THREE ESSAYS IN TOURISM ECONOMICS

BY JON MCFARLANE

A THESIS PRESENTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF ECONOMICS

UNIVERSITY OF STRATHCLYDE

GLASGOW, SCOTLAND

JULY 2024

Author Note

This research is funded through an ESRC Collaborative Studentship between the University of Strathclyde and VisitScotland (project reference: 2267800) through the Scottish Graduate School of Social Science Doctoral Training Partnership (grant reference: ES. P000681/1).

Table of Contents

List of Figures

List of Tables

Declaration of Authenticity and 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:

Acknowledgements

I would like to acknowledge the financial support of the Economic Social and Research Council through the Scottish Graduate School of Social Sciences (Project number ES.P000681/1) and VisitScotland. Specifically, Raymond MacIntyre who has been extremely supportive throughout. I am tremendously grateful for the opportunity to partake in this project.

I would like to thank my supervisory team, Dr Grant Allan and Dr Gioele Figus. Both supervisors have helped to open doors for me in my life that I could not have imagined. They have given me unwavering support whenever I have needed it, despite their busy schedules, and I am tremendously grateful for it. I have learned a lot from their skills, knowledge and expertise in Input-Output modelling, Computable General Equilibrium, thesis writing, and project management, to name just a few. They have shown great patience in my PhD journey and helped me through some difficult times. For me, though, the biggest compliment that I could say about both is that they are great people with great hearts. They are a pleasure to know and have worked with. I will always be grateful for the shared experiences that we have had and the growth that I have experienced as an economist and a researcher as a result of their teachings.

Thank you to all staff members in the department who have given me time to discuss my research and to have friendly conversations, such as Professor Julia Darby, Professor Stuart McIntyre, Dr David Comerford, Dr Kevin Connolly, Dr Otto Lenhart, Dr Markus Gheritz, and Dr Sharada Davidson to name a few. I appreciate you all sharing your knowledge and experiences. Those conversations and little nuggets of information are vital to where I have got to now.

Thank you to my PhD colleagues that I have had the pleasure to know throughout my studies. We were able to, despite the pandemic, create a positive safe and strong network of support that has helped support me through my research. They have given me great laughs when I have needed it, some great tips and great stories along the way. I am grateful to have had the chance to share an office with you all including Genarro, Sam, Orion, Ross, Slawek, Lateef, Arnold, Yuri, and Baland. A special mention to Geoffroy Duparc-

Portier, who has helped me overcome some CGE challenges and has been a constant source of positivity, and who I hope will be a friend for life.

Dr Michael Vallely is one of my closest friends and a PhD colleague from the University of Glasgow. We started the PhD process together. He has been a constant source of encouragement, and his grit and determination to achieve great things have inspired me every single day throughout the process.

Thank you to my colleagues at ORE Catapult, including Jamie Platts, David Maxwell, and Tom Quinn for supporting me during my last year of writing up, allowing me some flexibility in order to write up the thesis.

Thank you to William Reynolds, my first economics teacher in school who ignited my passion for economics. His humour and stories describing economics concepts still stick with me today.

Finally, to my family. To Claire, thank you for your incredible kindness, unconditional love, support, great words of advice and calm whenever I have needed it. Thank you to James, my twin brother, for pushing me on to do more and better everyday. Thank you to Cooper, my younger brother, for having conversations with me and shedding new perspectives on life, including chilling out a bit! To my mum for supporting me in whatever I do and being consistently available throughout my life whenever I have needed her. To my dad, thank you for teaching us that hard work always pays off but that it is important to switch off too. You all inspire me everyday. This PhD is dedicated to you all.

Abstract

This thesis is a collection of three chapters that seek to analyse policies aimed at tourism. Within the three chapters are developments and extensions of two different macroeconomic modelling techniques: Input-Output (IO) and Computable General Equilibrium (CGE) modelling. These models have been developed and used to understand a variety of different scenarios that are applicable in the Scottish tourism context and can be adapted to other tourism regions. Chapter 2 uses a tourism-specific Input Output (IO) framework to assess the macroeconomic impacts of a tourism subsidy, considering the government's cost in imposing the subsidy. Chapter 3 considers an accommodation tax through the lens of a tourism-extended CGE model. AMOSTRAVEL is described in Chapter 3. It has been developed as a tourism-specific CGE model, including the introduction of domestic and inbound tourism categories for analysis. Chapter 4 builds on this analysis by including an environmental extension to the tourism CGE model. Chapter 4 analyses three different policies that affect tourism demand: An accommodation tax, a land transport tax and a fuel sales tax. In all three chapters, the macroeconomic effect of policies aimed at tourism is analysed through macroeconomic models.

Chapter 2, titled *VAT Reduction to the Accommodation Sector in Scotland: An Application of Input-Output Modelling*, uses IO modelling to understand a tourism subsidy in the form of a VAT reduction specifically to the Accommodation sector. The chapter makes two distinct contributions to the literature. First, we account for the costs associated with fiscal policy at a regional level to encourage additional tourism consumption. Previous studies have assumed that policies aimed at encouraging tourism have no cost to the regional government. We show that introducing a cost unambiguously reduces economic activity, so the net effect of such a policy would depend on the increase in tourism expenditure resulting from a policy intervention. We repeat this analysis by disaggregating spending across different tourism categories. This involves a disaggregation of Scottish national accounts.

Chapter 3 is titled *Incorporating Tourism Heterogeneity in a Computable General Equilibrium Framework for a Small Regional Economy.* CGE models are widely used to analyse changes in tourism demand. Due to their reliance on economic accounts, the models have limited detail on different categories of tourism demand and are often limited to the analysis of changes in "inbound" (i.e. non-resident) tourism demand. Such analysis, however, cannot account for the interconnections between inbound and domestic (i.e., resident) tourism, which generally is a large part of total tourism consumption. In this chapter, we outline a methodology to address these issues using a case study of Scotland. We first address these problems by using the tourism disaggregated national accounts in Chapter 1, which includes spending for five different consumption categories: domestic day visitors and overnight visitors, Great Britain day visitors and overnight, and international overnight visitors. These categories are then incorporated into AMOSTRAVEL using conventional utility functions that reflect the price-sensitive behaviour of both domestic and international tourists. We highlight the added value of our disaggregation through a variety of tourism-specific simulations and compare our approach to more traditional methods. Results from simulation and methodological implications are fundamental not only for the academic literature but also as a guide to policymakers focused on making tourism decisions.

Chapter 4, titled *Reducing Emissions through Fiscal Interventions and the Impacts on Tourism Spending and the Economy,* assesses the environmental impacts of three potential taxes on tourism. Taxes like these will naturally have a negative impact on tourism demand but will also have negative impacts on key economic indicators such as GDP, Employment, and Household Consumption, as seen in Chapter 2. However, another important implication of these policy changes is the environmental impact. We analyse the emissions impacts of three policies aimed at tourists through environmental extensions to AMOSTRAVEL. We introduce a methodological novelty in this chapter as we include industrial emissions (emissions relating to industries in the national accounts) and consumption emissions (emissions relating to the consumption categories that are presented in the model. We find that there are different economic impacts from each of the taxes; the accommodation tax is the most negative and has the most environmental (emissions reductions) of the three taxes. Although there is no way to suggest that these results reflect reality, the results raise some interesting questions for tourism policy in balancing economic impacts vs environmental impacts.

1 Introduction

Over the last decades, tourism has become a significant part of the worldwide economy (Dwyer, 2021). The International Monetary Fund has continually identified tourism as a key area for growth in the bi-annual World Economic Outlook Report (e.g. IMF, 2023). Therefore, tourism is a sector that is expected to continue to contribute significantly to the world economy, especially in "service-oriented economies" where tourism spending is intensive.

According to the World Travel and Tourism Council (WTTC), in 2023, the tourism sector contributed approximately 9% of the global Gross Domestic Product (GDP) (WTTC, 2023) and consists of 334 million jobs (UNWTO, 2024), or approximately 1 in 10 jobs worldwide. This number is expected to continue to grow, and the jobs created are expected to become increasingly diverse in terms of the type and locations (Dwyer et al. 2020).

Therefore, to understand the impacts of tourism spending on the economy and otherwise, tourism research is fundamentally important (Dwyer et al., 2020). With the substantial increase in tourism demand has come an increase in tourism research and policies targeted at tourists (Wickramasinghe & Naranpanawa, 2022). There are both positive and negative impacts of tourism demand and modelling such as what is presented in this thesis can help us to understand these impacts from an economic and an environmental point of view.. Tourism research is fundamentally important to governments, policymakers, tourism industries and bodies, and tourists themselves to understand two main components: (1) the current impact of tourism consumption and the policies associated with it and (2) to understand how we can use the resources that we have available to ensure that tourism can reach its potential in being a force for positive change in terms of job creation and general positive impacts on the economy.

There are two significant groups of tourist's consumption for any destination: Inbound tourists and domestic tourists. Inbound tourism consumption is "the tourism consumption of a non-resident visitor within the economy of reference" (UNWTO[1], 2024). Domestic tourism consumption is the "tourism consumption of a resident visitor within the country

[1] These definitions are from the UNWTO glossary of tourism terms https://www.unwto.org/glossary-tourism-terms#I

(UNWTO, 2024). However, one general finding in recent years is that there has been a significant recovery, especially in terms of domestic tourism, post-COVID-19 (Allan et al., 2022; Arbulu et al., 2021).

There are some negative externalities that can be attributed to tourism spending. One is that too many tourists go to the same place at the same time, creating overtourism (Mihalic, 2019). This overtourism creates frustration amongst residents because the standard of living of the destination reduces despite the residents not being directly involved in tourism spending. In addition to this, according to Wall (2020) an increase in the tourism businesses created to cope with this increased demand of tourism does not impact sufficiently the negative externalities of touristic activity and inadvertently creates more tourism.

Another externality is the environmental damage that is associated with increasing concern around the environmental impact of tourism. According the WTTC tourism accounted for around 8% global GHG emissions (WTTC, 2023). This has given rise to concepts such as “sustainable tourism” (UNWTO, 2024) where tourism stakeholders take account of tourisms social and environmental impacts. Tourists are becoming increasingly aware of the environmental impacts of their tourism consumption and take into account this when choosing destinations (Gomes & Lopez, 2023).

Hence, governments understand that with increased tourism spending there is an opportunity to expand the tax bases and revenues from taxation, whilst not impacting residents. Fundamentally, whilst tourists use public services in tourist destinations, they do not contribute to the maintenance of the services that they use by contributing to the public budget. One way that this can be addressed is through taxation. Given this, there has been an increase in policies that are targeted at tourists, which also have an impact on the macroeconomy. To sustain and increase the understand the consequences of changes to tourism policy, specifically tourism taxes, continued research and economic modelling is required.

This thesis is comprised of three Chapters which use different economic modelling techniques to understand the whole economy consequences of policies aimed at tourism. The case study that is used for all three Chapters in Scotland.

Within the three Chapters are developments and extensions of two different macroeconomic modelling techniques: Input-Output (IO) and Computable General Equilibrium (CGE) modelling. These models have been developed and used to understand a variety of different scenarios that are applicable in a regional context and can be adapted to other tourism regions. The case study that is used for all three chapters in Scotland. Chapter 2 uses a tourism-specific Input Output (IO) framework to assess the macroeconomic impacts of a tourism subsidy, considering the government's cost in imposing the subsidy. Chapter 3 considers an accommodation tax through the lens of a tourism-extended CGE model: AMOSTRAVEL is described. It has been developed as a tourism-specific CGE model, including the introduction of domestic and inbound tourism categories for analysis. Chapter 4 builds on this analysis by incorporating an environmental extension to the AMOSTRAVEL model. Chapter 4 analyses three hypothetical policies that affect tourism demand: An accommodation tax, a land transport tax and a fuel sales tax. In all three Chapters, the macroeconomic effect of policies aimed at tourism is analysed through macroeconomic models.

Chapter 2, titled "Value Added Tax (VAT) reduction to the Accommodation sector in Scotland: An application of Input-Output (IO) modelling" uses IO modelling to understand a tourism subsidy in the form of a VAT reduction applied specifically to the Accommodation sector. The Chapter makes two distinct contributions to the literature. First, we account for the costs associated with fiscal policy at a regional level to encourage additional tourism consumption. Previous work in the literatures have used multisectoral models (Ferrari et al., 2019) however have assumed that policies aimed at encouraging tourism have no cost to the regional government. We show that introducing a cost unambiguously reduces economic activity, so the net effect of such a policy would depend on the increase in tourism expenditure resulting from a policy intervention. We repeat this analysis by disaggregating spending across different tourism categories. This involves a disaggregation of Scottish national accounts which is also used in subsequent chapters.

Chapter 3 develops a CGE approach to understand the whole economy consequences of tourism policy changes. Computable General Equilibrium (CGE) models are widely used to analyse changes in tourism demand. Due to their reliance on economic accounts, these models usually have limited detail on different categories of tourism demand and are often limited to the analysis of changes in "inbound" (i.e. non-resident) tourism demand. Such analysis, however, cannot account for the interconnections between inbound and domestic (i.e., resident) tourism, which generally is a large part of total tourism consumption. In this Chapter, we outline a methodology to address these issues using a case study of Scotland. We first address these problems by using the tourism disaggregated national accounts in Chapter 1, which includes spending for five different consumption categories: domestic day visitors and overnight visitors, UK day visitors and overnight, and international overnight visitors. These categories are then incorporated into a CGE model termed, AMOSTRAVEL using conventional utility functions that reflect the price-sensitive behaviour of both domestic and international tourists. We highlight the added value of our disaggregation through simulations of a hypothetical accommodation tax which directly impacts on overnight visitors and compare our approach to more traditional methods. Results from this chapter show that despite the accommodation tax being targeted at overnight visitors there is an impact on day visitors. Whether this impact is positive or negative depends on the elasticity of substitution values used. Results from the simulation simulations and methodological implications are fundamental not only for the academic literature but also as a guide to policymakers focused on making tourism decisions.

Chapter 4, titled "Reducing Emissions through Fiscal Interventions and the Impacts on Tourism Spending and the Economy", extends the AMOSTRAVEL model to assess the environmental impacts of three hypothetical taxes. Some taxes such as an accommodation levy, will have a negative impact on overnight tourism demand, however, another important implication of these policy changes is the environmental impact. We analyse the emissions impacts of three policies aimed at tourists through environmental extensions to AMOSTRAVEL. We introduce a methodological novelty in this Chapter as we include industrial emissions (emissions relating to industrial fuel use) and consumption emissions (emissions relating to the consumption categories presented in the model). We find different economic impacts from each of the taxes; the accommodation tax is the most negative and has the most environmental benefit (i.e. the largest emissions reductions) of the three taxes. The findings raise some useful evidence for tourism policymakers in balancing economic impacts vs environmental impacts.

2 Chapter 2: Value Added Tax (VAT) reduction to the Accommodation sector in Scotland: An application of Input-Output (IO) modelling.

2.1 Introduction

Tourism is a fundamental component of contemporary economies. It has experienced sustained and exponential growth post-World War 2 (Dwyer et al. 2020). This is due to increased globalisation, reductions in costs and increased spending capacity to consume goods and services associated with tourism spending (Mikulic et al. 2021). Specifically in locations where tourism is intensive (Dwyer et al., 2021).

Since the turn of the millennium, with increased tourism spending, the sector has become one of the most diverse, profitable and rapidly growing economic sectors across many economies (Meng & Siriwardana, 2017). According to the UNWTO (2024), international tourism generated $1.4 trillion in receipts in 2023 on track to return to pre-pandemic levels. This tourism spending has important economic consequences and supports around 1 in 10 jobs worldwide (WTTC, 2024). By 2027, "travel and tourism are expected to support more than 400 million jobs globally, which equates to 1 in 9 of all jobs in the world; the sector is expected to contribute around 25% of global net job creation over the next decade" (Dwyer et al. 2021, p. 1).

Governments worldwide have recognised that tourism spending can increase profits within a destination through increased spending on tourism activities and as an opportunity to expand tax bases and shift the tax burden to tourists, and away from residents. As a consequence, there has been an increase in policies targeted at tourists but ultimately impacting the economy as a whole. To sustain the positive consequences of increased tourism, continued research and economic modelling of the effects and impacts of tourism spending. In addition, research and modelling of changes to policy around tourism in specific destinations are required.

The COVID-19 pandemic halted inbound tourism due to worldwide travel restrictions. As restrictions started to ease in 2021, there was a resurgence of tourism activity and spending, with domestic tourism spending increasing significantly more than inbound tourism (WTTC, 2022). This was primarily because of the volatility of travel restrictions mixed with fear of infection. However, this highlighted the importance of domestic visitors has on the tourism industry.

Destinations that have invested in tourism services and infrastructure have experienced the largest benefits of tourism spending worldwide (UNWTO, 2022). These investments have made these destinations popular tourist attractions. Hence, an important sector for a destination economy.

