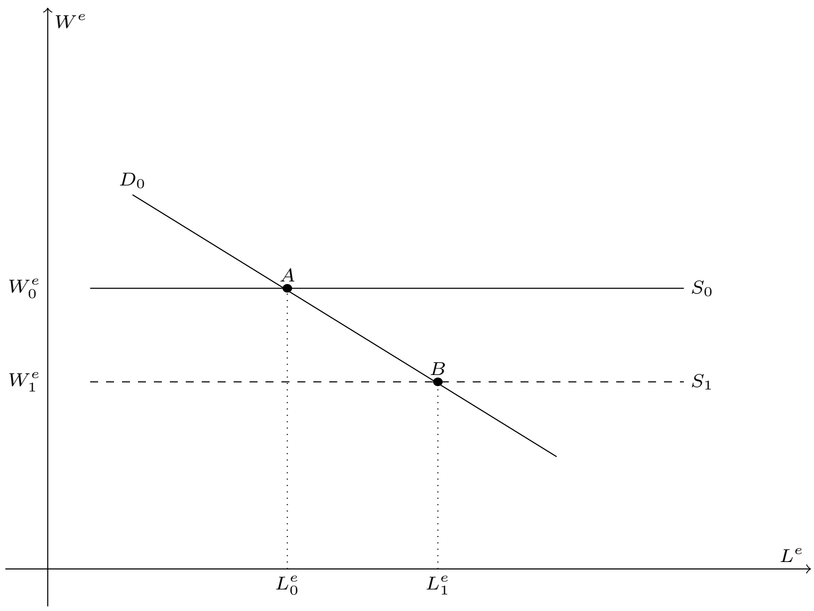
where ϵ is the elasticity of labour demand i.e. the responsiveness of labour demand to a change in wage. For the labour augmenting technical change to have a positive impact on employment, it requires $|\epsilon| > 1$ i.e., labour demand must be rather wage elastic.

According to the Hicks-Marshall (Hicks, 1963; Marshall, 1890) laws of derived demand, other things equal, the own-wage elasticity of demand for a category of labour is high if: the price elasticity of demand of output is high. Other factors can be easily substituted for labour. The supply of other factors of production is highly elastic. The cost of employing labour is a large share of the total cost of production.

Figure 8.2.1 shows the impact of a productivity stimulus on the demand for efficiency units of labour. The x-axis shows number of efficiency units of labour demanded (L^e), and the y-axis details the wage per efficiency units of labour (W^e).

Initially it is assumed that the "price of a worker" (W) is unaffected by the change. Then the price of an "efficiency unit" of labour falls by 5% ($W^e = W/1.05$). This is as if the price of an "old unit" of labour falls. The same input in efficiency units is required to produce the same output as before. But the number of workers required to supply those efficiency units has fallen. The cost of an efficiency unit of labour falls, if the wage in physical units is unchanged.

Figure 8.2.1: The impact of a labour augmenting technological stimulus on the demand for efficiency units of labour



As shown above the labour augmenting technical change can be presented as reducing the price of labour measured in efficiency units. An increase in the level of employment, however, requires that total expenditure on labour increases. This occurs only if the wage-elasticity of the demand for efficiency units of labour is greater than unity. A reduction in employment is seen if the increase in the demand for labour, as measured in efficiency units, is less than the increase in labour productivity itself.

The impact on employment (i.e. the number of workers not the number of efficiency units of labour demanded) will: increase if the 5% reduction in the efficiency wage stimulates a greater than 5% increase in the demand for efficiency units of labour - the case of a wage elastic demand for labour; be unchanged if the stimulus to the demand for efficiency units of labour is exactly 5% - the case of a labour demand function with unitary elasticity; decrease if the stimulus to the demand for efficiency units of labour is less than 5% - an inelastic labour demand curve.

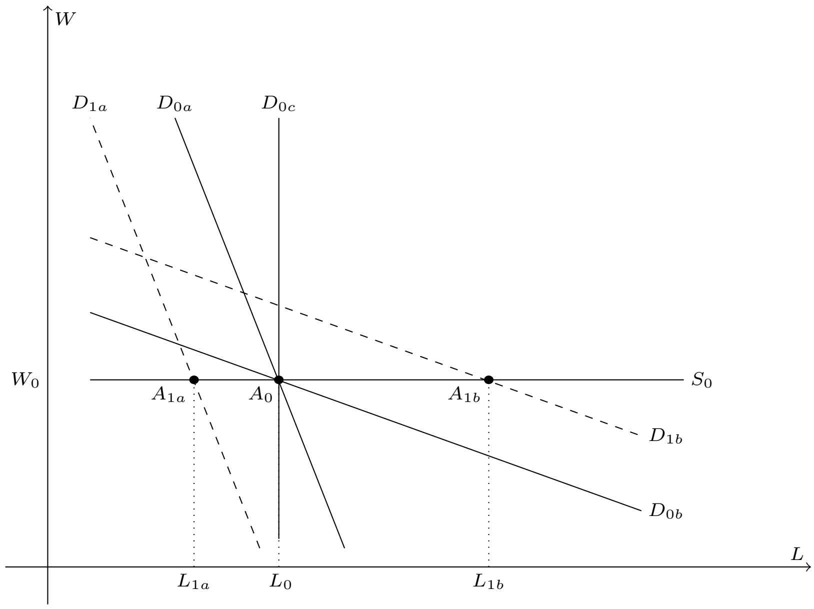
Figure 8.2.2 shows the impact of a labour augmenting technological stimulus on employment. The x-axis shows the labour demanded (L), and the y-axis details the (nominal) wage (W). The initial equilibrium at point A_0 is where the infinitely elastic labour supply curve intersects the negatively sloped demand curve for employees.

If the demand for efficiency units of labour is wage inelastic, $|\epsilon| < 1$, the employment demand curve shifts to the left in the nominal wage - employment space as a consequence of the labour augmenting technological stimulus. That is, the demand curve shifts from D_{0a} to D_{1a} and the new equilibrium is at A_{1a}.

If demand for efficiency units of labour is greater than unity, $|\epsilon| > 1$, employment is stimulated by the efficiency increase and the demand curve shifts from D_{0b} to D_{1b} and the new equilibrium is at A_{1a}.

Equilibrium employment is unaffected if the demand for efficiency units of labour is unitary-wage-elastic, $|\epsilon| = 1$, shown as as D_{0c}.

Figure 8.2.2: The impact of a labour augmenting technological stimulus on employment



The simplified partial equilibrium analysis provides analytical insights so that some of the aggregate impacts of a labour-augmenting efficiency shock can be reasonably foreseen. However, it is difficult to predict the impacts of skill-neutral and skill-differentiated efficiency shocks and their impacts on the skilled and unskilled labour markets.

Thus, a more complex modelling framework is required to combine the technical progress with regional specific conditions in product and labour markets. The next section details how the skill-neutral and the skill-differentiated are introduced into the AMOS CGE model.

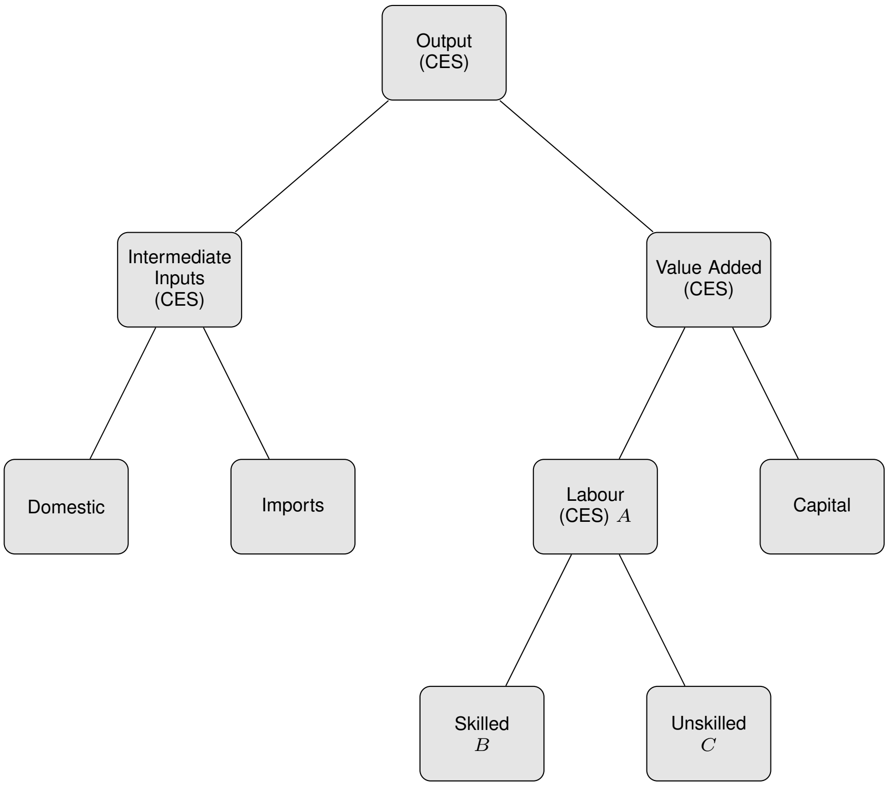
8.2.2 Technological progress in AMOSKI

The simulation strategy employed here is to use the skill-disaggregated AMOS model (AMOSKI) to introduce skill-neutral and skill-differentiated technological progress. Figure 8.2.3 shows the nested production structure of the AMOSKI model (see Chapter 6 for details).

To recall, skilled and unskilled labour are introduced into the demand side of the model by creating another level in the production hierarchy. To yield the aggregate labour input, skilled and unskilled labour are combined through a CES aggregation function.

The skill-neutral shock enters the production structure in the CES composite total demand function for skilled and unskilled labour, marked as A in Figure 8.2.3, and shown in equation 8.4. The skill differentiated shock is introduced at the individual demand functions for skilled;unskilled labour, marked as B and C respectively in Figure 8.2.3, and is shown in equations 8.5 and 8.6.

Figure 8.2.3: Production structure of the skill-disaggregated AMOS model



To recall, skilled and unskilled labour are introduced into the demand side of the model by creating another level in the production hierarchy. To yield the aggregate labour input, skilled and unskilled labour are combined through a CES aggregation function. The CES total labour demand, L, in the value-added production function for activity j is given as:

$$L_j = \phi_j^{\rho_j} \cdot [\delta_j^l \cdot (PY_j / w_j^p)]^{\rho_j} \cdot Y_j \tag{8.3}$$

where ϕ is a exogenous efficiency parameter (Hicks-neutral), δ is the labour share parameter in the value added function, PY is the price of value added, w^p the nominal price to producers of the composite labour input, ρ the elasticity of substitution between capital and composite labour, and Y is value added.

Skill-neutral (Harrod-neutral) labour efficiency is introduced into the model by an labour augmenting technology efficiency parameter, ξ, in the CES skill composite total demand function, L_z:

$$L_{zj} = \xi_j \cdot [\delta_s^l \cdot L_s^{\sigma_{ij}} + \delta_u^l \cdot L_u^{\sigma_{ij}}]^{\sigma_{ij}} \tag{8.4}$$

where σ is the elasticity of substitution between skilled and unskilled labour, here taken to be 1.01. As this elasticity proves to be crucially important in determining the skill specific labour market outcomes, a sensitivity analysis is conducted in Section 8.6.

Skill-differentiated technological change is similarly introduced into the model by a labour augmenting technology efficiency parameter, $\xi_j^{\sigma_{sj}}$ and $\xi_j^{\sigma_{uj}}$, in the labour demand function of each skill category:

$$L_{sj} = \xi_j^{\sigma_{sj}} \cdot [\delta_{sj}^l \cdot (w_j^p / w_{sj}^p)]^{\sigma_{sj}} \cdot L_j \tag{8.5}$$

$$L_{uj} = \xi_j^{\sigma_{uj}} \cdot [\delta_{uj}^l \cdot (w_j^p / w_{uj}^p)]^{\sigma_{uj}} \cdot L_j \tag{8.6}$$

The price of the composite labour input is:

$$w_j^p = [\delta_{sj}^{\rho_{zj}} \cdot w_{sj}^{(1-\rho_{zj})} + \delta_{uj}^{\rho_{zj}} \cdot w_{uj}^{(1-\rho_{zj})}]^{1/1-\rho_{zj}} \tag{8.7}$$

8.3 Simulation strategy

Results presented here show the impact of a permanent 5% increase in skill-neutral and skill-differentiated labour efficiency across all sectors using the myopic variant of the AMOSKI model. The increase in efficiency is modelled as a 5% in each period from time-period 1 onwards, and the simulations are run up to time-period 100. It must be noted that a gradual increase in efficiency yields similar long-run results, but with different adjustment paths. This is discussed in more detail in Section 8.6 when conducting the sensitivity analysis.

The simulations use the three migration variants of the model. This reflects the different levels of mobility across skill groups observed in empirical studies as outlined in Chapter 6. In the first closure, free migration, the supply side is unconstrained i.e. both skilled and unskilled workers migrate between regions in response to regional differentials in real wages and unemployment rates. In the second closure, skilled migration, only the skilled migrate between regions. In the third closure, no migration, both skilled and unskilled are geographically immobile.

Simulation results are analysed by detailing first the long-run results for ‘free migration’ closure where the supply side is unconstrained. The subsequent two closures increase the supply constraints in the labour market. In the ‘skilled migration’ model, migration for unskilled workers is unavailable. Last, in the ‘no migration’ closure migration is precluded.

The results for the skill-neutral technological progress are presented in Section 8.4. Section 8.5 details the simulation results for the skill-differentiated technological progress. Section 8.6 details the simulation results of the sensitivity analysis conducted around key parameters of the model. Section 8.7 summarises the key results for the skill-neutral and the differentiated technological progress.

The skill disaggregated AMOSKI model (see Chapter 6) is calibrated on a 2009 Social Accounting Matrix (SAM) for Scotland (as outlined in Chapters 2 and 3), containing 25 commodities and activities, labour (skilled and unskilled), capital, other value added, households, corporations, government, and the external sector (RUK/ROW). The model is subsequently parameterised using the annual data from the SAM, implying that each period in the period-by-period simulations is interpreted as a year.

To recall from Chapter 3, there are significant differences across sectors which are of key importance when interpreting sector specific simulation results. Table 8.3.1 summarises sector characteristics by key income and expenditure components as found in the 2009 SAM. This table is called to mind when analysing sector specific impacts of the efficiency shock.

The first three columns in Table 8.3.1 give labour costs of output broken down by skill category. Skill, and labour intensity of output varies significantly across sectors. There are a number of sectors that are high-skill intensive. For example, the Research & development, and the Public administration sector have a skilled wage share of output of 50% and 40% respectively. In contrast, the Wholesale & retail, the Food & beverage services, and the Rubber, plastic, cement & iron sector are more low-skill intensive with a unskilled wage share of output of 19%.

There are a number of sectors with very low wage shares of output. For example, the Real estate sector, and the Chemicals sector have a wage share of output of 3% and 8% receptively. In contrast, the Research & development, and the Public administration sector have the high wage shares of output with 54% and 51% respectively.

Imports and exports broken down by their RUK and ROW components in Table 8.3.1 show that the majority of industries have stronger import linkages with the RUK as compared to the ROW. Imports are a significant part of total costs for some sectors. For example, 40% of the total costs for the Chemical sector arise from RUK imports. There are a number of sectors which are highly export orientated. For example, the Financial services, the Mining, the Food & drink, and the Research & development sectors all have an export share of output of above 50%.

There are a number of sectors that mainly serve the domestic market. For example, 81% of incomes in the Food & beverages services, and the Real estate sector stem from domestic households. 72% of incomes in the Public administration sector comes from the public sector. The Accommodation sector, and the Food & beverages services sector have a relatively large share of incomes coming from Tourism (i.e. expenditure by non-residents) with 29% and 10% respectively.

The domestic serving sectors tend to be relatively more labour and also more skill intensive. The combination of these two factors is likely to have significant implications when considering labour market outcomes for each of the skill categories.

The Construction sector receives 53% of total incomes from providing investment goods. This is by far the largest capital share of output across all sectors. The second largest capital provider, in terms of share of output, is the Computer & information services sector with 17%.

To recall from Chapter 3, there are 2,229,931 FTE workers, of which 1,302,392 (58%) are skilled and 927,540 (42%) are unskilled. Sector 23, Public administration, is the largest employment sector with 610,655 workers. This is followed by sector 10, Wholesale and retail with 307,936 workers, sector 21, Professional services with 305,218 workers, and sector 9, Construction with 170,528 workers.

These sectoral characteristics are expected to influence the simulation results. In particular, the export and/or the skill intensity of the sectors is likely to have a significant impact on the overall outcomes of the skill-neutral and skill-differentiated labour efficiency shocks.

Table 8.3.1: Sector characteristics by key income and expenditure components

	% share of costs (expenditures)								% share of incomes (receipts)						
	S labour	U labour	Total labour	OVA	Taxes on exp.	RUK imports	ROW imports	Total imports	Households	Government	Capital	Tourism	RUK exports	ROW exports	Total exports
1. Agriculture, forestry and fishing	5	6	11	32	- 16	27	4	31	23	0	3	0	17	11	27
2. Mining	7	3	10	38	2	13	4	17	1	-	1	0	72	9	81
3. Food, drink and tobacco	10	11	21	19	2	17	6	23	23	-	0	0	24	31	55
4. Textile, leather, wood and paper	13	14	27	6	2	19	7	26	15	0	1	1	24	13	37
5. Chemicals	6	2	8	15	2	40	20	60	13	-	0	1	39	22	62
6. Rubber, plastic, cement and iron	13	19	33	7	4	17	6	23	6	-	1	0	13	15	29
7. Computer, electrical and transport eq.	19	10	29	7	1	17	12	29	8	-	11	0	16	23	39
8. Electricity, gas and water	7	5	12	20	3	12	8	20	28	3	0	0	18	2	20
9. Construction	14	10	24	17	1	12	3	15	2	0	53	0	8	1	9
10. Wholesale and retail	17	19	37	16	4	13	3	16	62	0	3	2	9	7	16
11. Land transport	13	17	30	12	5	15	4	19	27	-	0	1	10	5	15
12. Water transport	10	5	15	9	6	20	6	27	23	-	4	1	6	40	46
13. Air Transport	9	8	17	17	8	18	6	24	46	-	0	0	23	4	27
14. Post and support transport services	15	17	32	18	1	13	3	15	3	0	1	0	12	9	21
15. Accommodation	19	16	35	17	7	11	5	16	50	0	0	29	0	0	0
16. Food & beverage services	17	19	36	13	9	10	7	17	81	-	-	10	-	-	-
17. Telecommunication	23	8	32	22	2	13	4	17	37	1	3	0	10	7	17
18. Computer and information services	38	7	45	19	2	14	3	17	1	1	17	0	32	16	48
19. Financial services	15	6	21	29	4	11	2	13	16	-	0	0	47	8	55
20. Real estate	2	1	3	55	- 0	20	1	21	81	-	3	0	2	0	2
21. Professional services	28	10	38	18	1	14	2	16	4	0	3	0	29	10	39
22. Research and development	50	4	54	3	- 10	18	4	22	1	0	2	0	23	34	57
23. Public administration	40	12	51	7	3	11	4	15	14	72	0	0	1	1	2
24. Recreational services	25	14	39	12	4	13	3	16	53	15	1	4	4	2	7
25. Other services	26	17	43	22	3	10	3	12	66	0	1	1	4	1	5

8.4 Skill-neutral technological progress

This section presents results for a permanent 5% skill-neutral increase in total labour efficiency across all sectors. Sections 8.4.1, 8.4.2, and 8.4.3 detail the long-run results for the free migration closure, the skilled migration closure, and the no migration closures respectively. Section 8.4.4 gives the short-run results. Section 8.4.5 summarises the key results and compares these across the three migration variants of the model.

To recall, the short-run results are the same for all three migration closures since there is no migration in the first period irrespective of the assumptions about labour mobility, and myopic investment decisions made in period one are unaffected by future migration decisions.

The labour force is fixed in the short run, but the unemployment rate can change and labour is mobile across sectors. The total labour force is potentially adjusted from period to period through migration (depending on the migration closure used). Capital stock is fixed in the short run both in total and in its distribution across sectors. Capital stocks in individual production sectors vary through period by period flows of net investment.

The capital markets fully adjust in the long run models. All sectors earn the same return in the base period. In the short run and during the adjustment periods, capital rental rates can vary across sectors. Where the capital rental rate is greater than the user cost of capital, there is net investment. Conversely, there is disinvestment where the capital rental rate is less than the user cost of capital.

In the long run all sectors have the same capital rental rate which is then equal to the user cost of capital. The user cost of capital is driven by the capital price index, interest rate, together with the exogenous subsidies and relevant taxes, and depreciation rates. This is discussed in more detail when outlining the simulation results.

8.4.1 Long-run: Free migration

The free migration closure of the AMOSKI model ties down long-run unemployment rates and real wage rates to their initial equilibrium levels through the combination of regional bargained real wage and flow migration (McGregor et al., 2000). Any change in the real wage and the unemployment rate entail a migration response which in turn limits and ultimately reverse real wages changes until the labour market is in long-run equilibrium with zero net-migration flows. The free migration closure thereby imposes perfectly elastic supply of inputs across long-run equilibria.

To recall, migration responds to any gap between the unemployment rate and/or real wages between Scotland the RUK. The regional bargained real wage negatively relates the regional unemployment rate to the regional real wage.

Results presented here thereby mimic these found in an Input-Output system by effectively imposing perfectly elastic supply of inputs (McGregor et al., 1996). It still might be that nominal prices (e.g. wages and the user cost of capital) fall as the underlying prices fall due to the improvement in efficiency. Table 8.4.1 details the key macroeconomic long-run results for a permanent 5% increase in total labour efficiency across all sectors.

Initially the unemployment rate rises as a result of the increase in efficiency, and the real gross wage falls. Workers thereby migrate out of Scotland. Towards the long run, workers migrate back into Scotland as the unemployment rate falls and real wages rise. Real wages and the unemployment rate thereby return to their initial equilibrium levels due to the inflow of workers from outside Scotland (this is also shown in Figure 8.4.2).

There are no changes in exogenous prices, but the prices of domestically produced goods fall with the increase in labour efficiency, and this reduces CPI. Thereby all nominal prices, including the user cost of capital and nominal wages, fall in the long run.

Nominal wages fall by 3.31% for both the skilled and the unskilled in the long run. This is the same as the fall in the CPI (because the real wage remains constant). The relative wage therefore remains the same. Differences in skilled and unskilled employment are thereby driven by differential sectoral impacts. The wage, as measured in efficiency units, falls for both the skilled and the unskilled by 8.31% as compared to the base period.

The increase in efficiency generates export led expansion in economic activity through the fall in domestic prices. This export led growth stimulates domestic consumption, intermediate demand and investment (and thereby also derived demand for labour). Here the growth in output more than offsets any initial negative impacts on employment due to the increase in efficiency.

The increase in labour efficiency thereby decreases the price of labour, measured in efficiency units, and production costs fall. A reduction in production costs increases competitiveness, stimulating output and investment. Exports to RUK increase by 5.93% and by 6.17% to ROW. Investment increases by 6.33%, and GRP increases by 6.60% in the long run. There are, however, a number of conflicting pressures, especially for employment.

For employment there is a direct effect of the increase in efficiency. That is, labour efficiency, as measured in efficiency units, increases. Skilled/unskilled employment increases if the stimulus to labour demand coming through substitution- and output effects is greater than the negative impact of the direct increase in labour efficiency.

Table 8.4.1: Long-run, free migration, effects of a 5% increase in total labour efficiency. In % changes

GRP Income measure	6.60
Consumer Price Index	- 3.31
Unemployment Rate	- 0.00
Unemployment Rate S	- 0.00
Unemployment Rate U	- 0.00
Total Employment	1.69
Total Employment S	1.39
Total Employment U	2.27
Nominal Gross Wage	- 3.31
Nominal Gross Wage S	- 3.31
Nominal Gross Wage U	- 3.31
Real Gross Wage	0.00
Real Gross Wage S	0.00
Real Gross Wage U	0.00
Labour force	1.69
Labour force S	1.39
Labour force U	2.27
Households Consumption	1.49
Investment	6.33
Capital Stock	6.33
Replacement cost of capital	- 3.24
Export RUK	5.93
Export ROW	6.17
FTE Employment	39,134
FTE Employment S	18,079
FTE Employment U	21,054

LR = long-run. S = Skilled; U = Unskilled

There is a substitution effect between labour and other inputs as the price of labour, measured in efficiency units, falls. Substitution increases employment in efficiency units, per unit of output. Production becomes less labour intensive in physical terms as the elasticity of substitution between labour and capital is 0.3.

Substitution effects are bigger where the elasticity of substitution between input is higher, the output effects are bigger the more sensitive output is to changes in price. This significantly depends on the extent that output is traded i.e. the stimulus to exports due to the increase in competitiveness.

The capital labour ratio thereby falls, though the demand for capital could rise. In this case, although the price of labour in efficiency units falls, investment increases. In the production of output there is an output effect due to the fall in domestic prices. The increased competitiveness of the product increases output (and derived employment).

Capital stocks rise driven by net investment, which is affected by the gap between the capital rental rate and the user cost of capital that opens in the short run. The increase in investment further reinforces the output effect (and the impact on employment). The new steady-state equilibrium is reached by adjustments in the factors of production, notably the expansion of capital and labour.

The capital rental rate is what sectors earn for the actual capital stock in existence in this period (it indicates profitability), if it is rented out in this period for one period. i.e. the return on the fixed capital stock in a sector. The capital rental depends on the demand for capital and the capital stock. As demand for capital increases in that sector, the capital rental rate increases.

The replacement cost of capital (user cost) is the annualised cost of producing one unit of new capital for the user. A price signal is given to increase capital by investing, if the capital rental rate is higher than the user cost of capital. Thereby capital can be rented out at a higher rate than it costs to produce. The investment function can thus be viewed as responding to the difference between the two.

Total employment increases by 1.69% in the long run. Skilled employment sees a smaller percentage increase when compared to unskilled employment, 1.39% and 2.27% respectively. Any negative employment effects seen in the short run are reversed here in the long run and employment increases. Here the proportionate change in employment is equal to the proportionate change in the labour force.

The stimulus to exports is not skill-neutral and this drives the non-neutral impacts on employment. Even though all of the sectors experience the same shock, there are significant differences across sectors. Therefore, the sectoral production and sales characteristics play a significant part. This is mainly because relative prices of skilled and unskilled labour remain unchanged.

Table 8.4.2 details the long-run results at the individual sector level for a permanent 5% increase in total labour efficiency across all sectors. The increase in labour efficiency leads to a fall in output prices. The fall in output prices thereby reflects the labour intensity of the sectors. The fall in prices stimulates exports and total output increases.

This increases the demand for workers and skilled and unskilled employment increases (in the majority of the sectors). Capital stocks and investment rise in all sectors and the capital rental rate falls in the long run. Continued investment in turn further reinforces the output effect.

Sectors typically see a stimulus to output due to the fall in prices and the corresponding increase in exports. The export led growth stimulates domestic consumption, intermediate demand and investment too. This increase in output further stimulates the demand for skilled and unskilled labour. Notably, the percentage change in skilled and unskilled employment is equiproportional within each sector as the relative wage remains the same.

Table 8.4.2: Long-run free migration results: 5% increase in total labour efficiency. In % changes

	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	6.83	-2.37	2.65	2.65	4.91	4.91	6.19	6.19	-3.24
2. Mining	6.23	-1.76	3.26	3.26	3.63	3.63	6.82	6.82	-3.24
3. Food, drink and tobacco	7.12	-2.88	3.81	3.81	6.01	6.01	7.39	7.39	-3.24
4. Textile, leather, wood and paper	8.37	-2.93	5.01	5.01	6.13	6.13	8.63	8.63	-3.24
5. Chemicals	6.26	-2.05	3.22	3.22	4.23	4.23	6.78	6.78	-3.24
6. Rubber, plastic, cement and iron	9.97	-3.11	6.75	6.75	6.52	6.52	10.44	10.44	-3.24
7. Computer, electrical and transport eq.	9.08	-2.95	5.65	5.65	6.16	6.16	9.30	9.30	-3.24
8. Electricity, gas and water	5.96	-2.67	2.78	2.78	5.56	5.56	6.33	6.33	-3.24
9. Construction	9.80	-3.23	6.20	6.20	6.79	6.79	9.86	9.86	-3.24
10. Wholesale and retail	5.46	-3.51	2.08	2.08	7.41	7.41	5.60	5.60	-3.24
11. Land transport	6.61	-3.16	3.42	3.42	6.63	6.63	6.99	6.99	-3.24
12. Water transport	7.39	-2.76	4.41	4.41	5.75	5.75	8.01	8.01	-3.24
13. Air Transport	6.02	-2.90	3.12	3.12	6.07	6.07	6.68	6.68	-3.24
14. Post and support transport services	8.88	-3.18	5.39	5.39	6.69	6.69	9.02	9.02	-3.24
15. Accommodation	2.34	-3.59	-1.02	-1.02	7.58	7.58	2.40	2.40	-3.24
16. Food & beverage services	2.84	-3.75	-0.46	-0.46	0.00	0.00	2.97	2.97	-3.24
17. Telecommunication	6.39	-3.30	2.95	2.95	6.94	6.94	6.50	6.50	-3.24
18. Computer and information services	10.30	-3.70	6.63	6.63	7.84	7.84	10.31	10.31	-3.24
19. Financial services	7.98	-2.91	4.81	4.81	6.09	6.09	8.43	8.43	-3.24
20. Real estate	3.07	-2.47	-0.13	-0.13	5.13	5.13	3.31	3.31	-3.24
21. Professional services	9.30	-3.29	5.75	5.75	6.92	6.92	9.40	9.40	-3.24
22. Research and development	9.36	-3.49	4.82	4.82	7.37	7.37	8.44	8.44	-3.24
23. Public administration	0.63	-5.02	-3.24	-3.24	10.84	10.84	0.10	0.10	-3.24
24. Recreational services	3.59	-3.86	0.07	0.07	8.19	8.19	3.53	3.53	-3.24
25. Other services	4.48	-3.83	0.94	0.94	8.12	8.12	4.42	4.42	-3.24

S = Skilled; U = Unskilled

For example, the Computer & information services sector sees a 3.70% fall in prices. This stimulates exports, which increase by 7.84% to both the RUK and the ROW. Here the stimulus to output is also driven by investment, which increases by 10.31%, as it supplies investment goods to other sectors. Both skilled and unskilled employment increase by 6.63%.

There are, however, four sectors where a fall in skilled and unskilled employment is observed. For example, the Public administration sector experiences a 3.24% fall in skilled and unskilled employment. Similarly, skilled and unskilled employment in the Accommodation decreases by 1.02%. The sectors that experience a fall in employment mainly serve domestic markets i.e. have a very small (or zero) export share of output.

To recall from Section 8.3, the Accommodation and the Food & beverages services sector are strongly linked to non-Scottish tourism (i.e. expenditure by non-residents), the Public administration sector has strong linkages to the Government, and the Real estates sector mainly serves Households. These sectors thereby do not (directly) benefit from the export led growth.

The stimulus to labour demand in those sectors that experience a fall in employment does not exceed the negative impact of the direct increase in labour productivity. The fall in prices and the corresponding stimulus to exports, however, more than offsets the negative impacts seen in sectors that mainly serve the domestic market. Overall, the stimulus to output through the increase in efficiency is thereby mainly driven by export orientated sectors.

The differential impact on the skilled and unskilled employment is best analysed when considering FTE employment figures. Total FTE employment increase by 39,134 in the long run, 18,079 skilled and 21,054 unskilled. That is, the export led growth stimulated through the increase in efficiency has benefited the unskilled, as against the skilled, in terms of FTE employment.

Exports, however, generally generate more skilled than unskilled FTE employment (in this model closure). Chapter 7 details the simulation results for a £500m increase in exports. The results show that exports are generally more unskilled intensive in terms of percentage changes, and more skill intensive in real (FTE) terms.

Given that: the efficiency shock enters the system as skill-neutral; the stimulated output growth comes mainly through increased exports; export led growth is generally more skill intensive, one could expect a bias towards a stronger increase in skilled FTE employment as compared to unskilled FTE employment. As this is not the case, FTE employment figures at sector level are analysed.

Figure 8.4.1 details the running total of skilled and unskilled long-run FTE employment at sector level. The data show the summation of FTE employment, which is updated each time the FTE employment figure of a sector is added to the sequence, by adding the employment figure of the sector to the previous running total.

To recall from Chapter 3, the data in the 2009 SAM for Scotland gives 1,302,392 skilled and 927,540 unskilled FTE workers. 66% of wage earnings go to skilled, and 33% go to unskilled workers. The Public administration sector is the single largest employment sector, covering 27% of Scottish FTE workers. This sector is also ranked second highest by skill intensity in terms of FTE employment. 71% of workers in the Public administration sector are skilled.

The Public administration sector sees a 3.24% fall in both skilled and unskilled employment (as detailed in Table 8.4.2). This fall in employment is large enough to tilt the overall results in favour of the unskilled. Removing the negative FTE employment impact generated in this sector from the total FTE employment figures shifts the FTE employment figures to benefiting the skilled.

Sector 21, Professional services, is very dominant in contributing to the absolute number of skilled and unskilled employment changes. The Professional services covers nearly 15% of Scottish FTE employment and is a sector with high skill intensity. This sector sees a 5.75% increase in skilled and unskilled employment, a 10,392 increase in skilled and 6,738 increase in unskilled FTE employment.

The negative impact on FTE employment seen in sectors that mainly serve the domestic market, and the relative size and skill intensity of these sectors, is one of the main factors that determine the overall impact on skilled and unskilled employment. In particular, employment contractions seen in the Public administration sector, have the potential to shift the overall employment effects in favour of the unskilled, as is the case here.

Figure 8.4.1: Running total of skilled and unskilled long-run, free migration, FTE employment at sector level

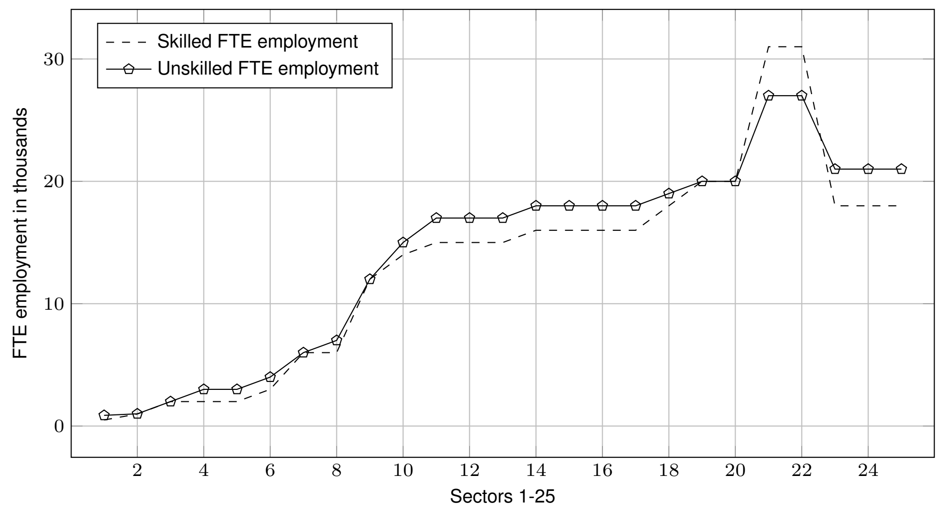
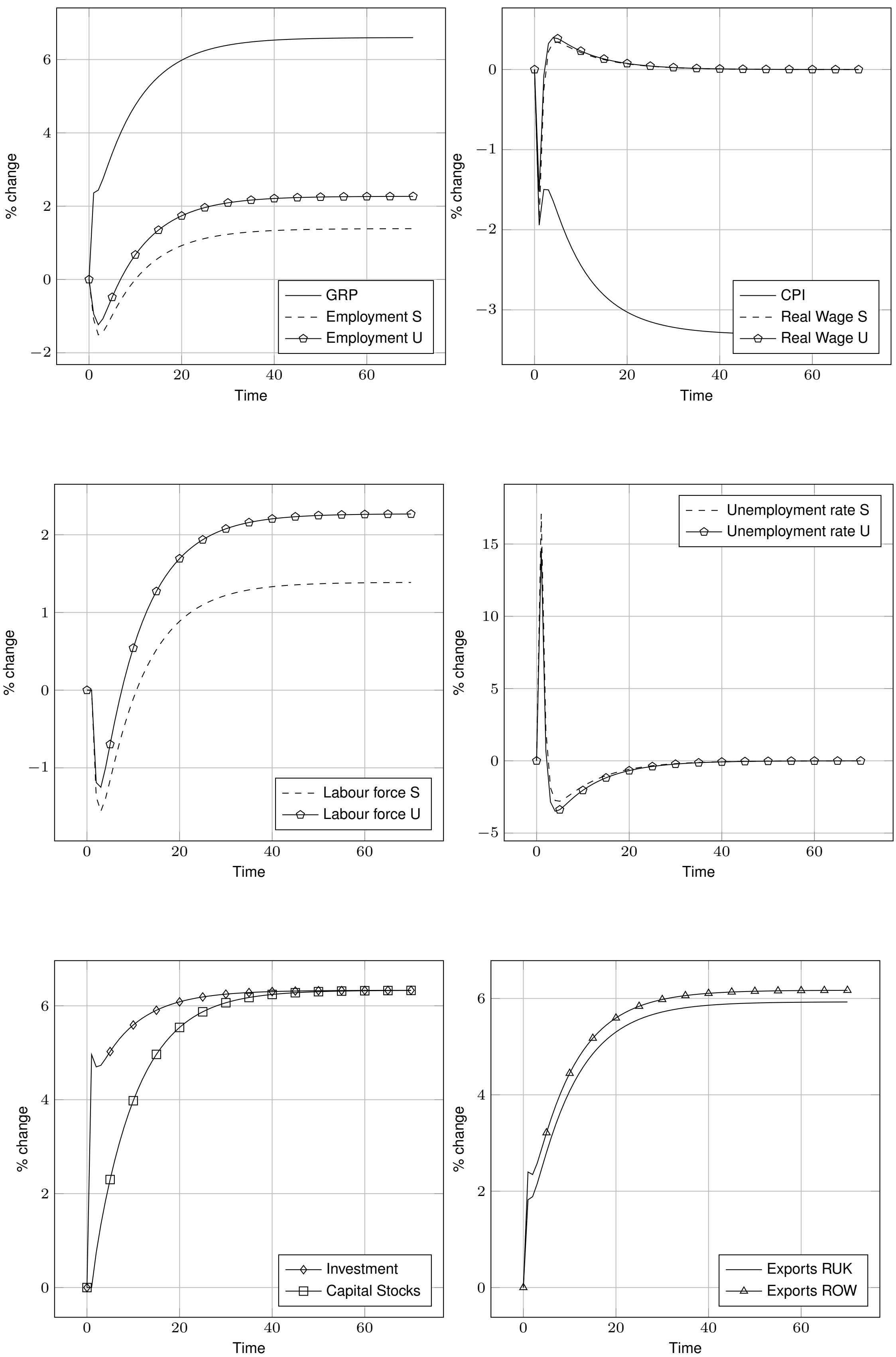


Figure 8.4.2 details the aggregate long-run free migration transition paths of GRP, employment, CPI, real wages, labour force, unemployment rates, investment, capital stocks, and exports. These figures report the percentage change from base year values. The adjustment paths detail the initial negative effects on employment, the unemployment rate, and the labour force, and how some of these negative effects are reduced, or offset, towards the long run.

Employment is at its lowest in period two, where total employment is 1.42% below its initial level, -1.51% for the skilled and -1.23% for the unskilled. Out-migration reaches its peak in time-period three where the total labour force decreases by 1.45% as compared to its initial level. This is a 1.56% fall for the skilled and 1.25% fall for the unskilled labour force.

Figure 8.4.2: Aggregate transition paths - increase in total labour efficiency - long-run - free migration



8.4.2 Long-run: Skilled migration

Table 8.4.3 details the key macroeconomic long-run results for a permanent 5% increase in total labour efficiency across all sectors in the free- and skilled migration closures. The increase in efficiency causes a fall in output prices, which in turn stimulates exports, output, and employment. Increased investment also further reinforces the stimulus to output. Nominal wages fall, and employment increases in the long run. There are, however, some significant differences to the free migration closure.

In the free migration closure both the skilled and unskilled long-run unemployment rates, and the skilled and unskilled real wages are tied down to their initial equilibrium values through the combination of regional bargained real wage and flow migration. Both the skilled and unskilled labour force is available in the long run with an infinitely elastic supply at the base year real wage.

In contrast to the free migration closure, the unskilled labour force is fixed in the skilled migration closure. This means that in response to changes in the demand for unskilled labour, the unskilled real wage and unemployment rate will adjust. If demand for unskilled labour rises, unskilled real wages will rise and their unemployment rate falls. The unskilled unemployment rate falls towards the long-run by 10.94%, and the unskilled real wage rises by 1.31%.

The skilled labour force is available at infinitely elastic supply, which ties down the skilled unemployment rate and the skilled real wage to their initial equilibrium. Skilled labour thereby experience the same adjustment mechanisms seen in the free migration closure, as detailed in Section 8.4.1, where the skilled unemployment rate, and the skilled real wage revert back to their initial equilibrium.

Neither the aggregate unemployment rate nor aggregate real wages revert back to their initial equilibrium levels in the skilled migration closure. Aggregate unemployment rate falls by 5.47%, and the total real wage falls by 0.65%. CPI falls by 3.31% in the free migration closure and by 3.00% in the skilled migration closure. Nominal wages fall by 3.31% in the free migration closure, and by 2.37% in the skilled migration closure.

As prices fall by less in the skilled migration closure as compared to the free migration closure there is less stimulus to exports and output. The stimulus to output is thereby affected by the restriction of the supply of unskilled workers. Competitiveness effects stimulate exports to the RUK by 5.34% and to the ROW by 5.56%. GPR sees a 5.94% increase.

The key here is that the bargaining power of unskilled workers is increased as demand for unskilled labour rises together with a fixed unskilled labour force. That is, unskilled workers are able to achieve an increase in their real wage, and a smaller cut to their nominal wages in the skilled migration closure as compared to the free migration closure.

Table 8.4.3: Long-run, free- and skilled migration, effects of a 5% increase in total labour efficiency. In % changes

	LR - Free migration	LR - Skilled migration
GRP Income measure	6.60	5.94
Consumer Price Index	- 3.31	- 3.00
Unemployment Rate	- 0.00	- 5.47
Unemployment Rate S	- 0.00	- 0.00
Unemployment Rate U	- 0.00	- 10.94
Total Employment	1.69	1.05
Total Employment S	1.39	1.23
Total Employment U	2.27	0.70
Nominal Gross Wage	- 3.31	- 2.37
Nominal Gross Wage S	- 3.31	- 3.00
Nominal Gross Wage U	- 3.31	- 1.73
Real Gross Wage	0.00	0.65
Real Gross Wage S	0.00	0.00
Real Gross Wage U	0.00	1.31
Labour force	1.69	0.81
Labour force S	1.39	1.23
Labour force U	2.27	-
Households Consumption	1.49	1.33
Investment	6.33	5.69
Capital Stock	6.33	5.69
Replacement cost of capital	- 3.24	- 2.93
Export RUK	5.93	5.34
Export ROW	6.17	5.56
FTE Employment	39,134	22,489
FTE Employment S	18,079	16,012
FTE Employment U	21,054	6,478

LR = long-run. S = Skilled; U = Unskilled

Table 8.4.3 shows that total employment increases by 1.05% in the long run. Skilled employment increases by 1.23% and unskilled employment increases by 0.70%. The stimulus to employment is smaller in the skilled migration closure when compared to the free migration closure for both skill categories.

However, the impact on the skilled and unskilled is reversed due to the asymmetric impact on skilled and unskilled nominal wages, and the corresponding sectoral impacts. The wage, as measured in efficiency units, falls for both the skilled and the unskilled. The skilled see a 8% fall, and the unskilled experience a 6.73% fall as compared to the base period.

The restriction in the supply of unskilled workers in the skilled migration closure causes further skilled for unskilled substitution, as compared to the free migration closure. That is, low skill intensive sectors experience a relative competitiveness penalty due to the lack of supply of unskilled workers. In contrast, high skill intensive sectors benefit from the inflow of skilled workers, and the resulting downward pressure on skilled wages. This is further discussed when analysing sector specific results.

In the skilled migration closure skilled employment sees a larger increase compared to unskilled employment as skilled workers become cheaper relative to unskilled workers. This is evident in the sector disaggregated results. Skilled and unskilled nominal wages fall by 3.00% and 1.73% respectively.

Sectors therefore substitute skilled for unskilled workers (and capital) as a result of relative price effects, skilled employment thereby increases more strongly than unskilled employment in both absolute and proportionate terms. The negative employment impact of sectors experiencing a contraction in employment, however, are again a major factor in determining the overall impact on skilled and unskilled employment.

As only the skilled are geographically mobile the labour force increases by 0.81% in the long run, as compared to the 1.69% increase in the free migration case. The skilled labour force increases by 1.23% whilst the unskilled labour force remains unchanged in the long run.

In the skilled migration closure the unskilled experience a long-run increase in the real wage, whilst the long-run skilled real wage is unchanged from base. In terms of changes in employment, however, the skilled are better off as they benefit from the skilled labour mobility and substitution effects between the skilled and unskilled.

Table 8.4.4 details the long-run results at the individual sector level for a permanent 5% increase in total labour efficiency across all sectors. As seen in the free migration results, all sectors experience a fall in output prices, and an increase in exports and total output. There are, however, some significant differences across sectors, and also between the free- and the skilled migration closures.

In the free migration closure there are four sectors that see a fall in both skilled and unskilled employment. These sectors mainly serve domestic markets. Similar observations can be made in the skilled migration closure. Here there are three sectors that see a decrease in both skilled and unskilled employment, and two sectors that see a decrease in unskilled employment only.

Unskilled employment falls by more than skilled employment in these sectors due to the supply restriction of unskilled workers. For example, in the Accommodation sector skilled and unskilled employment fall by 1.02% in the free migration case, and by 0.65% and 2.23% respectively with skilled migration.

The Recreational services sector sees a skilled and unskilled employment increase of 0.07% in the free migration closure. In the skilled migration closure skilled employment increases by 0.12% and unskilled employment falls by 1.26%.

To recall from Section 8.3, Sectors 15, 16, 20, 24, and 25 all mainly serve domestic households, and sector 23 mainly serves public sector consumption. As these domestic markets experience a low expansion the derived labour demand impact is muted. Moreover, unskilled employment falls in all of these sectors due to the substitution towards skilled workers.

The stimulus to labour demand in these sectors coming through the expansion in output and the substitution of labour for capital in production is smaller in these domestic serving sectors than the negative impact of the direct increase in labour productivity.