Scotland is one of the nations that has invested in tourism infrastructure and services. Given the relative geographic size of Scotland and comparatively low travelling times within Scotland compared to other destinations, Scotland, in recent decades, has become a popular choice for tourists.

The tourism sector was identified as a growth sector in 2014 and is still identified as such in the Scottish economy (Scottish Government, 2022). This highlights that the Scottish Government believes that the tourism sector is a sector in which Scotland has a comparative advantage in providing tourism services and, through this, can achieve sustained economic success. In addition, the Scottish Government and tourism partners published the Scotland Outlook 2030 (2020), which set out the plan to invest in the tourism sector to make Scotland the 21st-century leader in tourism.

Indeed, during the recent COVID-19 pandemic, the Scottish Tourism Response Team (STRT) stated that it would be beneficial to the Scottish tourism industry for the temporarily reduced VAT rate to be made permanent (STRT, 2021)[2]. The idea behind this policy was to support the sectors that were the most severely hit by the pandemic, hotels

[2] Link to UK government website for details: https://www.gov.uk/government/publications/introduction-of-a-new-reduced-rate-of-vat-for-hospitality-holiday-accommodation-and-attractions/introduction-of-a-new-reduced-rate-of-vat-for-hospitality-holiday-accommodation-and-attractions

being the most affected, and encourage increased demand through a VAT reduction being passed on to the consumers through a reduction in price.

Economic models can be used to assess the economic impacts of changes to policies in the tourism sector such as VAT reductions/increments. Economic models are a simplification of an economy, and the correct use of these models can help inform policy. Specifically, economy-wide models can be used if it is expected that an increase in spending in one sector results in increased spending in sectors across the value chain. For example, an increase in demand for accommodation (stimulated by lower VAT) will induce increased spending in the food and beverages, utilities and hotel supplies. Each of these, in turn, has its own supply chain.

This Chapter makes two contributions to the existing literature. First, we account for the costs associated with a fiscal policy at a regional level, which is designed to encourage additional tourism consumption. Previous studies have assumed that policies aimed at encouraging tourism have no cost to the government, i.e. the country/region benefits purely from the increase in tourism consumption without any offsetting reduction in government revenues or spending (e.g. Ferrari et al., 2019). In the results Chapter, we show that introducing a cost – via reduced government expenditure – will unambiguously reduce economic activity, so the net effect of such a policy would depend upon the scale of the increase in tourism expenditure that results from the policy intervention.

Due to this reduction in government expenditure, two different types of impacts are analysed: aggregate and sectoral impacts. Aggregate impacts are the impacts of the government spending reduction on the key macroeconomic variables such as gross output, employment, and income. Sectoral impacts break down the aggregate impacts by sector and show which industry benefitted or lost as a result of the policy changes.

Second, we repeat this analysis with a set of IO accounts with disaggregation of spending across different tourism categories. Previous applications of IO modelling (Cai, 2016; Guo et al. 2017, for example) have explored the impact of changes in tourism demand either only for non-residents or a high level of aggregation across tourism categories (e.g., non-residents and residents). In practice, however, while tourism demand in an economy consists of spending by residents and non-residents, both these groups will undertake short visits, e.g., day trips and longer-duration trips involving overnight stays. The spending by each category on each trip type will be different as each type of tourist has different spending patterns.

The remainder of this Chapter proceeds as follows. First, in Section 2.2.1 we review analyses of tourism from an economic perspective. Section 2.2.2 establishes how tourism can be viewed in a set of Input-Output (IO) accounts and describes how IO accounts can also be used as the basis for economic modelling. Section 2.2.3 reviews the critical papers from the academic literature which have used different economic techniques, including IO modelling, to understand the economic impact of tourism. Section 2.2.4 focuses more precisely on those papers that have used IO modelling to evaluate the consequence of fiscal policies directed at the level of tourism in a region (e.g., Ferrari et al., 2019). Section 2.2.5 identifies papers which have sought to disaggregate tourism spending in economic accounts, which informs our disaggregation. Section 2.3 sets out the methodology and data used. We begin by describing the properties of IO accounts and modelling and set out our approach to modelling the impact of a change in tourism demand following a policy intervention (a reduction in VAT on a category of tourism spending). We end this section by detailing the properties of the IO table used.

Section 2.4 shows our results from our analysis, comparing the costless policy with the case where the regional government fully bears the cost. Section 2.5 sets out our approach to disaggregation of tourism demand in the Scottish IO accounts, and how we identify five categories of tourism spending. This involves disaggregating the single vector for non-resident household spending in Scotland into three categories and identifying (and removing) two categories of tourism spending by Scottish residents from within the initial household spending vector in the national accounts.

In Section 2.6 we repeat the analysis of Section 2.4 using our more disaggregated accounts. In contrast to the aggregated approach used first, the disaggregated treatment shows the different impacts that the subsidy has on tourism spending categories.

Section 2.7 provides a discussion and conclusion of the Chapter.

2.2 Literature Review

2.2.1 General economic analysis of tourism

In recent decades, with the growth in tourism and its economic importance, there has been a parallel growth in economic analysis applied to tourism. According to the World Travel & Tourism Council, tourism expenditure has almost doubled since 2000 (WTTC, 2024). The application of economic approaches to tourism has spanned a variety of topics. Further, a wide variety of economic techniques have been used for this type of analysis (Dwyer et al., 2020; UNWTO, 2021).

There are three main strands of economic research applied to tourism: economic growth, by which we mean tourism led growth where "inbound tourism can support an increase in long-run economic growth through several channels" (Rasool, 2021, p.162). Some papers such as (Balaguer & Jorda, 2002; Lee & Chang, 2008; Antonakakis et al., 2015; Li et al., 2018; Song & Wu, 2022), analyse the potential for tourism as a potential growth factor whilst other assess economic development and the impact that tourism expenditure can have on improving the income distribution in a country (Rodenburg, 1980; Sinclair, 1998; Kim & Chen, 2006; Holzner, 2011; Njoya & Seetaram, 2018; Calero & Turner, 2020) and economic impact analysis (Sadler & Archer, 1975; Krishnaswamy; 1979; Forsyth et al. 2012; Liu et al., 2022). Through these concepts, economists have used a variety of techniques to understand the economic implications associated with changes in tourism demand.

2.2.2 Techniques used for tourism analysis

The techniques employed in the literature can be split into two broad categories (Dwyer et al., 2020): economic forecasting techniques, "where authors seek to predict what will happen in the future, with estimating what will happen at some future time" (Dwyer et al., 2020, p.159) and economic modelling, a tool that allows economists to simplify the economy in a way that is comprehensible for both researchers and policymakers (Hosoe et al., 2010).

Both types of economic analyses have been applied to tourism research. There are two types of statistical and econometric techniques that can be applied to tourism research: time series models and econometric (causal) techniques. Freightling (2001) and Li et al. (2006) compare different forecasting techniques for suitability in forecasting tourism demand. Song and Li (2008) review tourism forecasting techniques to assess which techniques are best and their suitability with specific research questions. Like Song and Li (2008), Peng et al., (2014) conduct a meta-analysis of forecasting models but with a focus on international tourism demand. Claveria & Torra (2014) compare neural techniques and time series models to forecast the number of day and overnight visitors to Catalonia. Econometric techniques used in tourism demand forecasting can seek to explain the determinants of tourism demand (Song & Li, 2008; Song et al, 2008; Martins et al., 2017; Shafiullah et al., 2019). Time series analysis has been widely used to forecast tourism demand (Preez & Witt, 2003; Chen et al., 2019; Bi et al., 2021). Because of the nature of time series models, variables can be observed over several periods to identify trends. The data that is used, solely historical data, is particularly suited to investigating seasonality in tourism (Freightling, 2001; Goh & Law, 2002; Vergori, 2017; Chen et al., 2019).

2.2.3 Use of models in tourism analysis

In addition to forecasting methods, economic modelling techniques can be used to understand the economic contribution of tourism and the economic consequences of changes in tourism demand. The economic contribution of tourism "measures the size and overall significance of the tourism industry within an economy" (Dwyer et al., 2020, p. 229). This type of research focuses on the size of the tourism industry relative to the economy as a whole and its contribution to the wider economy. Input Output (IO), Social Accounting Matrix (SAM), and Tourism Satellite Accounts (TSAs), can be used for this purpose (see Briassoulis, 1991; Pratt, 2015; Khoshkhoo et al., 2017; Jones, 2010; Akkemik, 2012; Croes & Rivera, 2017; and Freightling, 2010; Jones & Munday, 2010; Wu et al., 2019, respectively).

The main types of economic modelling techniques that are used in this literature are Input-Output (IO), Social Accounting Matrix (SAM), and Computable General Equilibrium (CGE) models. These modelling frameworks are also used to understand changes in tourism demand and the impact of it on the rest of the economy (Dwyer et al., 2020). Changes in tourism demand, demand shocks, can take many forms. Some examples of this are a natural disaster to a tourism destination (Blake & Sinclair; 2003; Pambudi et al., 2009; Ponjan & Thirawat, 2016;), a major sporting event (Blake, 2005; Dwyer, Forsyth & Spurr, 2006; Bohlmann & Van Heerdan; 2008; Allan et al, 2017; Dwyer & Forsyth, 2019) or a change in policy (Fletcher, 1989; Briassoulis, 1991; Hara, 2008; Meng et al. 2013; Dwyer, 2015; Mahadevan et al., 2017; Tohmo, 2018).

All the modelling techniques mentioned so far are multisectoral which means that they can capture the heterogeneity of industrial activities within a country, region, set of regions/countries, and the impacts on different sectors of the economy. They are ideally suited to capturing the consequences for the whole economy of changes in demand for tourism under a set of (model-specific) assumptions about the behaviour of industries when faced with an increase in demand. The next section sets out the Input Output method before examining applications of the IO method to understand the economic impact of changes in demand for tourism.

2.2.4 Input-Output analysis

Input-output (IO) analysis is a commonly used economic modelling technique for understanding the economic contributions of a particular sector and allows us to perform impact analysis. There are two main uses of IO analysis (Leontief, 1936; Miller & Blair, 2020). First, IO analysis is an accounting framework that explicitly states the interrelationships between industries in an economy. Where interrelationships refer to the consumption of goods produced by one sector purchased as the input(s) to another, as well as the links between production and consumption (e.g. the final uses of an industry's output). We will see in future sections that such accounts can be used to provide metrics of the connectedness of tourism with the rest of the economy.

The second application of IO analysis is to employ these accounts as an economic model, under a set of necessary assumptions. These “IO models” are most commonly used to understand the impact of a change in final demand on an economy as a whole. In Section 2.2.4, we set out in detail the nature of IO accounts before discussing applications to tourism which use IO accounts. We then set out the use of IO models in general and we review.

2.2.4.1 IO Accounts – Method

IO accounts show the interdependencies between sectors of an economy for a given period of time, typically a year (Miller & Blair, 2021). These accounts were first developed by Wassily Leontief (1936) and have spawned a substantial literature on a variety of different applications (Minx et al., 2009; Miller & Blair, 2021). These include applications to environmental policy changes (Towa et al., 2020) to the impact of sporting events (Kim et al., 2017).

IO accounts have been used for two main types of economic analysis. Attribution analysis and linkage analysis. Attribution analysis looks at the contribution of a particular sector to the wider economy through the multipliers that can be calculated from the input-output accounts. Linkage analysis analyses the interdependencies between sectors that act simultaneously as suppliers of output to other sectors and institutions and purchasers of inputs from other sectors and institutions.

One of the advantages of using IO accounts is that they can be used to understand the interconnectedness between sectors in an economy. There are two main ways to do this (1) attribution analysis and (2) linkage analysis. IO accounts allow the understanding of the direct, indirect and induced effects of a particular type of spending within an economy. In this case, tourism spending. Direct, indirect and induced impacts are described in the following paragraphs:

When there is an increase in final demand in a sector, there will be an increase in output to satisfy the demand of the increase in final demand (Oosterhaven, 2022). For example, if there is an increase in demand for accommodation, then there will be an increase in the output of the producers of the accommodation sector to satisfy that demand, such as the wholesale and retail sector. The wholesale and retail sector provide the accommodation sector with food, amongst other things. This is the *direct effect*.

The *indirect effects* are the changes in the supply chain of the producers of the original sector (Oosterhaven, 2022). For example, with the increase in wholesale and retail output in response to the increase in demand for accommodation, there will also be an increase in output for the agriculture sector which needs to increase its output to satisfy the increase in demand for the wholesale and retail sector.

Due to the increase in demand for the sectors from the direct and indirect effects, there is a requirement for more jobs to be created to satisfy that demand and, hence, more income. Some of this income will be re-spent throughout the economy, known as the *induced effect* (Oosterhaven, 2022). For example, with the increased demand in the accommodation sector, the wholesale and retail sector and the agriculture sector, there will be an increase in employment and income. A proportion of this income will be spent on other sectors throughout the economy, which is the induced effect.

The relationships between the sectors in the economy can be described in a system of linear equations where the output of a sector is comprised of its sales to other sectors (for use in intermediate production) and sales to different categories of final demand. The economy is assumed to be made up of a number, n, sectors. This is defined by equation 2.1 below as per Miller & Blair (2021, p.84):

$$x_i = z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i \qquad 2.1$$

$$x_i = \sum_{j=1}^{n} z_{ij} + \boldsymbol{f}_i \qquad 2.2$$

Here equation *2.2* is a condensed version of equation 2.1 where x_i is the total output of sector i, z_{ij} is sales from sector i to sector j and is represented in matrix form. This is sales from one sector to another called intermediate sales (Miller & Blair, 2021). f_i here is the vector of final demand.[3]

Let

$$x = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} \qquad Z = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ Z_{n1} & \cdots & Z_{nn} \end{bmatrix} \qquad f = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix} \tag{2.3}$$

Hence equation *2.2* can be written as follows:

$$\boldsymbol{x} = \boldsymbol{Z} + \boldsymbol{f} \tag{2.4}$$

Here x is the vector of output, Z is the matrix of sales from one industry to another and f is the vector of final demand.

The next step of the analysis is to calculate the technical coefficients a_{ij} (Miller and Blair, 2021). This is a matrix, so a_{ij}, is represented as A, which is found by dividing the sales from one sector to another by the total gross output of a sector represented in the equation below.

[3] Keeping consistent with the IO literature and notation for standard IO equations lower cases letters represent vectors and upper-case letters are matrices

$$a_{ij} = \frac{z_{ij}}{x_j} \qquad 2.5$$

Recall that z_{ij}, is interindustry sales from one sector, sector i, to another sector, sector j. The total output for sector j, is denoted x_j. This is the ratio of sales from one sector of total sales.

Using simple algebra, by changing the subject, equation 2.5 can be re-written as:

$$z_{ij} = a_{ij}x_j \qquad 2.6$$

Therefore, the z values from equations 2.1 and *2.2* can be replaced by $a_{ij}x_j$ shown below:

$$x_i = a_{i1}x_1 + \cdots + a_{ij}x_j + \cdots + a_{in}x_n + f_i \qquad 2.7$$

Rearranging equation 2.7 to make f_i the subject:

$$f_i = x_i - a_{i1}x_1 - \cdots - a_{ij}x_j \ldots - a_{in}x_n \qquad 2.8$$

Equation 2.9 is a condensed version of equation 2.8.

$$\boldsymbol{f} = \boldsymbol{x} - \boldsymbol{Ax} \qquad 2.9$$

The identity matrix is a diagonal matrix where the diagonals are 1's and the rest are 0's as shown in equation 2.10 for the case of a 3x3 matrix.

$$I = \begin{matrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix} \qquad 2.10$$

As noted previously in most input-output literature, the vectors in these equations for simplicity are written in lower-case and the matrices are written in uppercase, as below:

$$(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{x} = \boldsymbol{f} \qquad 2.11$$

Equation 2.11 can be re-arranged to make x the subject.

$$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{f} = \boldsymbol{L} \qquad 2.12$$

Here x is output, I is the identity matrix, A is the technical coefficient matrix and F is the final demand matrix, but f is a vector of total final demand. Depending on the research f can constitute different elements of final demand. For example, the final demand vector can be made up of final consumption from households, government spending, and non-residents (tourism) consumption. L is the Leontief inverse (Leontief 1936; Miller & Blair, 2009, 2021). "This makes clear the dependence of each of the gross outputs on the values of each of the final demands" (Miller & Blair, 2009, p.22). From this, the authors can calculate coefficients for key economic variables such as Output, Employment, Income and Gross Value Added (GVA).

Attribution analysis analyses how much spending in a particular sector of final demand contributes to Output, Income, Employment, and GVA. For example, attribution analysis allows us to show how important a sector is to overall economic activity. For the tourism case, how important is spending on accommodation to overall economic activity or how much spending is supported by domestic tourists. This can be important for initially understanding the overall impact that tourism consumption has on the rest of the economy.

2.2.4.2 Input-Output Models – Method

The applications reviewed above used an IO framework to understand the economic relationships between industries and the relationships between industries and demand, in accounting analyses. The Input-Output framework can also be used for modelling purposes when – under a set of assumptions about the nature of the macroeconomy and the production functions of firms- the IO accounts can be used to model the sectoral (and by summing these, the economy-wide) impacts of an exogenous change.

The key equation for the most common type of IO modelling – demand-driven - appears similar to equation 2.12 but instead includes the change in final demand, which equals a change in output.

$$\Delta x = (I - A)^{-1}\Delta \mathrm{f} \qquad 2.13$$

Equation 2.13 represents the change in output, Δx, is equal to the Leontief inverse $(I - A)^{-1}$ multiplied by the change in exogenous final demand, Δf. This equation allows the researcher to introduce changes in final demand and the impact that the change in demand has on output. These changes are transmitted through the interrelationships between the sectors of the economy through the Leontief inverse.

Note that we have exogenous final demand as a vector f here. In practice, final demand can be composed of a number of column vectors relating to consumption of domestic production, including households, government, and changes to export demand. In many IO accounts tourism consumption is included within the export's component of final demand. Hence non-resident spending is not typically separately identified. The export column can be disaggregated in a way such that non-resident expenditure is separated from other exports and categorised as inbound tourism or international tourism (Cai, 2016; Lopez et al, 2013; Khanal et al., 2014). This is reasonable as spending from people outside of a destination is normally spending from tourists. Other studies include two vectors of tourist spending in final demand. Most commonly, these vectors are split into international (or inbound) tourists and domestic tourist spending (Fletcher 1989, Briassoulis 1991, Klijs et al., 2015), where domestic tourists are disaggregated from the vector of domestic consumption in the IO table. Further disaggregation can be done, such as in Murillo et al. (2013), where day trips are disaggregated from the rest of tourism spending.

Equation 2.14 shows the change in employment, ΔE, is driven by the employment coefficients, w, multiplied by the Leontief inverse and final demand.

$$\Delta E = w(I - A)^{-1}\Delta f = L\Delta f \qquad 2.14$$

Equations 2.15 and 2.16 are the equations[4] that determine how changes in final demand affect changes in GVA[5] and Income (Y)[6], respectively.

$$\Delta GVA = g(I - A)^{-1}\Delta f = L\Delta \mathrm{f} \qquad 2.15$$

$$\Delta Y = y(I - A)^{-1}\Delta f = L\Delta f \qquad 2.16$$

2.2.4.3 Input-Output modelling applications in tourism

There have been several papers that have used IO modelling to analyse the economy-wide impacts of changes in tourism expenditure. Some papers examine the changes in total tourism spending, while others examine changes in categories of tourism, and, for instance, they distinguish between inbound and domestic tourism.

---

[4] The sectoral employment output coefficients, w, is found by dividing sectoral employment by output calculated directly from national accounts

[5] The sectoral GVA-output coefficient, *g,* the GVA effect, is found by dividing sectoral GVA by sectoral output straight from national accounts

[6] The sectoral income-output coefficient, y, the income effect, is found by dividing the compensation of employees by sectoral output straight from the national accounts.

Studies using the IO modelling approach can be grouped into three main categories. First and the most common focus of the studies that use IO models are assessments of the economy-wide impact of changes in inbound tourism spending (Dwyer, 2000; Chhabra et al., 2003; Oosterhaven & Fan, 2006; Cai, 2016; Guo et al. 2017). For instance, Guo et al. (2017) analyse the impacts of non-resident expenditures on the Gulf Coast economies of Mississippi and Alabama, given that these regions are particularly sensitive to natural disasters. Guo et al., (2017) show that inbound tourism spending accounted for $17.6 billion in sales revenue. Which in turn generated $9.4 billion in value-added and $5.9 billion in labour income in 200,000 jobs but found that the benefits of this to the wider economy are smaller than expected.

Second, there are studies that use IO models to analyse the impact of domestic tourism on an economy (Haddad et al., 2013; Tsukui et al., 2017; De Santana Ribeiro, 2022). For instance, De Santana and Ribiero (2022) look at the impacts of domestic tourism expenditure and whether this expenditure can reduce regional inequalities in Brazil. The results show that domestic tourism has had the largest economic impact in the North-East region in Brazil with 12.41 million spent in North East despite being the poorest region in Brazil.

Finally, some studies analyse the consequences of changes in both domestic and international tourism expenditure separately but in the same paper (Klijs et al., 2015; Tohmo, 2018; Sun et al., 2020). These papers show compare the impacts of policy changes on domestic and inbound tourism.

In terms of the spatial perspective, these models can be categories into three main groups: national models, regional models, and multi-regional models. This is dependent on the context and motivations of the study. Of the papers in the literature review, Ooosterhaven & Fan (2006) and Khanal et al. 2014, employ national models of China and Lao PDR, respectively. Chabbra et al., (2003) and Guo et al., (2017) employ regional input-output models. Tsukui et al. (2017) and De Santana Ribeiro et al. (2022) use multi-region input-output tables as a basis for their model.

2.2.4.4 Changes in fiscal policy using the IO method

Rather than modelling the impact of changes in demand, a small number of papers conjecture that these are the result of policy actions. Both Manente & Zanette (2010) and Ferrari et al. (2017) assess the effects of a VAT reduction on accommodation and the food and beverage sector in Tuscany and the whole of Italy, respectively.

Manente & Zanetti (2010) analyse the effects of a change in VAT rate to the hotels and restaurants (food and beverage) sector from 10% to 5% for the whole of Italy. This reduction in VAT leads to an increase of tourism spending by 42.4 million euros. They use a multi-regional input-output model to assess the economic consequences for a reduction in VAT rate to the hotels and restaurants industry. This approach that they use is a sensible one given that they calculate and consider the amount of VAT that is given up, in monetary value, as a result of the VAT rate changing.

First, unlike Ferrari et al., (2017) Manente & Zanetti. (2010) consider the cost of the implementation of the VAT reduction in terms of government revenues. They understand that a consequence of a reduction in tax rate ultimately comes at a cost to the Government.

If the VAT rate in the hotel industry is reduced from 10% to 5%, then the revenue that the government receives from the "hotels and restaurant" industry is halved, assuming constant demand, which results in an initial loss for the government of 1.7 billion euros, everything else being equal. However, they consider that through increases in consumption and investment in other taxable aspects of the economy as a result of the policy change, the estimated fiscal loss associated with the policy would be 616 million euros.

$$\Delta g = \Delta GIVA + \Delta ET^{e} \tag{2.17}$$

Where Δg is the total change in government expenditure, $\Delta GIVA$ is the initial loss of VAT levy, and ΔET^{e} is the expected change in total tax levies as a result of the change in government spending.

From this they derive the increase in tourism consumption that would arise from the reduction in price. They find that tourism consumption would increase by 4.44% as a result of the VAT cut. The tax cut also encourages investment in the tourism sector as well. The estimated investment in the tourism sector is found by analysis the previous ten years investment in the tourism industry. The "net" effect is presented in terms of employment. Manente & Zanente find that there would be a net increase of 100,000 FTEs where 38% of the jobs created would be in the hotels and restaurants industries and the other 62% would be spread throughout the economy.

Ferrari et al. (2017) model the impact that an 8% increase in (inbound) tourism expenditure produces following a two-percentage-point reduction in VAT in accommodation and the food and beverage sector. This results in a positive demand for the tourism industry and a positive effect on all the macroeconomic variables that are assessed: output, employment, and income.

Of the literature examined that use IO modelling to assess a change in fiscal policy aimed at tourists they look at the gross impact of the VAT reduction in terms of tourism demand. The assumption made in these studies is the reduction in VAT is at least partially passed on to the consumer through a reduction in price. The intention of the VAT reduction in both cases is to stimulate tourism demand. However, there is a cost to the government of implementing a fiscal change such as this, and this is a limitation of Ferrari et al. (2017), which is accounted for in Manente & Zanette (2010).

When considering the net impacts Manente and Zanette (2010) show the net positive change as a result of tax through jobs created. An assumption that they make is that the reduction in government spending means that "public consumption is reduced proportionally in all industries" (Manente & Zanette, 2010, p. 416). We build on this by considering, also through the perspective of FTEs, the effect of the government sending reducing job losses primarily in public service industries. This allows for the net effect of the policy in terms of jobs lost and gained and which sectors benefit or lose out as a result of the implementation of the policy.

In addition, Ferrari et al. (2017) and Manente & Zanette (2010) both analyse a policy that is aimed at the “hotels and restaurants industry” for a region and a nation, respectively. However, this Chapter looks at a VAT reduction for accommodation, a policy commonly used when attempting to stimulate tourism demand (Dwyer et al., 2020). We aim to understand how much tourism spending has to increase to offset the fiscal cost of implementing a VAT reduction in accommodation. In our disaggregation (see Section 2.5) we disaggregate accommodation from the food and beverage services sector to analyse the impacts of a policy that is aimed at the accommodation sector, and hence overnight visitors are impacted, and its effects on the food and beverages sector and the wider economy.

2.3 Methodology and Data

2.3.1 Data

Our data for our analysis comes from the Scottish Input Output accounts, which are produced annually by the Scottish Government. We use the symmetric Industry-by-Industry tables for 2017 (Scottish Government, 2020) which were the latest available at the time of this work[7]. IO tables show the Scottish economy in this year across 98 industries.

In terms of final consumption, the Scottish IO tables show final consumption across ten categories: Households, Non-Profit Institutions Serving Households (NPISH), Central Government, Local Government, Gross Fixed Capital Formation, Valuables, Change in Inventories, Non-Resident Households, Rest of the UK Exports and Rest of the World Exports.

For ease of exposition and analysis, we aggregate the production sectors in the IO, focusing on separately identifying those most relevant for our analysis, i.e. those which comprise the production-side of tourism industries, those that sell output to tourism

[7] Like many IO accounts, there is a lag between the end of the year and the publication of IO accounts for that year. For instance, the 2017 tables became available in Autumn of 2020 (Scottish Government, 2020).

demand and those which are the focus of government spending (e.g. health, education). The sectors in the IO accounts in which tourism spending is significant include "Accommodation", "Food and beverage", and transport sectors ("Air transport", "Land transport", "Water transport"), so these sectors are separately identified in our IO table. We, therefore, aggregate the Scottish IO table to 27 sectors, which are shown in Table 2.1

2.3.2 Changes in tourism and Government demands

We are interested in exploring the impact on a regional economy of increases in tourism demand (spending) resulting from fiscal policies encouraging tourism, such as reductions in VAT or other taxes. Our specific focus is on the increase in tourism demand necessary to offset the policy's costs, under the assumption that the regional government's budget is required to fully absorb the cost of the policy.

In practice, we require three steps: first, calculate the revenue lost from the reduction in tax receipts; second, use our IO framework to quantify the (negative) economic impact of this lost revenue through reduced government spending; and third, calculate the increase in tourism spending necessary to offset the negative impact of reduced government spending.

We focus on the impact on Gross Value Added (GVA) of reduced government spending in step two and find (in step 3) the required increase in tourism necessary to fully offset the fall seen in step 2. Once the change in GVA is fully offset, we are particularly interested in how the impact differs across sectors of the economy, given the different pattern of spending by government and tourism.

Step 1: Calculating the change in revenue

We model an illustrative five percentage point reduction in VAT (from 20% to 15%) payable on Accommodation. We estimate the lost revenue by firstly finding the spending on the Accommodation (C_a) sector as a share of total spending in Scotland (C_{tot}) and multiplying this by the total amount of VAT paid in Scotland.

C_a is the sum of Scottish household spending on accommodation (C_a^{hh}) and non-resident spending in accommodation (C_a^{nr}).

$$C_a = C_a^{hh} + C_a^{nr} \tag{2.18}$$

While C_{tot} is the total consumption of Scottish residents (C_{tot}^{hh}) and non-residents (C_{tot}^{nr}).

$$C_{tot} = C_{tot}^{hh} + C_{tot}^{nr} \tag{2.19}$$

From equation 2.18 and equation 2.19, we estimate C_a/C_{tot} as 3.69%.

We then multiply this share by the figure for total VAT revenues in Scotland (VAT_{tot}) which in 2017 was £10,146 million (Scottish Government, GERS 2021) and get a figure of £374.7 million.

A change of five percentage points in VAT on Accommodation would, therefore, reduce VAT revenues by one quarter (i.e., 20% to 15%), so we apply this share by the VAT from Accommodation in Scotland (£374.7 million), which gives us an estimate of lost revenue of £93.7 million. As a share of total central government spending (taken from the column total of the IO table), this equates to 0.37%.

Step 2: The impact of a reduction in (central) government spending

$$\sum_{i=1}^{n} \Delta GVA_i = \Delta GVA_g = \hat{g}(I - A)^{-1} \cdot \gamma G \tag{2.20}$$

Notes: γ change in government spending

Step 3: The increase in tourism demand (2.45%[8] (aggregated) = 108.34 million)

$$\sum_{i=1}^{n} \Delta GVA_i = \Delta GVA_t = \hat{g}(I-A)^{-1} \cdot \theta T \qquad 2.21$$

Notes: θ is the change in tourism spending

We set θ so that:

$$\Delta GVA_g + \Delta GVA_t = 0 \qquad 2.22$$

We offset the GVA to give us an understanding of the impacts on the other macroeconomic variables that are assessed through IO modelling like output, employment and income. An interesting policy concern is the impact of increased tourism spending on employment and income. The jobs created to satisfy increased tourism demand are typically paid less than those in other sectors, such as the public sector. By offsetting the GVA we can understand if there is a positive or negative impact on employment and income. The jobs created in the tourism sector will have lower wages, on average, than the jobs lost due to the subsidy. Offsetting the GVA allows the analysis of the economy-wide income impact and compares it to the economy-wide employment impact.

[8] This number changes to 2.65% for the disaggregated version because RUK Day visitors are removed and Domestic overnight cisitors are included

Table 2.1 Sectoral aggregation, SIC codes and attribution

Number	Sector name	SIC codes	Abbreviation	Share of output sold to non-residents	Share of non-resident spending by sector	Income (£m) per unit of output (£m)	Employment per unit of output, FTE/£million
1	Agriculture, forestry and fishing	1-5	AFF	1.46%	1.83%	0.14	8.8
2	Mining	6-8	MIN	0.38%	0.30%	0.33	6.8
3	Food, drink and tobacco	9-27	FDP	0.64%	1.52%	0.21	4.2
4	Textiles, leather, wood and paper	28-33	TEX	1.26%	1.10%	0.25	6.4
5	Chemicals	34-39	CHE	0.71%	0.70%	0.24	2.6
6	Rubber, plastic, cement & iron	40-45	RPC	0.44%	0.51%	0.32	8.2
7	Computer, electrical & transport equipment	46-53	CET	0.32%	0.92%	0.25	5.0
8	Electricity, gas and water	54-57	EGW	0.27%	1.03%	0.12	2.1
9	Construction	58	CON	0.10%	0.43%	0.25	8.7
10	Wholesale & retail	59-61	W&R	2.91%	14.47%	0.39	13.8
11	Land transport	62-63	LTR	3.36%	3.26%	0.38	11.2
12	Water transport	64	WTR	6.24%	0.48%	0.38	6.3
13	Air transport	65	TTR	0.74%	0.24%	0.26	3.8
14	Post & transport services	66-67	PTS	0.62%	0.77%	0.38	10.5
15	Accommodation	68	ACC	45.95%	27.64%	0.40	17.4
16	Food & Beverage services	69	FBS	26.86%	29.99%	0.42	21.9
17	Telecommunications	70-72	TEL	5.09%	4.82%	0.35	8.1
18	Computer and Information services	73-74	CIS	0.24%	0.21%	0.40	9.2
19	Financial services	75-77	FIN	0.17%	0.83%	0.24	3.9
20	Real estate	78-80	RES	0.15%	0.71%	0.04	1.5
21	Professional services	81-84 & 86-94	PSR	0.36%	1.77%	0.41	15.0
22	Research & Development	85	R&D	0.05%	0.02%	0.35	7.7
23	Public administration	95	PAD	0.01%	0.03%	0.46	8.1
24	Education	96	EDU	0.28%	0.65%	0.61	23.3
25	Health	97-98	HEA	0.07%	0.34%	0.51	13.2
26	Recreational services	99-103	RSR	4.38%	4.73%	0.39	16.6
27	Other	104-106	OTH	1.27%	0.69%	0.33	15.0

2.4 Results: Aggregated tourism spending

In this section, we show the results from our analysis of the impact of a VAT reduction and change in non-resident tourism in a model with a single tourism spending vector, reflecting non-residents' spending in Scotland. We begin with looking at the impact of a reduction in government spending equivalent to the lost government revenues from a lower rate of VAT, which we term "Simulation 1". Our second simulation "Simulation 2" is then the change in non-resident tourism spending necessary to offset the negative impact of Simulation 1 on GVA.