Table 8.4.4: Long-run skilled migration results: 5% increase in total labour efficiency. In % changes

	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	6.15	-2.14	3.11	1.04	4.42	4.42	5.57	5.57	-2.93
2. Mining	5.60	-1.59	2.86	1.58	3.26	3.26	6.14	6.14	-2.93
3. Food, drink and tobacco	6.41	-2.60	3.95	2.07	5.41	5.41	6.65	6.65	-2.93
4. Textile, leather, wood and paper	7.53	-2.65	5.04	3.14	5.53	5.53	7.77	7.77	-2.93
5. Chemicals	5.64	-1.85	2.76	1.55	3.81	3.81	6.10	6.10	-2.93
6. Rubber, plastic, cement and iron	8.97	-2.81	7.06	4.70	5.87	5.87	9.39	9.39	-2.93
7. Computer, electrical and transport eq.	8.17	-2.67	5.07	3.71	5.55	5.55	8.36	8.36	-2.93
8. Electricity, gas and water	5.36	-2.42	2.56	1.16	5.01	5.01	5.69	5.69	-2.93
9. Construction	8.80	-2.93	5.72	4.19	6.12	6.12	8.86	8.86	-2.93
10. Wholesale and retail	4.91	-3.18	2.41	0.53	6.68	6.68	5.04	5.04	-2.93
11. Land transport	5.95	-2.86	3.85	1.73	5.97	5.97	6.29	6.29	-2.93
12. Water transport	6.65	-2.49	3.98	2.60	5.18	5.18	7.20	7.20	-2.93
13. Air Transport	5.41	-2.63	2.94	1.46	5.47	5.47	6.01	6.01	-2.93
14. Post and support transport services	7.99	-2.88	5.41	3.48	6.02	6.02	8.12	8.12	-2.93
15. Accommodation	2.10	-3.25	-0.65	-2.23	6.84	6.84	2.15	2.15	-2.93
16. Food & beverage services	2.56	-3.40	0.14	-1.73	0.00	0.00	2.67	2.67	-2.93
17. Telecommunication	5.75	-2.99	2.51	1.31	6.25	6.25	5.85	5.85	-2.93
18. Computer and information services	9.26	-3.35	5.65	4.58	7.06	7.06	9.27	9.27	-2.93
19. Financial services	7.18	-2.64	4.23	2.96	5.49	5.49	7.58	7.58	-2.93
20. Real estate	2.76	-2.23	-0.29	-1.44	4.62	4.62	2.97	2.97	-2.93
21. Professional services	8.36	-2.98	5.03	3.81	6.23	6.23	8.46	8.46	-2.93
22. Research and development	8.42	-3.16	3.93	2.97	6.64	6.64	7.59	7.59	-2.93
23. Public administration	0.56	-4.55	-3.15	-4.22	9.77	9.77	0.08	0.08	-2.93
24. Recreational services	3.22	-3.50	0.12	-1.26	7.37	7.37	3.17	3.17	-2.93
25. Other services	4.03	-3.47	0.98	-0.48	7.31	7.31	3.98	3.98	-2.93

S = Skilled; U = Unskilled

Sectors where the stimulus to labour demand is greater than the negative impact of the direct increase in labour productivity see a larger increase in skilled employment as compared to unskilled employment. This is due to the substitution of skilled for unskilled workers as the supply of unskilled workers is restricted and the unskilled real wage rises.

This substitution effect is particularly visible in low skill intensive sectors. For example, the Rubber, plastic, cement & iron sector sees a strong stimulus to output coming through both exports and investment. Despite the sector being low skilled, the increase in demand for labour translates to an increase of 7.06% in skilled employment, and an increase of 4.70% in unskilled employment.

The impact on employment is again analysed by detailing the impact of the efficiency shock on FTE employment. Total FTE employment increases by 22,489 in the long run. This is a 16,012 increase in skilled, and a 6,478 increase in unskilled FTE employment.

Figure 8.4.3 details the running total of skilled and unskilled long-run FTE employment at sector level. The stimulus to skilled employment is more marked as compared to the one seen in the free migration closure. This skill-bias is consistent with the results seen in an export demand shock in the skilled migration closure (see Chapter 7 for details).

As in the free migration case there is a large stimulus to FTE employment coming through sector 21, Professional services. Again, there is a significant contraction of FTE employment in sector 23, Public administration, which mainly serves public sector consumption.

Figure 8.4.3: Running total of skilled and unskilled long-run, skilled migration, FTE employment at sector level

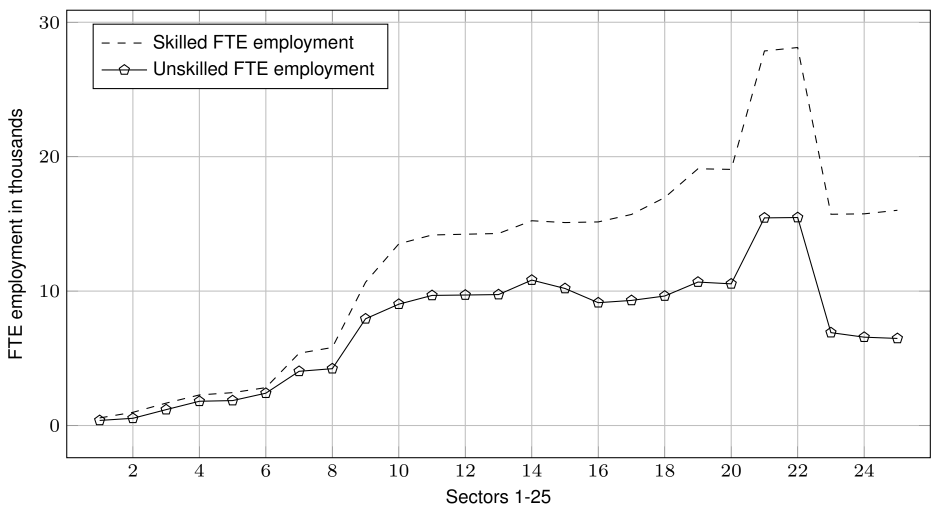
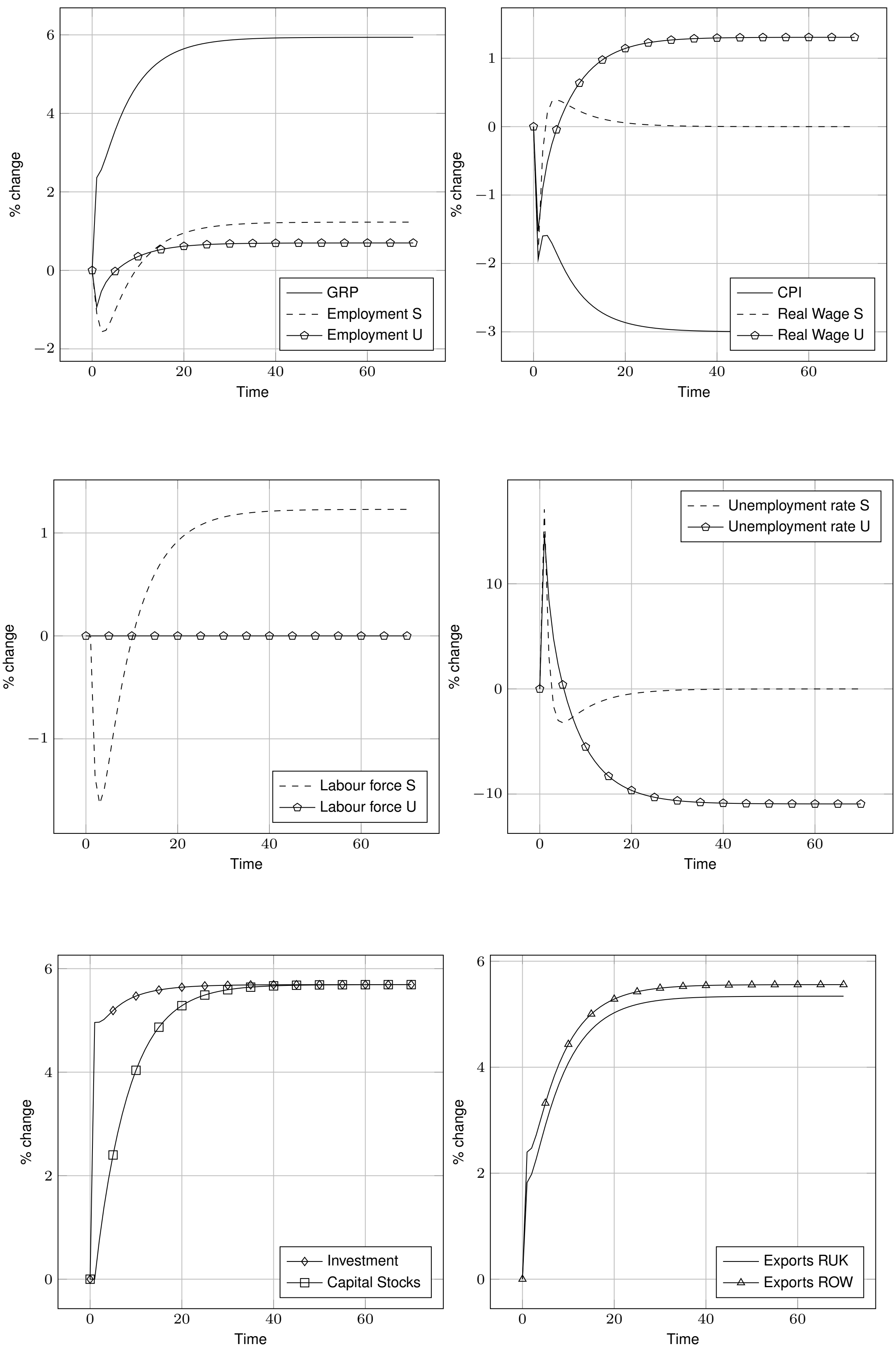


Figure 8.4.4 details the aggregate long-run skilled migration transition paths of GRP, employment, CPI, real wages, labour force, unemployment rates, investment, capital stocks, and exports. The adjustment paths detail the initial negative effects on employment, the unemployment rate, and the labour force, and how some of these negative effects are reduced, or offset, towards the long run.

Figure 8.4.4: Aggregate transition paths - increase in total labour efficiency - long-run - skilled migration



8.4.3 Long-run: No migration

Table 8.4.5 details the key macroeconomic long-run results for a permanent 5% increase in total labour efficiency across all sectors. In the no migration closure neither skilled nor unskilled migrate between regions in response to changes in real wage and unemployment rate. That is, the total workforce remains fixed throughout the simulation, the skilled and unskilled unemployment rate and real wage vary in the long run in response to changes in labour demand.

The main adjustment mechanism seen in the free- and the skilled migration closures are also seen here. That is, the increase in efficiency stimulates investment, reduces output prices. This in turn increases exports, output, and employment. Nominal wages fall, whilst employment increases in the long run. The unemployment rate and the real wage do not revert back to their initial equilibrium as the skilled and unskilled labour force remains fixed.

The most direct impact, as compared to the other migration closures, is that the skilled real wage increases in the long run in the no migration closure (but by less than the unskilled real wage). The total real wage increases by 0.94%, 0.71% for the skilled and 1.16% for the unskilled.

The bargaining power of skilled and unskilled workers is increased as demand for labour rises together with a fixed labour force. That is, both skilled and the unskilled workers are able to achieve an increase in their real wage, and a smaller cut to their nominal wages in the no migration closure as compared to the skilled and the free migration closures.

Prices thereby fall by less than in the skilled migration closure. This in turn reduces the stimulus to exports and thereby the stimulated demand for labour. All sectors experience a competitiveness penalty in the no migration closure as the supply of both skilled and unskilled workers is restricted. This in turn causes some crowding out of output.

The aggregate unemployment rate falls by 7.78% in the long run. In contrast to the other migration closures, the unemployment rate falls here for both skill groups due to the migration assumptions. The skilled unemployment rate decreases by 5.75% and the unskilled falls by 9.82% in the long run.

Nominal wages fall by 1.80% in the long run, a 2.02% decrease for the skilled and a 1.58% decrease for the unskilled. The wage, as measured in efficiency units, falls by 7.02% for the skilled, and by 6.58% for the unskilled as compared to the base period. As seen in skilled migration closure, the fall in the nominal wage is deeper for the skilled, reflecting the differences in the real wage.

Total employment increases by 0.46% in the long run as compared to 1.69% in the free migration closure. As seen in the free migration closure, the unskilled see a stronger percentage increase in employment (0.63%) as compared to the increase seen by the skilled (+0.37%).

As in the free migration case, the unskilled benefit here from a larger percentage increase in employment than the skilled. In terms of the real wage, the unskilled see a smaller increase as compared to the skilled. Reflecting this, the unskilled see a smaller fall in the nominal wage. Thus, the unskilled are better off both in terms of increases in employment and cuts to the nominal wage relative to the skilled. The unskilled benefit here more in terms of increases in the real wage as compared to the skilled.

Table 8.4.5: Long-run, free-, skilled- and no migration, effects of a 5% increase in total labour efficiency. In % changes

	LR - Free migration	LR - Skilled migration	LR - No migration
GRP Income measure	6.60	5.94	5.34
Consumer Price Index	- 3.31	- 3.00	- 2.71
Unemployment Rate	- 0.00	- 5.47	- 7.78
Unemployment Rate S	- 0.00	- 0.00	- 5.75
Unemployment Rate U	- 0.00	- 10.94	- 9.82
Total Employment	1.69	1.05	0.46
Total Employment S	1.39	1.23	0.37
Total Employment U	2.27	0.70	0.63
Nominal Gross Wage	- 3.31	- 2.37	- 1.80
Nominal Gross Wage S	- 3.31	- 3.00	- 2.02
Nominal Gross Wage U	- 3.31	- 1.73	- 1.58
Real Gross Wage	0.00	0.65	0.94
Real Gross Wage S	0.00	0.00	0.71
Real Gross Wage U	0.00	1.31	1.16
Labour force	1.69	0.81	-
Labour force S	1.39	1.23	-
Labour force U	2.27	-	-
Households Consumption	1.49	1.33	1.19
Investment	6.33	5.69	5.11
Capital Stock	6.33	5.69	5.11
Replacement cost of capital	- 3.24	- 2.93	- 2.65
Export RUK	5.93	5.34	4.80
Export ROW	6.17	5.56	5.00
FTE Employment	39,134	22,489	10,590
FTE Employment S	18,079	16,012	4,778
FTE Employment U	21,054	6,478	5,812

LR = long-run. S = Skilled; U = Unskilled

Notably, GRP increases are similar across the three migration cases. This indicates that the impact of freeing up capital seems to have a larger impact, as compared to freeing up labour. This is discussed in more detail in the next section when analysing the short-run results.

Table 8.4.6 details the long-run results at the individual sector level for a permanent 5% increase in total labour efficiency across all sectors. As seen in the skilled migration results, all sectors experience a fall in output prices, and an increase in exports and total output as compared to the base. The main difference to the skilled migration closure is the magnitude of the impact. The induced stimulus to output is smaller here as prices do not fall as strongly.

Table 8.4.6: Long-run no migration results: 5% increase in total labour efficiency. In % changes

	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	5.52	-1.93	1.65	0.94	3.98	3.98	5.01	5.01	-2.65
2. Mining	5.03	-1.44	1.86	1.43	2.93	2.93	5.51	5.51	-2.65
3. Food, drink and tobacco	5.76	-2.35	2.51	1.87	4.87	4.87	5.97	5.97	-2.65
4. Textile, leather, wood and paper	6.76	-2.40	3.48	2.84	4.97	4.97	6.98	6.98	-2.65
5. Chemicals	5.06	-1.67	1.81	1.40	3.43	3.43	5.48	5.48	-2.65
6. Rubber, plastic, cement and iron	8.06	-2.54	5.04	4.24	5.28	5.28	8.44	8.44	-2.65
7. Computer, electrical and transport eq.	7.34	-2.41	3.81	3.35	4.99	4.99	7.51	7.51	-2.65
8. Electricity, gas and water	4.82	-2.18	1.52	1.04	4.51	4.51	5.11	5.11	-2.65
9. Construction	7.90	-2.64	4.29	3.77	5.50	5.50	7.95	7.95	-2.65
10. Wholesale and retail	4.42	-2.88	1.12	0.48	6.01	6.01	4.53	4.53	-2.65
11. Land transport	5.35	-2.58	2.28	1.56	5.37	5.37	5.65	5.65	-2.65
12. Water transport	5.97	-2.25	2.82	2.35	4.66	4.66	6.47	6.47	-2.65
13. Air Transport	4.86	-2.37	1.82	1.31	4.92	4.92	5.40	5.40	-2.65
14. Post and support transport services	7.19	-2.60	3.80	3.15	5.42	5.42	7.30	7.30	-2.65
15. Accommodation	1.88	-2.94	-1.48	-2.02	6.15	6.15	1.93	1.93	-2.65
16. Food & beverage services	2.30	-3.07	-0.92	-1.57	0.00	0.00	2.40	2.40	-2.65
17. Telecommunication	5.16	-2.70	1.59	1.18	5.62	5.62	5.26	5.26	-2.65
18. Computer and information services	8.32	-3.03	4.49	4.13	6.35	6.35	8.32	8.32	-2.65
19. Financial services	6.45	-2.38	3.11	2.67	4.94	4.94	6.81	6.81	-2.65
20. Real estate	2.47	-2.02	-0.91	-1.31	4.16	4.16	2.67	2.67	-2.65
21. Professional services	7.52	-2.69	3.85	3.43	5.60	5.60	7.60	7.60	-2.65
22. Research and development	7.56	-2.86	3.01	2.68	5.97	5.97	6.82	6.82	-2.65
23. Public administration	0.50	-4.12	-3.45	-3.82	8.79	8.79	0.06	0.06	-2.65
24. Recreational services	2.90	-3.16	-0.67	-1.14	6.64	6.64	2.84	2.84	-2.65
25. Other services	3.62	-3.13	0.07	-0.43	6.58	6.58	3.58	3.58	-2.65

S = Skilled; U = Unskilled

The sectors predominantly serving public and household consumption experience a fall in employment. The stimulus to labour demand coming through the expansion of output and the substitution of labour for capital in production does not exceed the negative impacts of the direct increase in labour productivity in these sectors.

Compared to the free- and the skilled migration closures the negative impacts of the direct increase in labour productivity are more prominent here due to the restriction in the supply of workers and corresponding price effects.

For example, the Accommodation sector sees a 1.48% fall in skilled, and a 2.02% fall in unskilled employment. The sectors experiencing the fall in employment see output increases of below 2.91%. The Other services sector just maintains an increase in skilled employment, but experiences a fall in unskilled employment with a 3.62% increase in total output.

The Recreational services sector, and the Food & beverages services sector experiences a fall in both skilled and unskilled employment in the no migration case. In the skilled migration case these two sectors experience a fall in only unskilled employment.

Sectors seeing comparatively large increases in output through increased investment and/or exports also see strong increases in the stimulated demand for labour. The Rubber, plastic, cement & iron sector sees an 8.06% increase in output, and a corresponding 5.04% increase in skilled- and a 4.24% increase in unskilled employment.

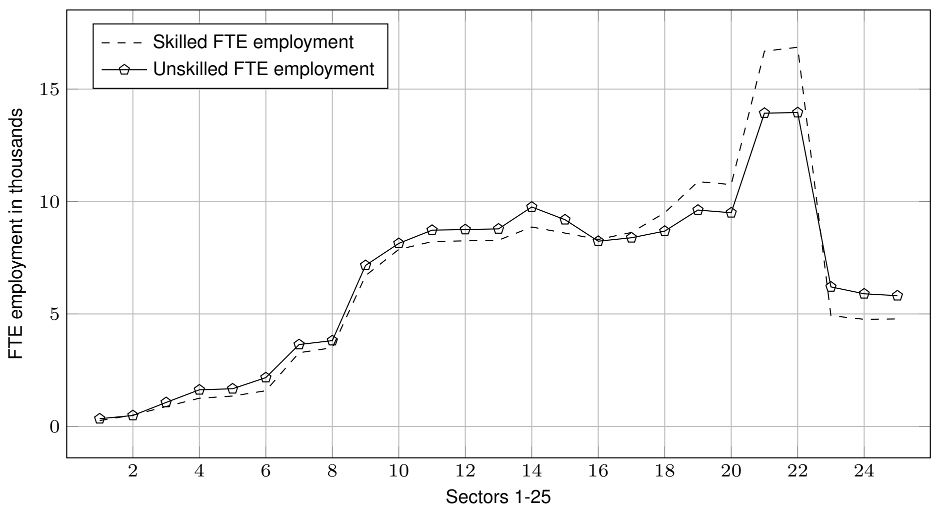
The Rubber, plastic, cement & iron sector is an example of strong substitution effects between skilled and unskilled workers. Despite the sector being low skill intensive, skilled employment sees larger percentage increases as skilled rather than unskilled workers are employed to meet the increased demand.

The differential impact on skilled and unskilled employment is again best analysed by detailing the impact of the efficiency shock on FTE employment. Total FTE employment increases by 10,590 in the long run. This is a 4,778 increase in skilled, and a 5,812 increase in unskilled FTE employment. Unskilled FTE increases here by more than skilled FTE employment.

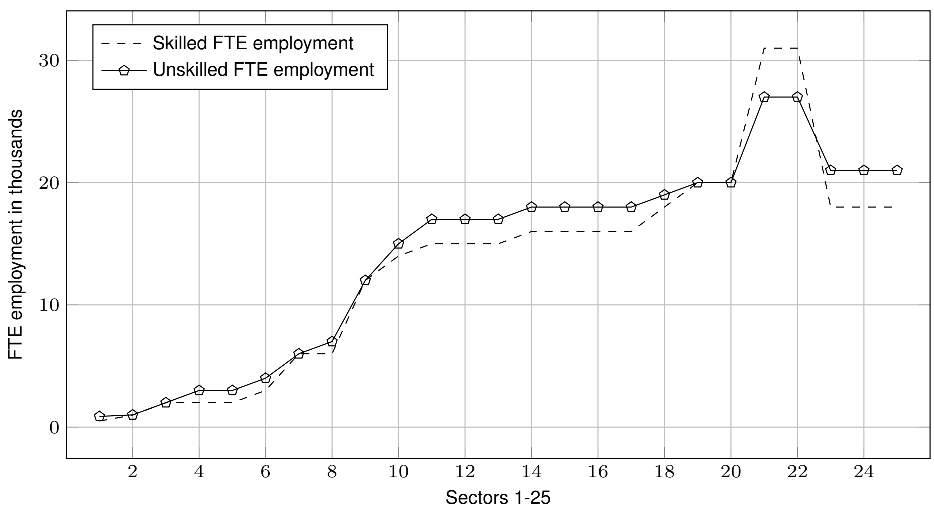
A stimulus to exports, however, is expected to be more skill intensive in this closure (see Chapter 7 for details). Again, the contraction in employment seen in the sectors that mainly serve the domestic market is a major factor in determining the impact on total skilled/unskilled FTE employment.

Figure 8.4.5 details the running total of skilled and unskilled long-run FTE employment at sector level. The fall in sector 22, Public administration, shifts FTE employment to be more unskill intensive. Large increases in both skilled and unskilled FTE employment are driven here by the expansion of sector 21, Professional services. This pattern is similar to the one seen in the free migration closure (as detailed below for comparison).

Figure 8.4.5: Running total of skilled and unskilled long-run, no migration, FTE employment at sector level



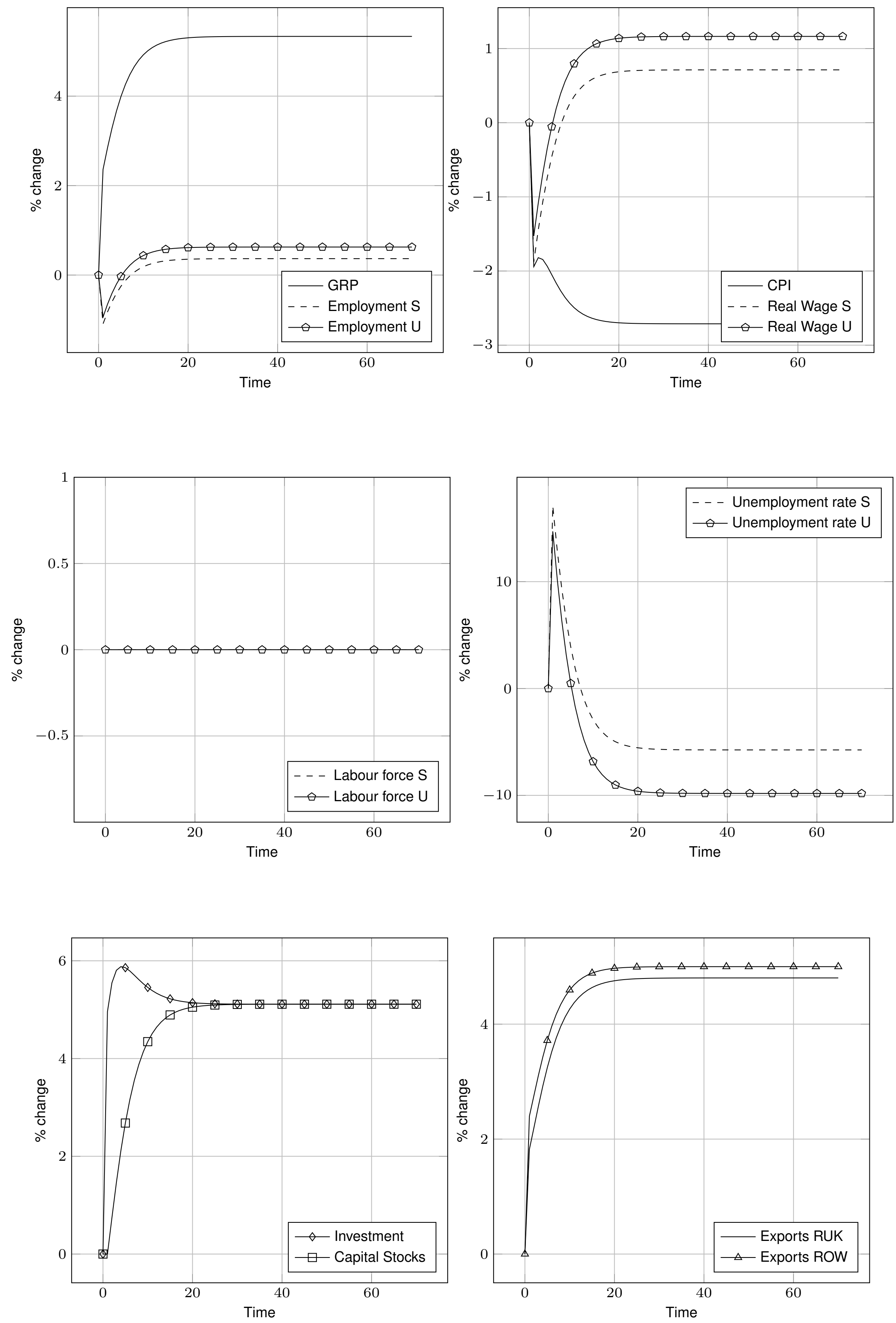
Running total of skilled and unskilled long-run, free migration, FTE employment at sector level



As seen in the free migration case, the negative impact on FTE employment seen in sectors that mainly serve the domestic market, and the relative size and skill intensity of these sectors, is one of the main factors that determine the overall impact on skilled and unskilled employment.

Figure 8.4.6 details the aggregate long-run no migration transition paths of GRP, employment, CPI, real wages, labour force, unemployment rates, investment, capital stocks, and exports. The adjustment paths detail the initial negative effects on employment, the unemployment rate, and the labour force, and how some of these negative effects are reduced, or offset, towards the long run.

Figure 8.4.6: Aggregate transition paths - increase in total labour efficiency - long-run - no migration



8.4.4 Short-run

Table 8.4.7 details the short- and long-run results for a permanent 5% increase in total labour efficiency across all sectors. To recall, the short-run results are the same for all three migration closures since there is no migration in the first period irrespective of the assumptions about labour mobility, and myopic investment decisions made in period one are unaffected by future migration decisions.

That is, the labour force is fixed in the short run, but the skilled and unskilled unemployment rate can change and labour is mobile across sectors. The capital stock is fixed in the short run in both total and its distribution across sectors.

The increase in efficiency increases the supply of labour and decreases the price of labour, as measured in efficiency units, and production costs fall. CPI falls by 1.94%. This stimulates exports to the RUK (+1.82%) and the ROW (+2.40%), and thereby also output in the short run. Moreover, the demand for capital is stimulated in the short run as rental rates exceed user costs and investment proceeds (+4.96%). GRP increases by 2.36% in the short run.

For employment there is a direct effect of the increase in efficiency. As the price of labour, as measured in efficiency units, falls as a result of the increase in efficiency there is a substitution effect between labour and other inputs. In the production of output there is an output effect due to the fall in domestic prices.

The increased competitiveness of the product increases output (and derived employment). The fixed capacity in the short run, however, adds as a constraint and increases costs, so limiting beneficial competitiveness effects.

The short run is thereby characterised by a fall in employment (in efficiency units employment increases) and an increase in the unemployment rate. Real wages fall as governed by the bargained real wage function. The price of domestically produced goods fall with the increase in labour efficiency, and this reduces CPI, and nominal wages fall. A reduction in the cots increases competitiveness, and thereby output and the derived demand for labour.

Total employment decreases here in the short run by 1.04% as less workers are needed. Despite the shock being skill-neutral, i.e. both skilled and unskilled efficiency is equally increased, there are again differences in the skilled and unskilled labour markets although these are less marked here.

The increase in efficiency leads to a stronger percentage fall in skilled employment (-1.09%) as compared to unskilled employment (-0.94%). The skilled thereby see a smaller stimulus to labour coming through the expansion of output and the substitution of labour for capital in production, as compared to the unskilled. This is again discussed in more detail when considering sector level results.

Table 8.4.7: Short- and long-run effects of a 5% increase in total labour efficiency. In % changes

	LR - Free migration	LR - Skilled migration	LR - No migration	SR
GRP Income measure	6.60	5.94	5.34	2.36
Consumer Price Index	- 3.31	- 3.00	- 2.71	- 1.94
Unemployment Rate	- 0.00	- 5.47	- 7.78	15.89
Unemployment Rate S	- 0.00	- 0.00	- 5.75	17.08
Unemployment Rate U	- 0.00	- 10.94	- 9.82	14.70
Total Employment	1.69	1.05	0.46	- 1.04
Total Employment S	1.39	1.23	0.37	- 1.09
Total Employment U	2.27	0.70	0.63	- 0.94
Nominal Gross Wage	- 3.31	- 2.37	- 1.80	- 3.61
Nominal Gross Wage S	- 3.31	- 3.00	- 2.02	- 3.78
Nominal Gross Wage U	- 3.31	- 1.73	- 1.58	- 3.44
Real Gross Wage	0.00	0.65	0.94	- 1.70
Real Gross Wage S	0.00	0.00	0.71	- 1.87
Real Gross Wage U	0.00	1.31	1.16	- 1.52
Labour force	1.69	0.81	-	-
Labour force S	1.39	1.23	-	-
Labour force U	2.27	-	-	-
Households Consumption	1.49	1.33	1.19	- 0.87
Investment	6.33	5.69	5.11	4.96
Capital Stock	6.33	5.69	5.11	-
Replacement cost of capital	- 3.24	- 2.93	- 2.65	0.04
Export RUK	5.93	5.34	4.80	1.82
Export ROW	6.17	5.56	5.00	2.40
FTE Employment	39,134	22,489	10,590	- 22,901
FTE Employment S	18,079	16,012	4,778	- 14,197
FTE Employment U	21,054	6,478	5,812	- 8,704

SR = short-run; LR = long-run. S = Skilled; U = Unskilled

The aggregate unemployment level increases by 15.89% in the short run. Reflecting the employment changes where the efficiency shock has cost more skilled jobs, the skilled unemployment level increases by 17.08%, and the unskilled by +14.70%.

Nominal wages fall by 3.61% in the short run. Skilled workers see a larger percentage fall in the nominal wage (-3.78%) as compared to the wage cut seen by unskilled workers (-3.44%), reflecting changes in the unemployment rate. The fall in the nominal wage, however, limits the fall in employment in the short run.

When moving from the short-run to the free migration case, by removing the restrictions on labour and capital, GRP increases from 2.36% to 6.60%. When only removing the restrictions on capital whilst restricting labour, as done in the no migration closure, GRP increases from 2.36% in the short run to 5.34% in the long run.

The GRP difference between the long-run free migration, and the long-run no migration cases, is 1.24%. The impact of labour is thereby comparatively small. The impact of loosening the restrictions of capital, however, are significant here. GRP increases from 2.36% in the short run to 5.34% in the long run with no migration, a 2.98% increase in GRP. The impact of freeing up capital is here larger than the impact of freeing up labour.

Capital is a smaller share of value added than labour. But, there is an expansion in labour force from the increase in efficiency, so that the subsequent migration (in the long run) is relatively small (below 2%) as compared to the increase in capital (above 5%). The capital stock is fixed in the short run in both total and its distribution across sectors. Variations in capital rental rate indicate large benefits from reallocating existing capital.

Table 8.4.8 details the short-run results at the individual sector level for a permanent 5% increase in total labour efficiency across all sectors. The increase in total labour efficiency is characterised by a fall in output prices and employment, and an increase in exports, output, investment and capital rental rates, for the majority of sectors. There are, however, some prominent exceptions from this.

The initial stimulus to investment provided by the increase in labour efficiency can be seen in its impact on rental rates and user cost of capital. The elasticity of substitution between labour and capital is important here. Where this is low, capital and labour are close complements. If demand for labour (in efficiency units) rises, demand for capital will too.

Rental rates reflect the changes which are required to ensure that the demand for capital equals the fixed capital stock in a competitive market. The higher the price elasticity of demand facing the more export orientated sectors ensures that at any given wage rate the fall in prices is less than in the sectors serving the domestic market, and so rental rates are higher in the more export orientated sectors.

In the short run the user cost of capital can rise because the capital price index rises. The capital price index rises because there is only a fixed amount of capital in each sector. The increase in the capital rental rate in, for example Construction, increases the user cost to other sectors. The user cost (the replacement cost of capital) increases in each sector by 0.04%. But in all sectors there is an expansion after period one and this brings down the user cost of capital, and also brings down the capital rental rate.

Capital rental rates fall in four sectors. The RUK and ROW exports share of output is at, or below 2% in these four sectors. The Food & beverage services sector does not have any exports. That is, capital rental rates fall here in the short run in sectors that mainly serve the domestic market.

Capital rental rates increase in the remaining sectors. Exports are a stronger contributor to output in these sectors. Capital rental rates increase in these sectors between 1.05% and 22.89%, as seen in the Recreational services sector and the Construction sector. The stimulus to investment also further reinforces the stimulus to output in these sectors.

In the case of the export orientated sectors, the gap between the user cost of capital and the capital rental rate adds to the incentive to invest. In the sectors mainly serving the domestic markets, investment is not stimulated as the capital rental rate does not exceed the user cost of capital, and disinvestment can be observed.

Table 8.4.8: Short-run results: 5% increase in total labour efficiency. In % changes

	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	1.38	-0.38	-0.90	-1.45	0.76	0.76	-	3.55	3.63
2. Mining	0.96	-0.15	-1.25	-1.59	0.31	0.31	-	3.07	3.15
3. Food, drink and tobacco	1.90	-0.98	-0.40	-0.90	1.98	1.98	-	5.43	5.58
4. Textile, leather, wood and paper	3.79	-1.56	1.29	0.79	3.20	3.20	-	11.20	11.69
5. Chemicals	1.53	-0.53	-0.81	-1.14	1.06	1.06	-	4.62	4.74
6. Rubber, plastic, cement and iron	4.86	-1.59	2.58	1.95	3.25	3.25	-	15.18	16.05
7. Computer, electrical and transport eq.	4.64	-1.38	2.02	1.65	2.82	2.82	-	14.15	14.92
8. Electricity, gas and water	1.25	-0.84	-1.12	-1.49	1.70	1.70	-	3.41	3.50
9. Construction	6.12	0.68	4.13	3.72	-1.35	-1.35	-	21.21	22.89
10. Wholesale and retail	1.94	-2.09	-0.66	-1.16	4.31	4.31	-	4.54	4.65
11. Land transport	2.31	-1.64	-0.06	-0.62	3.37	3.37	-	6.39	6.57
12. Water transport	2.45	-1.08	0.07	-0.29	2.20	2.20	-	7.50	7.75
13. Air Transport	1.38	-1.14	-0.97	-1.37	2.31	2.31	-	3.83	3.92
14. Post and support transport services	2.92	-1.15	0.54	0.04	2.34	2.34	-	8.63	8.94
15. Accommodation	0.37	-2.86	-2.53	-2.96	5.97	5.97	-	-1.62	-1.57
16. Food & beverage services	0.51	-2.97	-2.33	-2.84	0.00	0.00	-	-1.19	-1.15
17. Telecommunication	1.83	-1.52	-0.81	-1.13	3.11	3.11	-	4.64	4.76
18. Computer and information services	3.90	-1.31	1.25	0.96	2.68	2.68	-	11.80	12.34
19. Financial services	1.62	-0.68	-0.73	-1.06	1.37	1.37	-	4.88	5.01
20. Real estate	-0.07	-1.14	-2.60	-2.91	2.33	2.33	-	-1.43	-1.38
21. Professional services	3.37	-1.17	0.79	0.47	2.38	2.38	-	10.11	10.52
22. Research and development	6.02	-2.67	2.27	2.01	5.55	5.55	-	15.38	16.27
23. Public administration	-0.01	-4.62	-3.59	-3.89	9.92	9.92	-	-4.78	-4.66
24. Recreational services	1.15	-2.87	-1.82	-2.19	6.01	6.01	-	1.01	1.05
25. Other services	1.32	-2.65	-1.57	-1.96	5.52	5.52	-	1.80	1.85

S = Skilled; U = Unskilled

Only sectors that experience the stimulus to output (through investment and/or high export demand) see an increase in employment. The sectors seeing an increase in output are typically sectors that are more export orientated.

The two sectors experiencing a fall in output, the Real estate and the Public administration sector, both have a very low export share of output. The largest stimulus to output, employment is seen in the Construction sector. Here the stimulus to output is driven by supplying investment goods. The big variations in the capital rental rate (as against variations in output, employment, and prices) drive investment demand where there are similarly big variations.

Table 8.4.8 shows employment increases in some sectors as the negative impact of the direct increase in labour productivity is less than the stimulus to labour demand coming through the expansion in output and the substitution of labour for capital in production. And, vice versa for sectors that experience a fall in skilled and unskilled employment. In every sector skilled employment increases more (or falls less) than unskilled because of the bigger fall in the nominal wage.

The increase in total labour efficiency leads to a fall in output prices in all sectors, with the exception of the Construction sector. The Construction sector experiences a 0.68% increase in output prices due to the change in capital and rental rates. In contrast, the Public administration sector, a labour intensive sector, sees the largest decrease in output prices (-4.62%), whilst the smallest fall in output price is seen by the Mining sector (-0.15%). Sectors with high price reductions in the short run typically serve domestic markets where the reductions in price additionally reflect a fall in the capital rental rate.

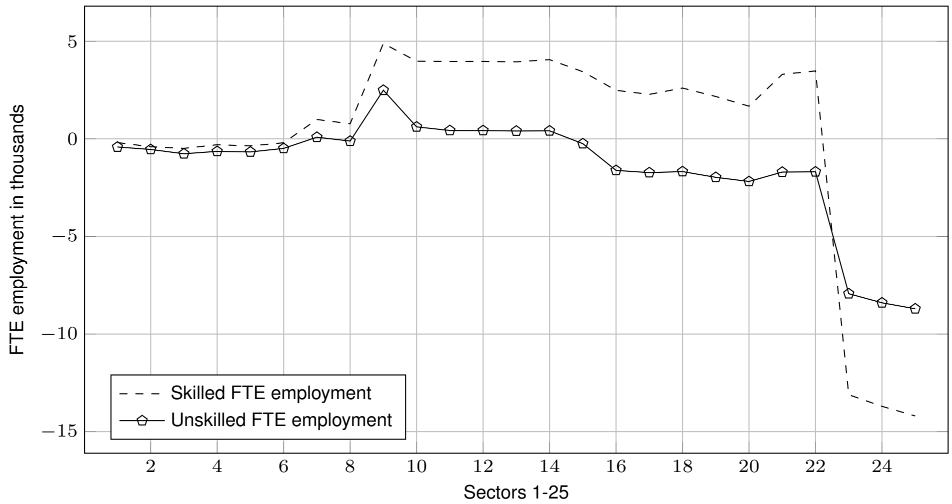
All sectors, with the exception of the Construction sector, see increases in exports to both the RUK and the ROW. The Construction sector experiences negative competitiveness effects due to the increase in output prices (+0.68%) and thereby sees falling exports (-1.35% to RUK and ROW). In contrast, the Public administration sector experiences a strong stimulus to its exports (+9.92% to RUK and ROW) due to the strong positive competitiveness effects i.e. it sees the biggest fall output prices (-4.62%). Exports, however, are a minuscule share of total demand in that sector.

The differential impact on skilled and unskilled employment is again analysed by detailing the impact of the efficiency shock on FTE employment. Total FTE employment falls by 22,901 in the short run. This is a 14,197 fall in skilled, and a 8,704 fall in unskilled FTE employment. Skilled FTE falls here by more than unskilled FTE employment.

Export led growth is, however, expected to be more skill intensive (see Chapter 7 for details) in the short run so that skilled employment should fall by less that unskilled employment. As seen in the free- and the no migration case, the negative impact on FTE employment seen in sectors that mainly serve the domestic market, and the relative size and skill intensity of these sectors, is one of the main factors that determine the overall impact on skilled and unskilled employment.

Figure 8.4.7 reaffirms this by detailing the running total of skilled and unskilled short-run FTE employment at sector level. Up until the fall in FTE employment seen in sector 22, Public administration, the skill-neutral stimulus to labour efficiency is more skill intensive.

Figure 8.4.7: Running total of skilled and unskilled short-run FTE employment at sector level



Both skilled and unskilled employment fall in the Public administration sector. The larger fall in skilled employment, however, shifts the overall employment impact. Total skilled employment thereby falls by more than total unskilled employment in the short run, mainly due to the fall in employment seen in the Public administration sector. There are big differential impacts on employment as a result of big sectors whose employment declines (sectors 10 and 23) by more than employment rises.

8.4.5 Summary

A skill-neutral increase in labour efficiency reduces employment in the short run and unemployment increases. This reduces wages through the bargained real wage function, and domestic prices fall. As domestic prices fall there is a stimulus to exports, and output rises. Investment is also stimulated by the rising gap between the user cost of capital and the capital rental rate.

Irrespective of the migration assumption there is an increase in GRP in the long run. This is driven mainly by export led growth, which in turn stimulates the demand for labour, and employment increases above its base in the long run.

The disparate impact on the skilled and the unskilled is driven mainly by sectoral characteristics. As domestic serving sectors do not benefit directly from the export led growth, some of these sectors experience a fall in employment. The relative size and skill intensity of these sectors, is one of the main factors that determine the overall impact on skilled and unskilled employment.

From a policy perspective it is of importance to consider the period-by-period adjustments that occur in the labour market. Figure 8.4.8 details aggregate transition paths for skilled and unskilled employment, unemployment, and real wages across the three migration closures, for a policy relevant time horizon.

The fall in skilled employment is deeper and prolonged as compared to the fall experienced by the unskilled. It takes between six and ten periods for employment to recover to its initial base. For unskilled this is between five and ten periods. The speed of the adjustment crucially depends on the migration assumption of the model. Similar observations can be made for the real wage and the unemployment rate.

The results of the skill-neutral increase in labour efficiency show that there are considerable negative effects in the labour market in the policy horizons that are of immediate importance. Moreover, the negative effects are more prominent for the skilled as compared to the unskilled. These negative effects, however, are reduced towards the long run for both skill categories.

It is important to note that even in cases where the real wage returns to its base, as is the case in some of the closures, there are significant cumulative benefits in terms of real wages when taking into account the periods in which the real wage is above its base.

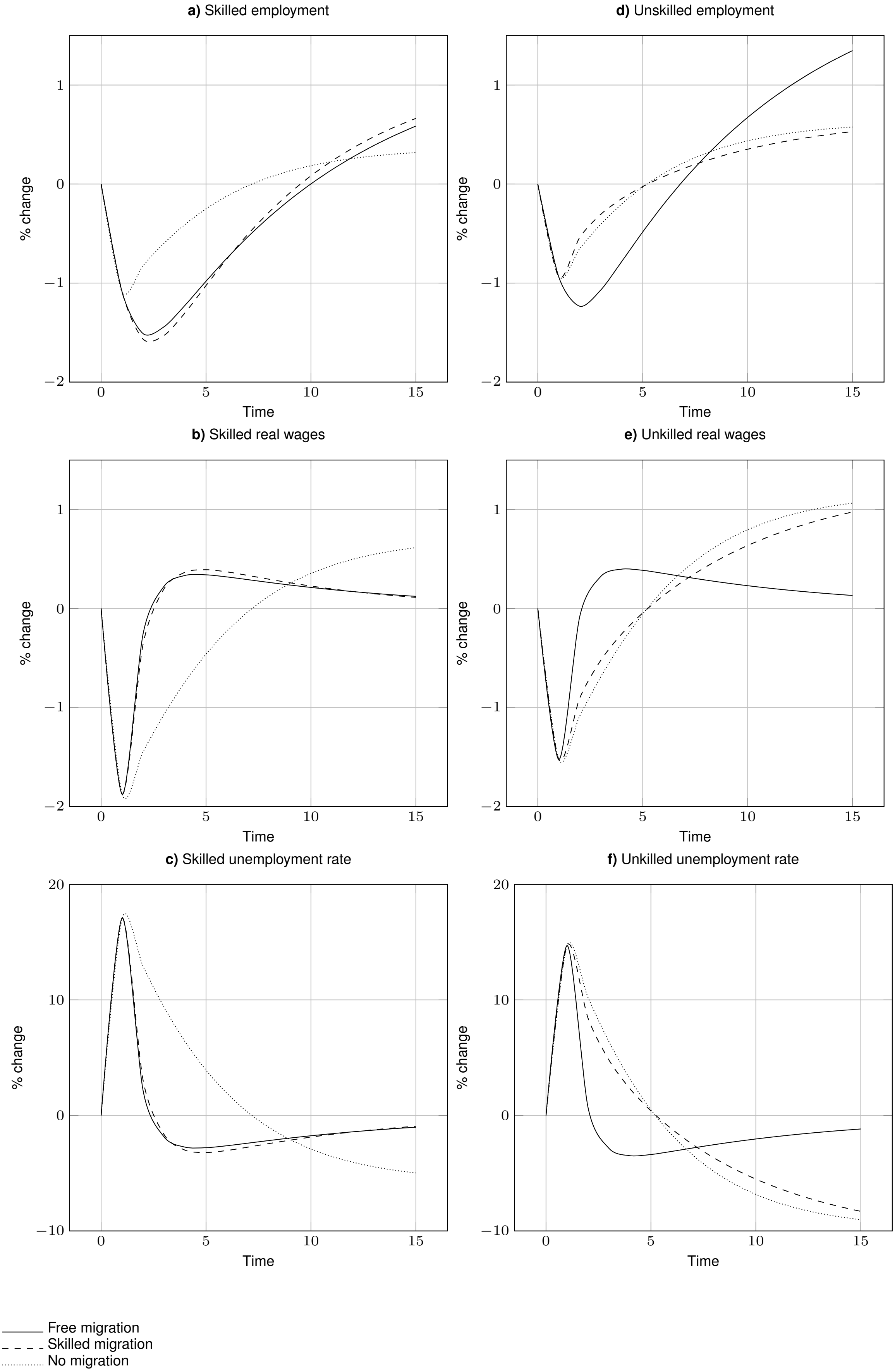
This is emphasized by the data in Appendix 8A which give the present values for GRP, and for skilled and unskilled employment and real wages. The results show that there are significant negative effects for employment and real wages in the first five, ten, and fifteen years following the shock. Even though these negative effects are experiences by both skill categories, the skilled experience deeper and more prolonged falls in employment and the real wage.

Towards year twenty, however, the negative present values for employment and real wages gradually turn positive, and are positive in year thirty for both the skilled and the unskilled. Thus, there are long term benefits for both skill categories regardless of whether skill-neutral or skill-differentiated labour efficiency is increased. These benefits, are however, skewed towards the unskilled.

The present values for FTE employment and real wage changes show that the unskilled are better off, as compared to the skilled, irrespective of the migration assumption. The skilled, however, also incur some benefits which are, depending on the migration assumption, close to these experienced by the unskilled.

Despite these negative effects incurred in the labour market, GRP increases from time period one onwards, and remains above base in all of the simulated periods. Appendix 8A shows that GRP present value changes are all positive. Irrespective of the time horizon, potential prospects of long term growth may thereby outweigh the negative labour market impacts seen in the initial years following the labour efficiency shock. This is discussed in more detail in Section 8.7 when considering the policy implications.

Figure 8.4.8: Aggregate transition paths for skilled and unskilled employment, unemployment, and real wages



8.5 Skill-differentiated technological progress

This section presents results for a permanent 5% skill-differentiated technical progress. That is, skilled efficiency is increased whilst unskilled efficiency remains unchanged, and vice versa. Results are presented and discussed following the approach taken in the skill-neutral case.

Sections 8.5.1, 8.5.2, and 8.5.3 detail the long-run results for the free migration closure, the skilled migration closure, and the no migration closures respectively. Section 8.5.4 details the short-run results. Section 8.5.5 summarises the key results and compares these across the three migration variants of the model.

The same short- and long run capital and labour market conditions (as detailed in Section 8.4) also hold here. That is, the short-run results are the same for all three migration closures. The labour force is fixed in the short run, but the unemployment rate can change and labour is mobile across sectors. The total labour force is potentially adjusted from period to period through migration (depending on the migration closure used).

To recall, the capital stock is fixed in the short run both in total and in its distribution across sectors. All sectors earn the same return in the base period. Capital stocks in individual production sectors vary through period by period flows of net investment. The capital markets fully adjust in the long run models.