2.4.1 Economy-wide and sectoral results of Simulation 1

Table 2.2 Aggregate absolute changes in key macroeconomic variables

	Absolute change from baseline
Change in Output	-£176.06 million
Change in Gross Value Added	-£108.34 million
Change in Income	-£68.18 million
Change in Employment	-1,779.30 (FTE)

Notes: Author's calculations

Table 2.2 shows the impacts of a 0.37% reduction in central government spending on Output, GVA, Income and Employment. From this table, we can see that a reduction in government spending causes negative impacts on all aggregates. This change in central government spending reduces total employment and GVA by 1,779 Full-Time Equivalent jobs (FTEs) and £108.34 million respectively.

Table 2.3 Sectoral changes in GVA, Income and Employment

	Changes in GVA, £million	% change in GVA	Changes in income, £million	Changes in employment, FTEs
Agriculture, forestry and fishing	-0.71	0.66%	-0.21	-13.27
Mining	-0.14	0.13%	-0.10	-2.05
Food, drink and tobacco production	-0.74	0.68%	-0.39	-7.99
Textiles, leather, wood and paper	-0.46	0.42%	-0.29	-7.38
Chemicals	-0.78	0.72%	-0.39	-4.16
Rubber, plastic, cement & iron	-0.38	0.35%	-0.29	-7.45
Computer, electrical & transport equipment	-0.74	0.68%	-0.54	-10.61
Electricity, gas and water	-2.48	2.29%	-0.83	-14.38
Construction	-1.47	1.36%	-0.85	-29.67
Wholesale & retail	-6.31	5.82%	-4.31	-153.20
Land transport	-1.06	0.98%	-0.83	-24.00
Water transport	-0.03	0.03%	-0.03	-0.46
Air transport	-0.18	0.17%	-0.15	-2.22
Post & transport services	-2.11	1.95%	-1.43	-39.40
Accommodation	-0.75	0.69%	-0.50	-21.40
Food & Beverage services	-1.72	1.59%	-1.28	-67.25
Telecommunications	-1.80	1.66%	-1.03	-23.78
Computer and Information services	-0.25	0.23%	-0.13	-3.00
Financial services	-3.30	3.05%	-1.69	-27.34
Real estate	-13.05	12.05%	-0.71	-25.21
Professional services	-3.77	3.48%	-2.46	-89.41
Research & Development	-0.10	0.09%	-0.07	-1.43
Public administration	-22.96	21.19%	-16.98	-300.70
Education	-3.32	3.06%	-2.55	-97.91
Health	-36.83	33.99%	-28.58	-737.63
Recreational services	-1.20	1.11%	-0.89	-37.87
Other	-1.67	1.54%	-0.67	-30.12
Total	**-108.34**	**100.00%**	**-68.18**	**-1,779.30**

Notes: Author’s calculations

The sectors which are most negatively impacted in terms of GVA, income, and employment are those sectors in which there is intensive government spending such as Education, Health, and Public administration. From Table 2.3 we can see the sectoral impacts on GVA, jobs and incomes of implementing a policy such as a decrease in VAT to accommodation. This was calculated by shocking the central government spending vector by 0.37% and hence all sectors where shocked by the same amount relative to initial sectoral central government spending (the cost to Government of forgoing the lost income from implementing a tax reduction in the accommodation sector)

While most of the impacts are in government-intensive sectors, there are impacts on other sectors, which are also important in absolute terms. For instance, in the Wholesale and Retail sector (while not directly experiencing a change in demand) sees employment reduce by 153 FTEs. The impacts outside of the public sectors, these arising through the indirect and induced effects of the change in government spending. As expected, a reduction in government spending has little impact on income and employment in tourism industries, with modest changes in sectors where tourism spending is concentrated: only 6.5% of the employment change seen (115/1779) is in Accommodation, Food and beverage services and the transport sectors.

2.4.2 Economy-wide and Sectoral Results of Simulation 2

With a reduced VAT on accommodation, we expect to see an increase in tourism expenditure. Simulation 2 is a 2.45% increase in (aggregated) tourism spending. This is the change in non-resident household spending that is required to increase Scottish Gross Value Added (GVA) by £108.34 million and thus compensate for the loss in GVA seen in Simulation 1.

Table 2.4 The impact on key economic aggregates of the 2.45% increase in non-residents expenditure

Macroeconomic variables	Absolute change from baseline
Change in Output	£190 million
Change in Gross Value Added	£108 million
Change in Income	£63 million
Change in Employment	2,460 (FTE)

Notes: Author's calculations

Table 2.4 shows the impacts of this 2.45% increase in non-residents spending on Output, GVA, Income and Employment. This is unambiguously positive on aggregate. Employment increases by 2,460.98 (FTEs) and (by construction) GVA by £108.34 million. In the following section we will analyse the net impacts of this increase in non-resident spending considering the costs associated with implementing policies (examined in Section 2.4.1). Now, we examine the impacts of the increase in tourism spending across different sectors.

Table 2.5 shows the sectoral impacts of the 2.45% increase in non-resident expenditure on GVA, income and employment. The section above displays the impacts that this increase in non-resident spending has on key economic aggregates. We can see the sectors that benefit the most from the increase in non-resident spending.

Table 2.5: The sectoral impacts of a 2.45% increase in non-resident spending to GVA, income and employment, absolute changes
Source: Author's calculations

Sectors	Changes in GVA (£million)	Changes in income (£million)	Changes in employment (FTE)
Agriculture, forestry and fishing	2.11	0.62	40
Mining	0.34	0.24	5
Food, drink and tobacco production	1.92	1.02	21
Textiles, leather, wood and paper	0.96	0.60	15
Chemicals	0.64	0.32	3
Rubber, plastic, cement & iron	0.62	0.47	12
Computer, electrical & transport equipment	0.99	0.71	14
Electricity, gas and water	2.63	0.88	15
Construction	1.76	1.02	36
Wholesale & retail	15.80	10.79	383
Land transport	2.90	2.25	65
Water transport	0.27	0.23	4
Air transport	0.28	0.25	4
Post & transport services	1.82	1.23	34
Accommodation	18.82	12.52	538
Food & Beverage services	19.73	14.64	770
Telecommunications	4.61	2.63	61
Computer and Information services	0.42	0.22	5
Financial services	3.70	1.90	31
Real estate	12.75	0.70	25
Professional services	5.43	3.54	129
Research & Development	0.15	0.10	2
Public administration	0.62	0.46	8
Education	1.66	1.27	49
Health	1.26	0.97	25
Recreational services	4.16	3.09	132
Other	1.99	0.79	36
Total	**108.34**	**63.47**	**2460.98**

The most positively affected sectors in terms of GVA, income and employment are Accommodation and Food and beverage services. This is followed by Wholesale and retail which sees an increase in 383.27 and is an important part of the supply chain of tourism demand in Scotland.

Overall, 68.7% of the jobs created as a result of the increase in tourism spending come from the Accommodation, Food and beverage, and Wholesale and retail sectors (1961/2461).

The sectors which see little benefit from the increase in tourism spending are sectors where there is little tourism spending. These include the public sectors, such as Public administration, Education, and Health and sectors which are unrelated to tourism spending such as mining and Chemical production.

2.4.3 Economy-wide and sectoral results of the net change of Simulation 1 and 2

Now we consider the "net effects" of Simulation 1 and Simulation 2 on Output, GVA, Income and Employment. Specifically, the consequences for macroeconomic and sectoral variables of a 2.45% increase in non-residents spending ("Simulation 2", Section 2.4.2), taking into account the cost of central government spending being reduced by the equivalent amount that a five-percentage point reduction in VAT to accommodation ("Simulation 1", Section 2.4.1).

Table 2.6 The net impacts of Simulation 1 and 2 on key economic aggregates

Macroeconomic variables	Simulation 1	Simulation 2	Net impact
Change in Output	-£176 million	£190million	£14.34 million
Change in GVA	-£108 million	£108million	£0.00 million
Change in Income	-£68 million	£63 million	-£4.71 million
Change in Employment	-1,779 (FTE)	2,460.(FTE)	681 (FTE)

Notes: Author's calculations

Table 2.6 shows the net results of an increase in non-resident spending by 2.45%, considering the costs of the government spending reduction. As explained previously, the increase in non-resident expenditure which is required to compensate for the £108.34 million lost in GVA from the 0.37% government spending reduction. Hence, the net change in GVA is 0.00 by construction. The net change in other economic aggregates, however, is not known a priori.

We can see from Table 2.6 that the net impact on Output and Employment (FTE) is positive, £14.34 million and 681.68 (FTE) respectively, while the net change in Income is negative £4.71 million. In short, there is more output and employment in the economy but less income. This occurs as the income from employment change as a result of the increase in tourism spending is lower than the change in income from employment because of the loss in government spending. Including multiplier effects, tourism spending thus appears to create more jobs *per unit of final demand* than central government spending, so that a switch from government spending to tourism adds employment. However, the opposite is true when Income is considered: we find a net reduction in Income following the increase in tourism demand and reduction in government spending. This is further investigated in the following section. Table 2.7 shows the sectoral impacts of the net changes of GVA, Income and Employment.

Table 2.7 The sectoral net changes in GVA, Income and Employment
Notes: Author's calculations

Sectors	Net changes in GVA (£million)	Net changes in Income (£million)	Net changes in Employment (FTEs)
Agriculture, forestry and fishing	1.40	0.41	26
Mining	0.20	0.14	3
Food, drink and tobacco production	1.18	0.62	13
Textiles, leather, wood and paper	0.50	0.31	8
Chemicals	-0.14	-0.07	-1
Rubber, plastic, cement & iron	0.24	0.18	5
Computer, electrical & transport equipment	0.24	0.17	3
Electricity, gas and water	0.15	0.05	1
Construction	0.30	0.17	6
Wholesale & retail	9.48	6.48	230
Land transport	1.83	1.43	41
Water transport	0.24	0.20	3
Air transport	0.11	0.09	1
Post & transport services	-0.30	-0.20	-5
Accommodation	18.08	12.02	517
Food & Beverage services	18.01	13.36	703
Telecommunications	2.81	1.60	37
Computer and Information services	0.17	0.09	2
Financial services	0.40	0.21	3
Real estate	-0.30	-0.02	-0
Professional services	1.66	1.09	39
Research & Development	0.05	0.03	1
Public administration	-22.34	-16.52	-293
Education	-1.66	-1.28	-49
Health	-35.58	-27.61	-712
Recreational services	2.97	2.20	94
Other	0.31	0.12	6
Total	**0.00**	**-4.71**	**682**

The sectors most positively impacted in terms of GVA, Income and Employment are those in which there is an increase in tourism spending: Accommodation and Food and beverage services. There are minor negative impacts to the sectors from Simulation 1 because there is little government spending associated with these sectors (see Table 2.3).

In addition, these sectors are the sectors in which tourism spending is most intensive and, therefore, the sectors that had the most significant positive impact from the increase in non-resident expenditures from Simulation 2 (see

Table 2.5). Hence, in terms of employment, these sectors create most of the net jobs. The sectors that see the most significant negative change in employment are education, health, and public administration. As seen at the aggregate level, the positive employment change that comes from the tourism sectors outweighs the negative employment change. This factor drives a substantial part of the overall employment change, 681 FTEs.

While there is a negative impact on Incomes at the aggregate level, looking at the sectoral results gives a clear picture of why this is the case. The income generated from the net increase in tourism expenditure for the sectors where tourism spending is intensive is £25.38 million; this is the sum of income in Accommodation and Foods and beverage services. Conversely, the income lost in the sectors where government spending is intensive: Health, Education and Public Administration is -£45.31 million.
A point to note is for each FTE job in the tourism sectors (Accommodation, Food and beverage services, has a relatively low income compared to the public sectors. For instance, as we see in the table above, income generated is £20,812 (employment change/ income change). On the other hand, in terms of each job lost in the sectors where the government spending is intensive, the income lost is £43,079. Intuitively, government jobs are paid more than tourism jobs on average, so even with more jobs, overall labour income still falls due to the change in the sectoral composition of employment.

2.5 Sensitivity Analysis – Disaggregation of tourism demand

In this Chapter we discuss why disaggregation of tourism spending within the national accounts could give us additional insights and describe our process for calculating a set of tourism spending categories in Scotland. We begin by discussing the benefits of disaggregation, before (Section setting out our approach.

2.5.1 Benefits of disaggregation of tourism demand

In our specific case, we know that the VAT reduction on accommodation spending will not only impact on non-residents but also domestic overnight. If we are increasing the spending for non-residents (the Rest of UK day visitors (RUKDV) + the Rest of UK overnight visitors (RUKON) + international overnight visitors (INTON)) only then for consumers of accommodation, we are missing a fundamental part of this spending, the domestic overnight categories. Our disaggregation allows us to account for this and include domestic overnight visitors in our calculations of the increase required to compensate for the losses in GVA. Another issue that our disaggregation accounts for is that there 'day visitors' within the non-residents. These types of tourists should be excluded from the calculation as these tourists do not spend any money in accommodation. Therefore, the spending categories that are included in overnight spending are (Domestic overnight visitors (DON) + the Rest of UK overnight visitors (RUKON) + International overnight visitors (INTON).

- **Scottish resident day visitor spending** –Spending by Scottish residents visiting Scottish destinations and spending less than 24 hours there (no spending in accommodation[9]) (UNWTO, 2024).
- **Scottish resident overnight spending** – Spending by Scottish residents visiting Scottish destination for more than 24 hours there, and making use of accommodation) (UNWTO, 2024)
- **Rest of UK day visitor spending** – Spending by rest of UK's residents visiting Scottish destinations and spending less than 24 hours there (no spending in accommodation). (UNWTO, 2024)
- **Rest of UK overnight visitor spending** – Spending by rest of UK's residents visiting Scottish destination for more than 24 hours there and making use of accommodation. (UNWTO, 2024)

[9] Accommodation in this context includes hotel and similar accommodation, camping grounds, recreational parks and trailer parks and other accommodation as of the Standard Industrial codes 2007 (see: https://www.ons.gov.uk/methodology/classificationsandstandards/ukstandardindustrialclassificationofeconomicactivities/uksic2007)

- **International overnight spending** – Spending by rest of the World's residents visiting Scottish destination for more than 24 hours there, and making use of accommodation.[10] (UNWTO, 2024)

Our next step is to incorporate these tourism spending categories into the national accounts for Scotland for 2017 (Scottish Government, 2020). This section begins with presenting a Schematic version of the Scottish Industry by Industry (IxI) Input-Output tables. Figure 2.2 shows a disaggregated version of the Scottish Input-Output tables where final demand has been disaggregated specifically for tourism analysis using the spending vectors that have been described above.

[10] The assumption that is made in the model is that there is no spending from international day visitors in Scotland. The assumption is that because of the method of travel that international visitors would have to undergo to get to Scotland then they would always spend more than a day in Scotland – making use of accommodation

Figure 2.1 Schematic standard (Scottish) IO table with tourism demand disaggregation

<table>
<tr><td colspan="3" rowspan="2"></td><td colspan="8">Final Demand</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="2">Domestic tourism</td><td></td><td colspan="3">Inbound tourism</td><td></td></tr>
<tr><td></td><td></td><td>Sectors</td><td>Households</td><td>Day visitors</td><td>Overnight Visitors</td><td>Other domestic</td><td>RUK day visitors</td><td>RUK overnight visitors</td><td>Int overnight</td><td>Exports</td><td>Gross Outputs</td></tr>
<tr><td rowspan="3">Primary inputs</td><td>Sectors</td><td>Intermediate quadrant</td><td colspan="8">Local Consumption demand quadrant</td><td>Total Sectoral Outputs</td></tr>
<tr><td>Imported
Taxes
Labour
Capital</td><td>Primary input quadrant</td><td colspan="8">Non-local consumption demand and taxes</td><td>Total primary and non-local inputs</td></tr>
<tr><td>Gross inputs</td><td>Total Sectoral inputs</td><td colspan="8">Total consumption demand</td><td></td></tr>
</table>

2.5.1.1 Incorporating the demand categories into Scottish IO accounts

We begin by disaggregating the non-resident tourism demand into three categories: RUK Overnight, RUK Day Visits and International Overnights. For the inbound tourist categories the non-resident spending is split into three different shares: 33% for RUK day visitors, 30% for RUK overnight and 37% for the international overnight visitors of the original non-resident expenditure vector from Figure 2.1 Schematic standard (Scottish) IO table with tourism demand disaggregation. These values came straight from the VisitScotland data inventory on their website at the time of writing. These shares are attributed to each of the categories given the amount of spending in Scotland by each spending category. One of the assumptions that is made in this study is that the spending patterns of the Great British Overnight visitors and the International Overnight are identical. Due to the lack of sectoral data for this application we assume the same spending patterns for overnight visitors and for the Great British day visitors we remove spending in accommodation.

Incorporating the domestic tourism spending categories, day visitors spending and overnight spending, follows a different process than the inbound categories. This is because domestic tourism consumption is part of household spending.

$$HH_c^n = HH_c^{or} - DV_c^d - ON_c^d \qquad 2.23$$

The new household consumption vector, HH_c^n, is created by disaggregating non-tourism spending, HH_c^{or}, from domestic day visitors spending, DV_c^d, and domestic overnight visitors spending, ON_c^d. Equation 24 represents that the new household spending category is separated from domestic tourism spending.

The domestic day visitors are found by using the day visitors vector that is created using tourism expenditure day visitors, and from the Scottish national accounts (Scottish Government, 2020). Since the basis for all spending patterns is the non-resident spending then this is the starting point. Each sectors spending is multiplied by the percentage of day visits that are attributed to Scottish residents of total day visitor spending[11].

The same process is undertaken for the domestic overnight category. Again, the difference between the domestic day visitor pattern of spending and the overnight pattern of spending is that there is spending in accommodation.

2.6 Results: Disaggregated tourism spending

We see in section 2.4 that a reduction in VAT on accommodation which led to an increase in aggregate non-resident tourism spending and no net effect on GVA led to higher employment, but lower Income and Output. As we only had the aggregated spending vector for non-resident spending, we were unable to include any impact of increased overnight stays by domestic residents (as overnight tourists) following the reduction in VAT. However, with newly disaggregated tourism demand vectors, we can now explore the extent to which overnight stays (irrespective of the tourists' place of residence) need to increase in order to offset the reduction in GVA from the cost of the VAT reduction policy.

We begin this section by looking separately at the increases in each overnight category of tourism spending that is required to offset the losses in GVA from the government spending reduction, "Simulation 1" which remains unchanged. Our simulations in this section – "Simulation 3.1", "Simulation 3.2", and "Simulation 3.3" are then the change in Domestic, The Rest of UK and International overnight tourism spending necessary to offset the negative impact on GVA of Simulation 1. In Section 2.6, we look at each individual tourism spending category and the amount that each overnight tourism spending category has to increase their spending to change offset the reduction in GVA from Simulation, and so can attribute the net impacts to different overnight spending vectors.

[11] The rest of the day visitors spending in this case is attributed to the rest of the Scottish day visitors.

2.6.1 Economy-wide and sectoral results of simulation 3.1, 3.2 and 3.3

Table 2.8 The increase in tourism spending that is required to offset the losses in GVA from simulation for disaggregated overnight spending categories

	Simulation 1	**Simulation 2**	**Simulation 3.1** **Domestic (DON)**	**Simulation 3.2** **Rest of UK (RUKON)**	**Simulation 3.3** **International (ION)**
	Reduction in government spending	Non-resident expenditure	Overnight visitors spending	Overnight visitors spending	Overnight visitors spending
Increase required		**2.45%**	**14.65%**	**7.16%**	**5.86%**
Net GVA (£million)	-108.34	0.00	0.00	0.00	0.00
Net employment (FTEs)	-1779.30	681.68	681.68	687.22	687.22
Net income (£million)	-68.18	-4.71	-4.71	-4.74	-4.74

Notes: Author's calculations

Table 2.8 shows the increases in each tourism spending category required to have a zero net change in GVA. In other words, the amount of tourism spending increase required to have an increase in £108.34 million GVA and hence a net zero change. This table shows that the percentage increase in tourism spending is different for each of the overnight spending categories presented. This reflects the shares of each of these overnight categories. Aside from the increase in tourism spending, when each category is increased in turn the results for the Rest of UK (RUK) overnight visitors are identical[12] with increases the required increases in tourism spending having a positive net change in employment and a negative net change in income by 687.22 (FTEs) and -£4.74 million respectively. For domestic overnight spending, the results are different, although there is still a positive impact on employment and a negative impact on income, 681.68 FTEs and -£4.71 million. As seen in Section 2.5, our disaggregation model assumes that domestic

[12] The same spending patterns are used for Rest of Great Britain overnight spending and international overnight spending.

overnight have a different pattern of spending than non-resident (inbound) overnight tourists which explain these differences.

Table 2.9 shows the sectoral impacts of the *net change* required to offset the losses from the government spending reduction for each of the overnight spending categories we have in our IO model. The right-hand column presents sectoral results for the Rest of the UK and International overnight visitors spending as they have the same spending patterns and therefore haver identical employment changes. The only difference, because of the relative spending in both categories, is the required spending to offset the losses in GVA from Simulation 1.

Table 2.9 The net sectoral impacts on employment (FTE) for each of the overnight tourism spending categories

	Tourism spending category	
	DON	**RUKON/ION (Inbound)**
Agriculture, forestry and fishing	26.29	24.01
Mining	2.98	2.61
Food, drink and tobacco production	12.68	11.70
Textiles, leather, wood and paper	7.92	6.74
Chemicals	-0.75	-1.02
Rubber, plastic, cement & iron	4.65	3.80
Computer, electrical & transport equipment	3.43	2.53
Electricity, gas and water	0.85	0.39
Construction	6.00	4.72
Wholesale & retail	230.06	202.40
Land transport	41.45	36.04
Water transport	3.30	2.89
Air transport	1.31	1.18
Post & transport services	-5.52	-7.71
Accommodation	517.02	680.05
Food & Beverage services	702.53	615.14
Telecommunications	37.01	31.63
Computer and Information services	2.11	1.86
Financial services	3.35	2.91
Real estate	-0.59	-0.81
Professional services	39.48	35.74
Research & Development	0.64	0.63
Public administration	-292.52	-292.71
Education	-49.01	-51.29
Health	-712.46	-713.09
Recreational services	93.85	82.74
Other	5.60	4.12
Total	**681.68**	**687.22**

Notes: Author's calculations**.** DON – Domestic Overnight

There are significant differences in the Accommodation (ACC) and Food and Beverage Services (FBS). For the domestic overnight category, the Food and Beverage services (FBS) sector has the most significant change in employment, 702.53 FTEs. On the other hand, the sector with the largest change in employment for the Rest of UK and International overnight tourists spending is the Accommodation sector (ACC), 680.05 FTEs.

Through disaggregating tourism expenditure, we understand that domestic tourists spend more in the Food and Beverage sector than in the Accommodation sector. This is because of the fact that domestic tourists are more likely to have shorter stays compared to inbound tourist (Dwyer et al., 2020) and hence a lower proportion of their budget is spent on accommodation relative to international overnight. This allows for a relatively larger proportion of spending to be included in the food and beverage sector. The opposite is the case for non-residents in the Rest of UK overnight visitors spending category and the International overnight spending category. The Wholesale and Retail sector (W&R) also sees a significant positive net change in employment for Domestic and Inbound tourism categories, with 230.06 FTEs and 202.40 FTEs, respectively.

The sectors that are the most negatively impacted in terms of employment change are the sectors in which government spending is intensive such as Education (EDU), Health (HEA) and Public Administration (PAD). The level of employment change is consistent in all overnight categories presented, with the worst affected employment change being in Health (HEA), with -712.46 FTEs of employment change for the domestic category and -713.09 FTEs for the inbound categories.

2.6.2 Attribution of the change off all overnight categories together

In this simulation we look at an across-the-board change in all overnight categories collectively which would offset the reduction in GVA from Simulation. From this, we can look at how much each of the overnight category's attribute to offsetting the lost GVA from the cost of a reduction in VAT on accommodation. We do this by increasing each of the overnight categories by *the same amount* so that the sum of impacts on GVA from the three categories (Domestic Overnight, Rest of UK Overnight, and International Overnight) offsets the loss in GVA from Simulation 1. By iteration, we find that the necessary percentage increase in each overnight tourism spending category required to generate a (total, i.e. when added together) GVA impact of £108.34 million is 2.65%.
Table 2.10 shows the sectoral impacts on GVA. Recall from Section 4.2 that to offset the losses in GVA from the Government spending reductions required a 2.45% increase in (the aggregate) non-residents spending. The column on the right of Table 2.9 "Sim 2" shows the positive effects that increasing non-resident expenditure had when we had only one column of tourism (and only non-resident) spending.

Table 2.10 The sectoral impacts on GVA of an increase of 2.65% in each overnight category required to offset the loss of 0.37% of Government spending

Sectors	DON (1)	RUKON (2)	INTON (3)	Sum (1+2+3)	Sim 2	Difference (Sum minus Sim 2)
Agriculture, forestry and fishing	0.38	0.73	0.90	2.01	2.11	-0.10
Mining	0.06	0.12	0.14	0.32	0.34	-0.02
Food, drink and tobacco production	0.35	0.68	0.83	1.85	1.92	-0.07
Textiles, leather, wood and paper	0.17	0.33	0.40	0.90	0.96	-0.06
Chemicals	0.12	0.22	0.27	0.60	0.64	-0.04
Rubber, plastic, cement & iron	0.11	0.21	0.26	0.58	0.62	-0.04
Computer, electrical & transport equipment	0.18	0.34	0.42	0.93	0.99	-0.05
Electricity, gas and water	0.47	0.94	1.15	2.56	2.63	-0.07
Construction	0.32	0.63	0.77	1.71	1.76	-0.05
Wholesale & retail	2.85	5.41	6.61	14.86	15.80	-0.93
Land transport	0.52	0.98	1.20	2.70	2.90	-0.20
Water transport	0.05	0.09	0.11	0.25	0.27	-0.02
Air transport	0.05	0.10	0.12	0.27	0.28	-0.01
Post & transport services	0.33	0.63	0.77	1.72	1.82	-0.10
Accommodation	3.39	9.05	11.06	23.50	18.82	4.67
Food & Beverage services	3.56	6.45	7.89	17.90	19.73	-1.84
Telecommunications	0.83	1.55	1.89	4.27	4.61	-0.33
Computer and Information services	0.08	0.15	0.18	0.41	0.42	-0.02
Financial services	0.67	1.35	1.64	3.66	3.70	-0.04
Real estate	2.30	4.66	5.70	12.66	12.75	-0.09
Professional services	0.98	1.95	2.38	5.30	5.43	-0.13
Research & Development	0.03	0.05	0.07	0.15	0.15	0.00
Public administration	0.11	0.23	0.28	0.61	0.62	-0.01
Education	0.30	0.58	0.71	1.60	1.66	-0.06

Health	0.23	0.45	0.55	1.23	1.26	-0.03
Recreational services	0.75	1.41	1.72	3.88	4.16	-0.29
Other	0.36	0.70	0.86	1.92	1.99	-0.07
Total	19.53	39.96	48.84	108.34	108.34	0.00
Attribution	18.03%	36.89%	45.08%	100.00%		

Notes: Author's calculations

As Table 2.10 The sectoral impacts on GVA of an increase of 2.65% in each overnight category required to offset the loss of 0.37% of Government spending shows if we increase each of the overnight categories by the same percentage, with the sum of the total change in GVA is £108.34 million we can see that each of the overnight categories contributes a different amount to the losses in GVA. International Overnight visitors are the largest contributor to the loss in GVA (45.08%), the rest of UK overnight categories (36.89%) and domestic overnights (18.03%) in overall change in GVA. These largely reflect the different totals of spending by each category (see Table 2.7 in Section 2.5).

The final column in Table 2.10 shows the difference between the sum of the three changes ("Sum") and the sectoral results from Simulation 2. Most notably, we can see that sum of the change for the three overnight categories is larger in Accommodation sector than the positive change in GVA from the increase in non-residents spending, £23.50 million and £18.82 million respectively. This can be explained by the domestic Overnight tourists now being included in this simulation and the Great British day visitors being excluded for the calculation. This shows the benefits from the disaggregation of national accounts in this type of tourism analysis.

Now we look at the sectoral effects on employment for each of the categories and compare the results found in sectoral employment from "Simulation 2" in Section 2.4. These are reported in Table 2.11.

Table 2.11The employment impacts of Sim 2 compared to other simulations

Sectors	DON (1)	RUKON (2)	INTON (3)	Sum (1+2+3)	Sim 2	Difference (Sim minus Sum 2)
Agriculture, forestry and fishing	7	14	17	38	40	-2
Mining	1	2	2	5	5	0
Food, drink and tobacco production	4	7	9	20	21	-1
Textiles, leather, wood and paper	3	5	6	14	15	-1
Chemicals	1	1	1	3	3	0
Rubber, plastic, cement & iron	2	4	5	11	12	-1
Computer, electrical & transport equipment	3	5	6	13	14	-1
Electricity, gas and water	3	5	7	15	15	0
Construction	6	13	16	35	36	-1
Wholesale & retail	69	131	160	361	383	-22
Land transport	12	22	27	61	65	-4
Water transport	1	1	2	3	4	-1
Air transport	1	1	2	3	4	-1
Post & transport services	6	12	14	32	34	-2
Accommodation	97	259	316	672	538	134
Food & Beverage services	139	252	308	698	770	-72
Telecommunications	11	20	25	56	61	-5
Computer and Information services	1	2	2	5	5	0
Financial services	6	11	14	30	31	-1
Real estate	4	9	11	24	25	-1
Professional services	23	46	56	126	129	-3
Research & Development	0	1	1	2	2	0
Public administration	1	3	4	8	8	0
Education	9	17	21	47	49	-2
Health	5	9	11	25	25	0

Recreational services	24	44	54	123	132	-9
Other	6	13	15	35	36	-1
Total	**444**	**910**	**1112**	**2466**	**2461**	**5**
Attribution	18.03%	36.89%	45.08%	100.00%		

Notes: Author's calculations

The total amount of jobs that are created because of each of the overnight categories being increased by 2.65% compared to the positive employment change in non-resident expenditure is larger of 5 FTE. This is due to the fact that the way that we calculate the offset in GVA is different and therefore the positive effects on employment and income are different.

Using the aggregated table, we found (Table 2.7 The sectoral net changes in GVA, Income and Employment) the positive employment change varies across the sectors: the sector with the most positive change was the Food and Beverage Services sector (FBS), with an overall employment change of 2,461. For comparison with our new results using the aggregated table we include these in the second last column of Table 10 ("Sim 2").

Using our newly disaggregated tourism categories. The fourth column ("Sum") is the addition of the sectoral employment changes when each category (DON, RGBON and INTON) are increased by 2.65%. Reading down this column and comparing to the sectoral results with the aggregate model ("Sim 2") we can compare the sectoral differences between these two approaches.

Overall, in terms of the total employment change, our result in the disaggregated model (2,466) is slightly larger than the total employment change for "Sim 2" (2461). Interestingly, there is a larger change in employment in the accommodation in the "Sum" column than in the "Sim 2" column.

We see that the total employment change for the (disaggregated) overnight spending categories are largely driven by changes in the Food and Beverage and the Accommodation sector (698 and 672 respectively). These changes are quite different to those in the aggregated model, where these sectors see changes in employment of 538 and 770. Our disaggregation therefore gives us results showing a more pronounced (positive) impact on Accommodation sector compared to the aggregated case.

If we look at the change in Accommodation and Food and Beverage sectors in the disaggregated model, we can see these impacts come from non-resident tourism categories. The changes in RGB overnight visitors and the International overnight visitors (INTON) produce larger positive employment impacts on accommodation than in the food and beverage sectors. For the domestic overnight visitors (DON) the opposite is true, the employment change in the food and beverage sectors (139) is larger than in accommodation (97).

Our results here would be consistent with our rationale for the need for further disaggregation of overnight tourism from the aggregated model. With the non-resident column, spending by domestic overnight tourists are not included and the RUK day visitors (who will not stay overnight in accommodation) are included. By disaggregating the tourism spending categories, we can correct this, and focus solely on the necessary changes in overnight tourism (both domestic and non-domestic) and reflect the truer pattern of spending for overnight tourism categories.

2.7 Discussion and conclusion

2.7.1 Policy implications

This research has different policy implications for different end users such as the Government and tourism organisations. It is becoming increasingly important to Government to understand the potential costs, in terms of financial and economic, of implementing a Government subsidy. The majority of current research in this area assumes that subsidies are costless to the Government and hence the positive results of a tourism subsidy are exaggerated. Including these costs can help the Government to understand where jobs output and income are lost as a result and in which sectors and the net effect of the positive demand as a result of lowering prices.

Furthermore including the disaggregation of tourism spending can help guide governments in which types of tourism categories to target with fiscal policy. For example given the fact that International overnight tourists have the largest spending in terms of the inbound categories, then this is where a tax could be targeted to generate the highest potential revenue.

2.7.2 Discussion and conclusion

The results shown in this Chapter demonstrate that the potential impact of a tourism subsidy towards the accommodation, through a five-percentage point VAT reduction, using Input-Output modelling.

In the first set of simulations, we find that the reduction in government spending that would be equal to a five-percentage point reduction in VAT to accommodation and find that the sectors that are most negatively impacted by this are the sectors where government spending is intensive. This is because the reduction in VAT revenues effect central government spending.