The main adjustment mechanisms seen in the skill-neutral case detailed in Section 8.4 are also generally observed here. Accordingly, the focus is here on detailing the disparate impacts of the skill-differentiated technological progress on the skilled and unskilled.

8.5.1 Long-run: Free migration

Table 8.5.1 details the key macroeconomic long-run results for a permanent 5% increase in skill-differentiated labour efficiency across all sectors. To recall, the free migration closure of the AMOSKI model ties down long-run unemployment rates and real wage rates to their initial equilibrium levels through the combination of regional bargained real wage and flow migration. Any change in the real wage and the unemployment rate entail a migration response which in turn limits and ultimately reverse real wages changes until the labour market is in long-run equilibrium with zero net-migration flows. The free migration closure thereby imposes perfectly elastic supply of inputs across long-run equilibria.

Initially the unemployment rate rises as a result of the increase in efficiency, and the real gross wage falls. Workers thereby migrate out of Scotland. Towards the long run, workers migrate back into Scotland as the unemployment rate falls and real wages rise. Real wages and the unemployment rate thereby return to their initial equilibrium levels due to the inflow of workers from outside Scotland.

There are no changes in exogenous prices, but the prices of domestically produced goods fall with the increase in labour efficiency, and this reduces CPI. Thereby all nominal prices, including the user cost of capital and nominal wages, fall in the long run.

When skilled efficiency is increased nominal wages fall by 2.14% for both the skilled and the unskilled. When unskilled efficiency is increased nominal wages fall by 1.12%. This is the same as the fall in the CPI (because the real wage remains constant). The relative wage therefore remains the same. Differences in skilled and unskilled employment are thereby driven by differential sectoral impacts.

The increase in efficiency generates export led expansion in economic activity through the fall in domestic prices. This export led growth stimulates domestic consumption, intermediate demand and investment (and thereby also derived demand for labour).

The increase in labour efficiency thereby decreases the price of skilled/unskilled labour, measured in efficiency units, and production costs fall. A reduction in production costs increases competitiveness, stimulating output and investment (Appendix 8C details the aggregate long-run free migration transition paths for selected key variables).

When skilled efficiency is increased, exports to RUK increase by 3.76% and by 3.92% to ROW. Investment increases by 3.99%, and GRP increases by 4.17% in the long run. When unskilled efficiency is increased the stimulated impact is comparatively smaller as prices do not fall as strongly.

Total employment increases by 1.01% in the long run when skilled efficiency is increased. Skilled employment sees a smaller percentage increase when compared to unskilled employment, 0.83% and 1.35% respectively.

When unskilled efficiency is increased total employment increases by 0.49%, 0.37% for the skilled, and 0.72% for the unskilled. The proportionate change in employment is here equal to the proportionate change in labour force for both types of efficiency change.

Skilled and unskilled efficiency is increased separately here. Despite this, the stimulus to unskilled employment is comparatively larger in both cases when compared to the stimulus to skilled employment. As identified previously, simulation in the skill-neutral labour efficiency simulations, sectoral effects are the decisive factors that determine the overall employment outcomes.

Table 8.5.1: Long-run, free migration, effects of a 5% increase in skill-differentiated labour efficiency. In % changes

	Skilled efficiency	Unskilled efficiency
GRP Income measure	4.17	2.13
Consumer Price Index	- 2.14	- 1.12
Unemployment Rate	- 0.00	- 0.00
Unemployment Rate S	- 0.00	- 0.00
Unemployment Rate U	- 0.00	- 0.00
Total Employment	1.01	0.49
Total Employment S	0.83	0.37
Total Employment U	1.35	0.72
Nominal Gross Wage	- 2.14	- 1.12
Nominal Gross Wage S	- 2.14	- 1.12
Nominal Gross Wage U	- 2.14	- 1.12
Real Gross Wage	0.00	0.00
Real Gross Wage S	0.00	0.00
Real Gross Wage U	0.00	0.00
Labour force	1.01	0.49
Labour force S	0.83	0.37
Labour force U	1.35	0.72
Households Consumption	0.91	0.45
Investment	3.99	2.04
Capital Stock	3.99	2.04
Replacement cost of capital	- 2.09	- 1.09
Export RUK	3.76	1.93
Export ROW	3.92	2.01
	-	-
FTE Employment	23,327	11,454
FTE Employment S	10,812	4,820
FTE Employment U	12,515	6,635

LR = long-run. S = Skilled; U = Unskilled

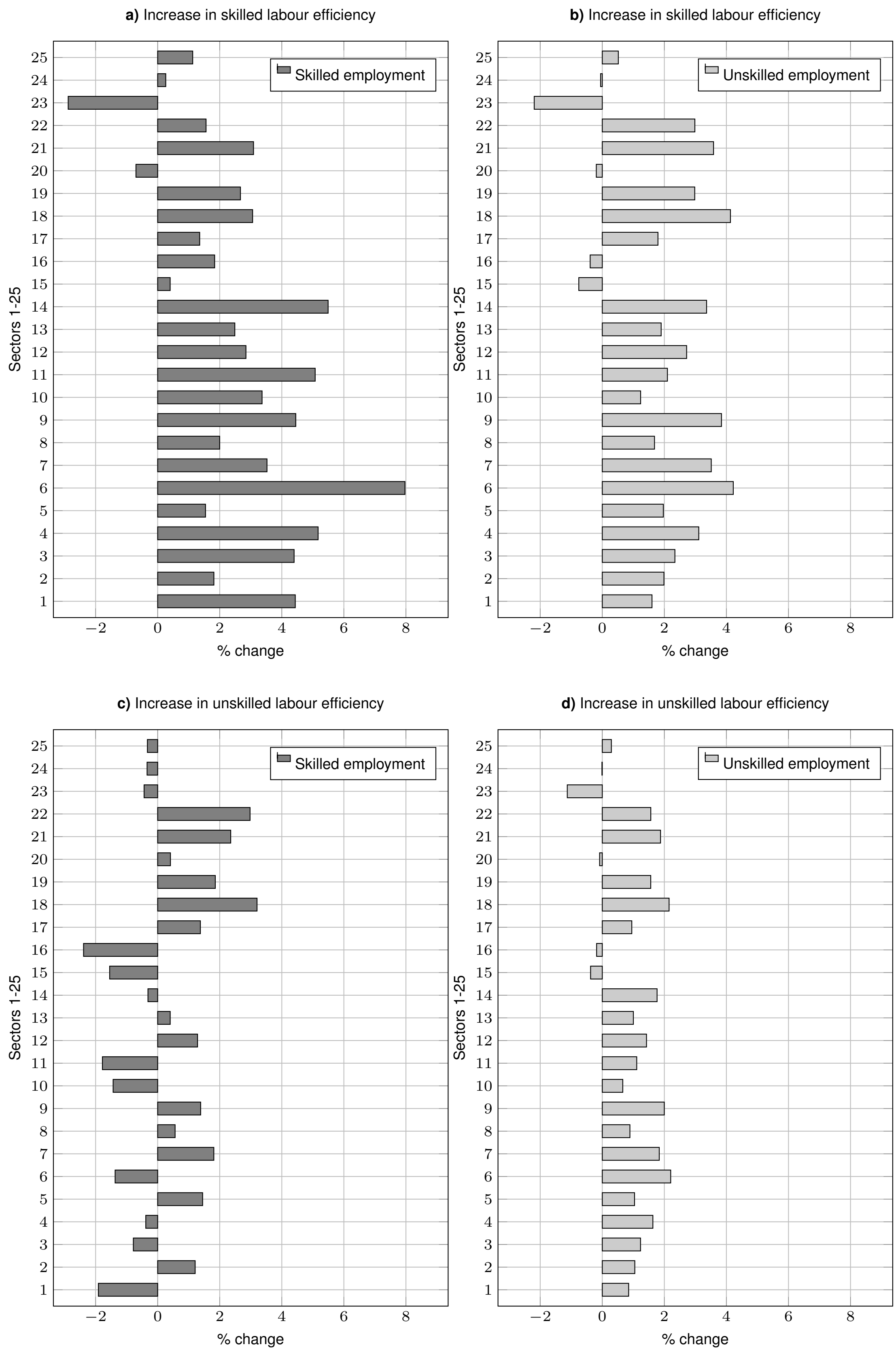
Table 8.5.2 and Figure 8.5.1 detail the long-run results at the individual sector level for a permanent 5% increase in skill-differentiated labour efficiency across all sectors. The increase in labour efficiency leads to a fall in output prices. The fall in output prices thereby reflects the labour and skill intensities of the sectors.

The fall in prices stimulates exports and total output increases. This increases the demand for workers and employment increases (in the majority of the sectors). Capital rentals rise in the short run, inducing more investment, and capital stocks rise towards the long run. The rise in capital stocks in turn mitigates the original increase in the rental rate. Investments in turn further reinforce the output effect.

Table 8.5.2: Long-run free migration results: 5% increase in skill-differentiated labour efficiency. In % changes

	5% increase in skilled efficiency									5% increase in unskilled efficiency								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	4.32	-1.52	4.43	1.60	3.11	3.11	3.91	3.91	-2.09	2.21	-0.79	-1.91	0.85	1.60	1.60	2.00	2.00	-1.09
2. Mining	3.93	-1.13	1.81	1.99	2.30	2.30	4.31	4.31	-2.09	2.01	-0.58	1.21	1.05	1.18	1.18	2.20	2.20	-1.09
3. Food, drink and tobacco	4.50	-1.86	4.40	2.34	3.82	3.82	4.67	4.67	-2.09	2.30	-0.97	-0.78	1.23	1.96	1.96	2.39	2.39	-1.09
4. Textile, leather, wood and paper	5.29	-1.89	5.17	3.11	3.90	3.90	5.45	5.45	-2.09	2.71	-0.99	-0.38	1.63	2.00	2.00	2.79	2.79	-1.09
5. Chemicals	3.96	-1.32	1.54	1.97	2.68	2.68	4.29	4.29	-2.09	2.03	-0.68	1.45	1.04	1.38	1.38	2.19	2.19	-1.09
6. Rubber, plastic, cement and iron	6.29	-2.01	7.97	4.22	4.14	4.14	6.59	6.59	-2.09	3.22	-1.05	-1.37	2.21	2.12	2.12	3.37	3.37	-1.09
7. Computer, electrical and transport eq.	5.73	-1.90	3.52	3.51	3.91	3.91	5.87	5.87	-2.09	2.93	-0.99	1.81	1.84	2.01	2.01	3.00	3.00	-1.09
8. Electricity, gas and water	3.77	-1.72	2.00	1.68	3.53	3.53	3.99	3.99	-2.09	1.93	-0.90	0.56	0.89	1.82	1.82	2.04	2.04	-1.09
9. Construction	6.16	-2.09	4.45	3.84	4.31	4.31	6.20	6.20	-2.09	3.14	-1.09	1.39	2.00	2.21	2.21	3.16	3.16	-1.09
10. Wholesale and retail	3.45	-2.27	3.36	1.24	4.71	4.71	3.54	3.54	-2.09	1.77	-1.19	-1.44	0.66	2.42	2.42	1.81	1.81	-1.09
11. Land transport	4.18	-2.04	5.08	2.10	4.21	4.21	4.42	4.42	-2.09	2.14	-1.06	-1.78	1.11	2.16	2.16	2.27	2.27	-1.09
12. Water transport	4.67	-1.78	2.84	2.72	3.65	3.65	5.05	5.05	-2.09	2.39	-0.93	1.28	1.43	1.88	1.88	2.58	2.58	-1.09
13. Air Transport	3.80	-1.87	2.49	1.90	3.86	3.86	4.21	4.21	-2.09	1.94	-0.98	0.40	1.00	1.98	1.98	2.16	2.16	-1.09
14. Post and support transport services	5.62	-2.05	5.49	3.36	4.24	4.24	5.71	5.71	-2.09	2.88	-1.07	-0.31	1.77	2.18	2.18	2.93	2.93	-1.09
15. Accommodation	1.47	-2.33	0.40	-0.76	4.83	4.83	1.50	1.50	-2.09	0.75	-1.22	-1.55	-0.38	2.49	2.49	0.76	0.76	-1.09
16. Food & beverage services	1.79	-2.43	1.84	-0.39	0.00	0.00	1.87	1.87	-2.09	0.92	-1.27	-2.39	-0.18	0.00	0.00	0.96	0.96	-1.09
17. Telecommunication	4.04	-2.13	1.35	1.79	4.40	4.40	4.11	4.11	-2.09	2.07	-1.11	1.38	0.95	2.26	2.26	2.10	2.10	-1.09
18. Computer and information services	6.49	-2.39	3.06	4.13	4.96	4.96	6.50	6.50	-2.09	3.32	-1.25	3.20	2.15	2.55	2.55	3.32	3.32	-1.09
19. Financial services	5.04	-1.88	2.67	2.98	3.87	3.87	5.32	5.32	-2.09	2.58	-0.98	1.86	1.56	1.99	1.99	2.72	2.72	-1.09
20. Real estate	1.92	-1.59	-0.70	-0.19	3.26	3.26	2.08	2.08	-2.09	0.98	-0.83	0.41	-0.09	1.67	1.67	1.06	1.06	-1.09
21. Professional services	5.87	-2.12	3.09	3.59	4.39	4.39	5.94	5.94	-2.09	3.01	-1.11	2.35	1.88	2.25	2.25	3.04	3.04	-1.09
22. Research and development	5.91	-2.26	1.56	2.98	4.67	4.67	5.33	5.33	-2.09	3.02	-1.18	2.98	1.56	2.39	2.39	2.72	2.72	-1.09
23. Public administration	0.38	-3.28	-2.88	-2.19	6.89	6.89	0.03	0.03	-2.09	0.19	-1.73	-0.44	-1.13	3.54	3.54	0.00	0.00	-1.09
24. Recreational services	2.26	-2.50	0.26	-0.05	5.20	5.20	2.22	2.22	-2.09	1.15	-1.31	-0.34	-0.01	2.67	2.67	1.13	1.13	-1.09
25. Other services	2.84	-2.48	1.13	0.52	5.15	5.15	2.80	2.80	-2.09	1.46	-1.30	-0.33	0.29	2.64	2.64	1.44	1.44	-1.09

Figure 8.5.1: Long-run free migration sectoral employment results: 5% increase in skill-differentiated labour efficiency.



Note: see Table 8.5.2 for full set of results.

As identified in previous simulations, sectors typically see a stimulus to output due to the fall in prices and the corresponding increase in exports. The export led growth stimulates domestic consumption, intermediate demand and investment too. This increase in output further stimulates the demand for skilled and unskilled labour. Notably, the percentage change in skilled and unskilled employment is equiproportional within each sector as the relative wage remains the same.

When skilled efficiency is increased there are two sectors where skilled employment falls. Skilled employment falls by 0.70% in the Real estates sector, and by 2.88% in the Public administration sector. Unskilled employment falls in five sectors. Sectors that see a fall in skilled and/or unskilled employment mainly serve domestic households and public sector consumption.

When unskilled employment is increased there is a large number of sectors that see a fall in skilled employment. Unskilled employment falls in five sectors. This time, however, the fall in employment is not only experienced in sectors that mainly serve the domestic market. For example, the Food and drink sector, an export led sector, sees a fall of 0.78% in skilled employment and a 1.23% increase in unskilled employment. The skilled thereby see a smaller stimulus to labour coming through the expansion of output and the substitution of labour for capital in production, as compared to the unskilled.

Figure 8.5.2 details the running total of skilled and unskilled long-run FTE employment at sector level for an increase in skilled, and unskilled efficiency. The FTE employment figures reconfirm that sectoral effects are the main drivers of the disparate impacts on skilled and unskilled employment.

The skilled and unskilled FTE employment results in Figure 8.5.2a show a similar pattern to that seen in the skill-neutral efficiency cases (see Section 8.4.1). The fall in the FTE employment in sector 23, Public administration, is significant enough to shift the overall results so that skilled employment increases by less than unskilled employment. Unskilled employment sees increases through stimulated demand coming mainly through the stimulus to exports.

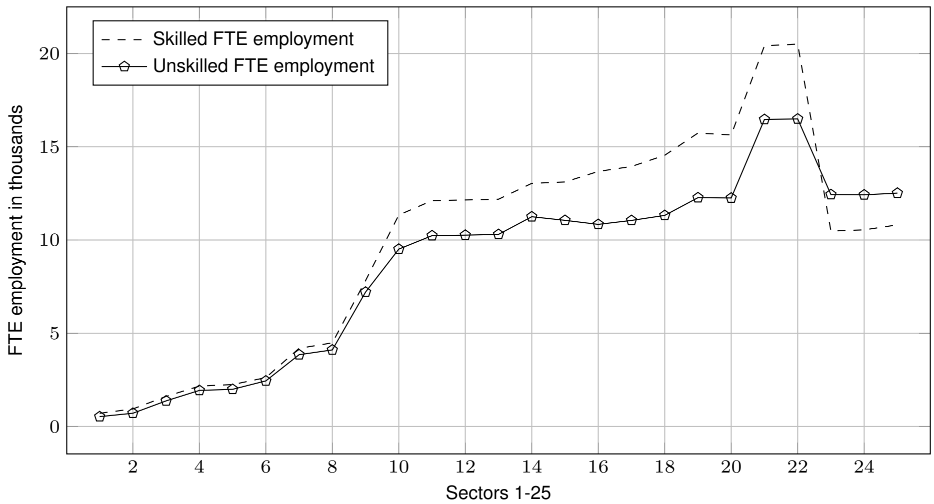
Figure 8.5.2b shows a pattern for unskilled labour similar to the one seen in the skill-neutral efficiency cases (see Section 8.4.1), and also similar to the results seen in the case where skilled efficiency is increased. The skilled, however, see a pattern that has not been observed in previous simulations.

The skilled experience a fall in FTE employment in the majority of sectors. The fall in skilled employment is particularly visible in sector 10, Wholesale and retail, sector Food & beverages services, and sector 23, Public administration. However, the stimulus to employment in some sectors is significant enough to increase total skilled employment above its base.

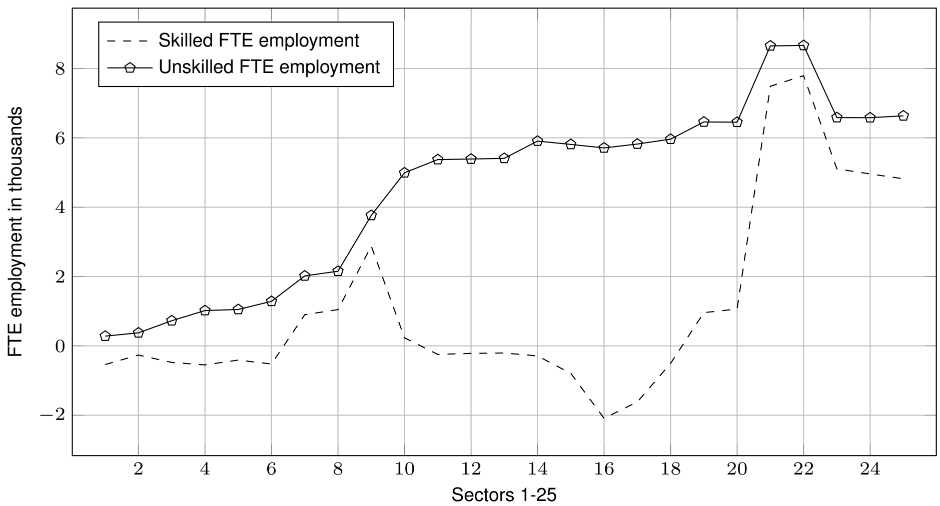
Skilled employment sees strong increases in sector 7, Computer, electrical and transport equipment, sector 9, Construction, and sector 21, Professional services. The increase in skilled employment in the Professional services sector is the main driver here.

Figure 8.5.2: Running total of skilled and unskilled long-run, free migration, FTE employment at sector level

a) Increase in skilled efficiency



b) Increase in unskilled efficiency



As seen in the skill-neutral simulation results, the negative impact on FTE employment seen in sectors that mainly serve the domestic market, and the relative size and skill intensity of these sectors, is one of the main factors that determine the overall impact on skilled and unskilled employment.

In particular, employment contractions seen in the Public administration sector, have the potential to shift the overall employment effects in favour of the unskilled, as is the case here. Moreover, the increase in skilled employment coming through the Professional services sector is vital in determining the overall impact on skilled employment.

8.5.2 Long-run: Skilled migration

Table 8.5.3 details the key macroeconomic long-run results for a permanent 5% increase in skill-differentiated labour efficiency across all sectors in the free- and skilled migration closures. As before, the increase in efficiency causes a fall in output prices, which in turn stimulates exports, output, and employment. Increased investment also further reinforces the stimulus to output. Nominal wages fall, and employment increases in the long run.

There are some significant differences to the free migration closure, and across the two skill-differentiated simulations. In contrast to the free migration closure, the unskilled labour force is fixed in the skilled migration closure. This means that in response to changes in the demand for unskilled labour, the unskilled real wage and unemployment rate adjusts.

The skilled labour force is available at infinitely elastic supply under the skilled migration closure, which ties down the skilled unemployment rate and the skilled real wage to their initial equilibrium in the long run. Skilled labour thereby experience the same adjustment mechanisms seen in the free migration closure, as detailed in Section 8.5.1, where the skilled unemployment rate, and the skilled real wage revert back to their initial equilibrium. Appendix 8C details the aggregate long-run skilled migration transition paths for selected key variables.

Neither the aggregate unemployment rate nor aggregate real wages revert back to their initial equilibrium levels in the skilled migration closure. When skilled efficiency is increased the aggregate unemployment rate falls by 3.36%, and the aggregate real wage falls by 0.39%. CPI falls by 1.91%, and nominal wages fall by 1.58%. Similar changes are seen when unskilled efficiency is increased. These main adjustments are, however, muted in comparison.

As prices fall by less when unskilled efficiency is increased, as compared to increasing skilled efficiency, there is less stimulus to exports and output. For example, exports to the RUK increase by 3.43% when skilled efficiency is increased, and by 1.76% when unskilled efficiency is increased.

The bargaining power of unskilled workers is increased as demand for unskilled labour rises together with a fixed unskilled labour force. That is, unskilled workers are able to achieve an increase in their real wage, and a smaller cut to their nominal wages in the skilled migration closure as compared to the free migration closure. This is irrespective of whether skilled, or unskilled efficiency is increased.

In both the skilled, and the unskilled efficiency shock, the unskilled see a larger percentage increase in employment as compared to the unskilled. The impact on the skilled and unskilled is thereby reversed, as compared to the free migration case, due to the asymmetric impact on skilled and unskilled real wages, and the corresponding sectoral impacts.

The restriction in the supply of unskilled workers in the skilled migration closure causes further skilled for unskilled substitution, as compared to the free migration closure. That is, low skill intensive sectors experience a relative competitiveness penalty due to the lack of supply of unskilled workers. In contrast, high skill intensive sectors benefit from the inflow of skilled workers, and the resulting downward pressure on skilled wages. This is further discussed when analysing sector specific results.

Table 8.5.3: Long-run, free- and skilled migration, effects of a 5% increase in skill-differentiated labour efficiency. In % changes

	LR - Free mig.		LR - Skilled mig.	
	Skilled efficiency	Unskilled efficiency	Skilled efficiency	Unskilled efficiency
GRP Income measure	4.17	2.13	3.80	1.95
Consumer Price Index	- 2.14	- 1.12	- 1.96	- 1.02
Unemployment Rate	- 0.00	- 0.00	- 3.36	- 1.82
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00
Unemployment Rate U	- 0.00	- 0.00	- 6.71	- 3.65
Total Employment	1.01	0.49	0.64	0.30
Total Employment S	0.83	0.37	0.75	0.33
Total Employment U	1.35	0.72	0.43	0.23
Nominal Gross Wage	- 2.14	- 1.12	- 1.58	- 0.82
Nominal Gross Wage S	- 2.14	- 1.12	- 1.96	- 1.02
Nominal Gross Wage U	- 2.14	- 1.12	- 1.19	- 0.61
Real Gross Wage	0.00	0.00	0.39	0.21
Real Gross Wage S	0.00	0.00	0.00	0.00
Real Gross Wage U	0.00	0.00	0.78	0.42
Labour force	1.01	0.49	0.49	0.22
Labour force S	0.83	0.37	0.75	0.33
Labour force U	1.35	0.72	-	-
Households Consumption	0.91	0.45	0.83	0.41
Investment	3.99	2.04	3.63	1.86
Capital Stock	3.99	2.04	3.63	1.86
Replacement cost of capital	- 2.09	- 1.09	- 1.91	- 1.00
Export RUK	3.76	1.93	3.43	1.76
Export ROW	3.92	2.01	3.57	1.84
FTE Employment	23,327	11,454	13,754	6,521
FTE Employment S	10,812	4,820	9,780	4,362
FTE Employment U	12,515	6,635	3,974	2,158

LR = long-run. S = Skilled; U = Unskilled

Sectors substitute skilled for unskilled workers (and capital) as a result of relative price effects, skilled employment thereby increases more strongly than unskilled employment in both absolute and proportionate terms. The negative employment impact of sectors experiencing a contraction in employment, however, are again a major factor in determining the overall impact on skilled and unskilled employment.

In both of the skill-differentiated simulations the unskilled experience a long-run increase in the real wage, whilst the long-run skilled real wage is unchanged from base. In terms of changes in employment, however, the skilled are better off as they benefit from the skilled labour mobility and substitution effects between the skilled and unskilled.

Table 8.5.4 and Figure 8.5.3 detail the long-run results at the individual sector level for a permanent 5% skill-differentiated increase labour efficiency across all sectors. As seen in the free migration results, all sectors experience a fall in output prices, and an increase in exports and total output. There are, however, some significant differences across sectors, and the two efficiency simulations.

When skilled efficiency is increased there are two sectors where skilled employment falls, six sectors where unskilled employment falls, and two sectors where both skilled and unskilled employment fall. These sectors, again, mainly serve domestic households and the public sector consumption. This pattern is similar to that seen in the free migration case.

There are a large number of sectors that see a fall in skilled employment, six sectors see a fall in unskilled employment, and five sectors see a fall in both skilled and unskilled employment, when unskilled efficiency is increased. This is again similar to the pattern seen in the free migration case.

Substitution effects are particularly visible in low skill intensive sectors when skilled efficiency is increased. For example, the Rubber, plastic, cement & iron sector sees a strong stimulus to output coming through both exports and investment. Despite the sector being low skilled, the increase in demand for labour translates to an increase of 8.17% in skilled employment, and an increase of 3.03% in unskilled employment.

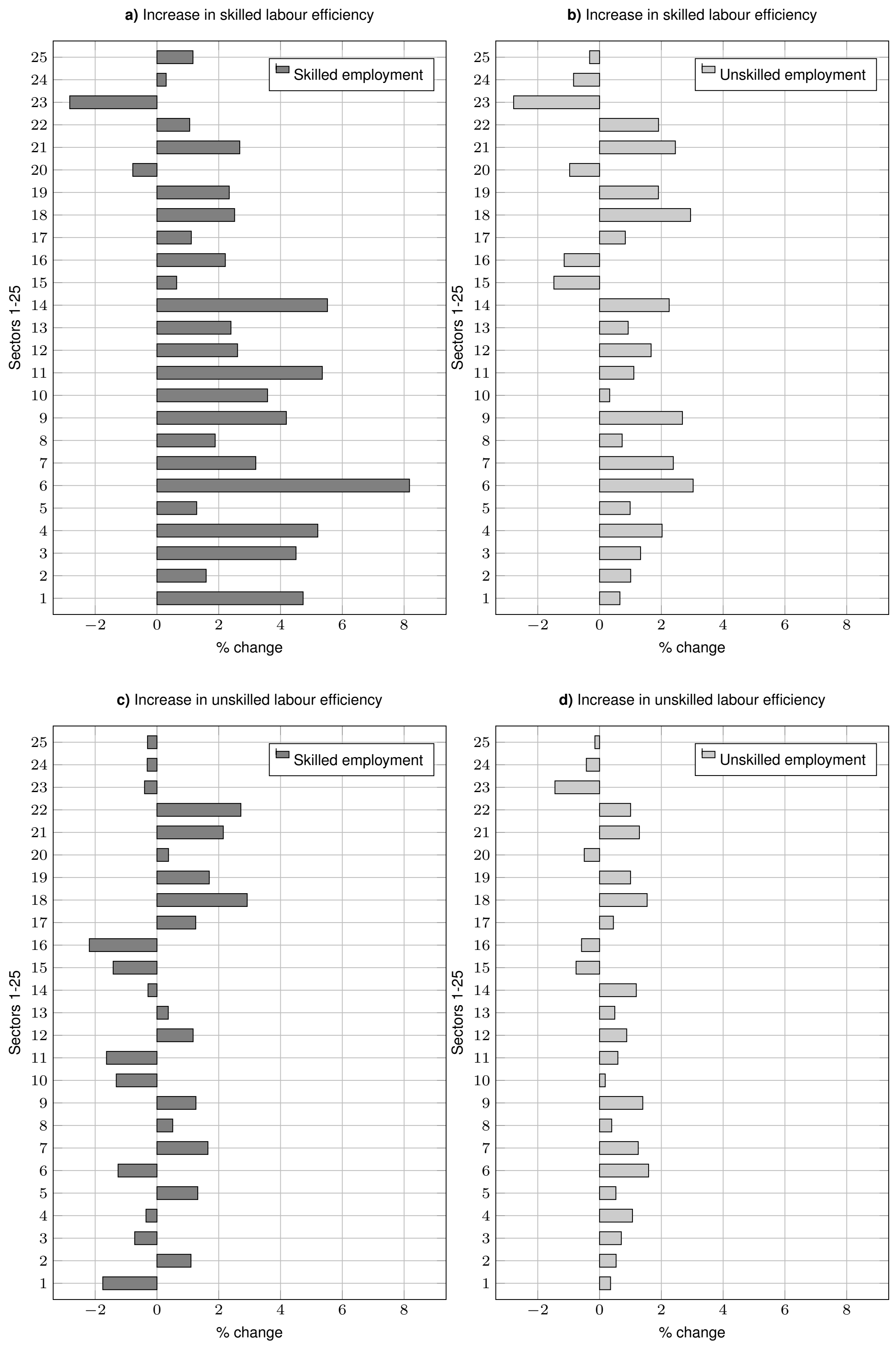
In contrast, when unskilled efficiency is increased the Rubber, plastic, cement & iron sees a 1.26% fall in skilled employment, and a 1.59% increase in unskilled employment. Similar observations can also be made in, for example, the Mining sector, and the Food & beverages services sector.

Figure 8.5.4 details the running total of skilled and unskilled long-run FTE employment at sector level. The stimulus to skilled employment is more marked as compared to the one seen in the free migration closure. This skill-bias is consistent with the results seen in an export demand shock in the skilled migration closure (see Chapter 7 for details). FTE employment figures detail again the significance of several sectors in driving the overall employment effects.

Table 8.5.4: Long-run skilled migration results: 5% increase in skill-differentiated labour efficiency. In % changes

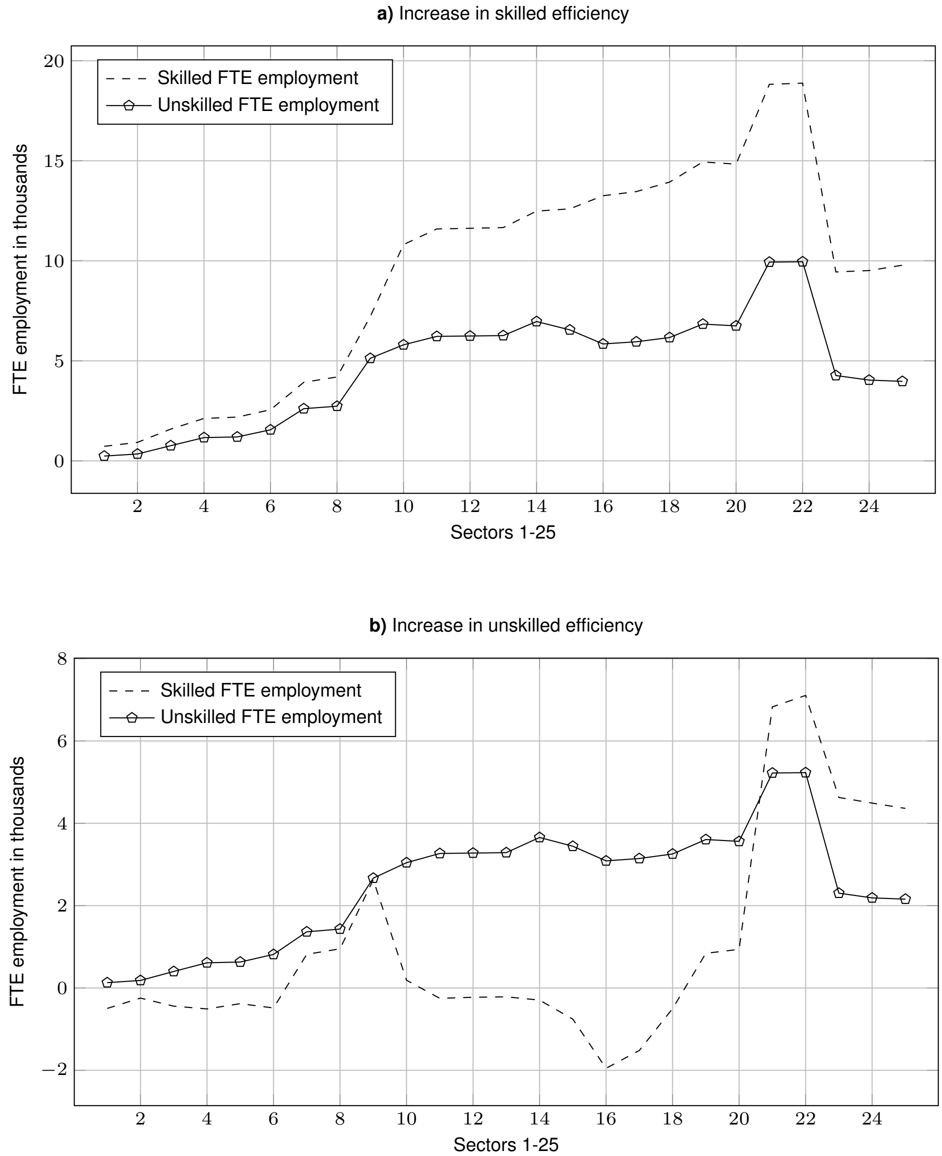
	5% increase in skilled efficiency									5% increase in unskilled efficiency								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	3.93	-1.39	4.73	0.66	2.84	2.84	3.56	3.56	-1.91	2.01	-0.72	-1.75	0.36	1.46	1.46	1.83	1.83	-1.00
2. Mining	3.58	-1.03	1.59	1.01	2.09	2.09	3.92	3.92	-1.91	1.83	-0.53	1.10	0.54	1.07	1.07	2.01	2.01	-1.00
3. Food, drink and tobacco	4.10	-1.70	4.50	1.33	3.48	3.48	4.25	4.25	-1.91	2.10	-0.88	-0.72	0.70	1.79	1.79	2.18	2.18	-1.00
4. Textile, leather, wood and paper	4.81	-1.73	5.21	2.02	3.55	3.55	4.97	4.97	-1.91	2.47	-0.90	-0.35	1.07	1.83	1.83	2.55	2.55	-1.00
5. Chemicals	3.60	-1.20	1.29	0.99	2.45	2.45	3.90	3.90	-1.91	1.85	-0.62	1.32	0.53	1.26	1.26	2.00	2.00	-1.00
6. Rubber, plastic, cement and iron	5.73	-1.83	8.17	3.03	3.77	3.77	6.00	6.00	-1.91	2.94	-0.95	-1.26	1.59	1.94	1.94	3.08	3.08	-1.00
7. Computer, electrical and transport eq.	5.22	-1.74	3.20	2.39	3.56	3.56	5.34	5.34	-1.91	2.67	-0.90	1.65	1.25	1.83	1.83	2.74	2.74	-1.00
8. Electricity, gas and water	3.43	-1.57	1.88	0.73	3.22	3.22	3.64	3.64	-1.91	1.76	-0.82	0.51	0.39	1.66	1.66	1.86	1.86	-1.00
9. Construction	5.61	-1.91	4.19	2.68	3.93	3.93	5.64	5.64	-1.91	2.87	-1.00	1.26	1.40	2.02	2.02	2.88	2.88	-1.00
10. Wholesale and retail	3.14	-2.08	3.58	0.33	4.29	4.29	3.22	3.22	-1.91	1.61	-1.09	-1.32	0.18	2.21	2.21	1.65	1.65	-1.00
11. Land transport	3.81	-1.86	5.35	1.11	3.84	3.84	4.03	4.03	-1.91	1.96	-0.97	-1.63	0.59	1.97	1.97	2.07	2.07	-1.00
12. Water transport	4.25	-1.62	2.61	1.67	3.33	3.33	4.60	4.60	-1.91	2.18	-0.85	1.17	0.88	1.71	1.71	2.36	2.36	-1.00
13. Air Transport	3.46	-1.71	2.40	0.93	3.52	3.52	3.84	3.84	-1.91	1.77	-0.89	0.37	0.49	1.81	1.81	1.97	1.97	-1.00
14. Post and support transport services	5.12	-1.88	5.52	2.25	3.86	3.86	5.20	5.20	-1.91	2.63	-0.98	-0.29	1.19	1.99	1.99	2.67	2.67	-1.00
15. Accommodation	1.33	-2.13	0.64	-1.48	4.40	4.40	1.36	1.36	-1.91	0.68	-1.12	-1.42	-0.76	0.00	2.27	0.69	0.69	-1.00
16. Food & beverage services	1.63	-2.22	2.21	-1.15	0.00	0.00	1.71	1.71	-1.91	0.84	-1.16	-2.19	-0.58	2.27	0.00	0.87	0.87	-1.00
17. Telecommunication	3.68	-1.95	1.11	0.83	4.01	4.01	3.74	3.74	-1.91	1.89	-1.02	1.25	0.45	2.06	2.06	1.92	1.92	-1.00
18. Computer and information services	5.91	-2.19	2.51	2.95	4.52	4.52	5.92	5.92	-1.91	3.03	-1.14	2.92	1.54	2.32	2.32	3.03	3.03	-1.00
19. Financial services	4.59	-1.72	2.34	1.91	3.52	3.52	4.85	4.85	-1.91	2.35	-0.89	1.69	1.00	1.81	1.81	2.48	2.48	-1.00
20. Real estate	1.75	-1.45	-0.78	-0.97	2.97	2.97	1.89	1.89	-1.91	0.89	-0.75	0.37	-0.50	1.53	1.53	0.96	0.96	-1.00
21. Professional services	5.35	-1.94	2.68	2.45	4.00	4.00	5.41	5.41	-1.91	2.74	-1.01	2.15	1.29	2.05	2.05	2.77	2.77	-1.00
22. Research and development	5.38	-2.06	1.06	1.91	4.25	4.25	4.85	4.85	-1.91	2.75	-1.07	2.72	1.00	2.18	2.18	2.48	2.48	-1.00
23. Public administration	0.35	-3.00	-2.82	-2.78	6.28	6.28	0.02	0.02	-1.91	0.17	-1.58	-0.40	-1.44	3.23	3.23	0.00	0.00	-1.00
24. Recreational services	2.06	-2.29	0.30	-0.84	4.74	4.74	2.02	2.02	-1.91	1.05	-1.20	-0.31	-0.43	2.44	2.44	1.03	1.03	-1.00
25. Other services	2.58	-2.27	1.17	-0.32	4.69	4.69	2.55	2.55	-1.91	1.33	-1.18	-0.31	-0.15	2.41	2.41	1.31	1.31	-1.00

Figure 8.5.3: Long-run skilled migration sectoral employment results: 5% increase in skill-differentiated labour efficiency.



Note: see Table 8.5.4 for full set of results.

Figure 8.5.4: Running total of skilled and unskilled long-run, skilled migration, FTE employment at sector level



8.5.3 Long-run: No migration

Table 8.5.5 details the key macroeconomic long-run results for a permanent 5% increase in skill-differentiated labour efficiency across all sectors. To recall, in the no migration closure neither skilled nor unskilled migrate between regions in response to changes in real wage and unemployment rate. That is, the total workforce remains fixed throughout the simulation, the skilled and unskilled unemployment rate and real wage vary in the long run in response to changes in labour demand.

Some of the main adjustment mechanism seen in the free- and the skilled migration closures are also seen here. That is, the increase in efficiency stimulates investment, reduces output prices. This in turn increases exports, output, and employment. Nominal wages fall, whilst employment increases in the long run. The unemployment rate and the real wage do not revert back to their initial equilibrium as the skilled and unskilled labour force remains fixed. Appendix 8C details the aggregate long-run no migration transition paths for selected key variables.

Table 8.5.5: Long-run, free-, skilled- and no migration, effects of a 5% increase in skill-differentiated labour efficiency. In % changes

	LR - Free mig.		LR - Skilled mig.		LR - No mig.	
	Skilled efficiency	Unskilled efficiency	Skilled efficiency	Unskilled efficiency	Skilled efficiency	Unskilled efficiency
GRP Income measure	4.17	2.13	3.80	1.95	3.44	1.79
Consumer Price Index	- 2.14	- 1.12	- 1.96	- 1.02	- 1.78	- 0.94
Unemployment Rate	- 0.00	- 0.00	- 3.36	- 1.82	- 4.83	- 2.51
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 3.60	- 1.64
Unemployment Rate U	- 0.00	- 0.00	- 6.71	- 3.65	- 6.06	- 3.37
Total Employment	1.01	0.49	0.64	0.30	0.28	0.14
Total Employment S	0.83	0.37	0.75	0.33	0.23	0.10
Total Employment U	1.35	0.72	0.43	0.23	0.39	0.22
Nominal Gross Wage	- 2.14	- 1.12	- 1.58	- 0.82	- 1.22	- 0.65
Nominal Gross Wage S	- 2.14	- 1.12	- 1.96	- 1.02	- 1.35	- 0.75
Nominal Gross Wage U	- 2.14	- 1.12	- 1.19	- 0.61	- 1.09	- 0.56
Real Gross Wage	0.00	0.00	0.39	0.21	0.57	0.29
Real Gross Wage S	0.00	0.00	0.00	0.00	0.44	0.20
Real Gross Wage U	0.00	0.00	0.78	0.42	0.70	0.38
Labour force	1.01	0.49	0.49	0.22	-	-
Labour force S	0.83	0.37	0.75	0.33	-	-
Labour force U	1.35	0.72	-	-	-	-
Households Consumption	0.91	0.45	0.83	0.41	0.75	0.38
Investment	3.99	2.04	3.63	1.86	3.29	1.71
Capital Stock	3.99	2.04	3.63	1.86	3.29	1.71
Replacement cost of capital	- 2.09	- 1.09	- 1.91	- 1.00	- 1.74	- 0.92
Export RUK	3.76	1.93	3.43	1.76	3.11	1.62
Export ROW	3.92	2.01	3.57	1.84	3.24	1.69
FTE Employment	23,327	11,454	13,754	6,521	6,587	3,361
FTE Employment S	10,812	4,820	9,780	4,362	2,997	1,366
FTE Employment U	12,515	6,635	3,974	2,158	3,590	1,995

LR = long-run. S = Skilled; U = Unskilled

The most direct impact, as compared to the other migration closures, is that the skilled real wage increases in the long run in the no migration closure (but by less than the unskilled real wage). When skilled efficiency is increased he aggregate real wage increases by 0.57%, 0.44% for the skilled and 0.70% for the unskilled. The aggregate real wage increases by 0.29%, 0.20% for the skilled and 0.38% for the unskilled, when skilled efficiency is increased.

Prices thereby fall by less than in the other migration closures. This in turn reduces the stimulus to exports and thereby the stimulated demand for labour. All sectors experience a competitiveness penalty in the no migration closure as the supply of both skilled and unskilled workers is restricted. This in turn causes some crowding out of output.

When skilled efficiency is increased the aggregate unemployment rate falls by 4.83% in the long run. In contrast to the other migration closures, the unemployment rate falls here for both skill groups due to the migration assumptions. The skilled unemployment rate decreases by 3.60% and the unskilled falls by 6.06% in the long run. Similar adjustment, even though muted, are seen when unskilled efficiency is increased.

Real wages rise by 0.57% in the long run, a 0.44% increase for the skilled and a 0.70% increase for the unskilled, when skilled efficiency is increased. Unskilled real wages also rise by more than skilled real wages when unskilled efficiency is increased, 0.38% and 0.20% respectively.

Total employment increases by 0.28% in the long run as compared to 1.01% in the free migration closure when skilled efficiency is increased. As seen in the free migration closure, the unskilled see a larger percentage increase in employment as compared to the increase seen by the skilled. This is again seen in both of the skill-differentiated simulation results.

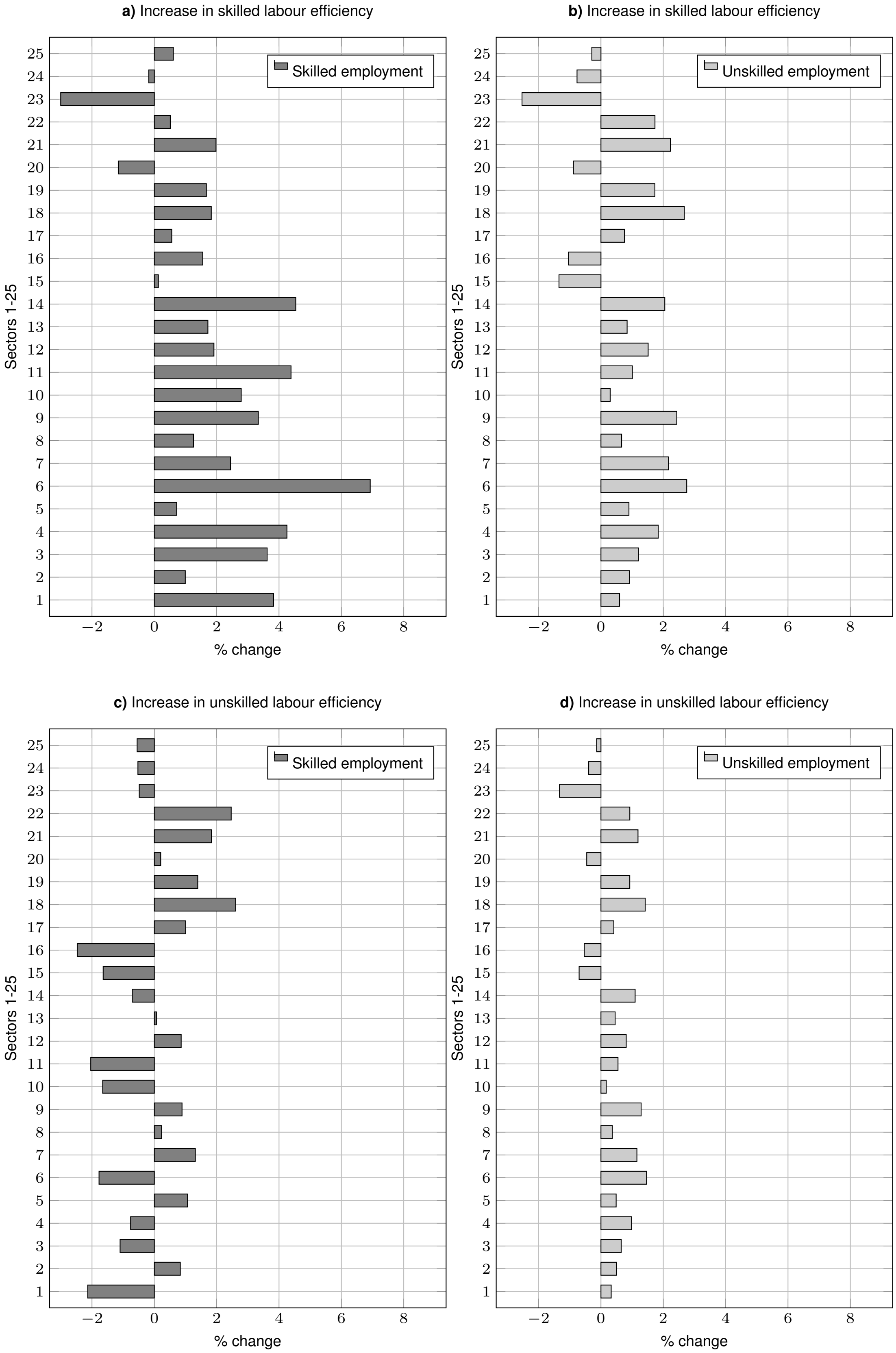
As in the free migration case, the unskilled benefit here from a larger percentage increase in employment than the skilled. In terms of the real wage, the unskilled see a larger increase as compared to the skilled. Reflecting this, the unskilled see a smaller fall in the nominal wage. Thus, the unskilled are better off both in terms of increases in employment and real wages relative to the skilled.

Table 8.5.6 and Figure 8.5.5 detail the long-run results at the individual sector level for a permanent 5% increase in skill-differentiated labour efficiency across all sectors. As seen in the skilled migration results, all sectors experience a fall in output prices, and an increase in exports and total output as compared to the base. The main difference to the skilled migration closure is the magnitude of the impact. The induced stimulus to output is smaller here as prices do not fall as strongly.

Table 8.5.6: Long-run no migration results: 5% increase in skill-differentiated labour efficiency. In % changes

	5% increase in skilled efficiency									5% increase in unskilled efficiency								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	3.56	-1.26	3.83	0.60	2.57	2.57	3.23	3.23	-1.74	1.85	-0.67	-2.14	0.33	1.34	1.34	1.68	1.68	-0.92
2. Mining	3.24	-0.93	0.99	0.91	1.90	1.90	3.55	3.55	-1.74	1.69	-0.49	0.83	0.49	0.99	0.99	1.85	1.85	-0.92
3. Food, drink and tobacco	3.72	-1.54	3.62	1.21	3.16	3.16	3.85	3.85	-1.74	1.93	-0.81	-1.10	0.65	1.65	1.65	2.01	2.01	-0.92
4. Textile, leather, wood and paper	4.36	-1.57	4.25	1.84	3.22	3.22	4.50	4.50	-1.74	2.27	-0.83	-0.76	0.98	1.68	1.68	2.34	2.34	-0.92
5. Chemicals	3.27	-1.09	0.72	0.90	2.22	2.22	3.54	3.54	-1.74	1.70	-0.57	1.07	0.49	1.16	1.16	1.84	1.84	-0.92
6. Rubber, plastic, cement and iron	5.19	-1.67	6.93	2.75	3.42	3.42	5.44	5.44	-1.74	2.70	-0.88	-1.77	1.46	1.78	1.78	2.83	2.83	-0.92
7. Computer, electrical and transport eq.	4.73	-1.58	2.45	2.17	3.23	3.23	4.84	4.84	-1.74	2.46	-0.83	1.32	1.15	1.69	1.69	2.52	2.52	-0.92
8. Electricity, gas and water	3.11	-1.43	1.26	0.66	2.92	2.92	3.30	3.30	-1.74	1.62	-0.75	0.23	0.36	1.53	1.53	1.71	1.71	-0.92
9. Construction	5.08	-1.73	3.34	2.43	3.56	3.56	5.11	5.11	-1.74	2.64	-0.92	0.89	1.29	1.86	1.86	2.65	2.65	-0.92
10. Wholesale and retail	2.85	-1.89	2.79	0.30	3.89	3.89	2.92	2.92	-1.74	1.48	-1.00	-1.66	0.17	2.03	2.03	1.52	1.52	-0.92
11. Land transport	3.45	-1.70	4.39	1.01	3.48	3.48	3.65	3.65	-1.74	1.80	-0.90	-2.04	0.55	1.82	1.82	1.90	1.90	-0.92
12. Water transport	3.85	-1.48	1.91	1.51	3.02	3.02	4.17	4.17	-1.74	2.00	-0.78	0.86	0.81	1.58	1.58	2.17	2.17	-0.92
13. Air Transport	3.14	-1.56	1.72	0.84	3.19	3.19	3.48	3.48	-1.74	1.63	-0.82	0.07	0.46	1.67	1.67	1.81	1.81	-0.92
14. Post and support transport services	4.64	-1.71	4.54	2.05	3.50	3.50	4.72	4.72	-1.74	2.42	-0.90	-0.71	1.10	1.83	1.83	2.46	2.46	-0.92
15. Accommodation	1.21	-1.94	0.13	-1.35	3.99	3.99	1.23	1.23	-1.74	0.63	-1.03	-1.64	-0.70	2.09	2.09	0.64	0.64	-0.92
16. Food & beverage services	1.48	-2.02	1.55	-1.04	0.00	3.64	1.55	1.55	-1.74	0.77	-1.07	-2.47	-0.54	0.00	0.00	0.80	0.80	-0.92
17. Telecommunication	3.33	-1.77	0.56	0.76	3.64	0.00	3.39	3.39	-1.74	1.74	-0.94	1.01	0.41	1.90	1.90	1.77	1.77	-0.92
18. Computer and information services	5.36	-1.99	1.83	2.67	4.10	4.10	5.36	5.36	-1.74	2.78	-1.05	2.61	1.42	2.14	2.14	2.79	2.79	-0.92
19. Financial services	4.16	-1.56	1.67	1.73	3.19	3.19	4.39	4.39	-1.74	2.16	-0.82	1.39	0.92	1.67	1.67	2.28	2.28	-0.92
20. Real estate	1.58	-1.32	-1.16	-0.88	2.69	2.69	1.71	1.71	-1.74	0.82	-0.69	0.20	-0.46	1.40	1.40	0.88	0.88	-0.92
21. Professional services	4.85	-1.76	1.98	2.23	3.62	3.62	4.90	4.90	-1.74	2.52	-0.93	1.83	1.19	1.89	1.89	2.55	2.55	-0.92
22. Research and development	4.87	-1.87	0.51	1.73	3.85	3.85	4.39	4.39	-1.74	2.53	-0.99	2.47	0.93	2.01	2.01	2.29	2.29	-0.92
23. Public administration	0.31	-2.73	-3.00	-2.53	5.69	5.69	0.02	0.02	-1.74	0.16	-1.46	-0.48	-1.33	2.98	2.98	0.00	0.00	-0.92
24. Recreational services	1.86	-2.08	-0.18	-0.77	4.30	4.30	1.83	1.83	-1.74	0.97	-1.10	-0.53	-0.39	2.25	2.25	0.95	0.95	-0.92
25. Other services	2.34	-2.06	0.61	-0.29	4.25	4.25	2.32	2.32	-1.74	1.22	-1.09	-0.55	-0.14	2.22	2.22	1.21	1.21	-0.92

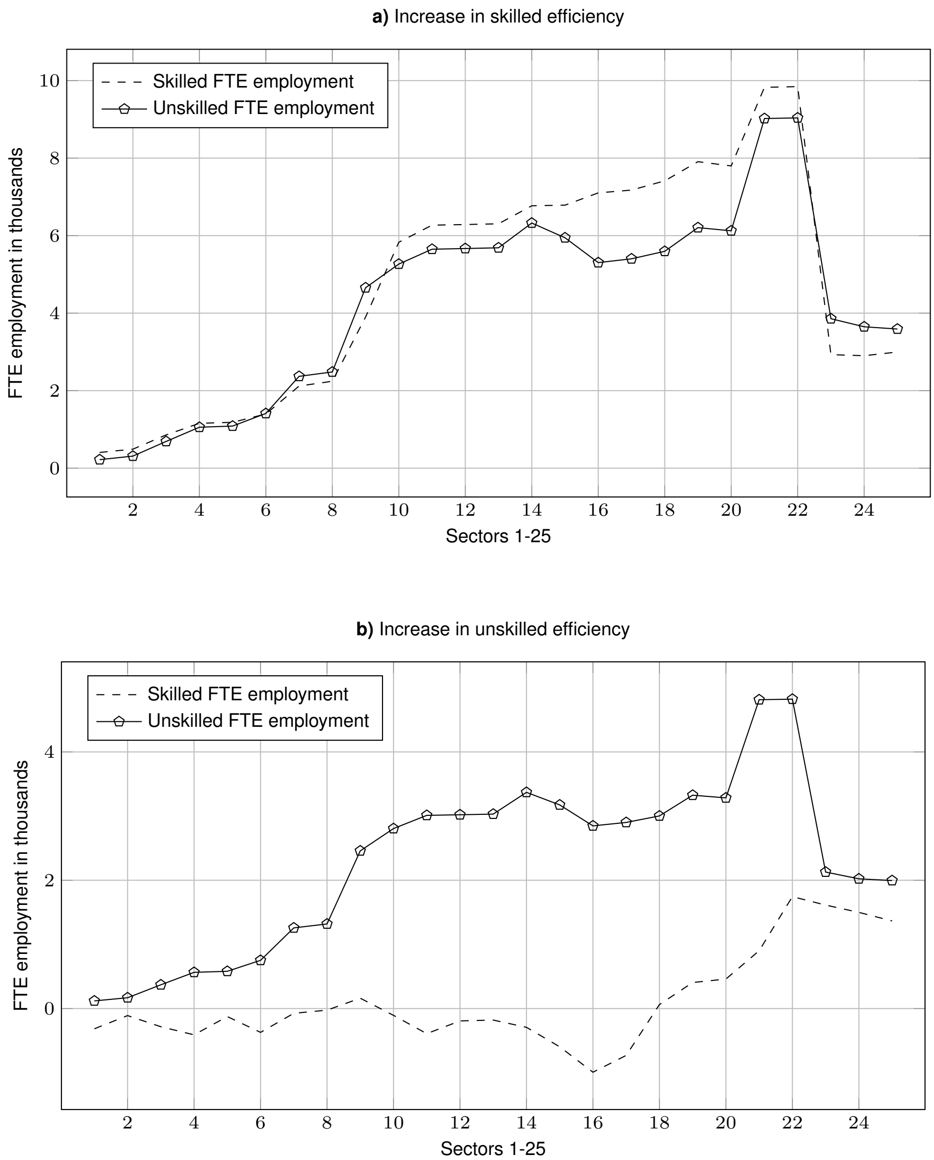
Figure 8.5.5: Long-run no migration sectoral employment results: 5% increase in skill-differentiated labour efficiency.



Note: see Table 8.5.6 for full set of results.

The adjustment patterns across sectors are similar to these seen in the free migration case. As prices, however, do not fall as strongly in the no migration case the impacts on the key variables are muted in comparison. Figure 8.5.6 reconfirms this by depicting the running total of skilled and unskilled long-run FTE employment at sector level.

Figure 8.5.6: Running total of skilled and unskilled long-run, no migration, FTE employment at sector level



The pattern in Figure 8.5.6 is similar to that seen in the free migration case. Large increases in unskilled FTE employment are again seen in sector 9 and 21. Unskilled FTE employment drops sharply in sector 23. The impact on skilled FTE employment is muted when unskilled efficiency is increased. This is particularly visible in sector 21, where skilled employment does not increase sharply, and sector 23, where it does not fall significantly.

8.5.4 Short-run

Table 8.5.7 details the short- and long-run results for a permanent 5% increase in skill-differentiated labour efficiency across all sectors. To recall, the short-run results are the same for all three migration closures since there is no migration in the first period irrespective of the assumptions about labour mobility, and myopic investment decisions made in period one are unaffected by future migration decisions. The labour force is fixed in the short run, but the skilled and unskilled unemployment rate can change and labour is mobile across sectors. The capital stock is fixed in the short run in both total and its distribution across sectors.

Table 8.5.7: Short- and long-run effects of a 5% increase in skill-differentiated labour efficiency. In % changes

	LR - Free mig.		LR - Skilled mig.		LR - No mig.		SR	
	Skilled efficiency	Unskilled efficiency	Skilled efficiency	Unskilled efficiency	Skilled efficiency	Unskilled efficiency	Skilled efficiency	Unskilled efficiency
GRP Income measure	4.17	2.13	3.80	1.95	3.44	1.79	1.56	0.83
Consumer Price Index	- 2.14	- 1.12	- 1.96	- 1.02	- 1.78	- 0.94	- 1.29	- 0.69
Unemployment Rate	- 0.00	- 0.00	- 3.36	- 1.82	- 4.83	- 2.51	10.26	5.25
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 3.60	- 1.64	10.89	5.79
Unemployment Rate U	- 0.00	- 0.00	- 6.71	- 3.65	- 6.06	- 3.37	9.63	4.71
Total Employment	1.01	0.49	0.64	0.30	0.28	0.14	- 0.67	- 0.35
Total Employment S	0.83	0.37	0.75	0.33	0.23	0.10	- 0.69	- 0.37
Total Employment U	1.35	0.72	0.43	0.23	0.39	0.22	- 0.61	- 0.30
Nominal Gross Wage	- 2.14	- 1.12	- 1.58	- 0.82	- 1.22	- 0.65	- 2.40	- 1.28
Nominal Gross Wage S	- 2.14	- 1.12	- 1.96	- 1.02	- 1.35	- 0.75	- 2.51	- 1.36
Nominal Gross Wage U	- 2.14	- 1.12	- 1.19	- 0.61	- 1.09	- 0.56	- 2.30	- 1.20
Real Gross Wage	0.00	0.00	0.39	0.21	0.57	0.29	- 1.13	- 0.59
Real Gross Wage S	0.00	0.00	0.00	0.00	0.44	0.20	- 1.23	- 0.67
Real Gross Wage U	0.00	0.00	0.78	0.42	0.70	0.38	- 1.02	- 0.51
Labour force	1.01	0.49	0.49	0.22	-	-	-	-
Labour force S	0.83	0.37	0.75	0.33	-	-	-	-
Labour force U	1.35	0.72	-	-	-	-	-	-
Households Consumption	0.91	0.45	0.83	0.41	0.75	0.38	- 0.58	- 0.31
Investment	3.99	2.04	3.63	1.86	3.29	1.71	3.32	1.78
Capital Stock	3.99	2.04	3.63	1.86	3.29	1.71	-	-
Replacement cost of capital	- 2.09	- 1.09	- 1.91	- 1.00	- 1.74	- 0.92	- 0.02	- 0.03
Export RUK	3.76	1.93	3.43	1.76	3.11	1.62	1.21	0.65
Export ROW	3.92	2.01	3.57	1.84	3.24	1.69	1.59	0.85
FTE Employment	23,327	11,454	13,754	6,521	6,587	3,361	- 14,754	-7,599
FTE Employment S	10,812	4,820	9,780	4,362	2,997	1,366	-9,050	- 4,813
FTE Employment U	12,515	6,635	3,974	2,158	3,590	1,995	-5,704	-2,786

SR = short-run; LR = long-run. S = Skilled; U = Unskilled

The increase in efficiency increases the effective supply of labour and decreases the price of labour, as measured in efficiency units, and production costs fall. CPI falls by 1.29% when skilled efficiency is increased, and by 0.69% when unskilled efficiency is increased. This stimulates exports, and thereby also output in the short run. Moreover, the demand for capital is stimulated in the short run as rental rates exceed user costs and investment proceeds.

As the fall in prices is less when unskilled efficiency is increased, as compared to when skilled efficiency is increased, the stimulus to exports is smaller. GRP increases by 1.56% in the skilled case, and by 0.83% in the unskilled case.

To recall, for employment there is a direct effect of the increase in efficiency. As the price of labour, as measured in efficiency units, falls as a result of the increase in efficiency there is a substitution effect between labour and other inputs. In the production of output there is an output effect due to the fall in domestic prices.

The increased competitiveness of the product increases output (and derived employment). The fixed capacity in the short run, however, adds a constraint and increases costs, so limiting beneficial competitiveness effects.

The short run is thereby characterised by a fall in employment (in efficiency units employment increases) and an increase in the unemployment rate. Real wages fall as governed by the bargained real wage function. The price of domestically produced goods fall with the increase in labour efficiency, and this reduces CPI, and nominal wages fall. A reduction in the prices increases competitiveness, and thereby output and the derived demand for labour.

In the case where skilled efficiency is increased total employment decreases in the short run by 0.67% as less workers are needed. Despite the shock being skill-differentiated, i.e. only skilled efficiency is increased, there are again differences in the skilled and unskilled labour markets although these are less marked when compared to long-run results.

The increase in skilled efficiency leads to a stronger percentage fall in skilled employment (-0.69%) as compared to unskilled employment (-0.61%). When unskilled efficiency is increased the skilled again see a larger fall in employment (-0.37%) as compared to the unskilled (-0.30%). The skilled thereby see a smaller stimulus to labour coming through the expansion of output and the substitution of labour for capital in production, as compared to the unskilled. This is again discussed in more detail when considering sector level results.

The aggregate unemployment level increases by 10.26% in the short run when skilled efficiency is increased. Reflecting the employment changes where the efficiency shock has cost more skilled FTE jobs, the skilled unemployment level increases by 10.89%, and the unskilled increases by 9.63%. The impact on unemployment is smaller when unskilled efficiency is increased as the impact on employment is comparatively smaller.

Nominal wages fall by 2.40% and 1.28% in the short run. In both skill-differentiated labour efficiency simulations the skilled see a larger cut to their nominal wages as compared to the cut seen by the unskilled, reflecting changes in the unemployment rate. The fall in the nominal wage, however, limits the fall in employment in the short run.

As seen in the skill-neutral efficiency simulations, the impact of labour on GRP is comparatively small when moving from the short- to the long run with free migration. There is a relative small difference in GRP between the free- and the no migration case. The impact of loosening the restriction of capital, however, is significant.

To recall, capital is a smaller share of value added than labour. But, there is an expansion in the labour force from the increase in efficiency, so that the subsequent migration (in the long run) is relatively small as compared to the increase in capital. The capital stock is fixed in the short run in both total and its distribution across sectors. Variations in capital rental rate indicate large benefits from reallocating existing capital.

Table 8.5.8 and Figure 8.5.7 details the short-run results at the individual sector level for a permanent 5% increase in skill-differentiated labour efficiency across all sectors. The increase in labour efficiency is characterised by a fall in output prices and employment, and an increase in exports, output, investment and capital rental rates, for the majority of sectors. There are, however, some prominent exceptions from this.

Capital rental rates fall in four sectors. The RUK and ROW exports share of output is at, or below 2% in these four sectors. The Food & beverage services sector does not have any exports. That is, capital rental rates fall here in the short run in sectors that mainly serve the domestic market. Capital rental rates increase in the remaining sectors. The stimulus to investment also further reinforces the stimulus to output in these sectors.

In the case of the export orientated sectors, the gap between the user cost of capital and the capital rental rate adds to the incentive to invest. In the sectors mainly serving the domestic markets, investment is not stimulated as the capital rental rate does not exceed the user cost of capital, and disinvestment can be observed.

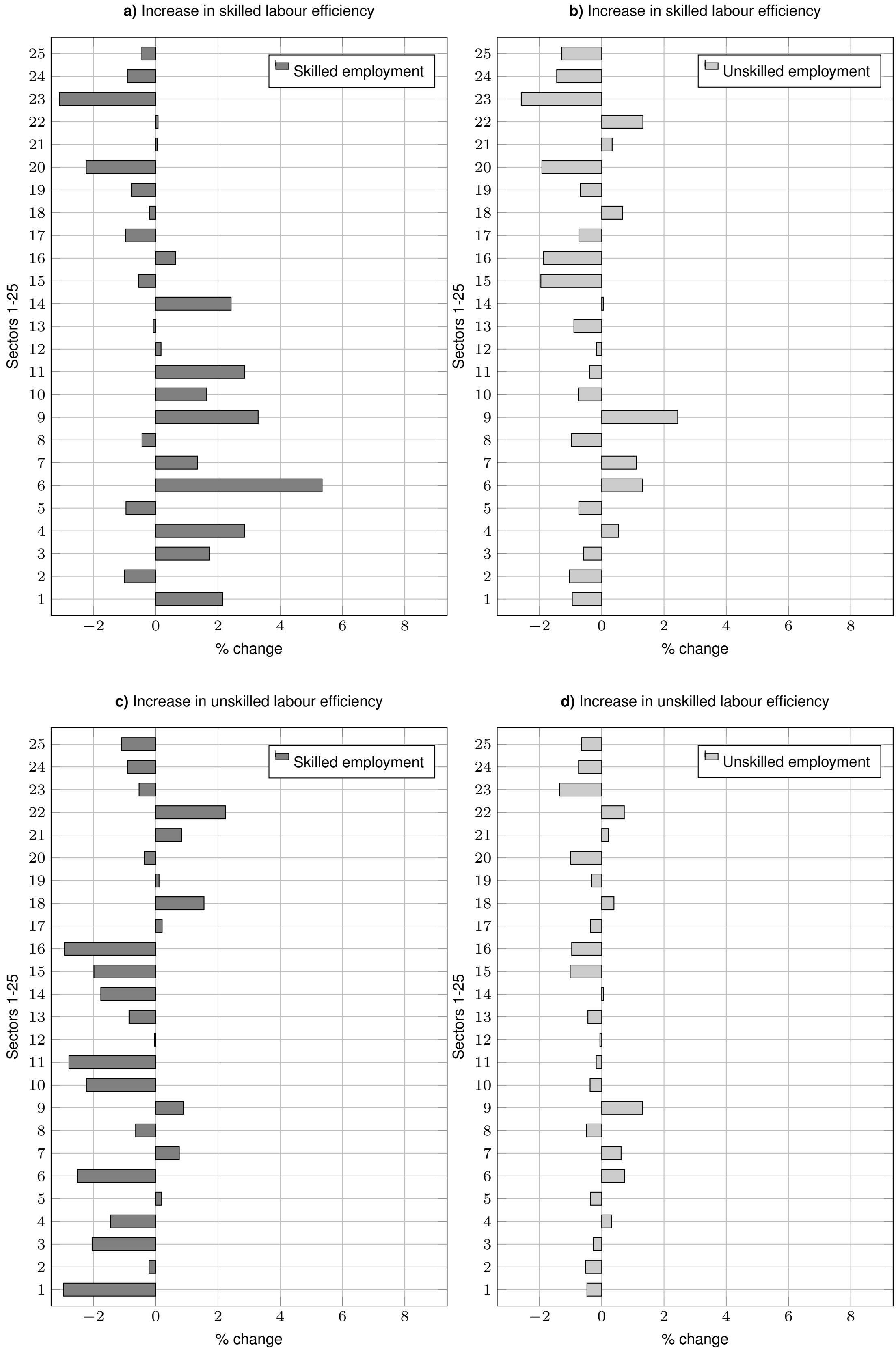
Only sectors that experience the stimulus to output (through investment and/or high export demand) see an increase in employment. The sectors seeing an increase in output are typically sectors that are more export orientated.

The two sectors experiencing a fall in output, the Real estate and the Public administration sector, both have a very low export share of output. The largest stimulus to output, employment is seen in the Construction sector. Here the stimulus to output is driven by supplying investment goods. The big variations in the capital rental rate (as against variations in output, employment, and prices) drive investment demand where there are similarly big variations.

Table 8.5.8: Short-run results: 5% increase in skill-differentiated labour efficiency. In % changes

	5% increase in skilled efficiency									5% increase in unskilled efficiency								
	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental	Total output	Output prices	Employment S	Employment U	RUK Exports	ROW Exports	Capital Stock	Investment	Capital Rental
1. Agriculture, forestry and fishing	0.92	-0.25	2.15	-0.95	0.51	0.51	-	2.40	2.41	0.49	-0.14	-2.96	-0.47	0.27	0.27	-	1.30	1.28
2. Mining	0.64	-0.10	-1.01	-1.04	0.21	0.21	-	2.09	2.08	0.34	-0.06	-0.21	-0.52	0.11	0.11	-	1.14	1.11
3. Food, drink and tobacco	1.27	-0.65	1.73	-0.58	1.32	1.32	-	3.66	3.69	0.68	-0.35	-2.04	-0.27	0.70	0.70	-	1.97	1.96
4. Textile, leather, wood and paper	2.50	-1.04	2.86	0.54	2.12	2.12	-	7.44	7.62	1.33	-0.56	-1.45	0.32	1.12	1.12	-	3.97	4.00
5. Chemicals	1.02	-0.35	-0.95	-0.73	0.71	0.71	-	3.13	3.14	0.55	-0.19	0.19	-0.36	0.38	0.38	-	1.69	1.67
6. Rubber, plastic, cement and iron	3.21	-1.06	5.34	1.31	2.15	2.15	-	10.07	10.41	1.70	-0.57	-2.52	0.73	1.14	1.14	-	5.36	5.43
7. Computer, electrical and transport eq.	3.06	-0.92	1.34	1.11	1.88	1.88	-	9.37	9.67	1.62	-0.50	0.76	0.62	1.00	1.00	-	4.99	5.04
8. Electricity, gas and water	0.84	-0.56	-0.44	-0.97	1.13	1.13	-	2.32	2.32	0.45	-0.30	-0.64	-0.49	0.60	0.60	-	1.26	1.24
9. Construction	4.01	0.39	3.29	2.44	-0.78	-0.78	-	13.89	14.56	2.12	0.18	0.88	1.31	-0.36	-0.36	-	7.32	7.47
10. Wholesale and retail	1.28	-1.38	1.64	-0.76	2.83	2.83	-	3.05	3.06	0.68	-0.74	-2.23	-0.37	1.49	1.49	-	1.64	1.62
11. Land transport	1.53	-1.09	2.86	-0.39	2.22	2.22	-	4.28	4.32	0.81	-0.58	-2.79	-0.18	1.18	1.18	-	2.30	2.29
12. Water transport	1.63	-0.72	0.17	-0.17	1.46	1.46	-	5.03	5.10	0.87	-0.39	-0.03	-0.06	0.78	0.78	-	2.71	2.70
13. Air Transport	0.92	-0.76	-0.08	-0.89	1.53	1.53	-	2.59	2.60	0.49	-0.41	-0.86	-0.44	0.82	0.82	-	1.40	1.38
14. Post and support transport services	1.94	-0.77	2.42	0.05	1.55	1.55	-	5.78	5.88	1.03	-0.41	-1.76	0.06	0.83	0.83	-	3.10	3.11
15. Accommodation	0.25	-1.89	-0.55	-1.96	3.90	3.90	-	-1.01	-1.03	0.13	-1.01	-1.98	-1.01	2.05	2.05	-	-0.51	-0.54
16. Food & beverage services	0.34	-1.97	0.64	-1.87	0.00	2.05	-	-0.71	-0.73	0.18	-1.04	-2.93	-0.96	0.00	0.00	-	-0.34	-0.37
17. Telecommunication	1.22	-1.01	-0.97	-0.73	2.05	0.00	-	3.13	3.15	0.65	-0.54	0.21	-0.36	1.08	1.08	-	1.69	1.67
18. Computer and information services	2.59	-0.88	-0.20	0.67	1.78	1.78	-	7.88	8.08	1.38	-0.47	1.55	0.39	0.95	0.95	-	4.22	4.25
19. Financial services	1.07	-0.45	-0.79	-0.69	0.91	0.91	-	3.29	3.31	0.57	-0.24	0.11	-0.33	0.49	0.49	-	1.78	1.76
20. Real estate	-0.05	-0.76	-2.23	-1.92	1.53	1.53	-	-0.90	-0.91	-0.02	-0.40	-0.36	-1.00	0.81	0.81	-	-0.45	-0.48
21. Professional services	2.23	-0.78	0.05	0.33	1.58	1.58	-	6.75	6.89	1.19	-0.42	0.83	0.21	0.85	0.85	-	3.61	3.63
22. Research and development	3.93	-1.76	0.07	1.32	3.62	3.62	-	10.10	10.44	2.06	-0.94	2.24	0.72	1.90	1.90	-	5.33	5.40
23. Public administration	-0.02	-3.07	-3.10	-2.58	6.44	6.44	-	-3.15	-3.13	-0.01	-1.64	-0.53	-1.36	3.36	3.36	-	-1.67	-1.69
24. Recreational services	0.76	-1.90	-0.91	-1.45	3.92	3.92	-	0.71	0.70	0.40	-1.01	-0.90	-0.74	2.06	2.06	-	0.40	0.37
25. Other services	0.88	-1.75	-0.45	-1.28	3.59	3.59	-	1.26	1.25	0.47	-0.93	-1.10	-0.65	1.88	1.88	-	0.70	0.67

Figure 8.5.7: Short-run sectoral employment results: 5% increase in skill-differentiated labour efficiency.



Note: see Table 8.5.8 for full set of results.

All sectors, with the exception of the Construction sector, see increases in exports to both the RUK and the ROW. The Construction sector experiences negative competitiveness effects due to the increase in output prices and thereby sees falling exports.

Table 8.5.8 shows employment increases in some sectors as the negative impact of the direct increase in labour productivity is less than the stimulus to labour demand coming through the expansion in output and the substitution of labour for capital in production. And, vice versa for sectors that experience a fall in skilled and/or unskilled employment.

The increase in skill-differentiated labour efficiency leads to a fall in output prices in all sectors, with the exception of the Construction sector. The Construction sector experiences a 0.39% and 0.18% increase in output prices due to the change in capital and rental rates. Sectors with high price reductions in the short run typically serve domestic markets where the reductions in price additionally reflect a fall in the capital rental rate.

Conditions similar to these are also seen in the skill-neutral labour efficiency simulations as detailed in Section 8.4. The disparate impact on employment is again analysed by considering FTE employment results. Figure 8.5.8 depicts the running total of skilled and unskilled short-run FTE employment at sector level.

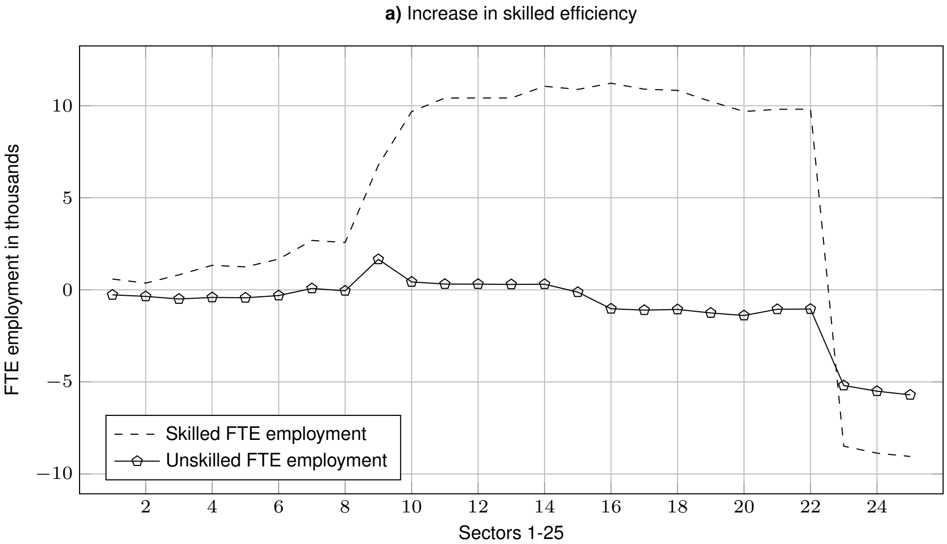
When skilled efficiency is increased there is a very clear tendency for skilled FTE employment to increase. The fall in skilled employment in the Public administration sector, however, is so significant that total FTE employment drops below base. This significant fall in skilled employment shifts the overall short-run results so that total skilled employment falls by more than total unskilled employment.

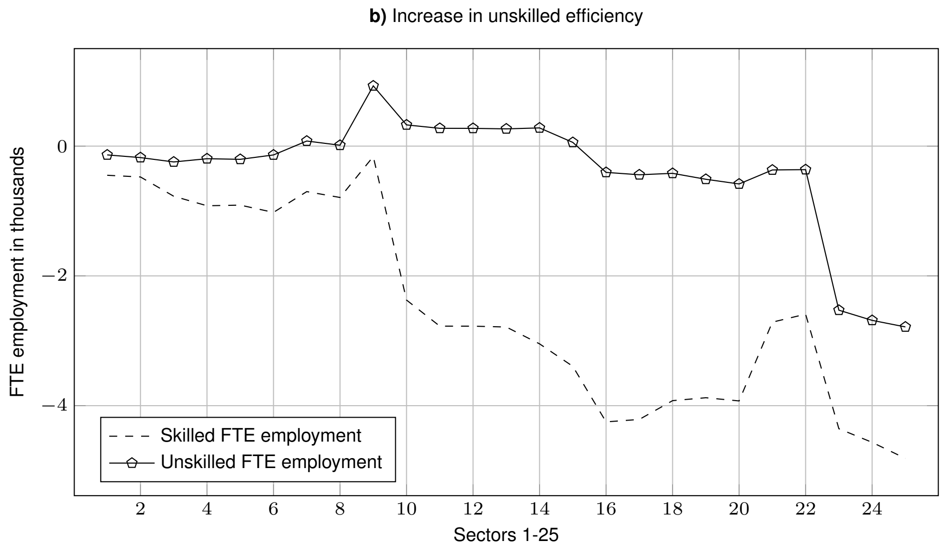
When unskilled efficiency is increased the pattern seen by the unskilled is similar to that seen when skilled efficiency is increased. That is, there is some significant growth in sector 9, Construction, and a relative large fall in sector 23, Public administration.

The skilled, however, see relative large falls in employment when unskilled efficiency is increased in the short run. There is some considerable expansion in the Construction, and the Professional services sector. This expansion is, however, not significant enough to counteract relative large falls in skilled employment in the Wholesale and retail, Food & averages, and the Public administration sectors.

Large sectoral impacts are once again the driving force. As seen in the skill-neutral labour efficiency simulations, the negative impact on FTE employment seen in sectors that mainly serve the domestic market, and the relative size and skill intensity of these sectors, is one of the main factors that determine the overall impact on skilled and unskilled employment.

Figure 8.5.8: Running total of skilled and unskilled short-run, FTE employment at sector level





8.5.5 Summary

As seen in the skill-neutral increase in labour efficiency, the skill-differentiated shock reduces employment in the short run and unemployment increases. This reduces wages through the bargained real wage function, and domestic prices fall. As domestic prices fall there is a stimulus exports, and output rises. Investment is also stimulated by the rising gap between the user cost of capital and the capital rental rate.

Again, GRP increases here in the long run irrespective of the migration assumption. This is driven mainly by export led growth, which in turn stimulates the demand for labour, and employment increases above its base in the long run.

Real wages fall by less when unskilled efficiency is increased as compared to the increase in skilled efficiency. This in turn implies that the stimulus to exports is smaller and output increases by less than in the case where skilled efficiency is increased. The stimulated demand for labour is thereby also muted.

As identified in the skill-neutral case, the disparate impact on the skilled and the unskilled is driven mainly by sectoral characteristics. In both skill-differentiated cases the short- and long-run results tend to favour the unskilled as against the skilled in terms of employment and real wage percentage changes. This bias towards the unskilled occurs mainly due to skill intensity of exports, and the relative size and skill intensity of sectors that mainly serve the domestic market.

The skilled generally see a larger fall in both employment and real wages in the short run. The recovery back to base is also slower for the skilled as compared to the unskilled. Towards the long run the unskilled see a larger percentage increase from base employment and real wages. Present values for employment and real wages in Appendix 8A reconfirm this.

The present values for employment and real wages also show that there are longer term benefits for both skill categories regardless of whether skilled or unskilled labour efficiency is increased (even if these benefits are skewed towards the unskilled). Moreover, there are economy wide benefits in terms of increases in GRP.

As seen in the skill-neutral case, GRP increases from time period one onwards despite the negative effects on the labour market and does not fall throughout the simulated periods. Appendix 8A shows that GRP present value changes are positive irrespective of the time horizon of the simulations . Thus, potential prospects of long term growth may outweigh the negative labour market impacts seen in the initial years following the labour efficiency shock. This is discussed in more detail in Section 8.7 when considering the policy implications.

8.6 Sensitivity analysis

This section details the results of the analysis conducted for gradual increases in labour efficiency. Moreover, a sensitivity analysis is conducted around the elasticity of substitution between skilled and unskilled labour, and the Armington trade elasticities for imports and exports.

Appendix 8B details the simulation results for a gradual increase in skill-neutral labour efficiency. Cumulative efficiency is increased by 0.1% in each period until it reaches 5% in period 50. The 5% increase is then maintained from period 50 to 100. The long-run results for the gradual adjustment are the same as the ones presented in Section 8.4 where the skill-neutral labour efficiency is increased ‘immediately’.

Figure 8.6.1 compares the period by period adjustment paths of GRP, and skilled- and unskilled employment for the 'immediate' and the gradual increase in skill-neutral labour efficiency across the three migration closures. Even though the same long-run steady-states are reached, there are significant differences in the paths of adjustment.

When labour efficiency is increased 'immediately' skilled and unskilled employment experience a sharp initial drop and then gradually increase above their base. This can be observed across the three migration closures. The speed of the adjustment and the magnitude of change for skilled and unskilled employment, however, significantly depend on the migration assumption (as discussed in Section 8.4).

In contrast, when labour efficiency is increased gradually, the fall in employment is less pronounced but is spread out across a larger number of time periods. Any negative effects are thereby prolonged but are less severe as compared to these seen when labour efficiency is increased 'immediately'. This is also observed when contrasting the impact on other macroeconomic variables. For example, Figure 8.6.1 shows that GRP sees a strong initial increase and then proceeds to rise above its base until it reaches its steady-state in period 40 when labour efficiency is increased 'immediately'. In contrast, GRP increases more moderately from period to period when efficiency is increased gradually.

To summarise, even though the long-run results are the same for the two cases the adjustments towards the new steady-state differ. When efficiency is increased 'immediately' any adjustments to the steady-state occur over a relatively small number of periods. In contrast, the adjustment to the long-run steady-state occurs over a larger number of periods and is less pronounced when labour efficiency is increased gradually. The initial negative impacts seen in the labour market may pose a challenge to policy makers in the political decision making process. Prolonged negative impacts on the labour market, even though comparatively small when efficiency is increased gradually, may incentivise policy makers to not pursue such policy. Section 8.7 discusses the policy implications in more detail.

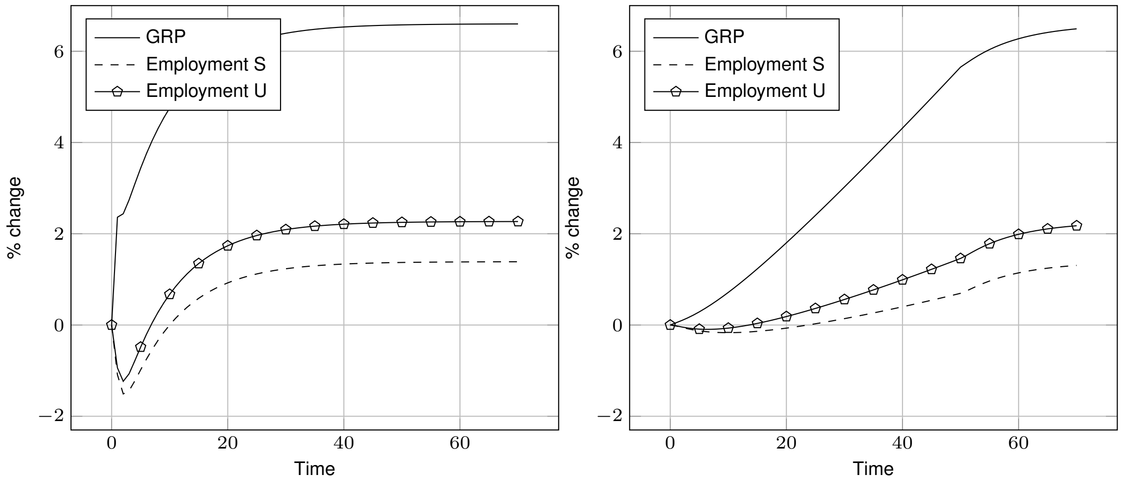
The following gives the results of the sensitivity analysis conducted around the elasticity of substitution between skilled and unskilled labour, and the Armington trade elasticities for imports and exports. To recall, details on each function and the elasticities used in the model are outlined in Chapter 6. The sensitivity analysis separately varies values of these two key elasticities whilst rerunning the skill-neutral and skill-differentiated increases in labour efficiency.

Table 8.6.1 summarises of the long-run results for the sensitivity analysis conducted around the substitution between skilled and unskilled, σ_S. Table 8.6.2 provides a summary of the results for the sensitivity analysis conducted around the Armington trade elasticities for imports and exports, σ_V. Appendix 8D details the full set of simulation results.

Figure 8.6.1: Aggregate transition paths: immediate and gradual increases in skill-neutral labour efficiency

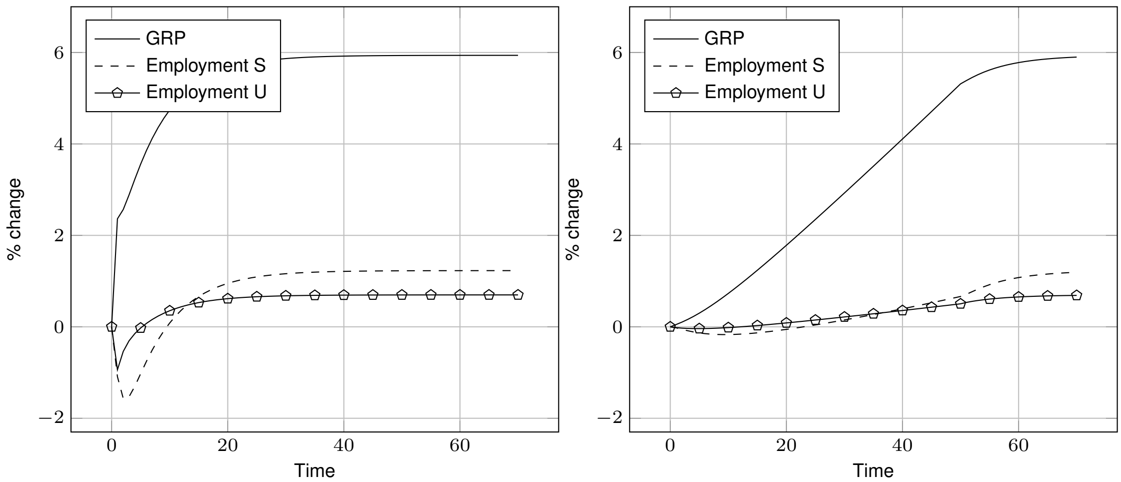
Free migration:

a) Immediate increase in total labour efficiency **b)** Gradual increase in total labour efficiency



Skilled migration:

a) Immediate increase in total labour efficiency **b)** Gradual increase in total labour efficiency



No migration:

a) Immediate increase in total labour efficiency **b)** Gradual increase in total labour efficiency

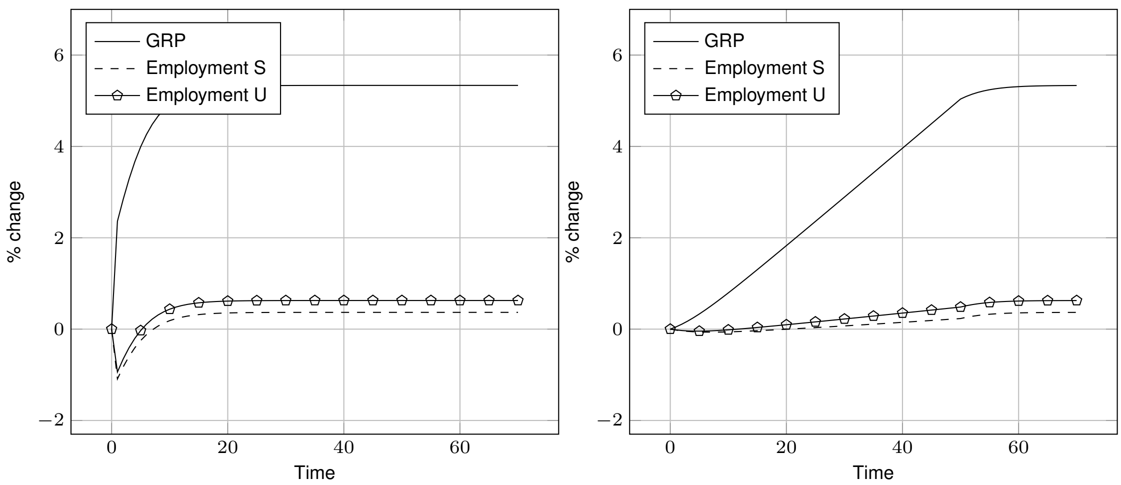


Table 8.6.1: Sensitivity analysis. Increase in labour efficiency. Elasticity of substitution between skilled and unskilled.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$
Total efficiency:									
GRP Income measure	6.60	6.60	6.60	5.81	5.94	5.99	5.34	5.34	5.34
Consumer Price Index	-3.31	-3.31	-3.31	-2.94	-3.00	-3.03	-2.71	-2.71	-2.71
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-5.29	-5.75	-5.91
Unemployment Rate U	-0.00	-0.00	-0.00	-12.86	-10.94	-10.06	-10.68	-9.82	-9.50
Total Employment S	1.39	1.39	1.39	0.98	1.23	1.34	0.34	0.37	0.38
Total Employment U	2.27	2.27	2.27	0.82	0.70	0.64	0.68	0.63	0.61
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.71	0.73
Real Gross Wage U	0.00	0.00	0.00	1.55	1.31	1.20	1.27	1.16	1.12
Skilled efficiency:									
GRP Income measure	4.16	4.17	4.18	3.27	3.80	4.03	3.41	3.44	3.44
Consumer Price Index	-2.14	-2.14	-2.15	-1.70	-1.96	-2.08	-1.77	-1.78	-1.78
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	1.82	-3.60	-5.53
Unemployment Rate U	-0.00	-0.00	-0.00	-15.20	-6.71	-2.68	-15.86	-6.06	-2.22
Total Employment S	0.13	0.83	1.24	-0.32	0.75	1.23	-0.12	0.23	0.35
Total Employment U	2.67	1.35	0.58	0.97	0.43	0.17	1.01	0.39	0.14
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.22	0.44	0.69
Real Gross Wage U	0.00	0.00	0.00	1.86	0.78	0.31	1.95	0.70	0.25
Unskilled efficiency:									
GRP Income measure	2.12	2.13	2.14	2.31	1.95	1.78	1.76	1.79	1.80
Consumer Price Index	-1.11	-1.12	-1.12	-1.21	-1.02	-0.94	-0.93	-0.94	-0.95
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-6.32	-1.64	0.17
Unemployment Rate U	-0.00	-0.00	-0.00	3.76	-3.65	-6.86	6.49	-3.37	-6.87
Total Employment S	1.06	0.37	-0.04	1.15	0.33	-0.04	0.40	0.10	-0.01
Total Employment U	-0.60	0.72	1.49	-0.24	0.23	0.44	-0.41	0.22	0.44
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.20	-0.02
Real Gross Wage U	0.00	0.00	0.00	-0.41	0.42	0.80	-0.70	0.38	0.80

LR = long-run. S = Skilled; U = Unskilled.

σ_S = Elasticity of substitution between skilled and unskilled.

See Appendix 8D for full set of results.

Skill-disaggregated AMOS σ_S = 1.01.

Table 8.6.2: Sensitivity analysis. Increase in labour efficiency. Armington trade elasticity.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$
Total efficiency:									
GRP Income measure	4.85	6.60	8.41	4.73	5.94	7.00	4.78	5.34	5.72
Consumer Price Index	-3.32	-3.31	-3.31	-3.23	-3.00	-2.79	-3.27	-2.71	-2.31
Total Employment S	-0.12	1.39	2.95	-0.11	1.23	2.42	-0.04	0.37	0.65
Total Employment U	0.57	2.27	4.03	0.20	0.70	1.11	0.20	0.63	0.92
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.08	0.71	1.29
Real Gross Wage U	0.00	0.00	0.00	0.36	1.31	2.17	0.35	1.16	1.75
Export RUK	2.92	5.93	9.03	2.87	5.34	7.53	2.88	4.80	6.17
Export ROW	3.04	6.17	9.40	2.99	5.56	7.84	3.00	5.00	6.43
Skilled efficiency:									
GRP Income measure	3.09	4.17	5.27	3.03	3.80	4.47	3.08	3.44	3.70
Consumer Price Index	-2.15	-2.14	-2.14	-2.10	-1.96	-1.83	-2.14	-1.78	-1.53
Total Employment S	-0.12	0.83	1.80	-0.11	0.75	1.52	-0.04	0.23	0.42
Total Employment U	0.28	1.35	2.44	0.10	0.43	0.71	0.10	0.39	0.59
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.08	0.44	0.82
Real Gross Wage U	0.00	0.00	0.00	0.18	0.78	1.33	0.18	0.70	1.09
Export RUK	1.87	3.76	5.69	1.84	3.43	4.83	1.86	3.11	4.00
Export ROW	1.94	3.92	5.93	1.92	3.57	5.03	1.93	3.24	4.17
Unskilled efficiency:									
GRP Income measure	1.59	2.13	2.69	1.56	1.95	2.29	1.60	1.79	1.93
Consumer Price Index	-1.12	-1.12	-1.12	-1.09	-1.02	-0.96	-1.13	-0.94	-0.81
Total Employment S	-0.11	0.37	0.86	-0.11	0.33	0.73	-0.04	0.10	0.21
Total Employment U	0.17	0.72	1.27	0.06	0.23	0.38	0.06	0.22	0.32
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.07	0.20	0.40
Real Gross Wage U	0.00	0.00	0.00	0.11	0.42	0.69	0.11	0.38	0.59
Export RUK	0.96	1.93	2.91	0.95	1.76	2.49	0.97	1.62	2.09
Export ROW	1.00	2.01	3.03	0.99	1.84	2.59	1.01	1.69	2.18

LR = long-run. S = Skilled; U = Unskilled.