Our second set of simulations analyse a 2.45% increase in tourism spending. The 2.45% increase in spending is the amount of tourism spending that is required to offset the lost GVA from simulation 1. These results are consistent with Ferrari et al. (2019), where the increase in tourism expenditure has a positive impact on the macroeconomic variables. As there is only an increase in spending to the economy and no cost in this simulation (the last set of simulations explore the net effects). The sectors where typically tourism spending is most intensive, such as the accommodation and the food and beverage sector, are more impacted. Although the tax is only implemented on the accommodation sector the results show that there is a complementarity between the accommodation sector and the food and beverage sector which is a common finding in the tourism literature (Ferrari et al., 2019; Manente & Zanetti, 2010).

We advance the work in Ferrari et al. (2019) where a costless reduction in VAT is introduced by considering the cost of this policy to the government. Following Manente et al. (2010) we calculate the cost in terms of government loss in government revenue by assuming that this results in a government spending cut of equal proportion. This means that the (positive) effects on the tourism demand as a result of the VAT reduction will be potentially offset by the cost of implementing the policy and we show the net effect of the policy.

We also demonstrate the value of disaggregating demand for different categories of tourists, especially domestic and international tourists. This is in contrast with the literature where domestic tourism is often neglected. Our results show that a VAT reduction has an overall positive impact on gross output and jobs even when this is offset by a reduction in government expenditure. However, interestingly, despite the overall increase in employment, overall labour income in the economy has falls. This highlights the nature of jobs in tourism and the fact that these generate less income on average than jobs in the government sectors.

In fact, when the sectoral results are analysed the employment that is lost due to the implementation of the policy are those jobs where the government spending is intensive. The jobs that are gained in the economy with the increased tourism spending are in sectors where the supported is largely supported by tourism. Although as a result of the increased tourism spending there is a net benefit in employment. This highlights the fact that the jobs that are created are of lower incomes than the public sector jobs that are lost. This is a concern for the industry and to ensure that Scotland continues to provide a high-quality tourism product then it is essential that there is investment made in the sector to increase training opportunities to make the jobs more attractive in terms of the conditions and the wages that are associated with employment in the tourism sectors.

Although these results provide important guidance to policy making the limitations with IO modelling have been well documented and leave scope for future research to build on and improve the model that is used to analyse this type of problem. We have overcome one of the limitations in that we have included the cost of the policy, the net effect. We understand that there is scope through other general equilibrium models to overcome some of these challenges that we will employ in future Chapters. However, there are other limitations of IO that must be considered here.

One of the key limitations of the IO method is that there are no supply-side capacity constraints (Rose, 1995; Dwyer 2006; Oosterhaven, 2015; Dwyer et al., 2020). This means that the effects of the change in tourism spending is totally demand driven. This simplest way to explain this is to say that in a case where there is an excess supply for tourism. This means that there is an assumption that there is no limit on the resources land, labour and capital and the assumption is that these resources flow freely. However, the reality is that there are constraints on supply. Let us take labour as an example. IO models would assume that given there is no constraints on the amount of labour that can be employed in a country that industry would simply hire more workers if demand increased. However, if supply capacity constraints exist the composition of labour and the price of labour would change to cope with the increase in demand, not necessarily the volume of workers. CGE models include supply side constraints and deal with employment relocation between sectors and changes in factors' prices[13].

Another limitation of IO in general and for modelling tourism in particular is that there are fixed prices and wages within the framework (Dwyer et al., 2020). Any change in demand for land, labour, or capital and in the cost of these inputs due to taxes or other policies cannot be captured. Again, CGE models include price sensitivity.

The key change that occurs in the economy when there is an increased tourism demand is that the nature of consumption and investment in the economy, the pattern of spending, will change in an economy as result of the extra income that is generated in the economy. The IO model assumes that the spending pattern stays the same as the previous period of consumption and investment decisions will also stay the same. CGE models can account for these changes in consumption due to the price mechanisms that are built into the model.

[13] There is a fairly large literature on these types of issues in the CGE field (see "Dutch disease" impacts.

Future research should aim to employ a Scotland specific Computable General Equilibrium model. These models are complex. However, the complexity of these models allows for less restrictive assumptions and can account for some of the limitations of IO modelling. Recently, these types of models have been employed in tourism analysis in various types of settings and it is to this end that future Chapters will use this modelling technique. However, "off the shelf" or standard CGE models do not account for some of the complexities that are associated with tourism spending, mainly that different policies affect different types of tourists in different ways. As we see in section 2.5 and 2.6 of this Chapter. We will use the spending categories that have been employed here to extend an existing CGE framework to assess future policies that are aimed at tourists in Scotland. Furthermore, another area for future research could be to understand the differences between RUK and International overnight spending and reflect them in the model. In the model, currently, these vectors are the same. The model could be updated to reflect this.

3 Chapter 3: Exploring the Impacts of Accommodation Taxes on Tourism: Insights from a CGE Analysis

3.1 Introduction

Tourism represents a fundamental source of external income for many regions, and it is seen as an opportunity for regions to create employment for residents (Murillo et al., 2013). However, despite the seemingly positive economic opportunities that come with increased tourism demand, there are growing concerns regarding "overtourism" (Mihalic, 2020), which is the phenomenon whereby the excessive presence of tourists in top-rated tourism destinations causes disruption to the lives of the residents and negatively impacts the attractiveness and "market value" through overuse (Dodds, 2019).

Negative externalities linked to overtourism, such as overcrowding and lack of seasonality, where tourists are not spread across each month of the year, can stretch the public budget (Dwyer et al. 2020). Fundamentally, whilst tourists use public services in tourist destinations, they do not contribute to the maintenance of the services that they use through taxation.

Accommodation taxes may be an effective way for Governments to raise revenue from tourists and simultaneously internalise negative externalities associated with tourism activities within the accommodation sector (Biagi et al., 2017). For this reason, many destinations have decided to implement *specific* or *ad valerom*[14] accommodation taxes (Dalir et al., 2021). Ad valerom taxes are used mainly by Governments as they, in most cases, generate more income (Dwyer et al. 2020).

Accommodation taxes reduce the externalities caused by tourism activities in crucial ways. First, accommodation taxes can reduce tourism demand in some capacity and,

[14] A specific tax refers to the consumer being charged a specific amount of money per unit consumed. For example, a £5 per bed regardless of the overall price of the accommodation. An ad valerom tax is a percentage tax, a 5% tax on accommodation.

therefore, minimise overcrowding associated with tourism. Second, the tax revenue can improve public services and increase the Government budget.

According to Gooroochurn & Sinclair (2005), because the tourism tax's tax burden is exported to non-residents, a tourism tax can increase social welfare if implemented correctly. It is a complex topic because many taxes can be deemed a tourism tax (Gooroochurn & Sinclair, 2005).

When a government chooses to employ a tourism tax, it has the choice of whether to implement a specific tourism tax or a general tax aimed at tourists, as discussed in Gago et al. (2009). A specific tourism tax in this context is a tax that is aimed directly at tourists, such as an accommodation tax. A general tax is implementing a tax that affects all economic agents, such as an increase in a Value Added Tax (VAT) or a change in Goods and Services Tax (GST). Gago et al. (2009) find that in the case of Spain, tourism taxation can positively impact the destination economy but find that implementing a general tax is more straightforward to implement from a government policy change perspective.

In the past three decades, tourism demand has grown exponentially due to simultaneously evolving factors. One of the most important reasons for this increased demand is that methods of travel between destinations have become less expensive relative to average incomes in a country (Incera & Fernandez, 2015). Therefore, there has been significant investment in touristic destinations (Dwyer et al., 2021).

With this increased tourism expenditure, there has been increased policy interest in tourism spending and policies aimed at tourism. Hence, an increase in the analysis of the economic impacts of the changes in tourism policy (Wickramasinghe & Naranpanawa, 2022).

An extensive literature has analysed the direct impact of accommodation taxes using various economic techniques. These include partial equilibrium, time series, and panel data methods (e.g., Biagi et al., 2017; Arguea & Hawkins, 2022). These methods are beneficial for assessing seasonality and tourism demand trends across time where robust data is available. However, these methods cannot capture the economy-wide impacts of tourism taxes and can be exclusively carried out ex-post where historical data is available.

To overcome these methodological constraints, another literature focuses on the economy-wide impacts of accommodation (and other tourism taxes) using Computable General Equilibrium (CGE) analysis. This methodology is used to understand and simulate the (ex-ante) impact of taxes aimed at tourists, including accommodation taxes (see, for instance, Forsyth et al., 2014; Ponjan & Thirawat, 2016).

Most of the literature in this area focuses on the taxation of inbound tourists and does not capture the changes tourism policy has on domestic tourism markets (Li et al., 2011; Wickramasinghe & Naranpanawa, 2022). This focus is perfectly reasonable for destinations primarily relying on inbound tourism, such as small island destinations (Pratt, 2015). However, the focus on inbound tourism taxation can be seen as a limitation in cases with strong domestic demand for tourism activities.

The tourism demand response to the pandemic perfectly illustrates the differences and importance of including domestic tourism in the analysis, as Allan et al. (2022) describe. Arbulu et al. (2021) suggests that replacing the lost international tourism with domestic tourism through policy change effectively mitigates the pandemic's negative impacts. Hence, highlighting the importance of the disaggregation of domestic and international tourism within tourism analysis.

In past CGE studies, domestic tourism demand is often neglected and aggregated with total household consumption. In addition, the current tourism CGE literature does not recognize the different spending patterns between day trips and overnight trips, which is recognised in the partial equilibrium literature (Murillo et al., 2013). An obvious example of this is that overnight visitors spend money in the accommodation sector whereas day trippers do not. Hence, these studies do not capture the impacts of policies targeted at overnight visitors, such as an accommodation tax, on day visitor demand.

The present work investigates how the introduction of an accommodation tax impacts domestic and inbound spending using a tourism-extended CGE model for Scotland, which we call AMOSTRAVEL. A key objective of the study is to capture the economy-wide implications of how a policy targeted at overnight visitors, an accommodation tax, impacts domestic spending on day trip touristic visits. The general equilibrium approach allows us to not only understand the system-wide impacts of this charge, including both the effects of an increase in the price of overnight stays on day trips and whether the re-spending of revenue generated through the newly introduced tax can mitigate some of the negative economic impacts of the accommodation tax.

The remainder of the Chapter is structured as follows. Section 3.2 is a literature review. Section 3.3 discusses the methodology and describes the specific CGE model used for this analysis. Section 3.4 describes the simulation strategy. Results are presented in section 3.5. The sensitivity analysis follows this in section 3.6. Lastly, section 3.7 discusses the results and section 3.8 is the conclusion.

3.2 Literature Review

In recent years, there has been an exponential growth in worldwide tourism demand. As a result, tourism analysis, in general, has seen a mirrored increase (Dwyer et al., 2020). From an economic research perspective, various econometric, statistical and economic modelling techniques have been used to understand the economic implications of the tourism sector and policies aimed at the tourism sector. Specifically, the focus of much of this research has been on tourism taxes.

3.2.1 Techniques that are used to analyse tourism taxes

Within the literature, two main strands of economic analysis are used to understand the economic impacts of tourism taxes. Firstly, econometric methods can be characterised by time series analysis or forecasting methods—for example, Bonham et al. (1996) and Arguea & Hawkins (2015). In addition, multisectoral models like Input-Output (IO) and Computable General Equilibrium (CGE) models are used to understand the economy-wide and sectoral implications of changes in tourism policy.

The econometric literature analyses the economic impacts of tourism taxes, mostly in accommodation taxes, using time series data or panel analysis (Bonham et al., 1996; Arguea & Hawkins, 2015; Biagi et al., 2017). Bonham et al. (1996) use a time series model to investigate the impacts of Hawaii's 5% “hotel room tax”. They find no significant effects on tourism demand due to the tax. Unlike Bonham et al. (1996), Arguea

& Hawkins (2015) find that there are substantial negative impacts on tourism demand due to the hotel room tax in the short run but no significant impacts in the long run.

Biagi et al. (2017) use a synthetic control method to investigate the impacts of an accommodation tax. They find that introducing the tax reduces demand for domestic tourism and does not affect demand for international tourism. Significantly, in Biagi et al. (2017), there is a distinction between domestic and inbound tourism spending. This is a crucial distinction because domestic tourism spending sometimes contributes to a significant proportion of total tourism spending. In addition, there must be a recognition that the spending patterns of domestic tourists are different from inbound tourists.

The econometric techniques allow for specific advantages when understanding the implications of tourism taxes. Specifically, the ex-post data used within the econometric methods allow for the analysis of seasonal issues through past trends. However, given the partial equilibrium nature of the econometric techniques, the economy-wide impacts of the taxes cannot be assessed. These economy-wide impacts are essential when considering and analysing changes in fiscal policy.

3.2.2 CGE analysis of tourism taxes

Computable General Equilibrium (CGE) models have been used increasingly in assessing the economy-wide impacts of changes to tourism policy and changes to tourism demand as a result. CGE models can overcome some of the methodological constraints that exist in the econometric techniques mentioned in section 3.2.1.

CGE models have been used in a variety of applications in tourism. These applications range from the effects of climate change policy on tourism demand (Meng et al., 2022) to investigating the tourism demand implications of policies that enable investment in the tourism sector (Banerjee et al., 2020)[15].

Further to the literature cited in the previous sections, some studies have employed CGE models to assess the economy-wide impacts of tourism taxes (Gooroochurn & Sinclair,

[15] For a systematic literature review of applications of CGE models in tourism see Wickramasinghe & Naranpanawa (2022)

2005; Thirawat & Ponjan, 2016; Meng & Pham, 2017; Mahadevan et al., 2017). Gooroochurn and Sinclair (2005) assess the effectiveness of employing tourism taxes to create revenue to reach government targets. The tourism targets are compared to non-tourism taxes. They find that from the assessed taxes, the tourism taxes are the most effective in raising revenues for the Government because tourists are less responsive to price changes than residents. Despite this, Thirawat & Ponjan (2016) find that a half-percent tax reduction applied to international tourists has a small positive impact on international tourism spending consumption in the short run but no long-run impact. Meng & Pham (2017) find that introducing a $23 per tonne carbon tax causes "a significant decline in both inbound and domestic tourism demand" (Meng & Pham, 2017, p.506). This is an environmental tax that directly effects inbound tourists. Here there is a $23 charge per tonne of carbon emissions in all sectors apart from household and agricultural sectors. Hence this tax impacts inbound tourists only in this paper. This has significant environmental implications, which will be explored further in Chapter 4. Crucially, the revenue collected is used to stimulate domestic tourism demand.

The existing CGE literature assesses the economy-wide impacts of tourism policies, but we build on this in three distinct ways. Firstly, we include an analysis of tourism heterogeneity. Much of the research in the current literature captures tourism spending as non-resident spending. Our methodological developments allow us to capture both the impacts of tourism taxes on domestic and inbound tourists. This is important in the case of Scotland because a significant proportion of Scottish tourism spending is from domestic tourists.

Where there is an acknowledgement of domestic tourism in the current literature, there is a lack of heterogeneity within the methodologies of domestic tourism. We recognise that there is a difference in spending between domestic day visitors and domestic overnight visitors, as Murillo et al. (2013) suggest. Part of the overnight visitor's consumption bundle is in accommodation, whereas domestic visitors do not spend in accommodation, for example. This allows the analysis of the impacts of accommodation taxes on domestic overnight visitors and the indirect effects on domestic tourists due to the change.

Third, in the current literature, there is a lack of literature on the elasticities of substitution between domestic tourism categories because of the lack of heterogeneity within the methodologies of domestic tourism. Our analysis includes testing a range of elasticities of substitution, which exists in partial equilibrium analysis, and we use a general equilibrium framework to allow for this analysis. This allows for the substitution from one consumption bundle to another. For example, from day visitors to overnight visitors spending or from tourism to non-tourism spending. To our knowledge, this is the first tourism-CGE analysis that includes these partial-equilibrium characteristics in a CGE and hence provides methodological advancements.

3.3 Methodology

The model used in this analysis is based on the AMOS CGE framework developed by Lecca et al. (2013) and coined AMOS-TRAVEL. The AMOS framework is a bespoke CGE framework in which most of its applications have been in the analysis of shocks to the Scottish economy.

In the following sections, we describe the model and how it has been extended to capture tourism:

3.3.1 Consumption

Aggregate household consumption is modelled using a conventional consumption function.

$$C_t = Y_t - S_t - TAX_t \quad (3.1)$$

In equation 3.1, total consumption, C_t is equal to household income, Y_t, minus savings, S_t, and taxes[16], TAX_t. t is a subscript for time, typically one year since the data used is produced annually.