σ_V = Elasticity of substitution between imports and domestic output in domestic demand.

See Appendix 8D for full set of results.

Skill-disaggregated AMOS σ_V = 2.00.

Table 8.6.1 gives the results for the sensitivity analysis on the elasticity of substitution between skilled and unskilled. This is the percentage change in demand for low (high) skill workers in response to a given percentage change in the price of high (low) skill workers, and is varied between: 0.6, 1.01, 1.25, where 1.01 is the default elasticity used in AMOSKI.

The economic intuition is that the skilled and the unskilled become closer substitutes and thereby experience greater competition over employment gains as the elasticity of substitution is increased. That is, as firms try to minimise their labour costs there is a shift in demand towards the skill category with the lowest wage costs. As the elasticity of substitution is increased it becomes easier for firms to substitute away from the skill category with the higher wage.

The results show that changes in the substitution between skilled and unskilled only have relatively small (or no) effects on GRP (and other aggregate variables) in cases where the labour force remains fixed, but changes are seen where migration occurs. In the skill-neutral case, for example, GRP is unchanged in the no migration closure when the elasticity is increased from 0.60 to 1.25. GRP, however, increases when the skilled are geographically mobile. Relatively large variations in employment across the two skill categories in all of the simulations.

Considering the case where the total labour efficiency is increased in the skilled migration closure the skilled real wage is at the initial equilibrium level but the unskilled real wage is 1.55% above its base value when σ_S is at 0.6. Unskilled workers are thereby comparatively more expensive. As σ_S is increased to 1.01 there is a shift away from unskilled workers, as they are more expensive, so that unskilled employment rises by less, and conversely skilled employment rises by more. With less demand for unskilled labour, due to the substitution away from the skilled, skilled real wage rises by less as compared to the case where σ_S is at 0.6. This mechanism can be observed across the migration closures.

When total labour efficiency is increased there are relatively large substitution effects between the two skill categories. This is visible particularly in the long run results for the no migration closure. Skilled employment rises as σ_S is increased, and vice versa, unskilled employment falls as σ_S is increased. Pronounced employment effects are also seen in the case when skilled labour efficiency is increased. As seen previously, skilled employment rises as σ_S is increased, and vice versa for unskilled employment.

When σ_S is below 1.01, however, there is a fall in skilled employment in the skilled migration and the no migration long-run closures. The stimulus to labour demand coming through the expansion of output and the substitution of labour for capital in production does not exceed the negative impacts of the direct increase in labour productivity (as the elasticity of demand is below one). In contrast to the other simulations, the substitution effects are so significant when unskilled efficiency is increased in the skilled migration closure that aggregate real wages rise when the elasticity of substitution is increased, whilst aggregate employment falls.

Table 8.6.2 details a summary of the results for the sensitivity analysis conducted around the Armington trade elasticities for imports and exports, σ_V. This elasticity is changed to, 1.00, 2.00, and 3.00, where 2.00 is the default elasticity used in the AMOSKI model. To recall, as the degree of substitutability is increased from 1.00 to 3.00 the system becomes more sensitive to competitiveness changes. The demands for Scottish goods are determined via an export demand function according to which the quantity of goods exported is related to the relative regional price, given constant prices and income for the RUK and the ROW. Domestic and imported inputs are obtained in the AMSOKI model via an Armington (1969) link and are relative-price sensitive.

Irrespective of whether labour efficiency takes the form of skill-biased or skill-neutral the following results can be observed when the Armington trade elasticity is increased from 1.00 to 3.00. The higher the elasticity the greater the responsiveness to competitiveness effects, which are in this case favourable due to the fall in prices arising from the increase in efficiency. The scale of the positive effects increases along with increases in the Armington trade elasticity.

That is, domestic goods become more competitive both in domestic and foreign markets the higher the elasticity. As there is more demand for domestic goods there is more stimulus to output, and stimulated demand for labour, the higher the Armington elasticity. The fall in prices, due to the increase in labour efficiency, thereby has a greater positive impact on exports the greater the Armington trade elasticity. Overall, there is a larger stimulus seen from an increase in labour efficiency when the Armington trade elasticity is increased.

These results emphasise that the degree of openness of the Scottish economy to trade flows is significantly important in influencing the overall results. Given that there is some uncertainty concerning the robustness of some of the elasticities used there is a clear need for more up to date econometric analysis.

8.7 Summary and policy implications

Table 8.7.1 summarises the simulations by detailing the key macroeconomic short- and long-run results for a permanent 5% increase in skill-neutral and skill-differentiated labour efficiency across all sectors, and the three migration closures.

There are some general effects that can be observed across the three migration closures and irrespective of the form the labour efficiency improvement takes. In all cases the increase in labour efficiency decreases the price of labour, measured in efficiency units, and production costs fall. There are a number of conflicting pressures for employment. That is, there is some downward pressure on employment as less labour is required to produce the same output.

The derived demand for labour, however, is stimulated through substitution- and competitiveness effects. Employment rises in the long run if the stimulus to labour demand coming through substitution- and output effects is greater than the negative impact of the direct increase in labour efficiency.

In the short run the increase in efficiency causes an initial fall in employment, and thereby also an increase in the unemployment level. The real wage also falls in the short run through the bargaining real wage function. Despite these initial negative effects seen in the labour market, GRP increases in all simulated periods above its base, mainly due to the stimulus to exports coming through the fall in domestic prices. There are, however, some significant differences across the three migration closures.

The free migration closure of the AMOSKI model ties down long-run unemployment rates and real wage rates to their initial equilibrium levels through the combination of regional bargained real wage and flow migration. Any change in the real wage and the unemployment rate entail a migration response which in turn limits and ultimately reverse real wages changes until the labour market is in long-run equilibrium with zero net migration flows. The free migration closure thereby imposes perfectly elastic supply of inputs across long-run equilibria.

It must be noted that even though both the employment rate and the real wage return to their base year levels, there are periods in which 'benefits' arise. That is, there are periods in which the real wage increases above its base, and periods in which the unemployment rate falls below its base. This is detailed in, for example, Figure 8.4.2.

Initially the unemployment rate rises as a result of the increase in efficiency, and the real gross wage falls. Workers thereby migrate out of Scotland in the free migration closure. Towards the long run, workers migrate back into Scotland as the unemployment rate falls and real wages rise. Real wages and the unemployment rate thereby return to their initial equilibrium levels due to the inflow of workers from outside Scotland.

In contrast to the free migration closure, the unskilled labour force is fixed in the skilled migration closure. This means that in response to changes in the demand for unskilled labour, the unskilled real wage and unemployment rate will adjust. If demand for unskilled labour rises, unskilled real wages rise and their unemployment rate falls. The skilled labour force is available at infinitely elastic supply in the skilled migration closure across long-run equilibria, which again ties down the skilled unemployment rate and the skilled real wage to their initial equilibrium in the long run. Skilled labour thereby experience the same adjustment mechanisms seen in the free migration closure.

The key in the skilled migration closure is that the bargaining power of unskilled workers is increased as demand for unskilled labour rises together with a fixed unskilled labour force. That is, unskilled workers are able to achieve an increase in their real wage, and a smaller cut to their nominal wages in the skilled migration closure as compared to the free migration closure.

Neither the aggregate unemployment rate nor aggregate real wages revert back to their initial equilibrium levels in the skilled migration closure. As prices fall by less in the skilled migration closure as compared to the free migration closure there is less stimulus to exports and output. The stimulus to output is thereby muted by the restriction of the supply of unskilled workers.

In the no migration closure the supply of labour is further restricted so that neither skilled nor unskilled migrate between regions. The most direct impact, as compared to the other migration closures, is that the skilled real wage increases in the long run in the no migration closure (but by less than the unskilled real wage). The bargaining power of skilled and unskilled workers is thereby increased as demand for labour rises together with a fixed labour force. That is, both skilled and the unskilled workers are able to achieve an increase in their real wage, and a smaller cut to their nominal wages in the no migration closure as compared to the skilled and the free migration closures.

Prices thereby fall by less than in the skilled migration closure. This in turn reduces the stimulus to exports, and thereby the stimulus to the demand for labour. All sectors experience a competitiveness penalty in the no migration closure as the supply of both skilled and unskilled workers is restricted. This in turn causes some crowding out of output.

Migration assumptions amplify the differential effects between the two skill categories. However, the general employment, unemployment, and real wage adjustment patterns of the two skill categories are similar across the skill-neutral and the skill-differentiated increases in labour efficiency.

That is, there is a clear tendency towards larger long run percentage increases in unskilled employment as compared to skilled employment. Also, the short run sees a smaller percentage fall in unskilled employment as compared to the fall seen in skilled employment. Skilled employment increases more strongly in the skilled migration case, which is mainly driven by the migration assumption. This holds irrespective of whether labour efficiency is increased as skill-neutral or skill-differentiated.

This ‘bias’ towards a stronger increase in unskilled employment is driven mainly by sectoral characteristics. Even though all of the sectors experience the same shock, there are significant differences across sectors. Moreover, the stimulus to exports is not skill-neutral and this drives the non-neutral impacts on employment.

Sectors typically see a stimulus to output due to the fall in prices and the corresponding increase in exports. The export led growth stimulates domestic consumption, intermediate demand and investment too. This increase in output further stimulates the demand for skilled and unskilled labour. There are, however, sectors that experience a fall in employment. These sectors mainly serve domestic households and public sector consumption. Some of these sectors, particularly the Public administration sector, hold a large share of total employment, and are also relatively skill intensive.

Table 8.7.1: Short- and long-run effects of a 5% increase in skill-neutral and skill-differentiated labour efficiency. In % changes

	LR - Free migration			LR - Skilled migration			LR - No migration			SR		
	Total efficiency	Skilled efficiency	Unskilled efficiency	Total efficiency	Skilled efficiency	Unskilled efficiency	Total efficiency	Skilled efficiency	Unskilled efficiency	Total efficiency	Skilled efficiency	Unskilled efficiency
GRP Income measure	6.60	4.17	2.13	5.94	3.80	1.95	5.34	3.44	1.79	2.36	1.56	0.83
Consumer Price Index	- 3.31	- 2.14	- 1.12	- 3.00	- 1.96	- 1.02	- 2.71	- 1.78	- 0.94	- 1.94	- 1.29	- 0.69
Unemployment Rate	- 0.00	- 0.00	- 0.00	- 5.47	- 3.36	- 1.82	- 7.78	- 4.83	- 2.51	15.89	10.26	5.25
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 0.00	- 0.00	- 5.75	- 3.60	- 1.64	17.08	10.89	5.79
Unemployment Rate U	- 0.00	- 0.00	- 0.00	- 10.94	- 6.71	- 3.65	- 9.82	- 6.06	- 3.37	14.70	9.63	4.71
Total Employment	1.69	1.01	0.49	1.05	0.64	0.30	0.46	0.28	0.14	- 1.04	- 0.67	- 0.35
Total Employment S	1.39	0.83	0.37	1.23	0.75	0.33	0.37	0.23	0.10	- 1.09	- 0.69	- 0.37
Total Employment U	2.27	1.35	0.72	0.70	0.43	0.23	0.63	0.39	0.22	- 0.94	- 0.61	- 0.30
Nominal Gross Wage	- 3.31	- 2.14	- 1.12	- 2.37	- 1.58	- 0.82	- 1.80	- 1.22	- 0.65	- 3.61	- 2.40	- 1.28
Nominal Gross Wage S	- 3.31	- 2.14	- 1.12	- 3.00	- 1.96	- 1.02	- 2.02	- 1.35	- 0.75	- 3.78	- 2.51	- 1.36
Nominal Gross Wage U	- 3.31	- 2.14	- 1.12	- 1.73	- 1.19	- 0.61	- 1.58	- 1.09	- 0.56	- 3.44	- 2.30	- 1.20
Real Gross Wage	0.00	0.00	0.00	0.65	0.39	0.21	0.94	0.57	0.29	- 1.70	- 1.13	- 0.59
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.44	0.20	- 1.87	- 1.23	- 0.67
Real Gross Wage U	0.00	0.00	0.00	1.31	0.78	0.42	1.16	0.70	0.38	- 1.52	- 1.02	- 0.51
Labour force	1.69	1.01	0.49	0.81	0.49	0.22	-	-	-	-	-	-
Labour force S	1.39	0.83	0.37	1.23	0.75	0.33	-	-	-	-	-	-
Labour force U	2.27	1.35	0.72	-	-	-	-	-	-	-	-	-
Households Consumption	1.49	0.91	0.45	1.33	0.83	0.41	1.19	0.75	0.38	- 0.87	- 0.58	- 0.31
Investment	6.33	3.99	2.04	5.69	3.63	1.86	5.11	3.29	1.71	4.96	3.32	1.78
Export RUK	5.93	3.76	1.93	5.34	3.43	1.76	4.80	3.11	1.62	1.82	1.21	0.65
Export ROW	6.17	3.92	2.01	5.56	3.57	1.84	5.00	3.24	1.69	2.40	1.59	0.85

The transmission mechanism that benefit the unskilled seem to be structural. That is, sectoral effects, and the 'unskill intensity' of Scottish exports tend to stimulate the unskilled labour market by more than the skilled labour market when labour efficiency is increased. The negative impact on employment seen in sectors that mainly serve the domestic market, and the relative size and skill intensity of these sectors, is one of the main factors that determine the overall impact on skilled and unskilled employment. In particular, employment contractions seen in the Public administration sector have the potential to shift the overall employment effects in favour of the unskilled.

Table 8.7.2 gives the present values for employment, real wages, and GRP changes for a number of policy relevant time horizons e.g. 1-5 years, 1-10 years, 1-15 years, 1-20 years, and 1-30 years for the skill-neutral increase in labour efficiency. It must be noted that the main characteristics discussed for the skill-neutral present values also hold for the skill-biased cases, although they differ in magnitude. To recall, Appendix 8A gives a description on the calculations of the present values, and also details the results for the skill-biased cases. Also, it must be noted that gradual increases in labour efficiency generates similar results as detailed in the sensitivity analysis in Section 8.6.

Table 8.7.2: Present values for GRP, employment, and real wage changes of the skill-neutral increase in labour efficiency

		PV$_{t=1..5}$	PV$_{t=1..10}$	PV$_{t=1..15}$	PV$_{t=1..20}$	PV$_{t=1..30}$
Free migration						
	GRP changes	12.87	29.41	46.54	62.52	150.99
	Total Employment S	- 73.66	- 91.83	- 76.42	- 48.37	175.01
	Total Employment U	- 38.14	- 29.58	3.04	42.87	309.84
	Real Gross Wage S	- 0.53	- 0.11	0.10	0.21	0.30
	Real Gross Wage U	- 0.13	0.11	0.23	0.29	0.34
Skilled migration						
	GRP changes	1.34	3.01	4.68	6.21	14.27
	Total Employment S	- 76.71	- 92.76	- 73.76	- 44.00	161.75
	Total Employment U	- 17.02	- 9.28	4.58	19.21	104.31
	Real Gross Wage S	- 0.55	- 0.07	0.13	0.22	0.28
	Real Gross Wage U	- 0.66	- 0.33	0.26	0.89	4.59
No migration						
	GRP changes	1.47	3.26	4.94	6.39	13.70
	Total Employment S	- 38.12	- 35.93	- 24.40	- 12.36	51.63
	Total Employment U	- 19.33	- 9.27	6.54	21.59	99.55
	Real Gross Wage S	- 2.16	- 2.03	- 1.31	- 0.56	3.45
	Real Gross Wage U	- 0.75	- 0.32	0.36	1.00	4.37

GRP in £million. FTE Employment in thousands. Real gross wage in £million.
See Appendix 8A for details and the skill-biased results.

The present values for GRP changes in Table 8.7.2 are positive across all of the policy relevant time horizons. The present values for employment and real wages are, however, unambiguously negative in years 1-5. In years 1-10 there are some positive present values for unskilled real wages. In the years 1-15 negative present values are largely seen in skilled employment and real wages whilst the remaining present values are positive.

Towards year twenty, however, present values for employment and real wages gradually turn positive, and are positive in year thirty for both the skilled and the unskilled. Thus, there are long term benefits for both skill categories regardless of whether skill-neutral or skill-differentiated labour efficiency is increased. These benefits, are however, skewed towards the unskilled.

The present values for the labour market variables reaffirm that there are significant negative effects in the first 5, 10, and 15 years after the shock. Even though these negative effects are experiences by both skill categories, the skilled see deeper and more prolonged falls in employment and the real wage. There are periods in which the present values for skilled employment and real wage are negative whilst these for the unskilled are positive. This may be a challenge for policy makers in the political decision making process.

The results show that policy makers must be significantly forward looking i.e. it would require policy makers to take into consideration a 20 year forward looking time-horizon in order to identify significant benefits to the labour market. Given that general elections for the Scottish Parliament are held every four years this may be difficult to achieve. The potential prospects of immediate and long term output growth may, however, outweigh the initial negative labour market impacts seen in the initial years following the shock. Given this, it must be stressed that the time horizon over which net-benefits of policies are assessed are crucial, as the negative effects experienced in the labour market in the time horizons immediately relevant for policy makers may limit the incentive to pursue such policy.

Chapter 9

Chapter 9

Thesis postlude

Scotland's Economic Strategy sets out a number of priorities for increasing long-term economic growth. These are underpinned by key policy initiatives such as increasing exports, making better use of skills in the workplace, and increasing the skilled workforce in a framework where these policies are intended to be 'mutually supportive' (Scottish Government, 2015). In order to achieve these objectives, policy makers require detailed data and modelling tools to assess potential system-wide impacts of policies set out within Scotland's Economic Strategy.

Currently, however, there are limited analytical tools available to assess the potential interactions and trade-offs between growth objectives set out by the Scottish Government. Moreover, there are no methods available to make system-wide and sectorally disaggregated assessments of policies that directly or indirectly affect labour market sub-categories, including workers with different educational attainments. This is despite the skill dimension being a crucial element within a number of key areas of the Economic Strategy. Multi-sectoral modelling tools that incorporate a disaggregated labour market can help to identify the potential macro-economic and distributional impacts of such policies.

This thesis constructs and applies multi-sectoral models with particular focus on analysing the skill-dimension. It also sheds light on: distributional aspect of policies across different household groups; sectoral impacts; how underlying characteristics of the Scottish economy influence policy outcomes; and whether policies within Scotland's Economic Strategy are 'mutually supportive'.

This thesis contributes to the multi-sectoral policy analysis of the Scottish economy through building and extending the commonly used Social Accounting Matrix (SAM) framework and conducting policy relevant analyses within Input-Output (IO), SAM and Computable General Equilibrium (CGE) models. The following subsection 9.1 summarises each of the chapters and highlights their contribution to the relevant literature.

9.1 Contributions

Chapter 2: Social Accounting Matrix for Scotland

Chapter 2 constructs a SAM for Scotland for 2009, which details the flows of incomes and expenditures through the Scottish economy in that year. SAMs for Scotland have been produced on a semi-regular basis over the past decade. However, thus far no consistent method for building a SAM for Scotland had been formalised.

The method developed in this thesis makes two distinct contributions to the Scottish SAM framework. First, this method is easily replicable for other base years and has since been employed a number times by the Fraser of Allander Institute and the Scottish Government. Second, this method improved the accuracy of many entries through employing a wider range of data sources than previous versions of Scottish SAMs. The SAM is publicly available and has proved valuable to other researchers, such as Allan et al. (2016) and Figus et al. (2016).

The SAM constructed in Chapter 2 therefore provides a highly disaggregated, comprehensive and consistent record of the interrelationships within, and characteristics of, the Scottish economy at the level of individual industrial sectors, factors of production and institutions. These data provide considerable insights to policy makers without the need to employ complex modelling techniques. However, these data also form the foundation upon which a range of multi-sectoral models can be developed, as is demonstrated in this thesis.

Chapter 3: Skill-disaggregated Social Accounting Matrix

The Scottish SAM, as computed in Chapter 2, assumes a homogeneous labour force and only reports aggregate employment and wage income figures for each of the industries contained in the SAM. Under these circumstances, wage rate differentials between sectors are interpreted as reflecting industry premia. Chapter 3 develops and applies a method to disaggregate the wage payment entries in the SAM by skill categories, distinguished by highest qualification attained. The skill-disaggregated SAM thereby provides a framework allowing the identification of wage and employment differentials by worker type and industry, reflecting economic conditions within the labour market more precisely.

The main contribution of Chapter 3 is to develop and apply a method to disaggregate the wage payment entries in the SAM. This generates a unique data set that sheds light on socio-economic issues such as the return to education. The data given in the skill-disaggregated SAM thereby provides considerable insights to policy makers into key structural characteristics of the Scottish labour market. However, the disaggregated SAM also forms the foundation upon which this thesis develops a variety of modelling techniques.

Chapter 4: Type II multiplier analysis

Chapter 4 compares methods for calculating IO Type II multipliers. These are formulations of the standard Leontief IO model which endogenise elements of household consumption. There are two basic IO Type II multiplier methods that are available in the literature and differences between the two do not appear to be explicitly acknowledged or understood. An analytical comparison of the two IO Type II multiplier methods with the SAM multiplier approach identifies the treatment of non-wage income generated in production as a central issue. The multiplier values for each of the IO and SAM methods are calculated using Scottish data for 2009.

Chapter 4 contributes to the methods used for policy analysis. The difference in methods for calculating IO Type II multipliers is potentially problematic for their interpretation, their use in modelling demand-side disturbances, and their value for comparing the structural characteristics of different economies. The results generated in this chapter are used to identify whether empirically this is a serious problem. The Scottish results suggest that it is. Given the variations in methods, it is valuable to standardise the Type II procedure, which requires choosing amongst the different formulations. If the SAM multipliers embody the most complete linking of income generated in production and the subsequent distribution to households for Scotland, the method used by the Scottish Government gives the closest to the SAM value though it does systematically underestimates the SAM multiplier values.

Despite some of the models coming close to SAM multipliers, the analysis presented in Chapter 4 shows that the tested Type II methods have a fundamental weakness; they all explicitly endogenise wages, and link household expenditure to these. A SAM multiplier incorporates income from other value added into household income in a way completely consistent with the standard demand-driven IO approach. It is therefore the only wholly satisfactory means of endogenising household consumption in the application of such an approach.

Chapter 5: Effects of exogenous demand shocks - a SAM modelling approach

Chapter 5 analyses the distributional effects of exogenous demand shocks within the Scottish economy. This is accomplished by employing a SAM model for Scotland that contains detailed information of the main transactors, as well as a disaggregated household account and two types of labour which are defined by their educational achievements. Also, any differential impacts on the two skill categories arising from the exogenous demand shock are used to identify whether that part of the Scottish economy reacting to the exogenous demand shock is more skilled or unskilled-intensive.

The results of the exogenous demand shock quantify the potential impacts on macroeconomic variables such as Gross Regional Product (GRP), output, employment, and wage rates. The results also show that these vary significantly depending on the sectors that experiences the initial demand stimulus. The ability to assess these potential impacts is of critical importance to policy makers.

The results also highlight potential trade-offs between policy objectives that are initially designed to be 'mutually-supportive'. For example, results suggest that exports (to both the RUK and the ROW) tend to be more unskilled intensive than the average. This would suggest a potential trade-off between the skills objective and the objective to increase exports.

These potential trade-offs are also highlighted in the impact on individual household groups as these also vary significantly depending on the sector that experiences the initial demand stimulus. The income effects from a demand stimulus tend to be skewed towards the higher income households. Over 59% of the additional incomes generated by the demand stimulus goes to the top 20% of households and only 5% to the bottom 20%. The exogenous demand shock therefore does not benefit the lowest household income bands very much due to their weak links with the labour market. This ability to assess potential impacts on individual household income groups is of particular importance to the Scottish Government as the policy of inclusive growth aims to tackle a range of issues from poverty and income inequality to health and life expectancy. Results presented here show that these exogenous demand shocks would have negative effects on income equality.

The modelling capacity developed in Chapter 5 contributes to the potential analysis of policies set out in the Scotland's Economic Strategy in several ways. First, potential system wide impacts of exogenous demand stimuli (as related to the export led growth strategy) are assessed and described in detail. This is done at the individual sector level, outlining potential impacts on output, employment (skilled and unskilled), and distributional effects on households with different income levels. Second, potential trade-offs between the main growth objectives of the Economic Strategy are identified. The analysis presented in this chapter is therefore of importance to several interrelated objectives set out within Scotland's Economic Strategy as it aids the identification of issues surrounding the policy of increasing international exports at the individual sector level, but also sheds light on the skill-dimension and distributional effects across households. These are key areas of interest to the Scottish Government.

Chapter 6: The skill-disaggregated AMOS model

Chapter 6 outlines the theoretical framework underpinning CGE models. Technical specifications of the myopic AMOS model are given and the skill related modifications and extensions that this thesis introduces into the model are outlined. The skill-disaggregated AMOS model (AMOSKI) enhances the standard model with a more detailed treatment of the labour market, incorporating two types of labour which are distinguished by their education levels. The skill-disaggregated model specifies different migration, labour demand, and wage functions for the two skill categories.

Model extensions presented in this chapter directly contribute to the current literature by developing a tool to better understand the skill-disaggregated labour market and potential impacts of skill-differentiated migration responses. The AMOSKI model is then employed in the following chapters to analyse system-wide impacts of potential policy shocks relevant to Scotland's Economic Strategy.

Chapter 7: Export demand shocks in the skill-disaggregated AMOS model

Chapter 7 employs the AMOSKI model to simulate a number of export shocks adopting different assumptions about the migration behaviour of skilled and unskilled labour. That is, demand shocks to the Food & drink sector, and the Financial services sector are simulated. These are key growth sectors of the Scottish economy, and the Food & drink sector is targeted directly by policy makers in their efforts to increase international exports.

The skill intensity of exports, as also assessed in the SAM model, is revisited in a CGE modelling context in order to gain policy relevant insights into the export characteristics of the Scottish economy. Using the AMOSKI model facilitates the separate identification of the varying impacts on the skilled and unskilled, whilst also detailing policy relevant system-wide impacts in a multi-sectoral modelling framework. As in the SAM model, results show that aggregate impacts vary significantly depending on the sector that experiences the stimulus. However, these differences are amplified when taking into account skill specific migration behaviour. The skill component of the AMOSKI model thereby significantly enhances the modelling capacity and the capability of potential policy analysis.

Chapter 7 contributes to the analysis of policies set out in the Scotland's Economic Strategy in several ways. First, the results presented in this chapter reconfirm and extend the analysis presented in Chapter 5 within a CGE modelling context. That is, potential system wide impacts of export demand shocks are assessed and the transmission mechanism described in detail. This is done at the individual sector level, outlining potential impacts of export demand shocks to key sectors of the Scottish economy. Results detail potential impacts on macroeconomic variables such as GRP, and also explicitly contrast skill-differentiated labour market impacts. Second, the CGE analysis allows for the modelling of skill-differentiated migration responses. Results show that this extension to the model significantly influences the results, and is thereby a crucial addition to the model specification. Third, results presented in this chapter confirm that export led growth strategies are not necessarily mutually supportive to the skill objectives within the Economic Strategy and thereby identify potential trade-offs between growth objectives.

The multi-sectoral model constructed and applied in Chapter 7 is therefore of importance to policy makers as it aids identification of: issues surrounding the policy of increasing international exports at the individual sector level; system-wide impacts of skill-differentiated migration responses; potential trade-offs between growth objectives; and it also sheds light on the skill-dimension of export led growth policies. This modelling capacity is of key importance to policy makers when formalising export led growth policies, and when assessing potential system-wide impacts, and trade-offs between other objectives within the Economic Strategy.

Chapter 8: Technical progress in the skill-disaggregated AMOS model

A key policy of the Scottish Government is 'to make better use of skills in the workplace'. This is interpreted here as encouraging a labour augmenting (Harrod-neutral) efficiency improvements where fewer workers are required to produce the same levels of output, with unchanged levels of other inputs. Given the importance of the skill dimension a range of alternative cases of labour-augmenting efficiency improvements are modelled in Chapter 8 using the AMOSKI model. That is, both skill-differentiated (a differential increase in skilled, as against unskilled, efficiency and vice versa), and skill-neutral (an equal increase in labour efficiency across all skill types) labour-augmenting improvements are introduced into the model and analysed.

Chapter 8 contributes to current policy analysis by analysing potential system-wide impacts of labour-augmenting technological change, a key long-term growth policy of the Scottish Government, in detail. Moreover, skill-differentiated and skill-neutral improvements in labour efficiency are modelled to gain a better understanding of the skill-dimension of this policy.

The results also highlight potential trade-offs that policy makers face. That is, results show that technological change potentially generates negative short-term impacts in the labour market, but positive overall economic impacts on GRP growth in both the short- and long-run. Also, these negative labour market impacts are biased towards one skill category. This bias towards one skill category highlights that the objective to increase labour augmenting technological change is not necessarily mutually supportive to the skill objectives within the Economic Strategy. This means that policy makers face a number of decisions that may be hard to implement in a political decision making context.

As also identified in Chapters 5 and 7, the underlying sectoral structure of the Scottish economy is crucially important in determining overall economic outcomes. That is, there are a small number of sectors that strongly influence macroeconomic outcomes, as well as labour market outcomes at individual skill levels. The ability to identify sector specific impacts is therefore significantly important.

The modelling framework and the analysis presented in this chapter aids identification of: issues surrounding the policy of increasing labour efficiency; potential benefits and costs of technological change; key structural characteristics of the Scottish economy at the individual sector level; and potential trade-offs between growth objectives. These are a number of crucially important issues to policy makers and are largely unexplored in the current assessment of the Economic Strategy.

9.2 Further research

As stated in Chapter 2 there are some SAM entries which would benefit from the availability of more robust data. For example, more accurate figures for 'private pension' payments for Scottish households and the flow of funds between Scotland and the external sector would improve the accuracy of the Scottish SAM. Most publications only state the flow of funds between the UK and ROW, hence, more details on the interregional flows to and from Scotland and the RUK and ROW would also enhance the data quality of the SAM. Issues regarding this information will become more important with increased devolution.

The multiplier analysis in chapter 5 established which Type II multiplier offers the 'best fit' for Scottish data. Extending this research to other regions and countries would prove additional verification. This would provide researchers with an indication as to which method to use for which national dataset, and which method to select when using multiple datasets.

Heterogeneity of households is a challenge that needs to be confronted and embraced (Kim et al., 2016). Connections between the household and the labour income accounts are also of critical significance (Boeters & Savard, 2011). Moreover, assessing the impacts of policies on a range of household groups is of particular importance to the Scottish Government as it is concerned with promoting equality and inclusive growth. This has been addressed in this thesis through the use of the highly disaggregated SAM model for Scotland. However, a valuable extension to the AMOSKI model would be the disaggregation of the household accounts, and connecting these to the skill-disaggregated labour market.

The ability to model forward looking agents is needed when, for example, simulating the impact of temporary shocks. Allan et al. (2016), for example, show that behavioural characteristics and factor supply assumptions play a significant role in determining the economic impact of tourist expenditures, particularly where expenditures are temporary (i.e. of limited duration) and anticipated (i.e. known in advance). Further extensions to the AMOSKI model could thereby focus on introducing a closure that allows for the modelling of forward looking agents, as done by Lecca et al. (2013).

Given the high level of disaggregated skill data available in the SAM, future extension to the AMOSKI model could focus on introducing a larger number of skill categories into the CGE model. For example, the Scottish Government are particularly interested in the assessment of work-based learning programmes, including Modern Apprenticeships, delivered by Skills Development Scotland. The assessment of potential macroeconomic impacts of these programmes is largely unexplored in the current policy literature. Extension presented in this thesis provide a solid starting point for more detailed policy analysis that focuses on the assessment of system-wide impacts of work-based learning initiatives.

It should be noted, however, that any further skill-disaggregation must be accompanied by detailed microeconometric work on the required elasticities. Research presented in this thesis identified a lack of robust estimates for some of the elasticities - even at very aggregated skill levels.

Given the importance of the public sector to macroeconomic and skill specific outcomes, a proposed addition to the AMOSKI model is a more detailed treatment of the government sector. That is, the government sector could be further disaggregated to reflect the three government sectors operating in Scotland, namely the UK Government, the Scottish Government and the Local Government, as explored by Emonts-Holley (2016) for example. Within that framework it would be possible to explore the impact of various alternative endogenous policy responses at each level of government.

The skill extensions outlined in this thesis could be implemented in a interregional model (McGregor et al., 1999). This would allow modelling of potential spillover and feedback effects in the skill-disaggregated labour market more precisely. This may become particularly important to the Scottish Government in response to possible migration restrictions imposed by Britain's exit from the European Union. Furthermore, the interregional extension would be essential to capture aspects of the new Financial Framework that links Scotland and the UK, including the principle of 'no detriment'. While this thesis is based on a case study of Scotland, the modelling tools constructed and applied can potentially be applied in any regional context (where the data will allow).

Appendices

Appendix 3A

Sectoral wage and employment characteristics

	Labour income (£bn)				FTE Employment (th)				Wage rates (£th)		
	Skilled	%	Unskilled	%	Skilled	%	Unskilled	%	Average	Skilled	Unskilled
1. Agriculture	123	45	152	55	16	39	25	61	7	8	6
2. Forestry planting	9	60	6	40	1	53	1	47	8	9	7
3. Forestry harvesting	13	54	11	46	1	47	2	53	8	9	7
4. Fishing	4	16	22	84	0	15	2	85	9	10	9
5. Aquaculture	13	46	15	54	1	45	1	55	11	11	11
6. Coal & lignite	8	27	21	73	0	25	1	75	21	23	20
7. Oil & gas extraction, meta	-	-	-	-	-	-	-	-	-	-	-
8. Other mining	28	34	56	66	1	33	2	67	29	30	29
9. Mining Support	415	77	127	23	15	72	6	28	26	28	22
10. Meat processing	53	32	114	68	1	25	5	75	28	36	25
11. Fish & fruit processing	104	45	128	55	3	40	5	60	27	30	25
12. Dairy products, oils & fat	73	69	32	31	2	66	1	34	34	36	31
13. Grain milling & starch	1	6	11	94	0	5	0	95	43	51	42
14. Bakery & farinaceous	122	37	207	63	4	33	8	67	28	32	27
15. Other food	62	58	44	42	2	50	2	50	29	34	24
16. Animal feeds	14	54	12	46	0	46	0	54	32	37	27
17. Spirits & wines	362	51	342	49	4	46	5	54	74	83	66
18. Beer & malt	24	76	8	24	1	74	0	26	40	41	38
19. Soft Drinks	53	70	22	30	1	67	1	33	40	42	36
20. Tobacco	-	-	-	-	-	-	-	-	-	-	-
21. Textiles	65	41	92	59	3	37	4	63	23	26	22
22. Wearing apparel	36	42	49	58	2	42	2	58	20	21	20
23. Leather goods	-	-	16	100	-	-	1	100	27	-	27
24. Wood & wood products	103	45	125	55	3	41	5	59	29	32	27
25. Paper & paper products	83	44	103	56	2	42	3	58	34	36	33
26. Printing & recording	120	68	56	32	4	64	2	36	31	33	27
27. Coke, petroleum & petroche	88	80	22	20	2	76	1	24	41	43	35
28. Paints, varnishes & inks e	7	55	6	45	0	55	0	45	36	36	37
29. Cleaning & toilet preparat	14	63	8	37	0	58	0	42	29	31	25
30. Other chemicals	116	77	35	23	2	74	1	26	68	70	61
31. Inorganic chemicals, dyest	53	82	12	18	1	81	0	19	52	53	49
32. Pharmaceuticals	92	66	47	34	1	61	1	39	60	65	51
33. Rubber & Plastic	133	36	235	64	3	33	6	67	45	49	42
34. Cement lime & plaster	32	30	75	70	1	27	2	73	45	52	43
35. Glass, clay & stone etc	61	44	78	56	1	38	2	62	41	48	37
36. Iron & Steel	29	52	27	48	1	50	1	50	54	57	52
37. Other metals & casting	28	80	7	20	1	74	0	26	37	40	29
38. Fabricated metal	621	59	429	41	15	54	12	46	39	43	35
39. Computers, electronics & o	428	69	195	31	8	63	4	37	52	56	44
40. Electrical equipment	65	29	160	71	1	24	4	76	47	57	43

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	Labour income (£bn)				FTE Employment (th)				Wage rates (£th)		
	Skilled	%	Unskilled	%	Skilled	%	Unskilled	%	Average	Skilled	Unskilled
41. Machinery & equipment	521	65	281	35	10	61	6	39	51	54	46
42. Motor Vehicles	62	50	63	50	1	44	1	56	51	57	46
43. Other transport equipment	478	80	117	20	9	78	2	22	54	56	47
44. Furniture	48	64	28	36	2	61	1	39	29	30	27
45. Other manufacturing	153	65	81	35	4	60	3	40	35	38	30
46. Repair & maintenance	463	70	200	30	8	67	4	33	59	61	54
47. Electricity	429	68	202	32	7	62	5	38	52	57	44
48. Gas etc	160	76	50	24	4	72	2	28	37	39	31
49. Water & sewerage	208	72	81	28	3	67	2	33	56	60	47
50. Waste	147	36	266	64	3	33	7	67	42	45	40
51. Remediation & waste manage	1	67	1	33	0	61	0	39	15	17	13
52. Construction - buildings	854	60	575	40	28	56	22	44	28	30	26
53. Construction - civil engin	627	66	330	34	17	60	11	40	34	37	29
54. Construction - specialised	1,302	56	1,018	44	48	53	43	47	25	27	24
55. Wholesale & Retail - vehic	480	50	476	50	20	47	23	53	22	24	21
56. Wholesale - excl vehicles	1,003	44	1,291	56	29	38	46	62	31	35	28
57. Retail - excl vehicles	1,758	48	1,883	52	82	43	108	57	19	22	17
58. Rail transport	159	61	101	39	3	53	3	47	40	46	34
59. Other land transport	336	38	554	62	16	34	30	66	20	22	19
60. Water transport	64	64	36	36	2	61	1	39	39	41	36
61. Air transport	112	56	90	44	2	51	2	49	51	55	46
62. Support services for trans	482	52	444	48	13	46	15	54	33	37	29
63. Post & courier	214	39	340	61	6	35	12	65	31	34	29
64. Accommodation	442	55	367	45	23	49	24	51	17	19	15
65. Food & beverage services	665	47	755	53	39	42	53	58	16	17	14
66. Publishing services	177	76	55	24	6	70	3	30	27	30	22
67. Film video & TV etc	49	77	15	23	3	72	1	28	14	15	12
68. Broadcasting	39	86	6	14	1	79	0	21	47	51	32
69. Telecommunications	626	72	244	28	14	67	7	33	40	43	34
70. Computer services	741	85	128	15	23	80	6	20	30	32	23
71. Information services	56	78	16	22	2	76	1	24	32	33	30
72. Financial services	1,698	68	794	32	28	62	17	38	55	61	46
73. Insurance & pensions	813	80	209	20	14	74	5	26	55	59	43
74. Auxiliary financial servic	372	70	160	30	14	64	8	36	24	26	19
75. Real estate - own	161	75	55	25	11	70	5	30	13	14	11
76. Imputed rent	-	-	-	-	-	-	-	-	-	-	-
77. Real estate - fee or contr	107	73	39	27	7	67	3	33	15	16	12
78. Legal activities	383	81	89	19	15	75	5	25	23	25	18
79. Accounting & tax services	290	81	68	19	26	76	8	24	10	11	8
80. Head office & consulting s	543	90	61	10	16	87	2	13	33	35	26
81. Architectural services etc	1,844	90	212	10	49	87	8	13	36	38	28
82. Research & development	297	93	23	7	7	90	1	10	40	41	28
83. Advertising & market resea	88	81	20	19	4	78	1	22	19	20	16
84. Other professional service	117	83	24	17	7	79	2	21	15	16	12

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	Labour income (£bn)				FTE Employment (th)				Wage rates (£th)		
	Skilled	%	Unskilled	%	Skilled	%	Unskilled	%	Average	Skilled	Unskilled
85. Veterinary services	76	84	15	16	3	80	1	20	27	28	22
86. Rental & leasing services	210	60	138	40	8	54	7	46	23	25	20
87. Employment services	666	65	353	35	26	61	17	39	24	26	21
88. Travel & related services	101	67	49	33	4	62	3	38	21	23	18
89. Security & investigation	92	52	85	48	6	47	6	53	15	17	14
90. Building & landscape servi	217	36	386	64	18	30	40	70	10	12	10
91. Business support services	225	54	194	46	11	49	12	51	18	20	17
92. Public administration & de	3,624	72	1,440	28	95	67	47	33	36	38	31
93. Education	5,452	85	938	15	129	80	32	20	40	42	29
94. Health	4,507	79	1,210	21	130	73	49	27	32	35	25
95. Residential care	767	60	520	40	30	54	25	46	23	26	21
96. Social work	1,533	75	522	25	51	69	23	31	28	30	23
97. Creative services	124	90	14	10	4	87	1	13	28	29	22
98. Cultural services	148	70	64	30	7	63	4	37	19	21	15
99. Gambling	67	49	71	51	3	42	4	58	20	23	17
100. Sports & recreation	365	58	264	42	16	53	14	47	21	22	18
101. Membership organisations	182	83	38	17	15	76	5	24	11	12	8
102. Repairs - personal & hous	47	60	31	40	2	55	1	45	25	28	22
103. Other personal services	260	59	177	41	13	57	10	43	19	20	18
104. Households as employers	89	42	123	58	1	35	1	65	130	157	116
Total	41,974	66	21,587	34	1,302	58	928	42	29	32	23

Appendix 3B

Share of Standard Occupational Classification (SOC) employment share in each skill category

	SOC1	SOC2	SOC3	SOC4	SOC5	SOC6	SOC7	SOC8	SOC9
1. Higher degree	21	54	17	4	1	1	1	1	2
2. NVQ level 5	20	12	20	10	18	11	5	2	3
3. First/Foundation degree	23	33	25	6	3	4	2	1	3
4. Other degree	22	37	22	6	2	5	4	0	3
5. NVQ level 4	32	7	17	8	5	15	5	8	3
6. Diploma in higher educ	22	29	28	6	4	6	3	1	1
7. HNC,HND,BTEC etc higher	17	9	21	16	10	11	6	5	5
8. Teaching, further educ	25	44	16	-	-	12	1	-	1
9. Teaching, secondary educ	8	78	3	-	5	5	-	-	-
10. Teaching, primary educ	9	86	-	-	-	2	3	-	-
11. Teaching foundation stage	-	-	-	100	-	-	-	-	-
12. Teaching, level not stated	3	58	20	-	11	-	-	-	8
13. Nursing etc	10	2	61	3	0	18	5	0	1
14. RSA higher diploma	-	-	-	67	-	-	-	-	33
15. Other higher educ below degree	12	16	28	14	4	11	7	-	8
16. NVQ level 3	9	3	13	12	20	28	4	4	6
17. Advanced Welsh Bac'te	-	-	-	-	-	-	-	-	-
18. International Bac'te	10	16	-	27	-	-	18	-	29
19. GNVQ/GSVQ advanced	21	-	-	-	42	12	-	5	19
20. A level or equivalent	17	8	16	13	8	9	15	3	12
21. RSA advanced diploma	13	10	-	59	-	-	-	5	13
22. OND,ONC,BTEC etc, national	11	3	18	14	18	10	6	10	10
23. City & Guilds advanced craft/part 1	16	5	6	3	48	4	2	12	5
24. Scottish CSYS	37	6	19	11	3	4	15	3	2
25. SCE Higher or equivalent	18	4	15	25	8	7	10	4	10
26. Access qualifications	-	-	24	-	-	-	66	-	10
27. A,S level or equivalent	-	-	-	56	-	-	40	-	4
28. Trade apprenticeship	12	2	8	2	45	5	2	15	8
29. NVQ level 2 or equivalent	4	1	8	11	8	30	12	9	16
30. Intermediate Welsh Bac'te	-	-	-	-	-	-	-	-	-
31. GNVQ/GSVQ intermediate	-	-	-	40	-	12	23	6	19
32. RSA diploma	-	-	50	38	-	-	-	13	-
33. City & Guilds craft/part 2	20	6	4	6	13	8	4	26	14
34. BTEC,SCOTVEC first/general diploma etc	-	-	10	39	28	1	18	1	3
35. O level, GCSE grade A-C or equivalent	12	3	10	20	11	8	12	10	15
36. NVQ level 1 or equivalent	9	-	4	4	5	10	9	14	46
37. Foundation Welsh Bac'te	-	-	-	-	-	-	-	-	-
38. GNVQ,GSVQ foundation level	-	-	-	100	-	-	-	-	-
39. CSE below grade1,GCSE below grade c	7	1	5	9	10	5	17	15	30
40. BTEC,SCOTVEC first/general certificate	-	-	31	-	9	-	3	5	53
41. SCOTVEC modules	16	5	10	18	6	13	1	8	21
42. RSA other	16	-	5	54	-	-	13	1	10
43. City & Guilds Foundation/Part 1	12	-	8	-	27	40	-	4	10
44. YT,YTP certificate	-	-	-	-	43	29	12	15	-
45. Key Skills Qualif	26	-	-	2	12	8	11	12	28
46. Basic Skills Qualif	9	2	-	9	9	17	4	9	40
47. Entry Level qualif	27	-	3	14	-	2	-	27	27
48. Other qualif	10	4	6	8	13	11	6	21	22
49. No qualif	11	1	3	8	14	9	10	14	31
50. Don't know	16	3	6	18	14	8	9	11	15

Appendix 4A

Type I Output Multiplier

The Type I output multiplier (the "simple output multiplier") enables the estimation of knock-on effects throughout the economy of a change in final demand (Miller & Blair, 2009). The data used for this multiplier are the inter-industry linkages in the IxI table. That is the matrix made up of only the rows and columns of the inter-industry flows (see equation below).

It must be noted that the IxI, and thereby also the SAM tables, used for the calculations contain no data for industries 7 (Oil & gas extraction, metal ores) and 20 (Tobacco). Thus the total number of industries used here is 102, rather than the full 104 industries (under SIC 2007 code).

The first step in deriving IO multipliers is to construct the technical coefficient matrix, also referred to as the A-matrix. This matrix is calculated by dividing each entry of the inter-industry flows of the IO Tables by the relevant column total, i.e. the total expenditure in each sector (Miller & Blair, 2009).

Following the calculation outlined below, the Leontief Inverse is calculated. The column-sums of which are the output multiplier for each sector. Below is a brief outline of how the A-matrix of technical coefficients and the Leontief Inverse are derived.

First, the individual column entries of the inter-industry flows from the IO tables are divided by the relevant column total. For example, the first sector in the 2009 Scottish IxI table is Agriculture. The figure for the inter-industry flow from Agriculture to Agriculture is £339m and the column total ("Total output at basic prices") for Agriculture is £2,584.3m.

This results in the technical coefficient being estimated at 0.131 (this figure corresponds to the a_{11} in the equation below). Note that the A-matrix below is also labelled as A_{II}. The capital i's here are for the industry-by-industry coefficients.

$$A = \begin{pmatrix} a_{1,1} & \cdots & a_{1,j} \\ \vdots & \ddots & \vdots \\ a_{i,1} & \cdots & a_{i,j} \end{pmatrix}$$

The next step in order to be able to calculate the Leontief Inverse, is to construct the $(I - A)$-matrix. This matrix simply uses an identity matrix and subtracts the A-matrix from it.

The resultant matrix from this calculation has positive values on the diagonal (i.e. the inter-industry flow entries for the individual sectors between themselves). All other entries are negative. Following the example above, the identity matrix gives the value 1 for the Agriculture-Agriculture entry. This is then subtracted by the technical coefficient a_{11} at 0.131. The $(I - A)$-matrix entry (corresponding to $1 - a_{11}$) is calculated at 0.869.

$$I = \begin{pmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{pmatrix}$$

$$I - A = \begin{pmatrix} 1 - a_{1,1} & \cdots & 0 - a_{1,j} \\ \vdots & \ddots & \vdots \\ 0 - a_{i,1} & \cdots & 1 - a_{i,j} \end{pmatrix}$$

The last step for the calculation of the Leontief Inverse is inverting the $(I - A)$-matrix, thus deriving $L = (I - A)^{-1}$. The value for the Agriculture-Agriculture entry for the Leontief Inverse is calculated at 1.156 for the Type I output multiplier.

$$L = (I - A)^{-1} = Inverse \begin{pmatrix} 1 - a_{1,1} & \cdots & 0 - a_{1,j} \\ \vdots & \ddots & \vdots \\ 0 - a_{i,1} & \cdots & 1 - a_{i,j} \end{pmatrix}$$

The total output multiplier for the Agriculture sector is computed at 1.608 (see Appendix 4B). The Type I output multiplier gives the total value of production for all sectors required to satisfy a £1m increase in one sector. The Type I incorporates two distinct output effects. First, the direct effect shows the increase in production needed in sector i to satisfy the initial increase in final demand of £1m in sector i's output. Second, the indirect effect gives the increase in output that is generated as linkage effects in the production of intermediate inputs (Miller & Blair, 2009).

For example, if the final demand of the agriculture sector increases by £1m then the direct effect is a £1m increase in the Agriculture sector output (to satisfy the increase in final demand). The indirect effect is the additional output response by all other sectors, including the agriculture sector, to the initial shock. This second effect highlights the interdependencies of the various sectors in order to satisfy a final demand increase in one sector (Miller & Blair, 2009).

These multiplier effects are observed since sectors buy/sell intermediate inputs to one another. Therefore increase in sales in one sector increases output in others, this imposes a linear relationship between demand and output. IO analysis shows that, first, all output can be attributed to final demand, since all intermediate demand is endogenised. Second, as outlined above, multipliers show how a change in final demand results in the change in vector of outputs. The sum of these changes gives the value of the respective multiplier (Miller & Blair, 2009).

Appendix 4B

Output Multiplier: Type I, Type II, and SAM

	Type I	Type II: Miller & Blair	Type II: Batey1	Type II: Batey2	SAM
1. Agriculture	1.608	1.996	1.918	1.802	1.964
2. Forestry planting	1.615	2.111	2.011	1.863	1.972
3. Forestry harvesting	1.961	2.517	2.405	2.239	2.367
4. Fishing	1.611	1.995	1.918	1.803	1.933
5. Aquaculture	1.625	1.956	1.890	1.790	1.916
6. Coal & lignite	1.671	2.118	2.028	1.894	1.983
8. Other mining	1.435	1.985	1.874	1.709	1.786
9. Mining Support	1.501	1.858	1.786	1.679	1.847
10. Meat processing	1.917	2.410	2.311	2.163	2.250
11. Fish & fruit processing	1.695	2.229	2.122	1.962	2.044
12. Dairy products, oils & fats processing	1.923	2.478	2.366	2.200	2.300
13. Grain milling & starch	1.803	2.300	2.200	2.051	2.134
14. Bakery & farinaceous	1.426	2.088	1.955	1.756	1.840
15. Other food	1.609	2.189	2.072	1.898	1.980
16. Animal feeds	1.589	2.086	1.986	1.837	1.897
17. Spirits & wines	1.299	1.779	1.682	1.538	1.694
18. Beer & malt	1.367	1.814	1.724	1.590	1.746
19. Soft Drinks	1.493	2.057	1.944	1.774	1.872
21. Textiles	1.436	2.110	1.974	1.772	1.830
22. Wearing apparel	1.465	2.241	2.085	1.852	1.907
23. Leather goods	1.497	2.137	2.008	1.816	1.890
24. Wood and wood products	1.801	2.481	2.345	2.140	2.223
25. Paper & paper products	1.662	2.210	2.100	1.936	2.010
26. Printing and recording	1.378	2.232	2.060	1.804	1.883
27. Coke, petroleum & petrochemicals	1.204	1.312	1.290	1.258	1.321
28. Paints, varnishes and inks etc	1.421	1.972	1.861	1.696	1.756
29. Cleaning & toilet preparations	1.460	2.203	2.054	1.831	1.895
30. Other chemicals	1.251	2.099	1.928	1.674	1.765
31. Inorganic chemicals, dyestuffs & agrochemicals	1.314	1.939	1.814	1.626	1.716
32. Pharmaceuticals	1.349	2.018	1.884	1.683	1.776
33. Rubber & Plastic	1.491	2.266	2.110	1.878	1.948
34. Cement lime & plaster	1.594	2.257	2.124	1.925	1.997
35. Glass, clay & stone etc	1.473	2.207	2.059	1.839	1.915
36. Iron & Steel	1.401	2.067	1.933	1.734	1.803
37. Other metals & casting	1.449	2.032	1.915	1.740	1.831
38. Fabricated metal	1.481	2.251	2.096	1.865	1.941

Continued on next page

Table Appendix 4B – continued from previous page

	Type I	Type II: Miller & Blair	Type II: Batey1	Type II: Batey2	SAM
39. Computers, electronics & opticals	1.416	1.980	1.866	1.697	1.767
40. Electrical equipment	1.483	2.183	2.042	1.832	1.896
41. Machinery & equipment	1.519	2.304	2.146	1.911	1.983
42. Motor Vehicles	1.515	2.178	2.045	1.846	1.907
43. Other transport equipment	1.647	2.264	2.140	1.955	2.026
44. Furniture	1.574	2.284	2.141	1.928	1.999
45. Other manufacturing	1.403	2.301	2.121	1.851	1.913
46. Repair & maintenance	1.427	2.164	2.016	1.795	1.877
47. Electricity	2.053	2.405	2.335	2.229	2.345
48. Gas etc	1.260	1.544	1.487	1.401	1.482
49. Water and sewerage	1.287	1.733	1.643	1.509	1.708
50. Waste	1.493	2.195	2.054	1.843	1.941
51. Remediation & waste management	2.780	3.343	3.230	3.061	3.214
52. Construction - buildings	1.766	2.401	2.273	2.083	2.200
53. Construction - civil engineering	1.731	2.450	2.305	2.090	2.202
54. Construction - specialised	1.530	2.288	2.136	1.908	2.020
55. Wholesale & Retail - vehicles	1.335	2.116	1.959	1.725	1.815
56. Wholesale - excl vehicles	1.521	2.253	2.106	1.886	1.990
57. Retail - excl vehicles	1.352	2.139	1.981	1.745	1.858
58. Rail transport	1.764	2.582	2.418	2.172	2.265
59. Other land transport	1.400	2.033	1.906	1.716	1.810
60. Water transport	1.657	2.138	2.042	1.897	1.980
61. Air transport	1.467	1.920	1.829	1.693	1.792
62. Support services for transport	1.541	2.195	2.063	1.867	1.994
63. Post & courier	1.278	2.351	2.135	1.813	1.893
64. Accommodation	1.352	2.065	1.922	1.708	1.814
65. Food & beverage services	1.362	2.082	1.937	1.721	1.816
66. Publishing services	1.279	2.140	1.967	1.709	1.790
67. Film video & TV etc	1.454	2.100	1.970	1.777	1.869
68. Broadcasting	1.386	2.043	1.911	1.714	1.819
69. Telecommunications	1.393	2.067	1.931	1.729	1.859
70. Computer services	1.250	2.115	1.941	1.682	1.789
71. Information services	1.185	1.987	1.826	1.585	1.719
72. Financial services	1.222	1.785	1.671	1.503	1.665
73. Insurance & pensions	1.859	2.359	2.258	2.108	2.234
74. Auxiliary financial services	1.282	2.138	1.966	1.709	1.796
75. Real estate - own	1.465	1.768	1.707	1.616	1.817
76. Imputed rent	1.151	1.220	1.206	1.186	1.387
77. Real estate - fee or contract	1.503	2.198	2.059	1.850	1.971
78. Legal activities	1.241	2.069	1.903	1.655	1.781
79. Accounting & tax services	1.202	2.118	1.934	1.659	1.786
80. Head office & consulting services	1.391	2.267	2.091	1.828	1.914
81. Architectural services etc	1.437	2.239	2.078	1.838	1.953
82. Research & development	1.423	2.534	2.311	1.977	2.057

Continued on next page

Table Appendix 4B – continued from previous page

	Type I	Type II			
		Miller & Blair	Batey1	Batey2	SAM
83. Advertising & market research	1.250	2.019	1.864	1.634	1.772
84. Other professional services	1.330	2.039	1.896	1.684	1.801
85. Veterinary services	1.364	2.197	2.029	1.780	1.918
86. Rental and leasing services	1.324	1.911	1.793	1.617	1.751
87. Employment services	1.301	2.351	2.140	1.825	1.918
88. Travel & related services	1.520	1.936	1.852	1.728	1.786
89. Security & investigation	1.155	2.378	2.132	1.765	1.853
90. Building & landscape services	1.388	2.329	2.140	1.857	1.964
91. Business support services	1.285	1.985	1.844	1.634	1.769
92. Public administration & defence	1.410	2.240	2.073	1.824	1.903
93. Education	1.189	2.478	2.219	1.832	1.914
94. Health	1.362	2.290	2.103	1.825	1.902
95. Residential care	1.320	2.330	2.127	1.824	1.950
96. Social work	1.236	2.496	2.242	1.864	1.959
97. Creative services	1.474	2.398	2.212	1.935	2.005
98. Cultural services	1.356	2.382	2.176	1.868	1.948
99. Gambling	1.414	1.933	1.828	1.673	1.822
100. Sports & recreation	1.407	2.332	2.146	1.869	1.950
101. Membership organisations	1.436	2.329	2.150	1.882	1.970
102. Repairs - personal and household	1.357	2.121	1.967	1.738	1.822
103. Other personal services	1.233	1.947	1.804	1.590	1.732
104. Households as employers	1.000	2.405	2.122	1.701	1.799
Mean	1.465	2.156	2.017	1.810	1.910
Min	1.000	1.220	1.206	1.186	1.321
Max	2.780	3.343	3.230	3.061	3.214

Appendix 5A

Disaggregated Household Income-Expenditure Accounts for Scotland, 2009, in £million

			%					%	
Household 1			%					%	
1.	**Income**	**13,759**			10.	**Expenditure**	**13,759**		
2.	Skilled Income from Employment	1,150	8		11.	IO Expenditure	12,492	91	
3.	Unskilled Income from Employment	2,016	15		12.	Payments to Corporations	248	2	*
4.	Profit Income (OVA)	423	3		13.	Payments to Government	636	5	
5.	Income from Corporations	102	1		14.	Transfers to RUK	24	0	
6.	Income from Government	9,810	71		15.	Transfers to ROW	12	0	
7.	Transfers from RUK	117	1		16.	Payments to Capital	346	3	
8.	Transfers from ROW	141	1						
9.	Mixed and Proport. Income Unalloc.	- 1,284		*					
Household 2			%					%	
1.	**Income**	**8,216**			10.	**Expenditure**	**8,216**		
2.	Skilled Income from Employment	1,239	15		11.	IO Expenditure	6,509	79	
3.	Unskilled Income from Employment	2,323	28		12.	Payments to Corporations	228	3	*
4.	Profit Income (OVA)	354	4		13.	Payments to Government	1,356	17	
5.	Income from Corporations	387	5		14.	Transfers to RUK	4	0	
6.	Income from Government	3,603	44		15.	Transfers to ROW	2	0	
7.	Transfers from RUK	141	2		16.	Payments to Capital	117	1	
8.	Transfers from ROW	170	2						
9.	Mixed and Proport. Income Unalloc.	- 672		*					
Household 3			%					%	
1.	**Income**	**12,668**			10.	**Expenditure**	**12,668**		
2.	Skilled Income from Employment	3,443	27		11.	IO Expenditure	9,263	73	
3.	Unskilled Income from Employment	4,029	32		12.	Payments to Corporations	383	3	*
4.	Profit Income (OVA)	573	5		13.	Payments to Government	2,654	21	
5.	Income from Corporations	1,281	10		14.	Transfers to RUK	30	0	
6.	Income from Government	2,861	23		15.	Transfers to ROW	15	0	
7.	Transfers from RUK	218	2		16.	Payments to Capital	322	3	
8.	Transfers from ROW	263	2						
9.	Mixed and Proport. Income Unalloc.	- 730		*					
Household 4			%					%	
1.	**Income**	**18,517**			10.	**Expenditure**	**18,517**		
2.	Skilled Income from Employment	7,404	40		11.	IO Expenditure	12,378	67	
3.	Unskilled Income from Employment	5,268	28		12.	Payments to Corporations	905	5	*
4.	Profit Income (OVA)	584	3		13.	Payments to Government	4,547	25	
5.	Income from Corporations	2,632	14		14.	Transfers to RUK	23	0	
6.	Income from Government	2,047	11		15.	Transfers to ROW	11	0	
7.	Transfers from RUK	264	1		16.	Payments to Capital	652	4	
8.	Transfers from ROW	318	2						
9.	Mixed and Proport. Income Unalloc.	72		*					
Household 5			%					%	
1.	**Income**	**54,718**			10.	**Expenditure**	**54,718**		
2.	Skilled Income from Employment	28,738	53		11.	IO Expenditure	34,026	62	
3.	Unskilled Income from Employment	7,952	15		12.	Payments to Corporations	4,637	8	*
4.	Profit Income (OVA)	3,355	6		13.	Payments to Government	12,185	22	
5.	Income from Corporations	10,701	20		14.	Transfers to RUK	158	0	
6.	Income from Government	1,514	3		15.	Transfers to ROW	79	0	
7.	Transfers from RUK	1,114	2		16.	Payments to Capital	3,633	7	
8.	Transfers from ROW	1,344	2						
9.	Mixed and Proport. Income Unalloc.	2,613		*					

* = Balancing item
Adapted from Ross (2016a)

Appendix 6A

IO SIC07 to AMOS CGE Industry classification

AMOS CGE Industries	Scottish Input-Output Classification (based on SIC2007)											
1. Agriculture, forestry and fishing	1	2	3	4	5							
2. Mining	6	7	8	9								
3. Food, drink and tobacco	10	11	12	13	14	15	16	17	18	19	20	
4. Textile, leather, wood and paper	21	22	23	24	25	26						
5. Chemicals	27	28	29	30	31	32						
6. Rubber, plastic, cement and iron	33	34	35	36	37							
7. Computer, electrical and transport eq.	38	39	40	41	42	43	44	45	46			
8. Electricity, gas and water	47	48	49	50	51							
9. Construction	52	53	54									
10. Wholesale and retail	55	56	57									
11. Land transport	58	59										
12. Water transport	60											
13. Air Transport	61											
14. Post and support transport services	62	63										
15. Accommodation	64											
16. Food & beverage services	65											
17. Telecommunication	66	67	68	69								
18. Computer and information services	70	71										
19. Financial services	72	73	74									
20. Real estate	75	76	77									
21. Professional services	78	79	80	81	83	84	85	86	87	88	89	90	91
22. Research and development	82											
23. Public administration	92	93	94	95	96							
24. Recreational services	97	98	99	100								
25. Other services	101	102	103	104								

See Scottish Government (2013a) for IOC to SIC07 conversion.

Appendix 6B

The following gives a mathematical summary of the model structure of the AMOS (A Micro-Macro Model of Scotland) model. The mathematical description is kept as general as possible, to reflect the possibilities of AMOS as a flexible CGE framework.

The mathematical summary gives details on the price setting equations, technology in production, trade interactions, the behaviour of households and other institutions, the government sector, the trade balance, private, foreign and public assets.

The description is largely based on the AMOS model details found in Harrigan et al. (1991); McGregor et al. (1991) & Lecca et al. (2013), but is summarised here as adapted for Scotland, as a region of the UK, and is characterized by myopic agents. This model is used in Chapters 7 and 8 using the skill extensions as outlined in Chapter 6 .

Prices

$$PM_{i,t} = \epsilon_t \cdot PWM_i \cdot (1 + MTAX_i) \tag{6B.1}$$

$$PE_{i,t} = \epsilon_t \cdot PWE_i \cdot (1 - TE_i) \tag{6B.2}$$

$$PX_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PE_{i,t} \cdot E_{i,t}}{R_{i,t} + E_{i,t}} \tag{6B.3}$$

$$PQ_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PM_{i,t} \cdot M_{i,t}}{R_{i,t} + M_{i,t}} \tag{6B.4}$$

$$PIR_{j,t} = \frac{\sum_i VR_{i,j,t} \cdot PR_{j,t} + \sum_i VI_{i,j,t} \cdot \overline{PI_j}}{\sum_i VIR_{i,j,t}} \tag{6B.5}$$

$$PY_{j,t} \cdot a_j^Y = PX_{j,t} \cdot (1 - btax_j - sub_j - dep_j) - \sum_i a_{i,j}^V \cdot PQ_{j,t} \tag{6B.6}$$

$$UCK_t = Pk_t \cdot (ir + \delta) \tag{6B.7}$$

$$PC_t^{1-\sigma^C} = \sum_j \sum_h \delta_{j,h}^f \cdot PQ_{j,t}^{1-\sigma^C} \tag{6B.8}$$

$$Pgov_t^{1-\sigma^g} = \sum_j \delta_j^g \cdot PQ_{j,t}^{1-\sigma^g} \tag{6B.9}$$

$$w_t^b = \frac{w_t}{(1 + ssle + sse) \cdot (1 + ire)} \tag{6B.10}$$

$$Wagesetting \quad \begin{cases} ln[\frac{w_t}{cpi_t}] = \beta - \epsilon\, ln(u_t) & (Regional\, Bargaining) \\ \frac{w_t}{cpi_t} = \frac{w_{t=0}}{cpi_{t=0}} & (Fixed\, Real\, Wage) \\ w_t = w_{t=0} & (National\, Bargain.) \end{cases} \tag{6B.11}$$

$$rk_{j,t} = PY_{j,t} \cdot \delta_j^k \cdot A(\xi_{i,t})^{\varrho_j} \cdot \left(\frac{Y_{j,t}}{K_{j,t}}\right)^{1-\varrho_j} \tag{6B.12}$$

$$Pk_t = \frac{\sum_j PQ_{j,t} \cdot \sum_j KM_{i,j}}{\sum_i \sum_j KM_{i,j}} \tag{6B.13}$$

Production Technology

$$X_{i,t} = min\left(\frac{Y_{j,t}}{a_i^Y}; \frac{V_{i,j,t}}{a_{i,j}^V}\right) \tag{6B.14}$$

$$Y_{i,t} = \alpha_i^Y \cdot X_{i,t} \tag{6B.15}$$

$$V_{i,t} = \alpha^{V}_{i,j} \cdot X_{i,t} \tag{6B.16}$$

$$Y_{i,t} = A(\xi_{i,t}) \cdot \left[\delta^{k}_{i} \cdot K^{\rho_i}_{i,t} + \delta^{l}_{i} \cdot L^{\rho_i}_{i,t}\right]^{1/\rho_i} \tag{6B.17}$$

$$L_{j,t} = \left(A(\xi_{j,t})^{\rho_i} \cdot \delta^{l}_{j} \cdot \frac{PY_{j,t}}{w_t}\right)^{1/1-\rho_j} \cdot Y_{j,t} \tag{6B.18}$$

Trade

$$VV_{i,j,t} = \gamma^{vv}_{i,j} \cdot \left(\delta^{vm}_{i,j} VM^{\rho_{i,t}{}^{A}}_{i,t} + \delta^{vir}_{i,j} VIR^{\rho^{A}_{i}}_{i,t}\right)^{1/\rho^{A}_{i}} \tag{6B.19}$$

$$\frac{VM_{i,j,t}}{VIR_{i,j,t}} = \left[\left(\frac{\delta^{vm}_{i,j}}{\delta^{vir}_{i,j}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{1/1-\rho^{A}_{i}} \tag{6B.20}$$

$$VIR_{i,j,t} = \gamma^{vir}_{i,j} \cdot \left(\delta^{vi}_{i,j} VI^{\rho_i{}^{A}}_{i,t} + \delta^{vr}_{i,j} VR^{\rho_i{}^{A}}_{i,t}\right)^{1/\rho^{A}_{i}} \tag{6B.21}$$

$$\frac{VR_{i,j,t}}{VI_{i,j,t}} = \left[\left(\frac{\delta^{vr}_{i,j}}{\delta^{vi}_{i,j}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{1/1-\rho^{A}_{i}} \tag{6B.22}$$

$$E_{i,t} = \overline{E_i} \cdot \left(\frac{PE_{i,t}}{PR_{i,t}}\right)^{\sigma^{X}_{i}} \tag{6B.23}$$

Regional demand

$$R_{i,t} = \sum_{j} VR_{i,j,t} + \sum_{h} QHR_{i,h,t} + QVR_{i,t} + QGR_{i,t} + QHK_{i,t} \tag{6B.24}$$

Total production

$$X_{i,t} = R_{i,t} + E_{i,t} \tag{6B.25}$$

Households and other non-government institutions

$$\sum_{t=0}^{\infty} (1+\rho)^{-t} \frac{C_t^{1-\sigma} - 1}{1-\sigma} \tag{6B.26}$$

$$\frac{C_t}{C_{t+1}} = \left[\frac{PC_t \cdot (1+\rho)}{PC_{t+1} \cdot (1+r)} \right]^{-(1/\sigma)} \tag{6B.27}$$

$$W_t = NFW_t + FW_t \tag{6B.28}$$

$$\begin{aligned} NFW_t(1+r_t) = NFW_{t+1} &+ \sum_h dtr_h \cdot (ssl + ire) \cdot \sum_j L_{j,t} \cdot w_t \\ &+ \sum_h \sum_{\psi p} TRSF_{h,\psi p,t} + \sum_h TRG_h \cdot PC_t \\ &+ \sum_h REM_h \cdot \epsilon_t - \sum_{\psi p} \sum_h TRSF_{\psi p,h,t} \end{aligned} \tag{6B.29}$$

$$FW_t(1+r_t) = FW_{t+1} + d_\psi^K \cdot rk_{i,t} \sum_i K_i - \sum_h SAV_h \tag{6B.30}$$

$$\begin{aligned} YNG_{\psi,t} = d_\psi^L w_t \cdot \sum_i L_i + d_\psi^K \cdot rk_{i,t} \sum_i K_i + d_\psi^h \cdot rh_{i,t} \sum_i H_i \\ + \sum_{\psi p} TRSF_{\psi,\psi p,t} + PC_t \cdot TRG_\psi + \epsilon_t \cdot REM_\psi \end{aligned} \tag{6B.31}$$

$$TRSF_{\psi,\psi p,t} = PC_t \cdot \overline{TRSF_{\psi,\psi p}} \tag{6B.32}$$

$$SAV_{\psi,t} = mps_\psi \cdot YNG_{\psi,t} \tag{6B.33}$$

$$QH_{i,h,t} = \left(\delta^{f}_{i,h}\right)^{\rho^C_i} \cdot \left(\frac{PC_{i,t}}{PQ_{i,t}}\right)^{\rho^C_i} \cdot C_t \tag{6B.34}$$

$$QH_{i,h,t} = \gamma^{f}_{i,h} \cdot \left[\delta^{hr}_{i,h} \cdot QHR^{\rho^A_i}_{i,h,t} + \delta^{hm}_{i,h} \cdot QHM^{\rho^A_i}_{i,h,t}\right]^{1/\rho^A_i} \tag{6B.35}$$

$$\frac{QHR_{i,h,t}}{QHM_{i,h,t}} = \left[\left(\frac{\delta^{hr}_{i,h}}{\delta^{hm}_{i,h}}\right) \cdot \left(\frac{PM_{i,t}}{PR_{i,t}}\right)\right]^{1/1-\rho^A_i} \tag{6B.36}$$

Government

$$\begin{aligned} FD_t = \sum_i QG_{i,t} \cdot PQ_{i,t} + \overline{GS} + \sum_{\psi} TRG_{\psi,t} \cdot PC_t \\ -(d^k_g \cdot \sum_i rk_{i,t} \cdot K_{i,t} + d^h_g \cdot \sum_i rh_{i,t} \cdot H_{i,t} \\ + \sum_{i,t} IMT_{i,t} + \sum_h dtr_h \cdot (ssl + ire) \\ \cdot \sum_j L_{j,t} \cdot w_t + \overline{FE} \cdot \epsilon_t) \end{aligned} \tag{6B.37}$$

$$QG_{i,t} = \gamma^{g}_{i} \cdot \left[\delta^{gr}_{i} \cdot QGR^{\rho^A_i}_{i,t} + \delta^{gm}_{i} \cdot QGM^{\rho^A_i}_{i,t}\right]^{1/\rho^A_i} \tag{6B.38}$$

$$\frac{QGR_{i,t}}{QGM_{i,t}} = \left[\left(\frac{\delta^{gr}_{i}}{\delta^{gm}_{i}}\right) \cdot \left(\frac{PM_{i,t}}{PR_{i,t}}\right)\right]^{1/1-\rho^A_i} \tag{6B.39}$$

Investment demand

$$QV_{i,t} = \sum_i KM_{i,j} \cdot J_{j,t} \tag{6B.40}$$

$$QV_{i,t} = \gamma^{v}_{i} \cdot \left[\delta^{qvm}_{i} \cdot QVM^{\rho^A_i}_{i,t} + \delta^{qvr}_{i} \cdot QVIR^{\rho^A_i}_{i,t}\right]^{1/\rho^A_i} \tag{6B.41}$$

$$\frac{QVM_{i,t}}{QVIR_{i,t}} = \left[\left(\frac{\delta_i^{qvm}}{\delta_i^{qvir}} \right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}} \right) \right]^{1/1-\rho_i^A} \tag{6B.42}$$

$$QVIR_{i,t} = \gamma_i^{vir} \cdot \left[\delta_i^{qvi} \cdot QVI_i^{\rho_i^A} + \delta_i^{qvr} \cdot QVR_{i,t}^{\rho_i^A} \right]^{1/\rho_i^A} \tag{6B.43}$$

$$\frac{QVR_{i,t}}{QVI_{i,t}} = \left[\left(\frac{\delta_i^{qvr}}{\delta_i^{qvi}} \right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}} \right) \right]^{1/1-\rho_i^A} \tag{6B.44}$$

Investment path

$$J_{i,t} = I_{i,t} \cdot \left[1 - bb - tk + \frac{\beta}{2} \cdot \left(\frac{((I_{i,t}/K_{i,t}) - \alpha)^2}{I_{i,t}/K_{i,t}} \right) \right] \tag{6B.45}$$

$$\frac{I_t}{K_t} = \alpha + \frac{1}{\beta} \cdot \left[\frac{\lambda_{i,t}}{PK_t} - (1 - bb - tk) \right] \tag{6B.46}$$

$$\dot{\lambda}_{i,t} = \lambda_{i,t} \cdot (r_t + \sigma) - R_{i,t}^k \tag{6B.47}$$

$$\theta(x_t) = \frac{\beta}{2} \frac{(x_t - \alpha)^2}{x_t};\ and\ x_t = \frac{I_t}{K_t} \tag{6B.48}$$

$$R_{i,t}^k = rk_t - PK_t \cdot \left[\frac{I_{i,t}}{K_{i,t}} \right]^2 \cdot \theta_t'(I/K) \tag{6B.49}$$

Factors accumulation

$$KS_{i,t+1} = (1 - \delta) \cdot KS_{i,t} + I_{i,t} \tag{6B.50}$$

$$LS_{i,t+1} = \left(1 + \left(\zeta - v^u[ln(u_t) - ln(\overline{u}^N)] + v^w \left[ln(\frac{w_t}{cpi_t}) - ln(\frac{w^N}{cpi^N})\right]\right)\right) \cdot LS_{i,t} \qquad (6B.51)$$

$$K_{i,t} = KS_{i,t} \qquad (6B.52)$$

$$LS_t \cdot (1 - u_t) = \sum_j L_{j,t} \qquad (6B.53)$$

Taxes and subsidies

$$IBT_{i,t} = btax_i \cdot X_{i,t} \cdot PX_{i,t} \qquad (6B.54)$$

$$IMT_{j,t} = \sum_i MTAX_j \cdot VM_{i,j,t} \cdot PM_{i,t} \qquad (6B.55)$$

$$SUBSY_{i,t} = SUB_i \cdot X_{i,t} \cdot PX_{i,t} \qquad (6B.56)$$

Current account

$$M_{i,t} = \sum_j VI_{i,j,t} + \sum_j VM_{i,j,t} + \sum_h QHM_{i,h,t} + QGM_{i,t} + QVI_{i,t} + QVM_{i,t} \qquad (6B.57)$$

$$TB_t = \sum_i M_{i,t} \cdot PM_{i,t} - \sum_i E_{i,t} \cdot PE_{i,t} + \epsilon_t \cdot \left(\sum_\psi \overline{REM_\psi} + \overline{FE}\right) \qquad (6B.58)$$

Assets

$$VF_{i,t} = \lambda_{i,t} \cdot K_{i,t} \tag{6B.59}$$

$$D_{t+1} = (1 + r - \tau) \cdot D_t + TB_t \tag{6B.60}$$

$$Pgov_{t+1} \cdot GD_{t+1} = \left[1 + r - \tau g + \left(\frac{Pc_{t+1}}{Pc_t}\right) - 1\right] \cdot GD_t \cdot Pgov_t + FD_t \tag{6B.61}$$

Steady-state conditions

$$KS_{i,t} = I_{i,t}\delta \tag{6B.62}$$

$$R^k_{i,t} = \lambda_{i,t} \cdot (r_t + \delta) \tag{6B.63}$$

$$FD_t = -\left[r - \tau g + \left(\frac{Pc_{t+1}}{Pc_t}\right) - 1\right] \cdot Pgov_t \cdot GD_t \tag{6B.64}$$

$$TB_t = (-r - \tau) \cdot D_t \tag{6B.65}$$

$$\begin{aligned} NFW_t \cdot r_t = & \sum_h dtr_h \cdot (ssl + ire) \cdot \sum_j L_{j,t} \cdot w_t + \sum_h \sum_{\psi p} TRSF_{h,\psi p,t} \\ & + \sum TRG_h \cdot PC_t + \sum_h REM_h \cdot \epsilon_t - \sum_{\psi p} \sum_h TRSF_{\psi p,h,t} \end{aligned} \tag{6B.66}$$

$$FW_t \cdot r_t = d^K_\psi \cdot rk_{i,t} \cdot \sum_i K_i - \sum_h SAV_{h,t} \tag{6B.67}$$

Short-run conditions

$$KS_{i,t=1} = KS_{i,t=0} \tag{6B.68}$$

$$LS_{t=1} = LS_{t=0} \tag{6B.69}$$

$$GD_{t=1} = GD_{t=0} \tag{6B.70}$$

$$D_{t=1} = D_{t=0} \tag{6B.71}$$

Glossary

	Subscripts
i, j	Sectors
t	Time
ins	Institutions
υ	Domestic institutions
ψ	Domestic non-government institutions
h	Households
g	Government

	Prices
$PX_{i,t}$	Output Price
$PY_{i,t}$	Value Added Price
$PQ_{i,t}$	Commodity Price
$PR_{i,t}$	Regional Price
$PIR_{i,t}$	National Commodity Price (Scotland & RUK)
$PI_{i,t}$	RUK Price
$rk_{i,t}$	Shadow price of capital
w_t	Regional Nominal wage

w_t^b	After tax wage
PK_t	Capital good Price
UCK_t	User Cost of Capital
λ_i	Shadow price of capital
PC_t	Aggregate Consumption Price
$PGov_t$	Aggregate Price of Government consumption goods
ϵ_t	exchange rate (fixed)

Endogenous variables

$X_{i,t}$	Regional Supply
$R_{i,t}$	Regional Supply
$M_{i,t}$	Imports
$E_{i,t}$	Total Exports
$Y_{i,t}$	Value added
$L_{i,t}$	Labour demand
$K_{i,t}$	Physical capital demand
$KS_{i,t}$	Capital stock
$LS_{i,t}$	Labour supply
$VV_{i,t}$	Total intermediate inputs
$VM_{i,t}$	ROW intermediate inputs
$VR_{i,t}$	Regional Intermediate Inputs
$VI_{i,t}$	RUK Intermediate Inputs
$VIR_{i,t}$	National Intermediate Inputs (Scotland & RUK)
$QGR_{i,t}$	Regional government consumption
$QGM_{i,t}$	Imported government expenditures
C_t	Regional government expenditures
$QH_{i,h,t}$	ROW investment demand
$QHR_{i,h,t}$	Regional household consumption
$QHM_{i,h,t}$	Regional household consumption
$QV_{i,t}$	Investment by origin
$QVR_{i,t}$	Regional investment by sector of origin
$QVM_{i,t}$	ROW investment demand
$QVIR_{i,t}$	National investment (Scotland + RUK)
$QVI_{i,t}$	RUK investment demand
$I_{j,t}$	Investment by sector of destination j
$J_{j,t}$	Investment by destination j with adjustment cost
u_t	Regional unemployment rate
$R_{i,t}^k$	Marginal Net Revenue of capital

$SAV_{\psi,t}$	Domestic non-government saving
$YNG_{\psi,t}$	Domestic non-government income
$TRSF_{\psi,\psi p,t}$	Transfer among ψ
$HTAX_t$	Total household tax
TB_t	Current account Balance
$SUBSY_t$	Production subsidy

Exogenous variables

$\overline{REM_t}$	Remittance for ψ
$\overline{FE_t}$	Remittance for the Government
$QG_{i,t}$	Government expenditure
GS_t	Government savings
r_t	Interest rate

Elasticities

σ	Constant elasticity of marginal utility
ϱ_j	Elasticity between labour and capital in sector j
ρ_t^A	Elasticity in Armington function
σ_t^x	Elasticity of export with respect to term of trade
μ	Elasticity of real wage with respect to the unemployment rate
v^u	Elasticity of migration to the unemployment differential
v^w	Elasticity of migration to the real wage differential

Parameters

$a_{i,j}^V$	Input-Output coefficient for i used in j
a_i^Y	Share of value added in production
$\delta_j^{k,l}$	Shares of capital and labour in the value-added function
$\delta_{i,j}^{vm,vir,vr,vi}$	Share parameters in CES function for intermediate goods
$\delta_{i,j}^{qvm,qvir,qvr,qvi}$	Share parameters in CES function for investment goods
$\delta_{i,h}^{hr,hm}$	Share parameters in CES function for household consumption
$\delta_i^{gr,gm}$	Share parameters in CES function for government consumption
$\gamma_{i,j}^{vv,vir}$	Shift parameter in CES functions for intermediate goods
γ_i^f	Shift parameter in CES functions for household consumption goods
γ_i^g	Shift parameter in CES functions for government consumption
$btax_i$	Business tax

sub_i	Rate of Production subsidy
$MTAX_i$	Rate of Import Tax
$KM_{i,j}$	Physical capital matrix
mps_ψ	Institution rate of savings
ssl	Rate of social security paid by employees
sse	Rate of social security paid by employers
ire	Rate of direct household tax
cre	Rate of household consumption tax
ρ	Pure rate of consumer time preference
bb	Rate of distortion or incentive to investment
δ	Depreciation rate

Appendix 7A

Sensitivity analysis. £500m ROW export demand stimulus to FIN. Elasticity of substitution between skilled and unskilled.

	LR - Free migration	LR - Skilled migration			LR - No migration			SR		
		$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$
GRP Income measure	0.62	0.46	0.49	0.50	0.27	0.27	0.27	0.03	0.03	0.03
Consumer Price Index	0.00	0.08	0.07	0.06	0.19	0.19	0.19	0.23	0.23	0.23
Unemployment Rate	- 0.00	- 1.07	- 0.91	- 0.83	- 2.37	- 2.37	- 2.37	- 0.85	- 0.85	- 0.85
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.46	- 2.43	- 2.41	- 0.91	- 0.89	- 0.88
Unemployment Rate U	- 0.00	- 3.13	- 2.64	- 2.42	- 2.19	- 2.27	- 2.30	- 0.75	- 0.79	- 0.80
Total Employment	0.51	0.35	0.38	0.39	0.15	0.15	0.15	0.05	0.05	0.05
Total Employment S	0.51	0.43	0.49	0.51	0.16	0.15	0.15	0.06	0.06	0.06
Total Employment U	0.51	0.20	0.17	0.15	0.14	0.14	0.15	0.05	0.05	0.05
Nominal Gross Wage	0.00	0.20	0.17	0.16	0.47	0.47	0.47	0.33	0.33	0.33
Nominal Gross Wage S	0.00	0.08	0.07	0.06	0.49	0.48	0.48	0.34	0.33	0.33
Nominal Gross Wage U	0.00	0.44	0.37	0.34	0.44	0.44	0.45	0.31	0.31	0.32
Real Gross Wage	0.00	0.12	0.10	0.09	0.28	0.28	0.28	0.10	0.10	0.10
Real Gross Wage S	0.00	0.00	0.00	0.00	0.30	0.30	0.29	0.11	0.11	0.11
Real Gross Wage U	0.00	0.36	0.30	0.27	0.25	0.26	0.26	0.08	0.09	0.09
Labour force	0.51	0.28	0.32	0.34	-	-	-	-	-	-
Labour force S	0.51	0.43	0.49	0.51	-	-	-	-	-	-
Labour force U	0.51	-	-	-	-	-	-	-	-	-
Households Consumption	0.32	0.29	0.30	0.30	0.25	0.25	0.25	0.11	0.11	0.11
Investment	0.79	0.64	0.67	0.68	0.46	0.46	0.46	0.45	0.45	0.45
Capital Stock	0.79	0.64	0.67	0.68	0.46	0.46	0.46	-	-	-
Replacement cost of capital	0.00	0.08	0.07	0.06	0.18	0.18	0.18	0.33	0.33	0.33
Export RUK	- 0.00	- 0.14	- 0.12	- 0.11	- 0.31	- 0.31	- 0.31	- 0.67	- 0.67	- 0.67
Export ROW	3.04	2.90	2.92	2.93	2.71	2.71	2.71	2.58	2.58	2.58

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

FIN = Financial services.

σ_S = Elasticity of substitution between skilled and unskilled.

Skill-disaggregated AMOS σ_S = 1.01.

Sensitivity analysis. £500m ROW export demand stimulus to F&D. Elasticity of substitution between skilled and unskilled.

	LR - Free migration	LR - Skilled migration			LR - No migration			SR		
		$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$
GRP Income measure	0.48	0.31	0.34	0.35	0.19	0.19	0.19	0.03	0.03	0.03
Consumer Price Index	0.00	0.09	0.08	0.07	0.15	0.15	0.15	0.21	0.21	0.21
Unemployment Rate	- 0.00	- 1.19	- 1.01	- 0.92	- 1.98	- 1.98	- 1.98	- 0.74	- 0.74	- 0.74
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 1.49	- 1.60	- 1.65	- 0.50	- 0.56	- 0.58
Unemployment Rate U	- 0.00	- 3.48	- 2.93	- 2.69	- 2.92	- 2.69	- 2.61	- 1.19	- 1.08	- 1.04
Total Employment	0.42	0.25	0.27	0.29	0.13	0.13	0.13	0.05	0.05	0.05
Total Employment S	0.34	0.26	0.32	0.35	0.09	0.10	0.11	0.03	0.04	0.04
Total Employment U	0.57	0.22	0.19	0.17	0.19	0.17	0.17	0.08	0.07	0.07
Nominal Gross Wage	0.00	0.23	0.19	0.17	0.39	0.39	0.39	0.30	0.30	0.30
Nominal Gross Wage S	0.00	0.09	0.08	0.07	0.33	0.35	0.35	0.27	0.28	0.28
Nominal Gross Wage U	0.00	0.49	0.41	0.38	0.49	0.46	0.45	0.35	0.33	0.33
Real Gross Wage	0.00	0.14	0.12	0.11	0.23	0.23	0.23	0.09	0.09	0.09
Real Gross Wage S	0.00	0.00	0.00	0.00	0.18	0.19	0.20	0.06	0.07	0.07
Real Gross Wage U	0.00	0.40	0.33	0.31	0.33	0.31	0.30	0.13	0.12	0.12
Labour force	0.42	0.17	0.21	0.23	-	-	-	-	-	-
Labour force S	0.34	0.26	0.32	0.35	-	-	-	-	-	-
Labour force U	0.57	-	-	-	-	-	-	-	-	-
Households Consumption	0.26	0.23	0.23	0.23	0.20	0.20	0.20	0.09	0.09	0.09
Investment	0.57	0.41	0.44	0.45	0.30	0.30	0.30	0.41	0.41	0.41
Capital Stock	0.57	0.41	0.44	0.45	0.30	0.30	0.30	-	-	-
Replacement cost of capital	0.00	0.09	0.07	0.07	0.15	0.15	0.15	0.18	0.18	0.18
Export RUK	- 0.00	- 0.15	- 0.13	- 0.12	- 0.26	- 0.26	- 0.26	- 0.35	- 0.35	- 0.35
Export ROW	3.04	2.88	2.91	2.92	2.77	2.77	2.77	2.25	2.25	2.25

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

F&D = Food, drink & tobacco.

σ_S = Elasticity of substitution between skilled and unskilled.

Skill-disaggregated AMOS σ_S = 1.01.

Sensitivity analysis. £500m ROW export demand stimulus to FIN. Armington trade elasticity.

	LR - Free migration	LR - Skilled migration			LR - No migration			SR		
		$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$
GRP Income measure	0.62	0.52	0.49	0.46	0.31	0.27	0.24	0.05	0.03	0.02
Consumer Price Index	0.00	0.07	0.07	0.06	0.23	0.19	0.15	0.37	0.23	0.16
Unemployment Rate	- 0.00	- 0.99	- 0.91	- 0.84	- 2.97	- 2.37	- 1.97	- 1.27	- 0.85	- 0.63
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.98	- 2.43	- 2.05	- 1.28	- 0.89	- 0.67
Unemployment Rate U	- 0.00	- 2.88	- 2.64	- 2.43	- 2.94	- 2.27	- 1.82	- 1.25	- 0.79	- 0.54
Total Employment	0.51	0.41	0.38	0.35	0.19	0.15	0.13	0.08	0.05	0.04
Total Employment S	0.51	0.52	0.49	0.46	0.19	0.15	0.13	0.08	0.06	0.04
Total Employment U	0.51	0.18	0.17	0.16	0.19	0.14	0.12	0.08	0.05	0.03
Nominal Gross Wage	0.00	0.19	0.17	0.16	0.59	0.47	0.39	0.52	0.33	0.24
Nominal Gross Wage S	0.00	0.07	0.07	0.06	0.60	0.48	0.40	0.53	0.33	0.24
Nominal Gross Wage U	0.00	0.40	0.37	0.34	0.57	0.44	0.36	0.51	0.31	0.22
Real Gross Wage	0.00	0.11	0.10	0.10	0.35	0.28	0.23	0.15	0.10	0.07
Real Gross Wage S	0.00	0.00	0.00	0.00	0.36	0.30	0.25	0.15	0.11	0.08
Real Gross Wage U	0.00	0.33	0.30	0.28	0.33	0.26	0.21	0.14	0.09	0.06
Labour force	0.51	0.34	0.32	0.30	-	-	-	-	-	-
Labour force S	0.51	0.52	0.49	0.46	-	-	-	-	-	-
Labour force U	0.51	-	-	-	-	-	-	-	-	-
Households Consumption	0.32	0.32	0.30	0.28	0.31	0.25	0.21	0.15	0.11	0.08
Investment	0.79	0.70	0.67	0.64	0.52	0.46	0.42	0.57	0.45	0.40
Capital Stock	0.79	0.70	0.67	0.64	0.52	0.46	0.42	-	-	-
Replacement cost of capital	0.00	0.07	0.07	0.06	0.23	0.18	0.15	0.53	0.33	0.24
Export RUK	- 0.00	- 0.13	- 0.12	- 0.11	- 0.39	- 0.31	- 0.26	- 0.85	- 0.67	- 0.57
Export ROW	3.04	2.91	2.92	2.93	2.62	2.71	2.76	2.40	2.58	2.66

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

FIN = Financial services.

σ_V = Elasticity of substitution between imports and domestic output in domestic demand.

Skill-disaggregated AMOS σ_V = 2.00.

Sensitivity analysis. £500m ROW export demand stimulus to F&D. Armington trade elasticity.

	LR - Free migration	LR - Skilled migration			LR - No migration			SR		
		$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$
GRP Income measure	0.48	0.37	0.34	0.31	0.23	0.19	0.17	0.04	0.03	0.02
Consumer Price Index	0.00	0.08	0.08	0.07	0.19	0.15	0.13	0.32	0.21	0.16
Unemployment Rate	- 0.00	- 1.10	- 1.01	- 0.93	- 2.47	- 1.98	- 1.65	- 1.03	- 0.74	- 0.57
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.06	- 1.60	- 1.29	- 0.81	- 0.56	- 0.42
Unemployment Rate U	- 0.00	- 3.20	- 2.93	- 2.70	- 3.24	- 2.69	- 2.32	- 1.44	- 1.08	- 0.88
Total Employment	0.42	0.31	0.27	0.25	0.16	0.13	0.11	0.07	0.05	0.04
Total Employment S	0.34	0.36	0.32	0.29	0.13	0.10	0.08	0.05	0.04	0.03
Total Employment U	0.57	0.20	0.19	0.17	0.21	0.17	0.15	0.09	0.07	0.06
Nominal Gross Wage	0.00	0.21	0.19	0.18	0.48	0.39	0.32	0.44	0.30	0.23
Nominal Gross Wage S	0.00	0.08	0.08	0.07	0.44	0.35	0.28	0.42	0.28	0.21
Nominal Gross Wage U	0.00	0.45	0.41	0.38	0.56	0.46	0.39	0.49	0.33	0.26
Real Gross Wage	0.00	0.13	0.12	0.11	0.29	0.23	0.19	0.12	0.09	0.07
Real Gross Wage S	0.00	0.00	0.00	0.00	0.25	0.19	0.16	0.10	0.07	0.05
Real Gross Wage U	0.00	0.36	0.33	0.31	0.37	0.31	0.26	0.16	0.12	0.10
Labour force	0.42	0.24	0.21	0.19	-	-	-	-	-	-
Labour force S	0.34	0.36	0.32	0.29	-	-	-	-	-	-
Labour force U	0.57	-	-	-	-	-	-	-	-	-
Households Consumption	0.26	0.26	0.23	0.21	0.25	0.20	0.17	0.12	0.09	0.07
Investment	0.57	0.47	0.44	0.40	0.35	0.30	0.26	0.51	0.41	0.36
Capital Stock	0.57	0.47	0.44	0.40	0.35	0.30	0.26	-	-	-
Replacement cost of capital	0.00	0.08	0.07	0.07	0.19	0.15	0.12	0.31	0.18	0.13
Export RUK	- 0.00	- 0.14	- 0.13	- 0.12	- 0.32	- 0.26	- 0.21	- 0.47	- 0.35	- 0.29
Export ROW	3.04	2.89	2.91	2.92	2.70	2.77	2.81	2.09	2.25	2.35

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

F&D = Food, drink & tobacco.

σ_V = Elasticity of substitution between imports and domestic output in domestic demand.

Skill-disaggregated AMOS σ_V = 2.00.

Sensitivity analysis. £500m ROW export demand stimulus to FIN. Unemployment rate elasticity.