As in standard macroeconomic theory, household income comprises two components: capital income and labour income plus any transfers from the Government.

$$KY_t = dsr_{k,h} \sum_{j=1}^{J} KD_{j,t} \cdot rk_{j,t} \tag{3.2}$$

In equation 3.2, KY_t is capital income, $dsr_{k,h}$ is the share of capital income given to households. The share of capital income given to households is calibrated from the Social Accounting Matrix for Scotland (See section 0) which follows the structure in Connolly et al. (2021). j is a subscript for sectors, capital demand is $KD_{j,t}$ and capital rent from is represented as $rk_{j,t}$.

$$LY_t = dsr_{l,h} \sum_{j=1}^{J} LD_{j,t} \cdot W_t \tag{3.3}$$

In 3.3, labour income is LY_t, $dsr_{l,h}$ is the share of labour demand given to households, calibrated from the Social Accounting Matrix for Scotland. Labour demand is $LD_{j,t}$ and wages are represented as W_t.

One key characteristic of CGE models is the possibility of identifying consumer demand for a range of consumption goods. Given the focus on tourism spending in each period, household consumption is allocated to a tourism spending bundle and a non-tourism spending bundle. The part of household consumption allocated to tourism spending is referred to as domestic tourism, which is not usually considered in similar tourism CGE studies.

[16] This is an aggregate for all taxes in the economy.

Figure 3.1 Tourism-specific nested consumption

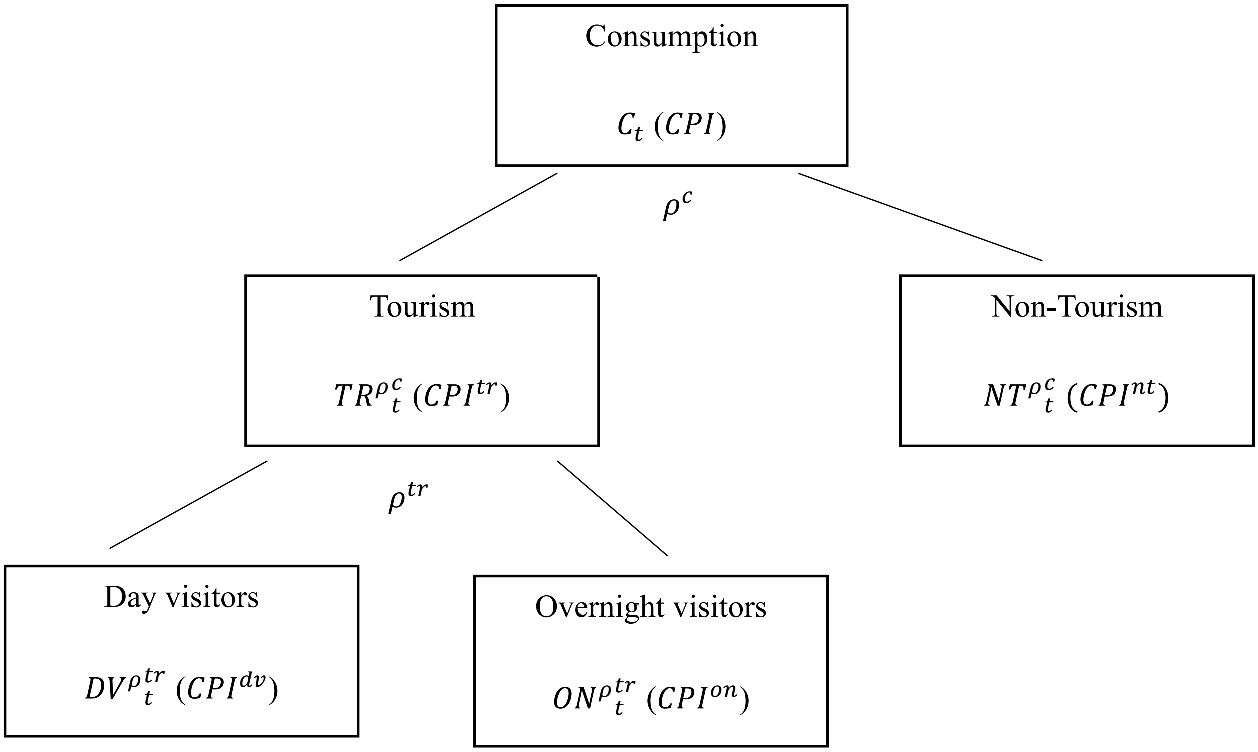


Figure 3.1 is a graphical representation which shows how consumption is broken down using constant elasticity of substitution functions. The CPI values inside each bracket are the price indexes associated with each consumption bundle; these are nested in the same way as demand (see appendix).

In the model, we allocate aggregate consumption using a constant elasticity of substitution function, where tourism and non-tourism are treated as imperfect substitutes. We also allocate tourism consumption, into day visitor spending and overnight visitor spending using another constant elasticity of substitution function, which is also treated as imperfect substitutes.

$$C_t = \gamma^c \left(\alpha^c \cdot TR_t^{\rho^c} + (1 - \alpha^c) \cdot NT_t^{\rho^c} \right)^{\frac{1}{\rho^c}} \qquad 3.4$$

As mentioned in the previous paragraph, consumption is a composite good comprising a tourism bundle and a non-tourism bundle. In equation 3.4, C_t is aggregate consumption; hence, the superscript c represents consumption. γ^c is the shift parameter for consumption

α^c is the share parameter which represents the share of tourism spending within aggregate consumption, ρ^c is the elasticity of substitution parameter[17] and measures the ease with which consumers can substitute tourism for non-tourism. $TR_t^{\rho^c}$ and $NT_t^{\rho^c}$ are tourism consumption and non-tourism consumption respectively.

$$TR_t = \gamma^{tr}\left(\alpha^{tr} \cdot DV_t^{\rho^{tr}} + (1-\alpha^{tr}) \cdot ON_t^{\rho^{tr}}\right)^{\frac{1}{\rho^{tr}}} \qquad 3.5$$

In the same way, tourism consumption is a composite between day visitors' spending and overnight spending by domestic tourists, as shown in Equation 3.5. tr represents tourism spending, γ^{tr} is the shift parameter for tourism spending for the CES function, α^{tr} is the share parameter, representing the share of day visitors spending within domestic tourism. $DV_t^{\rho^{tr}}$ and $ON_t^{\rho^{tr}}$ are day visitors spending and overnight visitors spending, respectively.

Further, day visitor and overnight visitor consumption is disaggregated to sectoral level using Leontief functions, where there is no substitution. I.e., if the price of accommodation increases, then the price of the whole bundle increases.

3.3.2 Inbound tourism spending

Each of the inbound tourism spending categories are consumption bundles, which are modelled as composite goods made up of a combination of domestically produced goods and services and imported goods and services as discussed in Armington (1969) and more recently in Hosoe et al. (2010). In addition to the domestic spending, we include three inbound spending categories in the model. The three categories that are included are as follows:

- Rest of the UK day visitors spending: Residents from the Rest of the UK who are visiting and spending less than 24 hours in Scotland. Hence, there is no spending on accommodation.
- Rest of the UK overnight spending: Residents from the Rest of the UK who are visiting Scotland and spending more than one day—hence, part of the consumption bundle is in accommodation.

[17] Given that there is a range of elasticities of substitution used in tourism analysis, we do sensitivity analysis which tests 900 different combinations of elasticities of substitution to mitigate any

- International overnight spending: Residents from outwith the UK who visit Scotland and spend on accommodation.

Demand for internal overnight spending is modelled using a conventional demand function.

$$ON_{i,t}^{int} = ON_{i,t=0}^{int} \cdot \left(\frac{PM_{i,t}}{CPI^{inton}}\right)^{\sigma_i^{tr}} \quad 3.6$$

In equation 3.6 $ON_{i,t}^{int}$ is international overnight spending, $PM_{i,t}$ is the price of imports and CPI^{inton} represents the price of the international tourism bundle. Here σ_i^{tr} is the elasticity that is assigned to the inbound tourism categories. The tax rate applied to overnight visitors is first fed through the CPI^{inton}.

$$ON_{i,t}^{ruk} = ON_{i,t=0}^{ruk} \cdot \left(\frac{PM_{i,t}}{CPI^{rukon}}\right)^{\sigma_i^{tr}} \quad 3.7$$

Like equation 3.6, equation 3.7 represents the demand for Rest of the UK overnight visitors, $ON_{i,t}^{ruk}$, using a conventional demand function where demand is dependent on the price of imports, the price of travelling to a similar destination, the price of its consumption bundle, the price of the overnight tourism bundle in Scotland, and the assigned elasticity value.

$$DV_{i,t}^{ruk} = DV_{i,t=0}^{ruk} \cdot \left(\frac{PM_{i,t}}{CPI^{dvruk}}\right)^{\sigma_i^{tr}} \quad 3.8$$

Equation 3.8 represents the Rest of the UK day visitor demand. The tax is not applied here as in this study; we consider a tax that is only applied to overnight visitors. As such, Rest of the UK Day visitor's demand depends on the price of imports (competitive destinations), the overall day visitor spending bundle price and the assigned elasticity value.

In all three equations the new demand for each of the inbound categories is determined by multiplying the initial value, the demand for each of the categories pre-shock multiplied by the price of imports divided by the CPI associated with each individual demand category. The reason why the price of imports is used in these equations is because the demand for inbound tourism depends on the price of the "tourism bundle" in other similar nations. The price of imports, in this case, is a proxy for that.

3.3.3 Government

Given that this Chapter analyses the economy-wide impacts of an accommodation tax which provides revenue to the government, the government segment of the model is crucial. Government income in AMOSTRAVEL comes from taxes, which include taxes on commodities, income taxes, and national insurance contributions and revenues from the tourism tax revenue ($TRTAX_t$).

$$\begin{aligned} GY_t = {} & (DSHR_{GOV,CAP} KY_t + \sum_i IBT_{i,t} + \sum_i IMT_{i,t} + HTAX_t + ETAX_t \\ & + CTAXTOT_t + \boldsymbol{TRTAX_t} + TINVT_t + +SAM_{IBT,TR^{ruk,ON}} \\ & + SAM_{IBT,TR^{ruk,DV}} + SAM_{IBT,TR^{INT,ON}} + SAM_{IBT,stock} \\ & + \sum_{fins} SAM_{IBT,fins} + \sum_i SUBSY_{i,t} + \sum_{fins} SAM_{gov,fins}) \cdot \epsilon_t \end{aligned} \quad 3.9$$

Crucially, though, when a government raises taxes or implements new taxes, it is important to isolate and identify the tax's effect on the wider economy. The model can use three different government budget equations, two of which are present in the general AMOS model (Lecca et al. (2013)).

$$GEXP_t = GEXP_{t=0} \quad 3.10$$

$$GEXP_t = GEXP_{t=0} + TRTAX_t \quad 3.11$$

$$GOVBAL_t = GY_t - GEXP_t \quad 3.12$$

Equation 3.10 is the case where Government spending, $GEXP_t$, is equal to the initial value of government expenditure, $GEXP_{t=0}$.[18] This is the value of government spending before any shock is simulated within the economy. This implies that if, for example, a new tax is imposed, government expenditures will not change from the initial value, which is calibrated directly from the Social Accounting Matrix.

The second government budget option is represented mathematically in equation 3.11. In this case, Government spending, $GEXP_t$, is equal to the initial value for Government spending, $GEXP_{t=0}$ plus the revenue that is collected from the tourism tax, $TRTAX_t$. This allows the understanding of the impact of the tourism tax revenue in isolation while keeping all other government incomes fixed i.e the impact of the tourism tax revenue on the wider economy.

Equation 3.12 is the government balanced budget equation. This allows alternative assumptions of government policy. When the assumption is that the Government's budget is balanced, when $GOVBAL_t = 0$, the government adjust its consumption or income by changing the taxes that are imposed within the economy so that the income received by government is equal to government expenditure.

The default setting in the model is that the government budget is endogenous, while government spending is exogenous given the fiscal relationship between the UK Government and the Scottish Government. This is the same across the standard AMOS model.

3.3.4 Production

The production component of the model is the same as the production structure that is used in the standard AMOS framework (Lecca et al., 2013). The model disaggregates gross outputs into intermediate inputs and value-added using a Leontief function by sectors choosing inputs for production. Hence, value-added and intermediate inputs cannot be substituted for each other. As in the standard model, value added is a composition of both capital and labour. When the demand for value added is increased

---

[18] $GEXP_{t=0} = \sum QG_{i,t=0}$ where $QG_{i,t}$ is the government consumption at the sectoral level

then so does the demand for capital and labour. Between the domestically produced inputs and the inputs that are produced throughout the rest of the world there is CES substitution imposed (Hosoe et al., 2010). Therefore, the intermediate inputs component of the production technology is such that it is a combination of domestic inputs and foreign inputs (Armington, 1969).

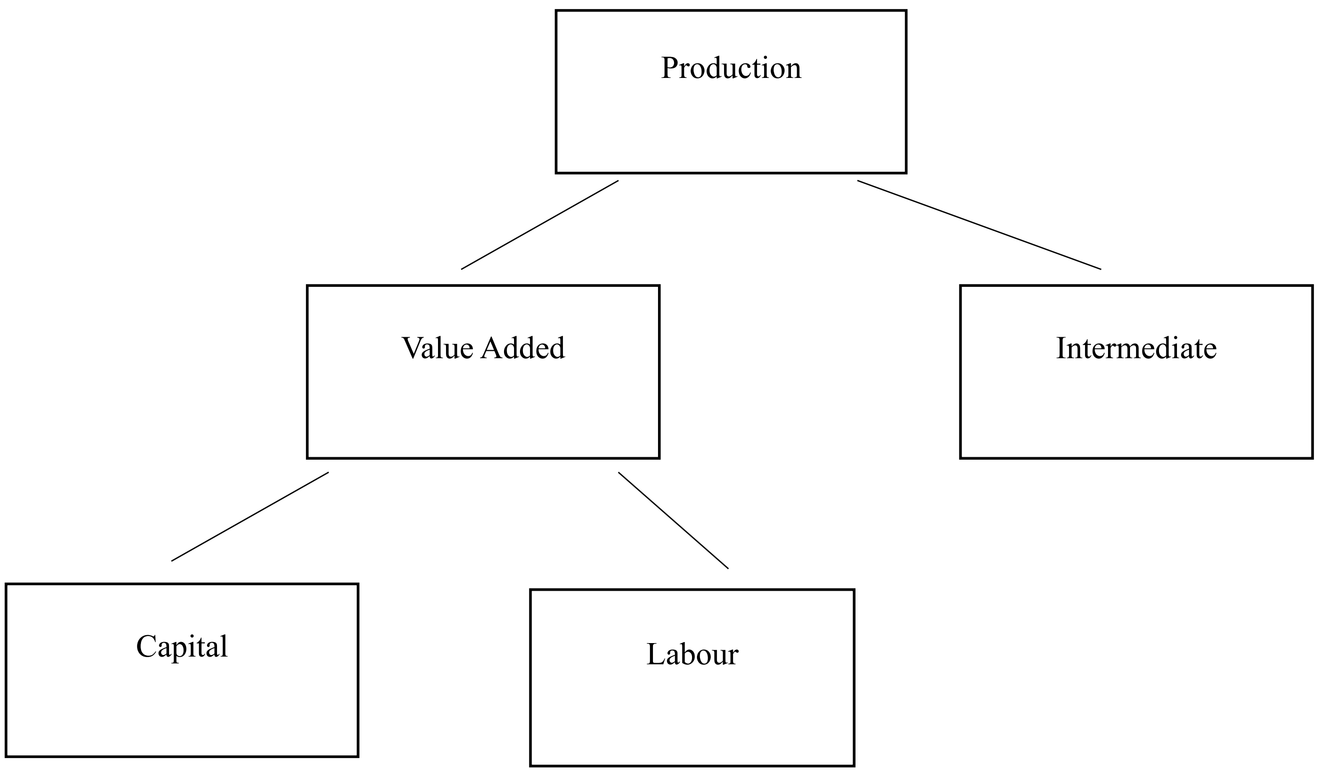


Figure 3.2 The structure of production in the AMOS (and AMOSTRAVEL) model

3.3.5 Investment

Investment decisions within the model are modelled based on Lecca et al. (2013). This follows (Hiyashi, 1982). This states that investments are made as a function of marginal q (where the firm is a price taker the marginal q is equal to average q). Investments are dependent on the value of the firms compared to the replacement cost of capital. A firm maximises profit as a function of profit $\pi_{t,}$ private investment I_t and adjustment costs.

$$Max \sum_{t=0} \frac{1}{(1+r)_t} (\pi_t - I_t(1 + g(x_t)) \qquad 3.13$$

3.3.6 Wages and labour market closures

The labour market regimes and labour supply are the same as they are in the standard AMOS framework. Hence the model used in this thesis incorporates three different market closures in terms of wage setting: Regional Bargaining, Wage Bargaining, and Fixed Real wage. The equations for each of the wage settings are shown in the equations below as in Lecca et al., (2013).