		LR - Skilled migration			LR - No migration			SR		
	LR - Free migration	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$
GRP Income measure	0.62	0.50	0.49	0.48	0.27	0.27	0.26	0.03	0.03	0.03
Consumer Price Index	0.00	0.06	0.07	0.07	0.18	0.19	0.19	0.22	0.23	0.23
Unemployment Rate	- 0.00	- 1.04	- 0.91	- 0.80	- 2.49	- 2.37	- 2.28	- 0.88	- 0.85	- 0.83
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.43	- 2.43	- 2.42	- 0.88	- 0.89	- 0.90
Unemployment Rate U	- 0.00	- 3.03	- 2.64	- 2.33	- 2.61	- 2.27	- 2.01	- 0.89	- 0.79	- 0.70
Total Employment	0.51	0.39	0.38	0.37	0.16	0.15	0.15	0.06	0.05	0.05
Total Employment S	0.51	0.49	0.49	0.49	0.16	0.15	0.15	0.06	0.06	0.06
Total Employment U	0.51	0.19	0.17	0.15	0.17	0.14	0.13	0.06	0.05	0.04
Nominal Gross Wage	0.00	0.16	0.17	0.18	0.46	0.47	0.48	0.32	0.33	0.33
Nominal Gross Wage S	0.00	0.06	0.07	0.07	0.48	0.48	0.48	0.33	0.33	0.33
Nominal Gross Wage U	0.00	0.34	0.37	0.39	0.42	0.44	0.46	0.31	0.31	0.32
Real Gross Wage	0.00	0.10	0.10	0.11	0.28	0.28	0.29	0.10	0.10	0.10
Real Gross Wage S	0.00	0.00	0.00	0.00	0.30	0.30	0.29	0.11	0.11	0.11
Real Gross Wage U	0.00	0.28	0.30	0.32	0.24	0.26	0.27	0.08	0.09	0.09
Labour force	0.51	0.32	0.32	0.32	-	-	-	-	-	-
Labour force S	0.51	0.49	0.49	0.49	-	-	-	-	-	-
Labour force U	0.51	-	-	-	-	-	-	-	-	-
Households Consumption	0.32	0.30	0.30	0.30	0.25	0.25	0.25	0.11	0.11	0.11
Investment	0.79	0.68	0.67	0.66	0.46	0.46	0.45	0.46	0.45	0.45
Capital Stock	0.79	0.68	0.67	0.66	0.46	0.46	0.45	-	-	-
Replacement cost of capital	0.00	0.06	0.07	0.07	0.18	0.18	0.18	0.33	0.33	0.33
Export RUK	- 0.00	- 0.11	- 0.12	- 0.12	- 0.31	- 0.31	- 0.32	- 0.67	- 0.67	- 0.67
Export ROW	3.04	2.93	2.92	2.91	2.71	2.71	2.70	2.58	2.58	2.57

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

FIN = Financial services.

ϵ = Unemployment rate elasticity in the bargained real wage function.

Skill-disaggregated AMOS ϵ_s = 0.120 and ϵ_u = 0.112.

Sensitivity analysis. £500m ROW export demand stimulus to F&D. Unemployment rate elasticity.

		LR - Skilled migration			LR - No migration			SR		
	LR - Free migration	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$	$\epsilon_s = 0.120$; $\epsilon_u = 0.090$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.134$
GRP Income measure	0.48	0.35	0.34	0.33	0.20	0.19	0.18	0.03	0.03	0.03
Consumer Price Index	0.00	0.07	0.08	0.08	0.15	0.15	0.16	0.21	0.21	0.21
Unemployment Rate	- 0.00	- 1.16	- 1.01	- 0.89	- 2.12	- 1.98	- 1.87	- 0.78	- 0.74	- 0.70
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 1.61	- 1.60	- 1.60	- 0.55	- 0.56	- 0.57
Unemployment Rate U	- 0.00	- 3.37	- 2.93	- 2.59	- 3.09	- 2.69	- 2.38	- 1.22	- 1.08	- 0.97
Total Employment	0.42	0.29	0.27	0.27	0.14	0.13	0.12	0.05	0.05	0.04
Total Employment S	0.34	0.32	0.32	0.32	0.10	0.10	0.10	0.03	0.04	0.04
Total Employment U	0.57	0.22	0.19	0.17	0.20	0.17	0.15	0.08	0.07	0.06
Nominal Gross Wage	0.00	0.18	0.19	0.20	0.37	0.39	0.40	0.29	0.30	0.30
Nominal Gross Wage S	0.00	0.07	0.08	0.08	0.34	0.35	0.35	0.27	0.28	0.28
Nominal Gross Wage U	0.00	0.38	0.41	0.43	0.43	0.46	0.48	0.32	0.33	0.34
Real Gross Wage	0.00	0.11	0.12	0.12	0.23	0.23	0.24	0.08	0.09	0.09
Real Gross Wage S	0.00	0.00	0.00	0.00	0.19	0.19	0.19	0.07	0.07	0.07
Real Gross Wage U	0.00	0.31	0.33	0.35	0.28	0.31	0.32	0.11	0.12	0.13
Labour force	0.42	0.21	0.21	0.21	-	-	-	-	-	-
Labour force S	0.34	0.32	0.32	0.32	-	-	-	-	-	-
Labour force U	0.57	-	-	-	-	-	-	-	-	-
Households Consumption	0.26	0.23	0.23	0.23	0.20	0.20	0.20	0.09	0.09	0.09
Investment	0.57	0.45	0.44	0.43	0.31	0.30	0.29	0.42	0.41	0.41
Capital Stock	0.57	0.45	0.44	0.43	0.31	0.30	0.29	-	-	-
Replacement cost of capital	0.00	0.07	0.07	0.08	0.14	0.15	0.15	0.18	0.18	0.18
Export RUK	- 0.00	- 0.12	- 0.13	- 0.14	- 0.25	- 0.26	- 0.27	- 0.35	- 0.35	- 0.35
Export ROW	3.04	2.92	2.91	2.90	2.78	2.77	2.76	2.25	2.25	2.25

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

F&D = Food, drink & tobacco.

ϵ = Unemployment rate elasticity in the bargained real wage function.

Skill-disaggregated AMOS ϵ_s = 0.120 and ϵ_u = 0.112.

Sensitivity analysis. £500m ROW export demand stimulus to FIN. Unemployment rate elasticity.

		LR - Skilled migration			LR - No migration			SR		
	LR - Free migration	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$
GRP Income measure	0.62	0.49	0.49	0.49	0.28	0.27	0.25	0.04	0.03	0.03
Consumer Price Index	0.00	0.07	0.07	0.07	0.18	0.19	0.19	0.22	0.23	0.23
Unemployment Rate	- 0.00	- 0.91	- 0.91	- 0.91	- 2.63	- 2.37	- 2.18	- 0.92	- 0.85	- 0.80
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 2.80	- 2.43	- 2.14	- 1.00	- 0.89	- 0.80
Unemployment Rate U	- 0.00	- 2.64	- 2.64	- 2.64	- 2.30	- 2.27	- 2.25	- 0.77	- 0.79	- 0.80
Total Employment	0.51	0.38	0.38	0.38	0.17	0.15	0.14	0.06	0.05	0.05
Total Employment S	0.51	0.49	0.49	0.49	0.18	0.15	0.14	0.06	0.06	0.05
Total Employment U	0.51	0.17	0.17	0.17	0.15	0.14	0.14	0.05	0.05	0.05
Nominal Gross Wage	0.00	0.17	0.17	0.17	0.45	0.47	0.49	0.32	0.33	0.33
Nominal Gross Wage S	0.00	0.07	0.07	0.07	0.45	0.48	0.50	0.32	0.33	0.34
Nominal Gross Wage U	0.00	0.37	0.37	0.37	0.44	0.44	0.45	0.31	0.31	0.32
Real Gross Wage	0.00	0.10	0.10	0.10	0.27	0.28	0.29	0.09	0.10	0.11
Real Gross Wage S	0.00	0.00	0.00	0.00	0.27	0.30	0.31	0.10	0.11	0.12
Real Gross Wage U	0.00	0.30	0.30	0.30	0.26	0.26	0.26	0.09	0.09	0.09
Labour force	0.51	0.32	0.32	0.32	-	-	-	-	-	-
Labour force S	0.51	0.49	0.49	0.49	-	-	-	-	-	-
Labour force U	0.51	-	-	-	-	-	-	-	-	-
Households Consumption	0.32	0.30	0.30	0.30	0.25	0.25	0.25	0.11	0.11	0.11
Investment	0.79	0.67	0.67	0.67	0.47	0.46	0.45	0.46	0.45	0.45
Capital Stock	0.79	0.67	0.67	0.67	0.47	0.46	0.45	-	-	-
Replacement cost of capital	0.00	0.07	0.07	0.07	0.17	0.18	0.19	0.33	0.33	0.33
Export RUK	- 0.00	- 0.12	- 0.12	- 0.12	- 0.30	- 0.31	- 0.32	- 0.67	- 0.67	- 0.67
Export ROW	3.04	2.92	2.92	2.92	2.72	2.71	2.70	2.58	2.58	2.57

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

FIN = Financial services.

ϵ = Unemployment rate elasticity in the bargained real wage function.

Skill-disaggregated AMOS ϵ_s = 0.120 and ϵ_u = 0.112.

Sensitivity analysis. £500m ROW export demand stimulus to F&D. Unemployment rate elasticity.

		LR - Skilled migration			LR - No migration			SR		
	LR - Free migration	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$	$\epsilon_s = 0.096$; $\epsilon_u = 0.112$	$\epsilon_s = 0.120$; $\epsilon_u = 0.112$	$\epsilon_s = 0.144$; $\epsilon_u = 0.112$
GRP Income measure	0.48	0.34	0.34	0.34	0.20	0.19	0.18	0.03	0.03	0.03
Consumer Price Index	0.00	0.08	0.08	0.08	0.15	0.15	0.16	0.21	0.21	0.21
Unemployment Rate	- 0.00	- 1.01	- 1.01	- 1.01	- 2.15	- 1.98	- 1.85	- 0.78	- 0.74	- 0.70
Unemployment Rate S	- 0.00	- 0.00	- 0.00	- 0.00	- 1.85	- 1.60	- 1.41	- 0.63	- 0.56	- 0.50
Unemployment Rate U	- 0.00	- 2.93	- 2.93	- 2.93	- 2.71	- 2.69	- 2.68	- 1.07	- 1.08	- 1.09
Total Employment	0.42	0.27	0.27	0.27	0.14	0.13	0.12	0.05	0.05	0.04
Total Employment S	0.34	0.32	0.32	0.32	0.12	0.10	0.09	0.04	0.04	0.03
Total Employment U	0.57	0.19	0.19	0.19	0.17	0.17	0.17	0.07	0.07	0.07
Nominal Gross Wage	0.00	0.19	0.19	0.19	0.37	0.39	0.40	0.29	0.30	0.30
Nominal Gross Wage S	0.00	0.08	0.08	0.08	0.33	0.35	0.36	0.27	0.28	0.28
Nominal Gross Wage U	0.00	0.41	0.41	0.41	0.46	0.46	0.46	0.33	0.33	0.33
Real Gross Wage	0.00	0.12	0.12	0.12	0.22	0.23	0.24	0.08	0.09	0.09
Real Gross Wage S	0.00	0.00	0.00	0.00	0.18	0.19	0.20	0.06	0.07	0.07
Real Gross Wage U	0.00	0.33	0.33	0.33	0.31	0.31	0.30	0.12	0.12	0.12
Labour force	0.42	0.21	0.21	0.21	-	-	-	-	-	-
Labour force S	0.34	0.32	0.32	0.32	-	-	-	-	-	-
Labour force U	0.57	-	-	-	-	-	-	-	-	-
Households Consumption	0.26	0.23	0.23	0.23	0.20	0.20	0.20	0.09	0.09	0.09
Investment	0.57	0.44	0.44	0.44	0.31	0.30	0.29	0.42	0.41	0.41
Capital Stock	0.57	0.44	0.44	0.44	0.31	0.30	0.29	-	-	-
Replacement cost of capital	0.00	0.07	0.07	0.07	0.14	0.15	0.15	0.18	0.18	0.18
Export RUK	- 0.00	- 0.13	- 0.13	- 0.13	- 0.25	- 0.26	- 0.27	- 0.35	- 0.35	- 0.35
Export ROW	3.04	2.91	2.91	2.91	2.78	2.77	2.76	2.25	2.25	2.25

LR = long-run; SR = short-run. S = Skilled; U = Unskilled

F&D = Food, drink & tobacco.

ϵ = Unemployment rate elasticity in the bargained real wage function.

Skill-disaggregated AMOS ϵ_s = 0.120 and ϵ_u = 0.112.

Appendix 7B

Effects of a £500m demand stimulus to exports. In % changes

	LR - Free migration	LR - Skilled migration	LR - No migration	SR
GRP Income measure	0.97	0.73	0.37	0.07
Consumer Price Index	0.00	0.13	0.32	0.58
Unemployment Rate	- 0.00	- 1.69	- 4.06	- 1.74
Unemployment Rate S	- 0.00	- 0.00	- 3.90	- 1.68
Unemployment Rate U	- 0.00	- 4.94	- 4.35	- 1.84
Total Employment	0.88	0.63	0.26	0.11
Total Employment S	0.83	0.79	0.25	0.11
Total Employment U	0.97	0.32	0.28	0.12
Nominal Gross Wage	0.00	0.32	0.81	0.79
Nominal Gross Wage S	0.00	0.13	0.80	0.79
Nominal Gross Wage U	0.00	0.70	0.82	0.79
Real Gross Wage	0.00	0.20	0.49	0.21
Real Gross Wage S	0.00	0.00	0.48	0.20
Real Gross Wage U	0.00	0.57	0.50	0.21
Labour force	0.88	0.52	-	-
Labour force S	0.83	0.79	-	-
Labour force U	0.97	-	-	-
Households Consumption	0.54	0.49	0.42	0.19
Investment	1.13	0.89	0.55	0.65
Capital Stock	1.13	0.89	0.55	-
Replacement cost of capital	0.00	0.13	0.31	0.64
Export RUK	1.89	1.67	1.34	1.08
Export ROW	1.52	1.29	0.95	0.78
FTE Employment	19,781	13,223	5,821	2,486
FTE Employment S	10,817	10,299	3,243	1,395
FTE Employment U	8,963	2,924	2,578	1,091

SR = short-run; LR = long-run. S = Skilled; U = Unskilled

Appendix 8A

The skill-neutral and skill-differentiated increase in labour efficiency generates positive and negative changes to key macroeconomic variables in the period-by-period simulations. Employment, for example, falls initially and then increases towards the long run. These changes over time can be taken into account by calculating period-by-period present values of a selected variable.

GRP changes (in £million) are discounted to present value terms following the approach taken by Allan et al. (2016). This is also done for period-by-period changes in FTE employment and the real wage. The present values are calculated using a 3.5% real discount rate as of the HM Treasury (2013) Green Book.

These figures are interpreted as, for example, the present value of the discounted sums of period-by-period changes in GRP. This is also done for a number of policy relevant time horizons. The present value of the skilled real wage is, negative for years 1 to 5. That is, the value of the real wage for the year five is below the value of the real wage in time period zero.

Present values for GRP, employment, and real wage changes of the skill-neutral increase in labour efficiency

	PV$_{t=1..5}$	PV$_{t=1..10}$	PV$_{t=1..15}$	PV$_{t=1..20}$	PV$_{t=1..30}$
Free migration					
GRP changes	12.87	29.41	46.54	62.52	150.99
Total Employment S	- 73.66	- 91.83	- 76.42	- 48.37	175.01
Total Employment U	- 38.14	- 29.58	3.04	42.87	309.84
Real Gross Wage S	- 0.53	- 0.11	0.10	0.21	0.30
Real Gross Wage U	- 0.13	0.11	0.23	0.29	0.34
Skilled migration					
GRP changes	1.34	3.01	4.68	6.21	14.27
Total Employment S	- 76.71	- 92.76	- 73.76	- 44.00	161.75
Total Employment U	- 17.02	- 9.28	4.58	19.21	104.31
Real Gross Wage S	- 0.55	- 0.07	0.13	0.22	0.28
Real Gross Wage U	- 0.66	- 0.33	0.26	0.89	4.59
No migration					
GRP changes	1.47	3.26	4.94	6.39	13.70
Total Employment S	- 38.12	- 35.93	- 24.40	- 12.36	51.63
Total Employment U	- 19.33	- 9.27	6.54	21.59	99.55
Real Gross Wage S	- 2.16	- 2.03	- 1.31	- 0.56	3.45
Real Gross Wage U	- 0.75	- 0.32	0.36	1.00	4.37

GRP in £million. FTE Employment in thousands. Real gross wage in £million.

Present values for GRP, employment, and real wage changes of the skill-differentiated increase in labour efficiency

		$PV_{t=1..5}$	$PV_{t=1..10}$	$PV_{t=1..15}$	$PV_{t=1..20}$	$PV_{t=1..30}$
Increase in skilled efficiency:						
Free migration						
	GRP changes	8.43	19.14	30.15	40.38	96.43
	Total Employment S	- 47.45	- 59.17	- 49.73	- 32.54	101.99
	Total Employment U	- 25.78	- 21.67	- 2.24	21.71	181.11
	Real Gross Wage S	- 0.34	- 0.07	0.06	0.12	0.18
	Real Gross Wage U	- 0.09	0.06	0.13	0.17	0.20
Skilled migration						
	GRP changes	0.88	1.96	3.04	4.02	9.18
	Total Employment S	- 49.52	- 59.96	- 48.20	- 29.79	96.23
	Total Employment U	- 11.47	- 6.99	1.47	10.46	62.71
	Real Gross Wage S	- 0.36	- 0.05	0.08	0.13	0.17
	Real Gross Wage U	- 0.45	- 0.27	0.09	0.47	2.68
No migration						
	GRP changes	0.97	2.13	3.21	4.14	8.86
	Total Employment S	- 24.29	- 22.96	- 15.73	- 8.18	31.96
	Total Employment U	- 12.94	- 6.97	2.74	12.03	60.19
	Real Gross Wage S	- 1.41	- 1.33	- 0.88	- 0.42	2.06
	Real Gross Wage U	- 0.51	- 0.26	0.15	0.54	2.58
Increase in unskilled efficiency:						
Free migration						
	GRP changes	4.44	10.03	15.74	21.02	49.77
	Total Employment S	- 26.06	- 33.83	- 30.59	- 23.26	36.60
	Total Employment U	- 12.00	- 8.33	2.90	16.13	101.29
	Real Gross Wage S	- 0.20	- 0.06	0.01	0.04	0.06
	Real Gross Wage U	- 0.04	0.04	0.08	0.10	0.11
Skilled migration						
	GRP changes	0.46	1.02	1.58	2.08	4.73
	Total Employment S	- 27.05	- 34.08	- 29.66	- 21.73	34.36
	Total Employment U	- 5.18	- 2.31	2.48	7.45	35.91
	Real Gross Wage S	- 0.20	- 0.05	0.02	0.04	0.06
	Real Gross Wage U	- 0.21	- 0.09	0.11	0.32	1.50
No migration						
	GRP changes	0.51	1.12	1.68	2.17	4.62
	Total Employment S	- 13.20	- 13.15	- 9.97	- 6.56	11.73
	Total Employment U	- 5.98	- 2.34	3.14	8.32	35.09
	Real Gross Wage S	- 0.78	- 0.78	- 0.58	- 0.38	0.74
	Real Gross Wage U	- 0.24	- 0.09	0.14	0.35	1.47

GRP in £million. FTE Employment in thousands. Real gross wage in £million.

Appendix 8B

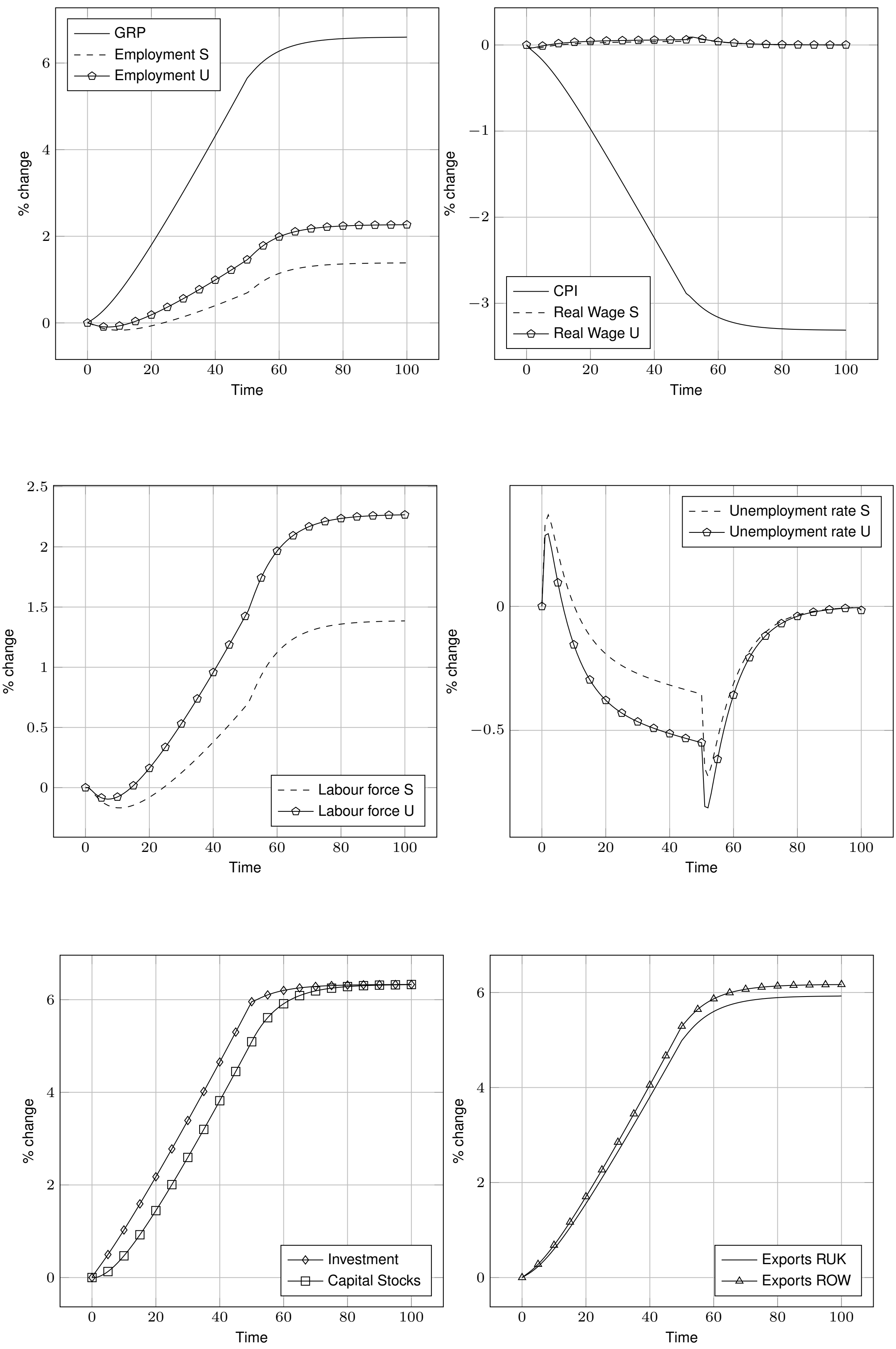
Results for a gradual increase in skill-neutral labour efficiency are detailed below. Cumulative efficiency is increased by 0.1% in each period until it reaches 5% in period 50. The 5% increase is then maintained from period 50 to 100. The main adjustments seen are similar to these seen when efficiency is not gradually increased (as outlined in Section 8.4), and the the long run results are the same. There is some divergence in the free migration case as the model needs to be run for more time periods for the unemployment rate to return to base. Also, the short run impact is smaller here as efficiency is increased by 0.1% as compared to the 5% increase modelled in Section 8.4. Adjustment paths thereby also differ and are detailed overleaf.

Short- and long-run effects of a gradual increase in total labour efficiency. In % changes

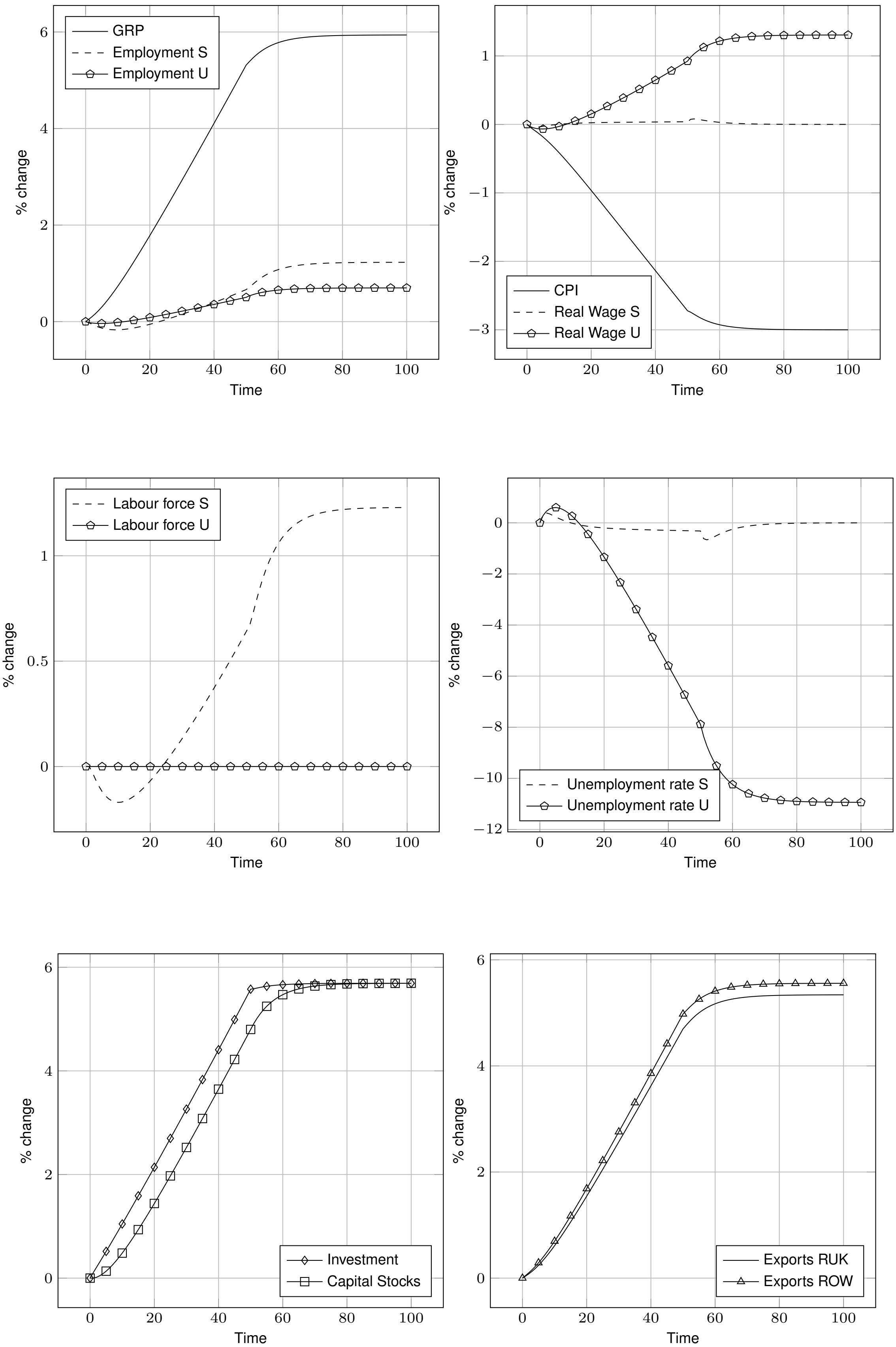
	LR - Free migration	LR - Skilled migration	LR - No migration	SR
GRP Income measure	6.60	5.94	5.34	0.05
Consumer Price Index	- 3.31	- 3.00	- 2.71	- 0.04
Unemployment Rate	- 0.02	- 5.47	- 7.78	0.31
Unemployment Rate S	- 0.01	- 0.00	- 5.75	0.33
Unemployment Rate U	- 0.02	- 10.94	- 9.82	0.29
Total Employment	1.69	1.05	0.46	- 0.02
Total Employment S	1.39	1.23	0.37	- 0.02
Total Employment U	2.27	0.70	0.63	- 0.02
Nominal Gross Wage	- 3.31	- 2.37	- 1.80	- 0.08
Nominal Gross Wage S	- 3.31	- 3.00	- 2.02	- 0.08
Nominal Gross Wage U	- 3.31	- 1.73	- 1.58	- 0.07
Real Gross Wage	0.00	0.65	0.94	- 0.04
Real Gross Wage S	0.00	0.00	0.71	- 0.04
Real Gross Wage U	0.00	1.31	1.16	- 0.03
Labour force	1.69	0.81	-	-
Labour force S	1.38	1.23	-	-
Labour force U	2.27	-	-	-
Households Consumption	1.49	1.33	1.19	- 0.02
Investment	6.33	5.69	5.11	0.11
Capital Stock	6.33	5.69	5.11	-
Replacement cost of capital	- 3.24	- 2.93	- 2.65	- 0.00
Export RUK	5.93	5.34	4.80	0.04
Export ROW	6.17	5.56	5.00	0.05

SR = short-run; LR = long-run. S = Skilled; U = Unskilled

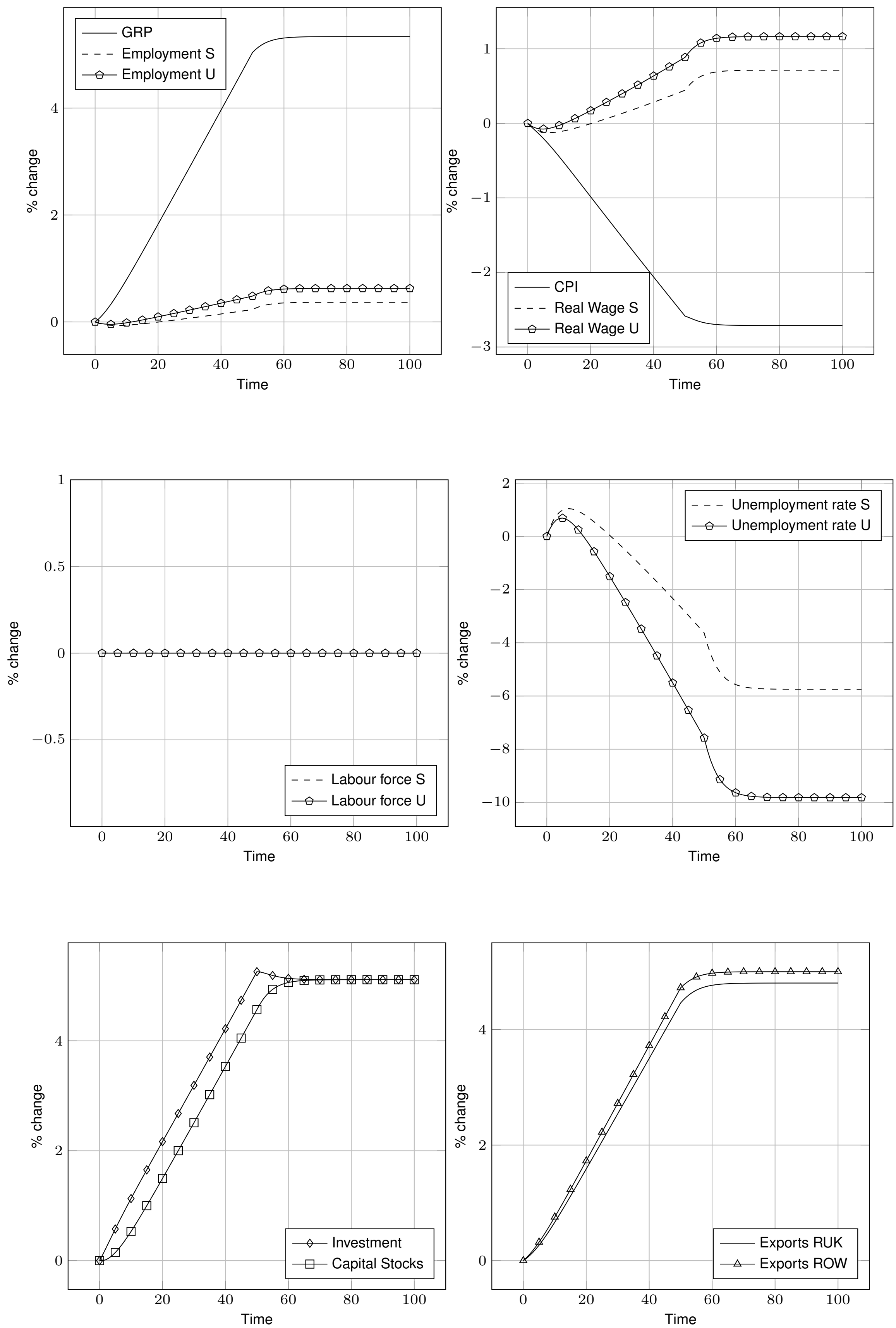
Aggregate transition paths - gradual increase in total labour efficiency - long-run - free migration



Aggregate transition paths - gradual increase in total labour efficiency - long-run - skilled migration



Aggregate transition paths - gradual increase in total labour efficiency - long-run - no migration

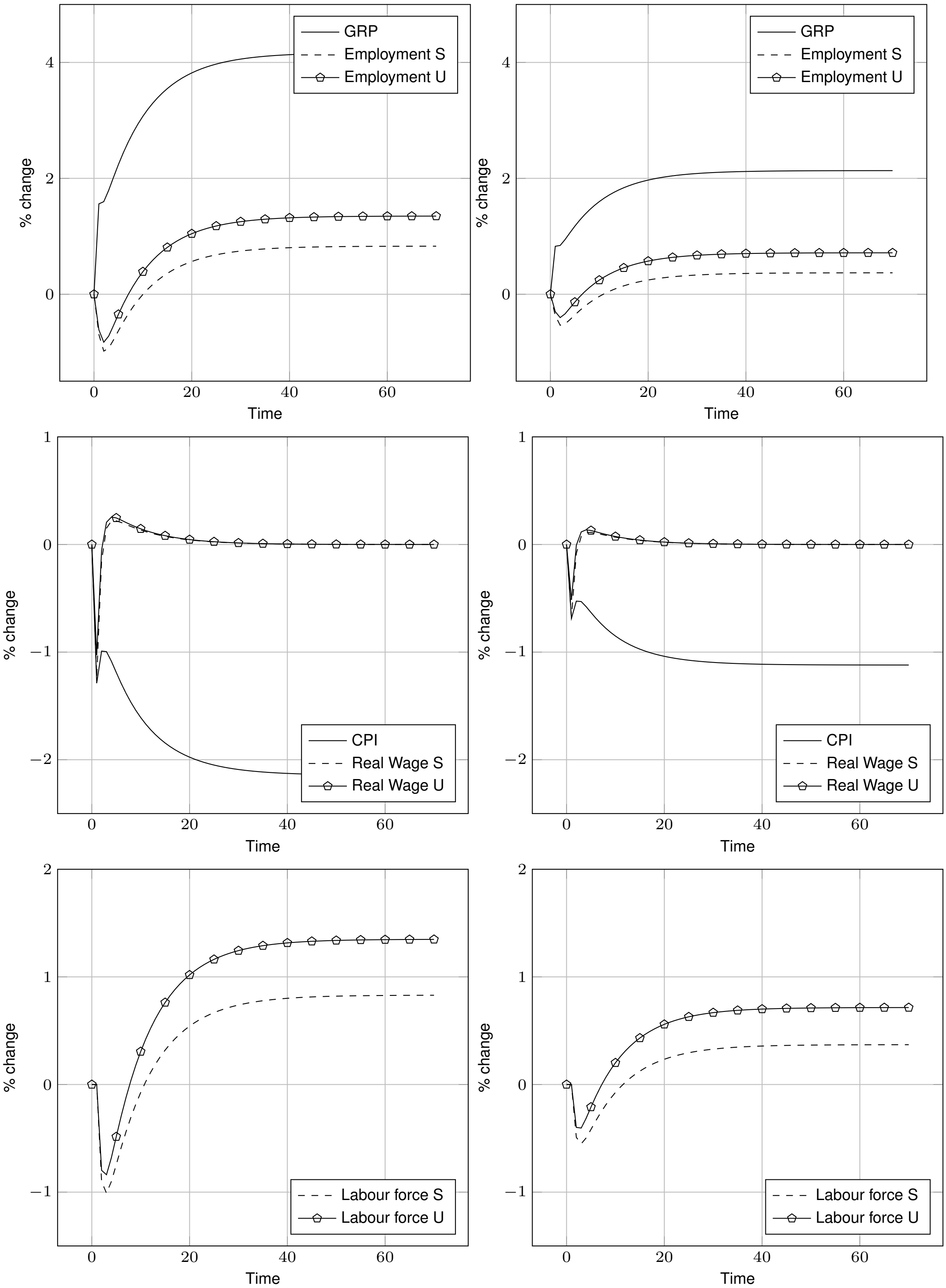


Appendix 8C

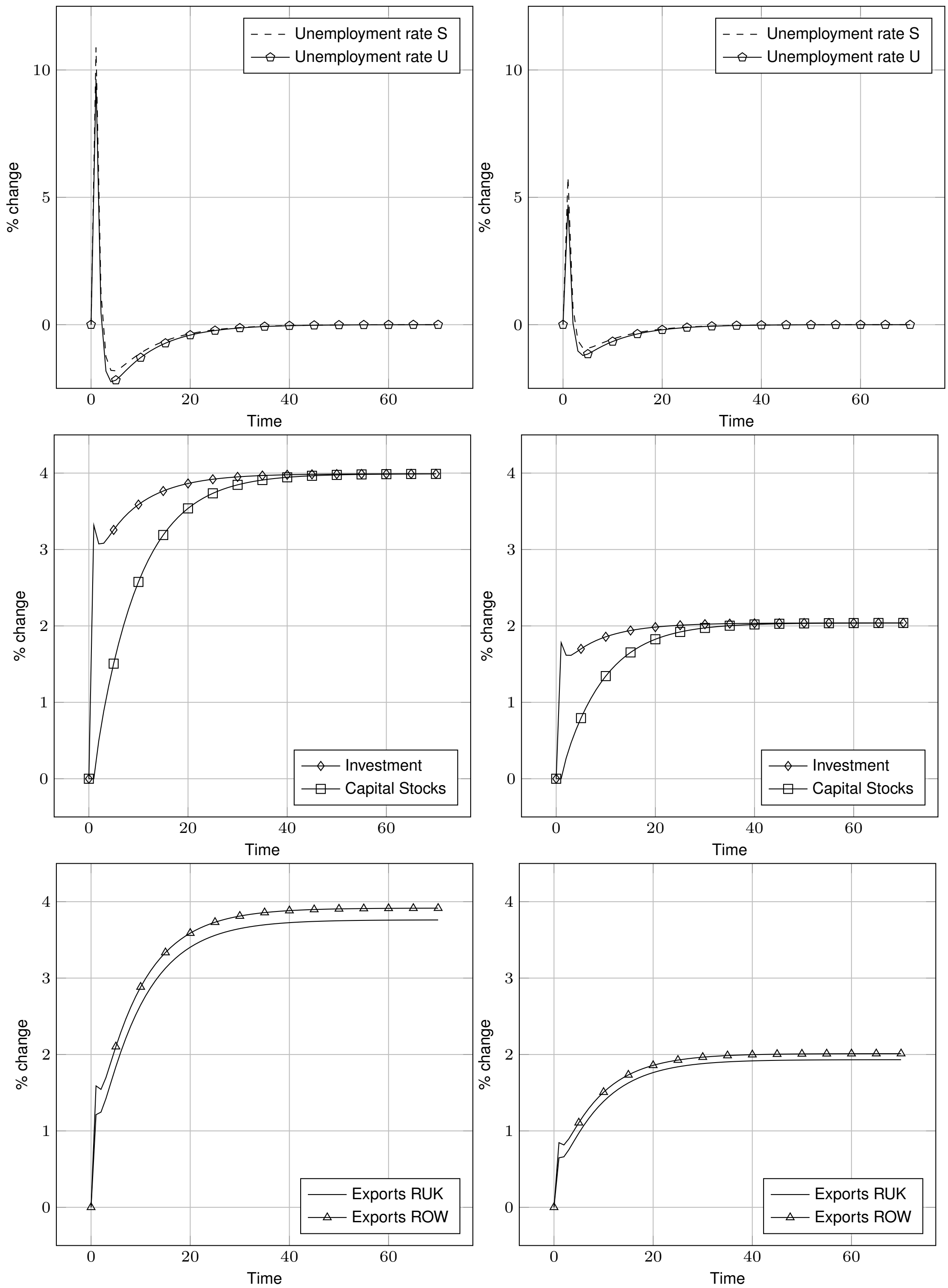
Aggregate transition paths - increase in skill-differentiated labour efficiency - long-run - free migration

a) Increase in skilled efficiency

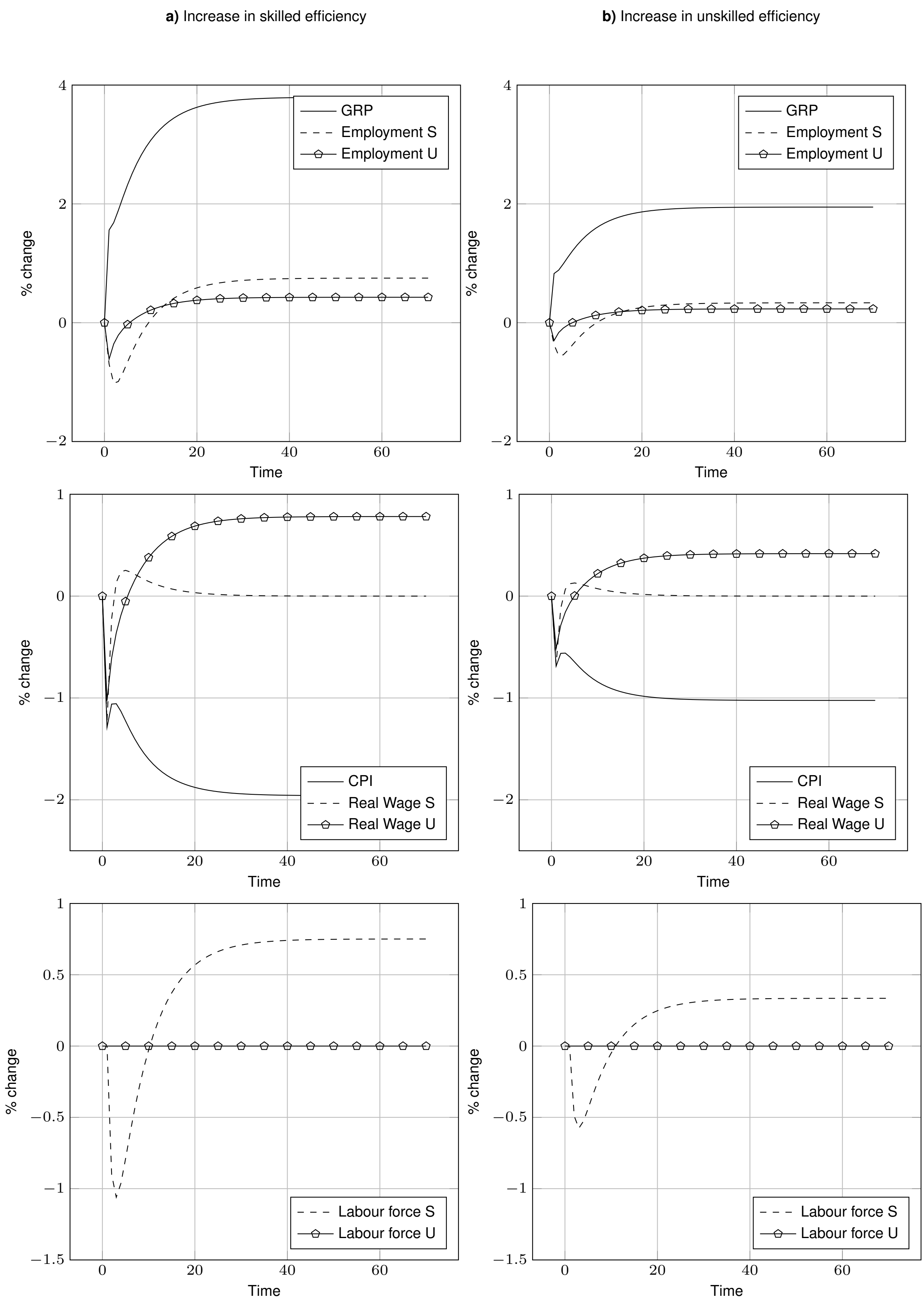
b) Increase in unskilled efficiency



a) Increase in skilled efficiency **b)** Increase in unskilled efficiency

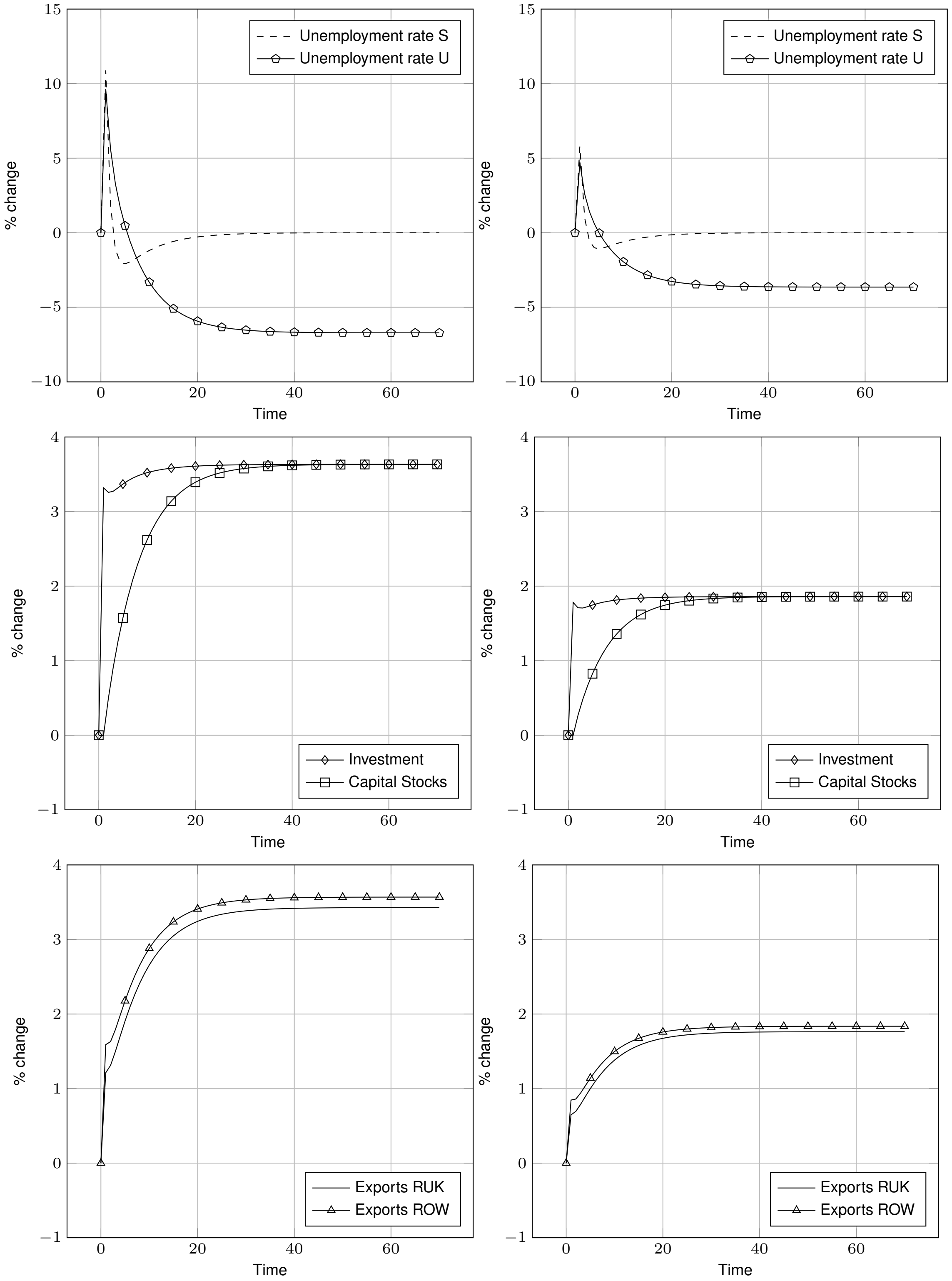


Aggregate transition paths - increase in skill-differentiated labour efficiency - long-run - skilled migration



a) Increase in skilled efficiency

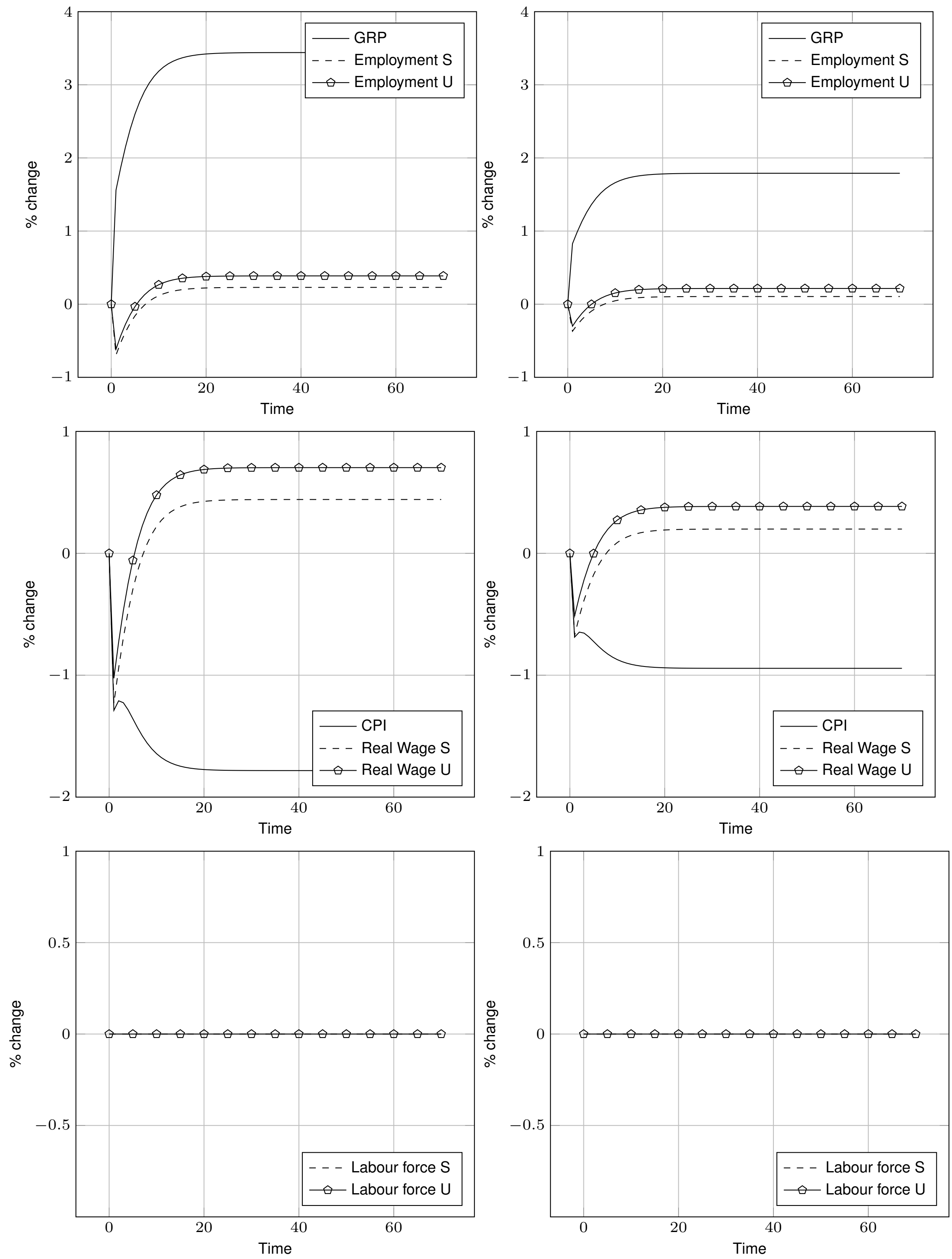
b) Increase in unskilled efficiency



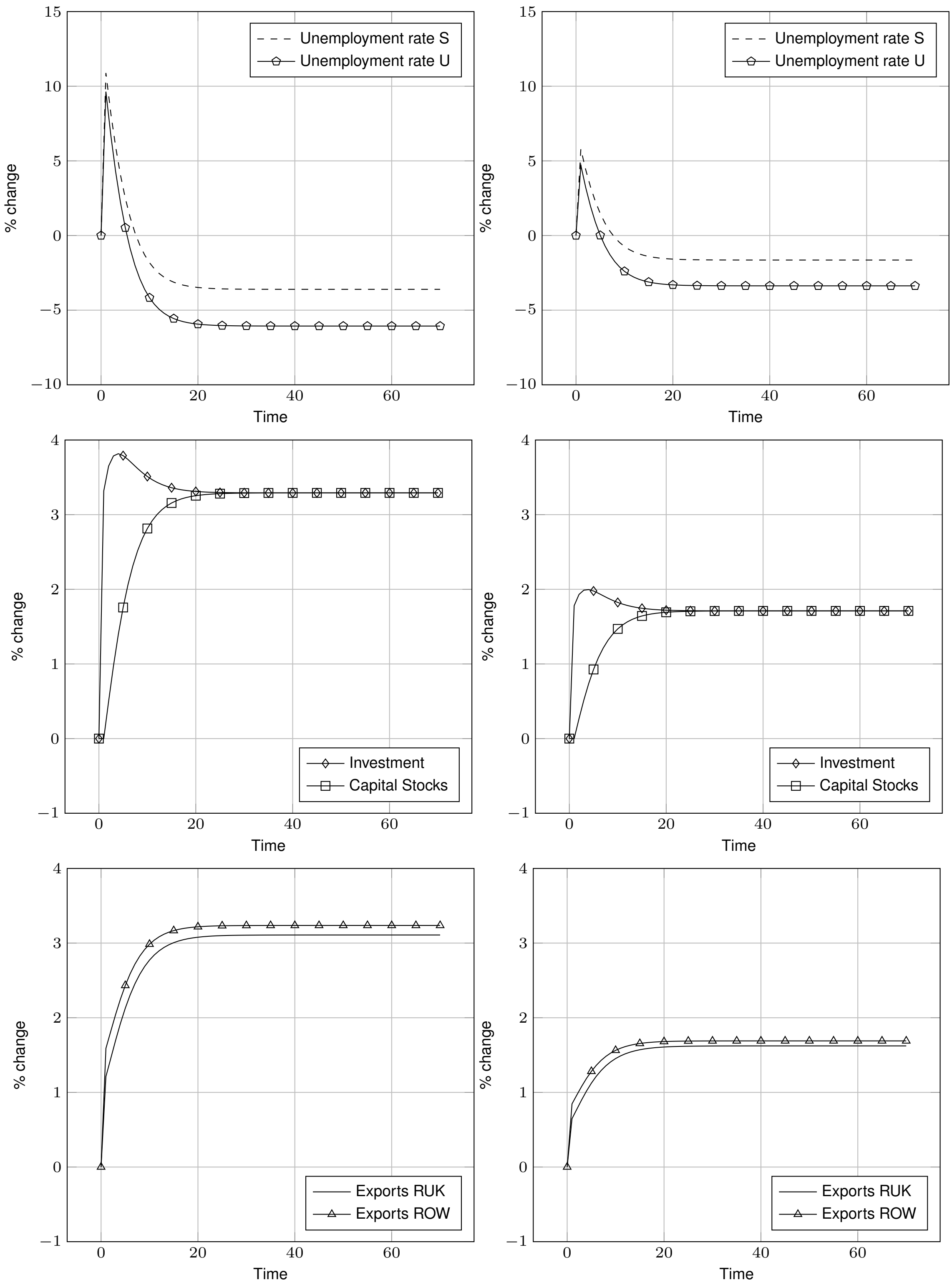
Aggregate transition paths - increase in skill-differentiated labour efficiency - long-run - no migration

a) Increase in skilled efficiency

b) Increase in unskilled efficiency



a) Increase in skilled efficiency **b)** Increase in unskilled efficiency



Appendix 8D

Sensitivity analysis. Increase in total labour efficiency. Elasticity of substitution between skilled and unskilled.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$
GRP Income measure	6.60	6.60	6.60	5.81	5.94	5.99	5.34	5.34	5.34
Consumer Price Index	-3.31	-3.31	-3.31	-2.94	-3.00	-3.03	-2.71	-2.71	-2.71
Unemployment Rate	-0.00	-0.00	-0.00	-6.43	-5.47	-5.03	-7.99	-7.78	-7.70
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-5.29	-5.75	-5.91
Unemployment Rate U	-0.00	-0.00	-0.00	-12.86	-10.94	-10.06	-10.68	-9.82	-9.50
Total Employment	1.69	1.69	1.69	0.92	1.05	1.10	0.46	0.46	0.46
Total Employment S	1.39	1.39	1.39	0.98	1.23	1.34	0.34	0.37	0.38
Total Employment U	2.27	2.27	2.27	0.82	0.70	0.64	0.68	0.63	0.61
Nominal Gross Wage	-3.31	-3.31	-3.31	-2.19	-2.37	-2.45	-1.77	-1.80	-1.81
Nominal Gross Wage S	-3.31	-3.31	-3.31	-2.94	-3.00	-3.03	-2.07	-2.02	-2.00
Nominal Gross Wage U	-3.31	-3.31	-3.31	-1.43	-1.73	-1.87	-1.47	-1.58	-1.62
Real Gross Wage	0.00	0.00	0.00	0.78	0.65	0.60	0.96	0.94	0.93
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.71	0.73
Real Gross Wage U	0.00	0.00	0.00	1.55	1.31	1.20	1.27	1.16	1.12
Labour force	1.69	1.69	1.69	0.64	0.81	0.88	-	-	-
Labour force S	1.39	1.39	1.39	0.98	1.23	1.34	-	-	-
Labour force U	2.27	2.27	2.27	-	-	-	-	-	-
Households Consumption	1.49	1.49	1.49	1.30	1.33	1.35	1.19	1.19	1.19
Investment	6.33	6.33	6.33	5.57	5.69	5.75	5.11	5.11	5.11
Capital Stock	6.33	6.33	6.33	5.57	5.69	5.75	5.11	5.11	5.11
Replacement cost of capital	-3.24	-3.24	-3.24	-2.87	-2.93	-2.96	-2.65	-2.65	-2.65
Export RUK	5.93	5.93	5.93	5.23	5.34	5.39	4.80	4.80	4.80
Export ROW	6.17	6.17	6.17	5.44	5.56	5.61	5.00	5.00	5.00

LR = long-run. S = Skilled; U = Unskilled.

σ_S = Elasticity of substitution between skilled and unskilled.

Skill-disaggregated AMOS σ_S = 1.01.

Sensitivity analysis. Increase in skilled labour efficiency. Elasticity of substitution between skilled and unskilled.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$
GRP Income measure	4.16	4.17	4.18	3.27	3.80	4.03	3.41	3.44	3.44
Consumer Price Index	-2.14	-2.14	-2.15	-1.70	-1.96	-2.08	-1.77	-1.78	-1.78
Unemployment Rate	-0.00	-0.00	-0.00	-7.60	-3.36	-1.34	-7.02	-4.83	-3.88
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	1.82	-3.60	-5.53
Unemployment Rate U	-0.00	-0.00	-0.00	-15.20	-6.71	-2.68	-15.86	-6.06	-2.22
Total Employment	1.01	1.01	1.01	0.12	0.64	0.87	0.27	0.28	0.28
Total Employment S	0.13	0.83	1.24	-0.32	0.75	1.23	-0.12	0.23	0.35
Total Employment U	2.67	1.35	0.58	0.97	0.43	0.17	1.01	0.39	0.14
Nominal Gross Wage	-2.14	-2.14	-2.15	-0.78	-1.58	-1.93	-0.92	-1.22	-1.32
Nominal Gross Wage S	-2.14	-2.14	-2.15	-1.70	-1.96	-2.08	-1.98	-1.35	-1.11
Nominal Gross Wage U	-2.14	-2.14	-2.15	0.14	-1.19	-1.78	0.15	-1.09	-1.54
Real Gross Wage	0.00	0.00	0.00	0.93	0.39	0.15	0.87	0.57	0.47
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.22	0.44	0.69
Real Gross Wage U	0.00	0.00	0.00	1.86	0.78	0.31	1.95	0.70	0.25
Labour force	1.01	1.01	1.01	-0.21	0.49	0.81	-	-	-
Labour force S	0.13	0.83	1.24	-0.32	0.75	1.23	-	-	-
Labour force U	2.67	1.35	0.58	-	-	-	-	-	-
Households Consumption	0.91	0.91	0.92	0.71	0.83	0.88	0.74	0.75	0.75
Investment	3.98	3.99	4.00	3.12	3.63	3.86	3.27	3.29	3.29
Capital Stock	3.98	3.99	4.00	3.12	3.63	3.86	3.27	3.29	3.29
Replacement cost of capital	-2.09	-2.09	-2.10	-1.65	-1.91	-2.03	-1.73	-1.74	-1.74
Export RUK	3.75	3.76	3.77	2.95	3.43	3.64	3.08	3.11	3.11
Export ROW	3.90	3.92	3.92	3.07	3.57	3.79	3.21	3.24	3.24

LR = long-run. S = Skilled; U = Unskilled.

σ_S = Elasticity of substitution between skilled and unskilled.

Skill-disaggregated AMOS σ_S = 1.01.

Sensitivity analysis. Increase in unskilled labour efficiency. Elasticity of substitution between skilled and unskilled.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$	$\sigma_S = 0.60$	$\sigma_S = 1.01$	$\sigma_S = 1.25$
GRP Income measure	2.12	2.13	2.14	2.31	1.95	1.78	1.76	1.79	1.80
Consumer Price Index	-1.11	-1.12	-1.12	-1.21	-1.02	-0.94	-0.93	-0.94	-0.95
Unemployment Rate	-0.00	-0.00	-0.00	1.88	-1.82	-3.43	0.09	-2.51	-3.35
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-6.32	-1.64	0.17
Unemployment Rate U	-0.00	-0.00	-0.00	3.76	-3.65	-6.86	6.49	-3.37	-6.87
Total Employment	0.49	0.49	0.49	0.67	0.30	0.13	0.12	0.14	0.14
Total Employment S	1.06	0.37	-0.04	1.15	0.33	-0.04	0.40	0.10	-0.01
Total Employment U	-0.60	0.72	1.49	-0.24	0.23	0.44	-0.41	0.22	0.44
Nominal Gross Wage	-1.11	-1.12	-1.12	-1.41	-0.82	-0.54	-0.88	-0.65	-0.56
Nominal Gross Wage S	-1.11	-1.12	-1.12	-1.21	-1.02	-0.94	-0.15	-0.75	-0.97
Nominal Gross Wage U	-1.11	-1.12	-1.12	-1.62	-0.61	-0.15	-1.62	-0.56	-0.15
Real Gross Wage	0.00	0.00	0.00	-0.21	0.21	0.40	0.04	0.29	0.39
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.20	-0.02
Real Gross Wage U	0.00	0.00	0.00	-0.41	0.42	0.80	-0.70	0.38	0.80
Labour force	0.49	0.49	0.49	0.76	0.22	-0.02	-	-	-
Labour force S	1.06	0.37	-0.04	1.15	0.33	-0.04	-	-	-
Labour force U	-0.60	0.72	1.49	-	-	-	-	-	-
Households Consumption	0.45	0.45	0.45	0.49	0.41	0.38	0.37	0.38	0.38
Investment	2.03	2.04	2.05	2.20	1.86	1.70	1.68	1.71	1.72
Capital Stock	2.03	2.04	2.05	2.20	1.86	1.70	1.68	1.71	1.72
Replacement cost of capital	-1.09	-1.09	-1.10	-1.18	-1.00	-0.91	-0.90	-0.92	-0.92
Export RUK	1.92	1.93	1.94	2.09	1.76	1.61	1.59	1.62	1.63
Export ROW	2.00	2.01	2.02	2.17	1.84	1.68	1.66	1.69	1.70

LR = long-run. S = Skilled; U = Unskilled.

σ_S = Elasticity of substitution between skilled and unskilled.

Skill-disaggregated AMOS σ_S = 1.01.

Sensitivity analysis. Increase in total labour efficiency. Armington trade elasticity.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$
GRP Income measure	4.85	6.60	8.41	4.73	5.94	7.00	4.78	5.34	5.72
Consumer Price Index	-3.32	-3.31	-3.31	-3.23	-3.00	-2.79	-3.27	-2.71	-2.31
Unemployment Rate	-0.00	-0.00	-0.00	-1.57	-5.47	-8.72	-1.22	-7.78	-12.26
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.66	-5.75	-10.13
Unemployment Rate U	-0.00	-0.00	-0.00	-3.14	-10.94	-17.44	-3.11	-9.82	-14.39
Total Employment	0.12	1.69	3.32	-0.00	1.05	1.97	0.04	0.46	0.74
Total Employment S	-0.12	1.39	2.95	-0.11	1.23	2.42	-0.04	0.37	0.65
Total Employment U	0.57	2.27	4.03	0.20	0.70	1.11	0.20	0.63	0.92
Nominal Gross Wage	-3.32	-3.31	-3.31	-3.06	-2.37	-1.74	-3.13	-1.80	-0.83
Nominal Gross Wage S	-3.32	-3.31	-3.31	-3.23	-3.00	-2.79	-3.34	-2.02	-1.05
Nominal Gross Wage U	-3.32	-3.31	-3.31	-2.88	-1.73	-0.68	-2.92	-1.58	-0.60
Real Gross Wage	0.00	0.00	0.00	0.18	0.65	1.09	0.14	0.94	1.52
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.08	0.71	1.29
Real Gross Wage U	0.00	0.00	0.00	0.36	1.31	2.17	0.35	1.16	1.75
Labour force	0.12	1.69	3.32	-0.07	0.81	1.59	-	-	-
Labour force S	-0.12	1.39	2.95	-0.11	1.23	2.42	-	-	-
Labour force U	0.57	2.27	4.03	-	-	-	-	-	-
Households Consumption	0.53	1.49	2.49	0.52	1.33	2.05	0.52	1.19	1.66
Investment	4.42	6.33	8.30	4.32	5.69	6.90	4.35	5.11	5.64
Capital Stock	4.42	6.33	8.30	4.32	5.69	6.90	4.35	5.11	5.64
Replacement cost of capital	-3.24	-3.24	-3.24	-3.15	-2.93	-2.73	-3.19	-2.65	-2.26
Export RUK	2.92	5.93	9.03	2.87	5.34	7.53	2.88	4.80	6.17
Export ROW	3.04	6.17	9.40	2.99	5.56	7.84	3.00	5.00	6.43

LR = long-run. S = Skilled; U = Unskilled.

σ_V = Elasticity of substitution between imports and domestic output in domestic demand.

Skill-disaggregated AMOS σ_V = 2.00.

Sensitivity analysis. Increase in skilled labour efficiency. Armington trade elasticity.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$
GRP Income measure	3.09	4.17	5.27	3.03	3.80	4.47	3.08	3.44	3.70
Consumer Price Index	-2.15	-2.14	-2.14	-2.10	-1.96	-1.83	-2.14	-1.78	-1.53
Unemployment Rate	-0.00	-0.00	-0.00	-0.80	-3.36	-5.55	-0.47	-4.83	-7.88
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.63	-3.60	-6.57
Unemployment Rate U	-0.00	-0.00	-0.00	-1.59	-6.71	-11.09	-1.57	-6.06	-9.19
Total Employment	0.02	1.01	2.02	-0.04	0.64	1.24	0.01	0.28	0.48
Total Employment S	-0.12	0.83	1.80	-0.11	0.75	1.52	-0.04	0.23	0.42
Total Employment U	0.28	1.35	2.44	0.10	0.43	0.71	0.10	0.39	0.59
Nominal Gross Wage	-2.15	-2.14	-2.14	-2.02	-1.58	-1.18	-2.09	-1.22	-0.59
Nominal Gross Wage S	-2.15	-2.14	-2.14	-2.10	-1.96	-1.83	-2.21	-1.35	-0.72
Nominal Gross Wage U	-2.15	-2.14	-2.14	-1.93	-1.19	-0.53	-1.96	-1.09	-0.46
Real Gross Wage	0.00	0.00	0.00	0.09	0.39	0.66	0.05	0.57	0.95
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.08	0.44	0.82
Real Gross Wage U	0.00	0.00	0.00	0.18	0.78	1.33	0.18	0.70	1.09
Labour force	0.02	1.01	2.02	-0.07	0.49	0.99	-	-	-
Labour force S	-0.12	0.83	1.80	-0.11	0.75	1.52	-	-	-
Labour force U	0.28	1.35	2.44	-	-	-	-	-	-
Households Consumption	0.31	0.91	1.53	0.31	0.83	1.29	0.31	0.75	1.06
Investment	2.81	3.99	5.20	2.76	3.63	4.40	2.80	3.29	3.64
Capital Stock	2.81	3.99	5.20	2.76	3.63	4.40	2.80	3.29	3.64
Replacement cost of capital	-2.09	-2.09	-2.09	-2.05	-1.91	-1.79	-2.09	-1.74	-1.49
Export RUK	1.87	3.76	5.69	1.84	3.43	4.83	1.86	3.11	4.00
Export ROW	1.94	3.92	5.93	1.92	3.57	5.03	1.93	3.24	4.17

LR = long-run. S = Skilled; U = Unskilled.

σ_V = Elasticity of substitution between imports and domestic output in domestic demand.

Skill-disaggregated AMOS σ_V = 2.00.

Sensitivity analysis. Increase in unskilled labour efficiency. Armington trade elasticity.

	LR - Free migration			LR - Skilled migration			LR - No migration		
	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$	$\sigma_V = 1.00$	$\sigma_V = 2.00$	$\sigma_V = 3.00$
GRP Income measure	1.59	2.13	2.69	1.56	1.95	2.29	1.60	1.79	1.93
Consumer Price Index	-1.12	-1.12	-1.12	-1.09	-1.02	-0.96	-1.13	-0.94	-0.81
Unemployment Rate	-0.00	-0.00	-0.00	-0.49	-1.82	-2.99	-0.18	-2.51	-4.16
Unemployment Rate S	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.61	-1.64	-3.25
Unemployment Rate U	-0.00	-0.00	-0.00	-0.97	-3.65	-5.98	-0.97	-3.37	-5.08
Total Employment	-0.01	0.49	1.00	-0.05	0.30	0.61	-0.00	0.14	0.25
Total Employment S	-0.11	0.37	0.86	-0.11	0.33	0.73	-0.04	0.10	0.21
Total Employment U	0.17	0.72	1.27	0.06	0.23	0.38	0.06	0.22	0.32
Nominal Gross Wage	-1.12	-1.12	-1.12	-1.04	-0.82	-0.62	-1.11	-0.65	-0.32
Nominal Gross Wage S	-1.12	-1.12	-1.12	-1.09	-1.02	-0.96	-1.20	-0.75	-0.42
Nominal Gross Wage U	-1.12	-1.12	-1.12	-0.99	-0.61	-0.27	-1.02	-0.56	-0.23
Real Gross Wage	0.00	0.00	0.00	0.05	0.21	0.35	0.02	0.29	0.49
Real Gross Wage S	0.00	0.00	0.00	0.00	0.00	0.00	-0.07	0.20	0.40
Real Gross Wage U	0.00	0.00	0.00	0.11	0.42	0.69	0.11	0.38	0.59
Labour force	-0.01	0.49	1.00	-0.07	0.22	0.48	-	-	-
Labour force S	-0.11	0.37	0.86	-0.11	0.33	0.73	-	-	-
Labour force U	0.17	0.72	1.27	-	-	-	-	-	-
Households Consumption	0.15	0.45	0.76	0.15	0.41	0.65	0.15	0.38	0.55
Investment	1.44	2.04	2.64	1.41	1.86	2.26	1.45	1.71	1.90
Capital Stock	1.44	2.04	2.64	1.41	1.86	2.26	1.45	1.71	1.90
Replacement cost of capital	-1.09	-1.09	-1.09	-1.07	-1.00	-0.94	-1.10	-0.92	-0.79
Export RUK	0.96	1.93	2.91	0.95	1.76	2.49	0.97	1.62	2.09
Export ROW	1.00	2.01	3.03	0.99	1.84	2.59	1.01	1.69	2.18

LR = long-run. S = Skilled; U = Unskilled.

σ_V = Elasticity of substitution between imports and domestic output in domestic demand.

Skill-disaggregated AMOS σ_V = 2.00.

References

Acemoglu, D. (2002). Technical Change, Inequality, and the Labor Market. *Journal of Economic Literature*, *40*(1), 7-72.

Adelman, I., & Robinson, S. (1986). U.S. Agriculture in a General Equilibrium Framework: Analysis with a Social Accounting Matrix. *American Journal of Agricultural Economics*, *68*(5), 1196-1207.

Allan, G., Dunlop, S., & Swales, K. J. (2007). The Economic Impact of Regular Season Sporting Competitions: The Glasgow Old Firm Football Spectators as Sports Tourists. *Journal of Sport and Tourism*, *12*(2), 63-97.

Allan, G., Lecca, P., & Swales, K. J. (2016). The impacts of temporary but anticipated tourism spending: an application to the glasgow 2014 commonwealth games. *Tourism Management*, *59*, 325-337.

Armington, P. (1969). A theory of demand for products distinguished by place of production. *Statistics Papers IMF*, 159-178.

Arpaia, A., Perez, E., & Pichelmann, K. (2009). Understanding Labour Income Share Dynamics in Europe. *European Commission*, *379*, 1-51.

Arrow, K., & Debreu, G. (1954). Existence of an equilibrium for a competitive economy. *Econometrica*, *22*, 265-290.

Autor, D. (2010). The Polarization of Job Opportunities in the U.S. Labor Market. *The Center for American Progress and The Hamilton Project*, 1-48.

Batey, P. W. J. (1985). Input-output models for regional demographic- economic analysis: some structural comparisons. *Environment and Planning A*, *17*(1), 73-99.

Batey, P. W. J., & Madden, M. (1983). Linked Population and Economic Models: Some Methodological Issues in Forecasting, Analysis and Policy Optimisation. *Journal of Regional Science*, *23*, 141-164.

Batey, P. W. J., & Rose, Z. A. (1990). Extended input-output models: Progress and potential. *International Regional Science Review*, *13*(1-2), 27-49.

Batey, P. W. J., & Weeks, M. J. (1989). *The Effects of Household Disaggregation in Extended Input-Output Models; in: Frontiers of Input- Output Analysis: Commemorative Papers*. Oxford University Press, New York.

Behar, A. (2010). The elasticity of substitution between skilled and unskilled labour in developing countries is about 2. *University of Oxford Department of Economics Discussion Paper Series*, *467*, 1-35.

Bell, D., & Eiser, D. (2013). Inequality in Scotland: trends, drivers, and implications for the independence debate. *University of Stirling, ESRC, and Future of the UK and Scotland*, 1-29.

Blanchflower, D., & Oswald, A. (1995). *The Wage Curve*. The MIT Press.

Boeters, S., & Savard, L. (2011). The labour market in cge models. *ZEW-Centre for European Economic Research Discussion Paper*(11-079).

Breisinger, C., Thoimas, M., & Thurlow, J. (2010). *Social Accounting Matrices and Multiplier Analysis*. International Food Policy Research Institute.

Brown, S., & Sessions, J. G. (1997). A Profile of UK Unemployment: Regional versus Demographic Influences. *Regional Studies*, *31*(4), 351-366.

Card, D. (1995). The wage curve: a review. *Journal of Economic Literature*, *33*(2), 785-799.

Czaika, M., & Hein, D. H. (2011). Determinants of migration to the uk. *Migration Observatory Briefing, COMPAS, University of Oxford*.

Debreu, G. (1959). *Theory of value. An axiomatic analysis of economic equilibrium*. John Wiley and Sons, New York.

De Melo, J., & Tarr, D. G. (1992). *A general equilibrium analysis of US foreign trade policy*. MIT Press.

De Menil, G. (1971). *Bargaining: Monopoly Power Versus Union Power*. Cambridge: MIT Press.

Dixon, P., & Parmenter, B. (1996). Computable general equilibrium modelling for policy analysis and forecasting. *Handbook of computational economics*, *1*, 3-85.

Dixon, S. (2003). Migration within Britain for job reasons. *Labour Market trends*, *April*(1), 191-201.

Edwards, H., & Whalley, J. (2002). Short and Long Run Decompositions of OECD Wage Inequality Changes. *NBER Working Paper*, *9265*, 1-35.

Elliott, R. J., & Lindley, J. (2006). Skill specificity and labour mobility: occupational and sectoral dimentsions. *The Manchester School*, *74*(3), 389-413.

Emonts-Holley, T. (2016). *Fiscal Devolution in Scotland: A Multi-Sectoral Analysis*. University of Strathclyde, PhD Thesis.

Emonts-Holley, T., & Ross, A. (2016). *Social Accounting Matrix (SAM) for Scotland 2009.* Retrieved 01.01.2016, from http://dx.doi.org/10.15129/7a2d1170-5d20-45c8-afbe-3c43d48d66c4

Figus, G., Lecca, P., Turner, K., & McGregor, G. P. (2016). Iincreased energy efficiency in scottish households: Trading-off economic benefits and energy rebound effects? *International Public Policy Institute*.

Fingleton, B., & Palombi, S. (2013). The Wage Curve Reconsidered: Is It Truly an Empirical Law of Economics. *Région et Développement*, *38*, 49-92.

Fraser of Allander Institute. (2014). Economic Impact Study into the Development of the UK Offshore Renewable Energy Industry to 2020. *Offshore Renewable Energy Catapult*.

Freeman, R. (1999). Demand for Education. In *Handbook of labor economics, vol 1* (p. Chapter 6). North Holland Publishers. (First published in Handbook of Labor Economics: Vol.I, Edited by 0. Ashenfelter and A. Layard. Netherlands: Elsevier Pubs, 1986.)

Galvez, V. J. (2014). Estimating a Wage Curve for the United Kingdom. *University of Edinburgh*, *Scottish Graduate Programme in Economics MSc dissertation*, Unpublished.

Giesecke, A. J., & Madden, R. J. (2013). Regional computable general equilibrium modeling. *Handbook of computable general equilibrium modeling*, *1*, 379-475.

Giesecke, A. J., Tran, N. H., Meagher, G. A., & Pang, F. (2011). *Growth and Change in the Vietnamese Labour Market: A Decomposition of Forecast Trends in Employment Over 2010-2020*. Monash University, Centre of Policy Studies and the Impact Project.

Gilmartin, M. (2010). *Evaluating the Economy-Wide Impact of Demand and Supply Disturbances in the UK: A Computable General Equilibrium Analysis of Current Regional and National Policy Concerns*. University of Strathclyde, PhD Thesis.

Golan, E. H., Vogel, S. J., Frenzen, P. D., & Ralston, K. L. (2000). The SAM Multiplier Model. *United States Department of Agriculture Economic Report*, *791*.

Goos, M., & Manning, A. (2007). Lousy and lovely jobs: The rising polarization of work in Britain. *The Review of Economics and Statistics*, *89*(1), 118-133.

Greenaway, D., Leybourne, S. J., Reed, G. V., & Whalley, J. (1993). *Applied General Equilibrium Modelling: Applications, Limitations and Future Development*. HMSO.

Gregg, P., Machin, S., & Manning, A. (2004). Mobility and Joblessness. University of Chicago Press. (Chapter 9 in Seeking a Premier Economy: The Economic Effects of British Economic Reforms, 1980-2000)

Hall, R. E. (1970). Why is the Unemployment Rate So High at Full Employment. *Brookings Papers on Economic Activity*, *2*(1), 339-396.

Hall, R. E. (1972). Turnover in the Labor Force. *Brookings Papers on Economic Activity*, *3*(1), 709-756.

Hamermesh, D. (1993). *Labour Demand*. Princeton, NJ, Princeton University Press.

Harrigan, F., McGregor, G. P., Dourmashkin, N., Perman, R., Swales, K. J., & Yin, Y. P. (1991). AMOS: A macro-micro model of Scotland. *Economic Modelling*, *8*(4), 424-479.

Harris, J. R., & Todaro, M. P. (1970). Migration, Unemployment and Development: A Two-Sector Analysis. *The American Economic Review*, *60*(1), 126-142.

Hendy, R., & Zaki, C. (2013). Assessing the Effects of Trade Liberalization on Wage Inequalities in Egypt: A Microsimulation Analysis. *The International Trade Journal*, *27*(1), 63-104.

Hermannsson, K. (2012). *The Overall Economic Impact of Higher Education Institutions (HEIs) on their Host Sub-regions: Multi-sectoral Analysis for the City of Glasgow*. University of Strathclyde, PhD Thesis.

Hicks, J. R. (1963). *The theory of wages*. 2nd edition. Macmillan, London.

HM Treasury. (2012). *Public Expenditure Statistical Analyses.* Retrieved 25/05/2013, from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/179563/pesa_complete_2012.pdf.pdf

HM Treasury. (2013). The Green Book. *Treasury Guidance*, 1-114.

Hosoe, N., Gasawa, K., & Hashimoto, H. (2010). *Textbook of Computable General Equilibrium Modelling Programming and Simulations*. Palgrave Macmillan.

Hutton, J. P., & Ruocco, A. (1999). Tax reform and employment in Europe. *International Tax and Public Finance*, *6*(3), 263-287.

Johansen, L. (1960). *A multi-sectoral study of economic growth* (Vol. 82). JSTOR.

Katz, L., & Murphy, M. (1992). Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, *107*(1), 35-78.

Kehoe, J. P., & Kehoe, J. T. (1994). A Primer on Static Applied General Equilibrium Models. *Federal Reserve Bank of Minneapolis Quarterly Review*, *18*(1), 1-31.

Kehoe, J. T., Srinivasan, T. N., & Whalley, J. (2005). *Frontiers in Applied General Equilibrium Modeling*. Cambridge.

Kennedy, S., & Borland, J. (2000). A wage curve for Australia. *Oxford Economic Papers*, *52*(1), 774-803.

Keuning, S. J., & de Ruuter, W. A. (1988). Guidelines to the construction of a Social Acconting Matrix. *Review of Income and Wealth*, *34*(1), 71-100.

Kim, K., Hewings, G. J. D., & Kratena, K. (2016). Household disaggregation and forecasting in a regional econometric input-output model. *Letters in Spatial and Resource Sciences*, *9*(1), 73-91.

Kim, K., Kratena, K., & Hewings, G. J. D. (2015). The extended econometric input-output model with heterogeneous household demand system. *Economic Systems Research*, *27*(2), 257-285.

King, B. B. (1981). What is a SAM? a layman's guide to social accounting matrices. *World Bank staff working paper,*(463), 1-59.

Layard, R., Nickell, S., & Jackman, R. (1991). *Unemployment : macroeconomic performance and the labour market*. Oxford University Press.

Lecca, P., McGregor, G. P., & Swales, K. J. (2013). Forward-looking and myopic regional Computable General Equilibrium models: How significant is the distinction? *Economic Modelling*, *3*(6), 160-176.

Leontief, W. (1953). Domestic Production and Foreign Trade; The American Capital Position Re-Examined. *Proceedings of the American Philosophical Society*, *97*(4), 332-349.

Leontief, W. (1986). *Input-Output Economics*. Oxford University Press.

Levy, F., & Murnane, J. R. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics*, *118*(4), 1280-1333.

Machin, S. (1995). *Changes in the Relative Demand for Skills in the UK Labor Market*. Chapter 7 in A.Booth and D.Snower (eds.) Acquiring Skills: Market Failures, Their Symptoms and Policy Responses, Cambridge University Press.

Maisonnave, H., Decaluwé, B., & Chitiga, M. (2009). Does South African affirmative action policy reduce poverty? A CGE analysis. *CIRPEE Working Paper*, *9*(36).

Manacorda, M., & Petrogolo, B. (1999). Skill Mismatch and unemployment in OECD Countries. *Economica*, *66*(262), 181-207.

Marshall, A. (1890). *Principles of Economics*. 1st edition. Macmillan, London.

McGregor, G. P., McVittie, E., Swales, K. J., & Yin, Y. P. (2000). Skill-Biased Demand Shifts: A Regional CGE Analysis. *Strathclyde Discussion Papers in Economics*, *1*(1), 1-30.

McGregor, G. P., Partridge, M. D., & Rickman, D. S. (2010). Innovations in regional computable general equilibrium (CGE) modelling. *Regional Studies*, *44*(10), 1307-1310.

McGregor, G. P., Swales, K. J., & Turner, K. (2008). The CO2 trade balance between Scotland and the rest of the UK: Performing a multi-region environmental input-output analysis with limited data . *Ecological Economics*, *66*(4), 662-673.

McGregor, G. P., Swales, K. J., & Yin, Y. P. (1991). Regional Public Sector and Current Account Deficits: Do They Matter? *in Bradley, J (ed.); The Two Economies of Ireland, Dublin, Oak Tree Press*.

McGregor, G. P., Swales, K. J., & Yin, Y. P. (1996). A long-run interpretation of regional input-output analysis. *Journal of Regional Science*, *36*(3), 479-501.

McGregor, G. P., Swales, K. J., & Yin, Y. P. (1999). Spillover and feedback effects in general equilibrium interregional models of the national economy: A requiem for interregional input-output? In *Understanding and interpreting economic structure* (p. 167-190). Springer.

McKenzie, L. (1960). *Matrices with dominant diagonals and economic theory*. In Arrow, K. J. and Symposium, F.S., Mathematical Methods in the Social Sciences, 1959: Proceedings Volume 4 of Stanford mathematical studies in the social sciences.

McNicoll, I., Kelly, U., & Marsh, R. (2001). *Scottish Labour Market Intelligence Model.* Retrieved 05.03.2013, from https://www.strath.ac.uk/slmipro/index.htm

Miller, R. E., & Blair, P. D. (1985). *Input-Output Analysis Foundations and Extensions*. Prince-Hall.

Miller, R. E., & Blair, P. D. (2009). *Input-Output Analysis Foundations and Extensions*. Cambridge University Press.

Miller, M. H., & Spencer, J. E. (1977). The static economic effects of the UK joining the EEC: A general equilibrium approach. *The Review of Economic Studies*, *44*(1), 71-93.

Millington, J. (2000). Migration and age: The effect of age on sensitivity to migration stimuli. *Regional Studies*, *34*(6), 521-533.

Minford, P., Stoney, P., Riley, J., & Webb, B. (1994). An econometric model of Merseyside: validation and policy simulations. *Regional Studies*, *28*(2), 563-575.

Minx, J. C., Wiedmann, T., Wood, R., Peters, G. P., Lenzen, M., Owen, A., … Baiocchi, G. (2009). Input-output analysis and carbon footprinting: an overview of applications. *Economic Systems Research*, *21*(3), 187-216.

Mitra-Kahn, H. B. (2008). Debunking the Myths of Computable General Equilibrium Models. *SCEPA Working Paper 2008-1*.

Nickell, S., & Bell, B. (1995). The collapse in demand for the unskilled and unemployment across the OECD. *Oxford Review of Economic Policy*, *11*(1), 40-62.

Nijkam, P., & Poot, A. (2005). The last word on the wage curve. *Journal of Economic Surveys*, *19*(3), 421-449.

Nomis. (2011). *Unemployment across the UK.* Retrieved 01/11/2014, from https://www.nomisweb.co.uk/articles/ref/stories/10/Unemployment%20across%20the%20UK%20since%202005.pdf

ONS. (2009). *Table 37a Annual pay. Gross in Pound Sterling. For male employee jobsa. United Kingdom 2009.* Retrieved 30.05.2013, from http://www.ons.gov.uk/ons/rel/ashe/annual-survey-of-hours-and-earnings/2009-results/2009-table-3.zip

ONS. (2010). *Table 37a Annual pay. Gross in Pound Sterling. For male employee jobsa. United Kingdom 2010.* Retrieved 30.05.2013, from http://www.ons.gov.uk/ons/rel/ashe/annual-survey-of-hours-and-earnings/2010-revised-results/2010-revised-table-3.zip

ONS. (2011a). *Labour Force Survey Background and Methodology.* Retrieved 27.06.2013, from http://www.ons.gov.uk/ons/guide-method/method-quality/specific/labour-market/labour-market-statistics/index.html

ONS. (2011b). *Regional Gross Disposable Household Income 1995-2009.* Retrieved 25/05/2013, from http://www.ons.gov.uk/ons/dcp171778_227345.pdf

ONS. (2012). *Families and Households, 2001 to 2011.* Retrieved 04/06/2013, from http://www.ons.gov.uk/ons/dcp171778_251357.pdf

ONS. (2013). *United Kingdom National Accounts - Blue Book 2011.* Retrieved 25/05/2013, from http://www.ons.gov.uk/ons/datasets-and-tables/downloads/xls-download.xls?dataset=bb

Partridge, M. D., & Rickman, D. S. (1998). Regional computable general equilibrium modeling: a survey and critical appraisal. *International Regional Science Review*, *21*(3), 205-248.

Partridge, M. D., & Rickman, D. S. (2010). Computable general equilibrium modelling for regional economic development analysis. *Regional Studies*, *44*(10), 1311-1328.

Pyatt, G., & Round, J. (1985). *Social accounting matrices: A basis for planning*. The World Bank.

Raa, T. T. (2006). *The Economics of Input-Output Analysis*. Cambridge University Press.

Reinert, A. K., & Roland-Holst, D. W. (1997). *Social Accounting Matrices*. Chapter 4 in in Francois, J. F., and Reinert A. K. (editors) Applied Methods for Trade Policy Analysis: A Handbook, Cambridge University Press.

Rogers, G., & Richmond, K. (2015). Scotland's labour market: 'job polarisation' and inclusive growth. *Fraser of Allander Economic Commentary*, *39*(1), 85-97.

Roland-Holst, W. D. (1990). Interindustry analysis with social accounting methods. *Economic Systems Research*, *2*(2), 125-146.

Roland-Holst, W. D., & Sancho, F. (1992). *Relative income determination in the United States: a social accounting perspective*. Universitat Autònoma de Barcelona, Departament d'Economia i d'Història Econòmica.

Ross, A. (2016a). *Social Accounting Matrix (SAM) for Scotland 2009 disaggregated by household income bands.* Retrieved 01.01.2016, from http://dx.doi.org/10.15129/6e1b59eb-ad81-420d-a7ea-73f75fe25bad

Ross, A. (2016b). *Social Accounting Matrix (SAM) for Scotland 2009 disaggregated by skills.* Retrieved 01.01.2016, from http://dx.doi.org/10.15129/773373f7-a3ca-44e7-a5ce-c45092cbf0b1

Round, J. (2003). *Social Accounting Matrices and SAM-based Multiplier Analysis*. Chapter 14 in Bourguignon F., and Pereira da Silva, LA. (editors) Techniques and Tools for Evaluating the Poverty Impact of Economic Policies, World Bank and Oxford University Press.

Sanders, M. (2005). *Technology And the Decline in Demand for Unskilled Labour: A Theoretical Analysis Of The US And European Labour Markets*. Edward Elgar Pub.

Scarf, H. (1967a). The approximation of fixed points of a continuous mapping. *SIAM Journal on Applied Mathematics*, *15*(5), 1328-1343.

Scarf, H. (1967b). *On the computation of equilibrium prices*. New York: Wiley.

Scottish Enterprise. (2014). *Tomorrow, the world: an export plan for Scotland's food and drink industry.* Retrieved 03.04.2015, from http://www.scottish-enterprise.com/knowledge-hub/articles/insight/export-plan-for-scotlands-food-and-drink-industry

Scottish Government. (2008). *The impact on the Scottish economy of reducing greenhouse gas emissions in Scotland: Illustrative findings from an experimental computable general equilibrium model for Scotland.* Retrieved 27.06.2015, from http://www.gov.scot/Publications/2008/11/13110942/0

Scottish Government. (2011). *Input-Output Methodology Guide.* Retrieved 25/01/2013, from http://www.scotland.gov.uk/Resource/Doc/919/0116738.pdf

Scottish Government. (2012a). *Estimates of Households and Dwellings in Scotland, 2011.* Retrieved 29/05/2013, from http://www.gro-scotland.gov.uk/files2/stats/household-estimates/he-11/2011-estimates-households-dwellings-scotland.pdf

Scottish Government. (2012b). *Making Better Use of Skills.* Retrieved 27.06.2013, from http://www.gov.scot/Topics/Education/skills-strategy/making-skills-work/utilisation

Scottish Government. (2013a). *2009 IO Tables.* Retrieved 27.06.2013, from http://www.scotland.gov.uk/Resource/0042/00422350.xlsx

Scottish Government. (2013b). *Government Expenditure and Revenue Scotland 2011-12.* Retrieved 25/05/2013, from http://www.scotland.gov.uk/Resource/0041/00415872.xlsx

Scottish Government. (2013c). *Industry by industry matrix at basic prices 1998-2009.* Retrieved 25/05/2013, from http://www.scotland.gov.uk/Resource/0042/00423822.xlsx

Scottish Government. (2013d). *Scottish National Accounts Tables 2012 Q4.* Retrieved 06/06/2013, from http://www.scotland.gov.uk/Resource/0042/00423120.xls

Scottish Government. (2014). *Growth Sector Statistics.* Retrieved 03.04.2015, from http://www.gov.scot/Topics/Statistics/Browse/Business/KeySectors

Scottish Government. (2015). *Scotland's Economic Strategy.* Retrieved 03.04.2015, from http://www.gov.scot/Topics/Economy/EconomicStrategy

Scottish Government. (2016a). *Computable General Equilibrium (CGE) Modelling and SG's CGE model.* Retrieved 02.02.2016, from http://www.gov.scot/Resource/0049/00491801.pdf

Scottish Government. (2016b). *Scotland's Economic Strategy.* Retrieved 01.06.2016, from http://www.gov.scot/Publications/2015/03/5984/downloads#res-1

Scottish Parliament. (2013). *Financial Scrutiny Unit Briefing: Understanding Corporation Tax Modelling.* Retrieved 27.06.2015, from http://www.scottish.parliament.uk/ResearchBriefingsAndFactsheets/S4/SB_13-53.pdf

Sharpio, C., & Stiglitz, J. E. (1984). Equilibrium unemployment as a worker discipline device. *American Economic Review*, *74*(1), 433-444.

Shoven, J. B., & Whalley, J. (1972). A general equilibrium calculation of the effects of differential taxation of income from capital in the US. *Journal of public economics*, *1*(3), 281-321.

Shoven, J. B., & Whalley, J. (1984). Applied general-equilibrium models of taxation and international trade: an introduction and survey. *Journal of Economic Literature*, *22*(3), 1007-1051.

Shoven, J. B., & Whalley, J. (1992). *Applying general equilibrium.* Cambridge university press.

Sørensen, P. B., Christiansen, V., & Dolado, J. J. (1997). Public finance solutions to the European unemployment problem? *Economic Policy*, *12*(25), 223-264.

Stone, R. (1954). Linear expenditure systems and demand analysis: an application to the pattern of British demand. *The Economic Journal*, *64*(255), 511-527.

Stuttard, N., & Frogner, M. (2003a). Developing a Pilot Social Accounting Matrix for the United Kingdom. *Economic Trends*, *594*, 80-93.

Stuttard, N., & Frogner, M. (2003b). Linking together economic and social data: Using social accounting matrices to look at the distribution of earnings. *Labour Market Trends*, *111*(5), 247-256.

The Data Service. (2013). *Summary of methodology used to calculate estimates of adult educational attainment within the population using Labour Force Survey data.* Retrieved 25/05/2013, from http://www.thedataservice.org.uk/NR/rdonlyres/D0F247C0-AB38-415E-97E1-31028C27EE94/0/MeasuringAdultEducationalAttainmentUsingtheLabourForceSurvey_March2013.doc

Thorbecke, E. (2000). *The Use of Social Accounting Matrices in Modeling.* Retrieved 01/11/2014, from http://econweb.arts.cornell.edu/et17/Erik%20Thorbecke%20files/Use_of_SAM_revised.pdf

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*. University of Strathclyde, PhD Thesis.

Turner, K., Cui, C., Ha, S. J., & Hewings, G. J. D. (2014). Input-output analyses of the pollution content of intra- and inter-national trade flows. *Contemporary Social Science*, *9*(4), 430-455.

Turner, K., Ha, S. J., Hewings, G. J. D., McGregor, G. P., & Swales, K. J. (2012). Econometric estimation of Armington import elasticities for a Regional CGE Model of the Illinois Economy. *Economic Systems Research*, *24*(1), 1-19.

UK Data Service. (2013). *Quarterly Labour Force Survey.* Retrieved 27.06.2013, from https://discover.ukdataservice.ac.uk/series/?sn=2000026#links (Office for National Statistics. Social Survey Division)

Walras, l. (1874). *Elements of Pure Economics*. Irwin.

West, R. G. (1995). Comparison of input-output, input-output+ econometric and computable general equilibrium impact models at the regional level. *Economic Systems Research*, *7*(2), 209-227.

Wiedmann, T., Lenzen, M., & Turner, K. (2007). Examining the global environmental impact of regional consumption activities. *Ecological Economics*, *61*(1), 15-26.

Yin, Y. P. (2002). *Skilled-Unskilled Wage and Employment Disparity - A CGE Simulation Analysis.* Retrieved 01/11/2014, from http://uhra.herts.ac.uk/handle/2299/1792 (In: Procs of the International Conference on Policy Modelling, EcoMod2002)