Regional bargaining:

$$\ln\left[\frac{w_t}{cpi_t}\right] = \omega - \varepsilon \ln(u_t) \qquad 3.14$$

Fixed real wage bargaining:

$$\frac{w_t}{cpi_t} = \frac{w_{t=0}}{cpi_{t=0}} \qquad 3.15$$

National bargaining:

$$w_t = w_{t=0} \qquad 3.16$$

Equations 3.14 to 3.16 are the three labour market closures, in the form of wage settings that are built into the model. Here w_t is the nominal wage, ε is the elasticity of wages that is related to the level of employment in the economy. The unemployment rate is denoted as u_t and the consumer price index is denoted as cpi_t.

The regional bargaining wage setting, in equation 3.14, in the labour market closure that is used for the simulations in this Chapter. The labour market is defined by the wage curve as in Blanchflower and Oswald (1994). Here the wage rate has a negative relationship to unemployment. When the unemployment rate increases, the real wage is decreased, and vice versa.

The fixed real wage closure in equation 3.15 assumes that the wage bargaining of the labour force remains constant because the wage rate and the consumer price index is fixed.

The national bargaining closure in equation 3.16 assumes that the nominal wage is fixed at the base year level. This represents a typical Keynesian closure. This means that the wage rate is fixed. This can be useful, especially in the Scottish case where the wage rate is set at the UK level and Scotland takes the wage rate that is set.

3.3.7 Elasticities

The elasticities of substitution are important in this model. Research on the elasticities associated with inbound tourism in Scotland has been conducted, and therefore, they are known and found in Chen et al. (2021). The demand elasticity is given for inbound tourism only and at the time of writing was the most up-to-date value for the Scottish inbound tourist categories specifically. Therefore, we apply this to the three inbound categories within the model.

However, the elasticity of substitution values for domestic tourism categories are unknown, and there has been no research conducted on this specifically for the Scottish case at the time of writing. To our knowledge there are also no specific elasticity of substitution values between tourism and non-tourism spending in Scotland, denoted

(ρ^c) and is shown in Figure 3.1. Calculations to quantify these elasticities should be considered in the future for the benefit of tourism research.

Further to this and to our knowledge, there is little research on the elasticity of substitution values between day visitor tourism spending and overnight spending. This elasticity is denoted ρ^{tr} also shown in Figure 3.1.

To account for this, we test a range of elasticity of substitution figures between 0.1 and 3.0 at 0.1 increments for both the elasticity of substitution values between day visitors and overnight visitors and tourism and non-tourism. This is an appropriate range to test how elasticities affect tourism demand as these are the most extreme cases of elasticity values used in the tourism literature where these values exist and in other industries too.

3.3.8 Data (Social Accounting Matrix)

The most common data sets used for CGE models are Social Accounting Matrices (SAM). Social Accounting Matrices allow for the estimation of coefficients and variables that are set outside of the model and that are endogenous to the model (Hosoe et al., 2010; Meng & Siriwardana, 2017). This process is referred to in the Computable General Equilibrium literature as the "calibration". CGE models are usually calibrated using a Social Accounting Matrix. Specifically, the Social Accounting Matrix (SAM) that is used for the CGE model in this Chapter is the Social Accounting Matrix for Scotland 2017 (Allan et al. 2021).

A Social Accounting Matrix can be defined as an extended version of input-output accounts, as described in Chapter 2. It is a matrix in which the rows and columns are the same, and the totals of the rows and columns are identical, i.e. it is symmetrical within an IxI framework. It allows the capture of interindustry consumption and between capital and labour, institutions which include households, corporations and government, the capital account and the external account. In addition, the SAM includes the disaggregation of the categories of inbound tourism spending. These accounts represent a snapshot of the economic interactions in a period of time, a year in this case, given that the national accounts used in constructing a social accounting matrix are produced annually.

The Social Accounting Matrix in this case build on the national accounts to capture the social data using a wide range of data such as the Government expenditure and Revenues Scotland (GERS) Scottish Government (2021), tourism expenditure data, which is produced annually by VisitScotland. This includes information on transfers between the institutions that are included in the model. The SAM also includes savings and investments. The Social Accounting Matrix that is used as the data set for the CGE model in this thesis follows the methodology that is used in Emonts-Holley & Ross (2014).

The SAM that is used in this Chapter is aggregated to 27 industries; the same disaggregation used in Chapter 2. The disaggregation and the relevant SIC codes are shown in Table *2.1* Sectoral aggregation, SIC codes and attribution, in the previous Chapter.

3.4 Simulation Strategy

We present three simulations to assess the economy-wide impacts of an accommodation tax using different government spending specifications within the model. In all simulations, we present a 5% accommodation, specifically a 5% increase in the price of accommodation[19].Given the current discussion around tourism taxes in Scotland, this type of analysis can help to guide some policy discussions. The accommodation tax is aimed exclusively at overnight visitors but will impact day visitor spending in the long run.

An example of how the tax is imposed on domestic overnight spending is shown in the equations below:

$$CPI_{t,d}^{on} = \sum_{i} \frac{PQ_{i,t} \cdot (1 + \tau_{acc}^{tr}) \cdot Q_{i,t=0,d}^{on}}{PQ_{i,t=0} \cdot Q_{i,,t=0,d}^{on}} \quad 3.17$$

$$ON_{t,d} = \left(\gamma^{\rho^{tr}} \cdot (1 - \alpha^{tr}) \cdot \frac{CPI_{t}^{tr}}{CPI_{t,d}^{on}}\right)^{\frac{1}{1-\rho^{tr}}} \cdot TR_{t,d} \quad 3.18$$

First the accommodation tax is applied to the specific CPI variable for domestic overnights $CPI_{t,d}^{on}$. The subscript d is domestic. The price of commodities, $PQ_{i,t}$, is multiplied by the change in the price of accommodation, the tax rate for accommodation τ_{acc}^{tr} multiplied by the initial demand for overnight, $Q_{i,t=0,d}^{on}$, divided by the initial price of the commodity multiplied by the demand for overnight night visits. This is then fed through in the domestic overnight spending equation, the CEs equation shown in equation 3.18.

The different specifications within the model are different ways that the revenues collected by the tourism tax can be recycled through the economy. Three simulations are

[19] This is a common tax rate for accommodation across Europe see: https://single-market-economy.ec.europa.eu/sectors/tourism/eu-funding-and-businesses/business-portal/financing-your-business/tourism-related-taxes-across-eu_en

presented: Simulation A, Simulation B and Simulation C, we will use "Sim" as a contraction for "Simulation" in this Chapter.

Sim A is where government expenditure is fixed. The tourism tax is collected by government but not re-spent throughout the economy. The aim of this simulation is to represent the economy-wide impacts of the revenue from the tax on accommodation while the revenue effects are not contributing further to the economy (this is the equivalent of the revenue of the tax being sent outside of the country).

Simulation B is where government expenditure is fixed and the revenues from the accommodation tax only are re-spent throughout the economy as a government demand injection. Other government spending is fixed, and the change in spending from the government is from the accommodation tax revenues in isolation. The results from this simulation will show the impacts of *only* the revenue collected from the accommodation tax being re-spent throughout the economy.

Simulation C is where government spending is endogenous to the model and dependent on revenues collected from all tax revenues, including the tax on accommodation. Here, the government has a balanced budget where Government revenues are equal to government expenditures.

As mentioned in the methodology section elasticities of substitution are an important factor in driving the level of change in tourism consumption. However, there is a lack of knowledge in calculating the specific elasticities needed for this model and for this research. Hence, we vary the values of elasticities of substitution for both tourism-related consumption decisions, tourism/ non-tourism, and day visitors/overnight from 0.1 to 3 in 0.1 increments. Therefore, the results are presented in intervals rather than points.

For the three simulations, we present the results in key economic variables in summary statistics form, given the 900 different elasticities of substitutions tested. Following this we present the sectoral results on GVA to reveal the impacts of implementing a tax on Accommodation and other tourism and non-tourism sectors. Finally, all results are presented in the long run.

3.5 Results

In this section of the Chapter, we present the results from our analysis of the 5% accommodation tax and its economy-wide impacts in terms of key macroeconomic variables and tourism spending aggregates. Given that there is no relevant information on the elasticity of substitution values between domestic tourism spending and domestic non-tourism spending and within domestic day visitors spending and domestic overnight spending we test every value from 0.1 to 3.0 in 0.1 increments for each of the elasticity values, hence 900 combinations of elasticities.

As referred to in the simulation strategy the way that we choose to present the results is in summary statistics form. In the aggregate results table for all simulations, there are four columns. On the left column, the "mean" values of each variable are presented. This is the average result of the 900 combinations of elasticity values that are tested. "Min" is the minimum value found for each variable and "Max" is the maximum value that is found through testing the 900 elasticity combinations. The right-hand side column, "SD", is the standard deviation, and this is important to present because it shows how much of an impact the elasticity of substitution values has on the result of each of the key variables. If the standard deviation is high, the result is dependent to a significant degree on the elasticity of substitution values. Conversely, if the value of the standard deviation is low, then it can be said that the combination of elasticities chosen has no effect on the result; the result does not change regardless of the combination of elasticity values assigned.

The sectoral impacts are analysed through the lens of the GVA impacts. The reason for this allows an intuitive representation of the varying impacts of the tourism and non-tourism sectors of the three simulations.

3.5.1 Macroeconomic results

3.5.1.1 Sim (Simulation) A

As a reminder, Sim A is the case where a 5% tax on accommodation is imposed by the government, and the revenue is collected, but the revenue is not re-spent throughout the economy, causing a contraction in the economy.

Table 3.1 Sim A - summary statistics of 5% accommodation tax with no government re-spending

Δ% from baseline	Mean	Min	Max	SD
GDP	-0.030	-0.031	-0.028	0.001
Consumer Price Index	0.062	0.062	0.063	0.000
Employment	-0.024	-0.025	-0.024	0.000
Nominal Gross wage	-0.066	-0.067	-0.065	0.000
Government spending	0.000	0.000	0.000	0.000
Government Revenue	0.056	0.055	0.057	0.001
Household spending	-0.091	-0.092	-0.090	0.001
Non-tourist spending	-0.079	-0.092	-0.067	0.007
Domestic Tourist Total	-0.360	-0.611	-0.110	0.150
Dom. Day spending	0.040	-0.585	0.669	0.270
Dom. Overnight visitors	-2.059	-3.875	-0.221	0.956
RUK day spending	0.023	0.022	0.023	0.000
RUK overnight spending	-1.764	-1.764	-1.763	0.000
International overnight	-1.764	-1.764	-1.763	0.000
Tourism tax revenue	80.861	80.677	81.049	0.097

Notes: GDP – Gross Domestic Product, Dom. – Domestic (Scottish)

Table 3.1 shows the aggregate impacts of a 5% tax on key economic variables and tourism spending aggregates. As in all aggregate tables, the results here are presented in terms of percentage changes from the baseline to achieve the post-equilibrium. In this case, the baseline is the initial equilibrium of the economy, pre-shock.

For Sim A the 5% accommodation tax has unanimous negative impacts on key economic variables. For the analysis of the key economic variables, we focus on the "mean" column. This is because of the fact that for all of the key economic variables, the combination of elasticity of substitution values used within the domestic tourism market consumption decisions does not affect the result. This is an interesting result and goes some way towards explaining why there is a lack of literature on the elasticity of substitution between domestic tourism consumption categories generally and none in the context of Scotland.

When referring to key economic variables, we mean GDP, Employment, and Nominal gross wage. The mean results of these are -0.030, -0.024, and -0.066, respectively. These are sensible results given the tax and the model specification. Firstly, because of the way the consumption bundles are set up across all categories, when the price of accommodation is increased, the price of the whole consumption bundle goes up because we are assuming that accommodation cannot be substituted with any other good or service throughout the economy.

As the price of the consumption bundles increases, this forces the general CPI in the economy up, as per Table 3.1 is 0.062. In addition, the tourism tax revenues are being collected by the government but not re-spent throughout the economy, i.e. household budgets are more constrained than they were a pre-accommodation tax. This is reflected in the household consumption result, -0.091. This mirrors the situation of these revenues being spent outside the country. Essentially, in this case, the economy is losing approximately £81 million and therefore, negative impacts on the macroeconomic variables are presented. In addition, Government revenues increase as a result of the collection of accommodation tax revenues, and Government spending does not change from the baseline.

Regarding the inbound tourism categories, the overnight categories are negatively impacted by the accommodation tax, both for the rest of the UK and international overnight visitors, at -1.764. The elasticity of substitution values does not impact this case because the substitution in this model is exclusively between domestic tourism consumption bundles. There is a potential future area of research to include substitution within the inbound tourism categories between RUK day visitors and RUK overnight visitors in this context. There is a small increase in the long-run RUK day visitor spending from the accommodation tax as accommodation is not included in this consumption bundle.

Scottish overnight visitors are the most negatively impacted by the accommodation tax of all the overnight categories -2.059 the mean impact, compared to 1.764 for the inbound overnight categories. This is because, as well as being impacted by the accommodation tax itself, the country's average income has decreased, constraining household budgets. Therefore, a greater reduction in demand for overnight tourism domestically compared to inbound categories. However, the severity of the reduction in sending is dependent on the combination of elasticity of substitution values. The evidence for this is that the “min”, the most negative, value is -3.875 compared to the “max” -0.221, resulting in a standard deviation of 0.956. The negative impact on overnight visitors can vary a lot depending on the value of elasticity of substitution and is therefore important for the result.

The accommodation tax can positively and negatively impact Scottish day visitors' spending depending on the combinations of elasticities of substitution chosen. In the case where there is a low elasticity of substitution between the tourism and non-tourism consumption bundle, i.e. where there is little substitution and high substitution between day visitors and overnight, then it can be the case that there is a positive impact on day visitors' spending, shown under the “max” column 0.669. The full table of results in shown in the Appendix in Table 7.2.

This is because in this case the consumer still consumes one of the tourism spending bundles despite the accommodation tax, because of the elasticity of substitution value that is assigned. Then once that decision has been made then the high level of substitutability between day visitors and overnight visitors means that the price increase in accommodation forces consumers away from consuming the overnight bundle to consuming the day visitors bundle.

Conversely, when there is a high level of substitution between consuming tourism and non-tourism and a low level of substitution between consuming day visitors and overnight then there is a negative impact on day visitors, shown in the “min” column, -0.585. On average however the accommodation tax causes an increase in Scottish day visitor spending, 0.040.

3.5.1.2 Sim (Simulation) B

The second simulation presented in this Chapter is the 5% accommodation tax, where the government collects revenue from the tourism tax. The government then re-spends the revenue from the tourism tax exclusively as a demand shock, while all other government spending remains fixed. This simulation keeps everything the same as Sim A apart from the re-spending of the tourism tax revenue. This simulation isolates the impact of the re-spending on the rest of the economy of the accommodation tax.

Table 3.2 Sim B - Summary statistics of 5% accommodation tax with re-spending of accommodation tax revenues as Government demand injection

Δ% from baseline	Mean	Min	Max	SD
GDP	-0.012	-0.013	-0.010	0.001
Consumer Price Index	0.080	0.080	0.081	0.000
Employment	-0.003	-0.003	-0.002	0.000
Nominal Gross wage	-0.007	-0.008	-0.006	0.000
Government spending	0.145	0.145	0.146	0.000
Government Revenue	0.095	0.094	0.096	0.001
Household spending	-0.054	-0.055	-0.054	0.001
Non-tourist spending	-0.042	-0.055	-0.029	0.007
Dom. Tourist Total	-0.327	-0.581	-0.073	0.152
Dom. Day spending	0.074	-0.555	0.706	0.271
Dom. Overnight spending	-2.027	-3.848	-0.184	0.957
RUK day tourist spending	0.002	0.002	0.003	0.000
RUK overnight spending	-1.784	-1.785	-1.784	0.000
International overnight	-1.784	-1.784	-1.784	0.000
Tourism tax revenue	80.861	80.677	81.049	0.097

Notes: GDP – Gross Domestic Product, Dom. – Domestic (Scottish)

Table 3.2 shows the economy-wide impacts of a 5% accommodation tax where only the revenues from the rest of the economy are re-spent as government demand injections.

When the revenues from the tax are collected and then re-spent, there is a very small, contractionary impact on the economy. This is evidenced through the changes in key macroeconomic variables like GDP, Employment and Nominal Gross wages, 0.012, 0.003, and 0.007, respectively. In comparison to Sim A the negative impact is much smaller. For example, the GDP impact in Sim A is around three times larger than Sim B, Sim A shown in Table 3.1 -0.030, and for Sim B it is -0.012.

The negative macroeconomic impacts are so small because the initial impact of the accommodation tax on employment, for example, is cancelled out. The government re-spends the revenue from the tourism tax as a government demand shock, which causes resource reallocation from tourism sectors to sectors where government spending is intensive, but there is no economy-wide impact.

In terms of the inbound overnight categories, both RUK overnight spending and International overnight spending, there is a 1.784 reduction in spending, slightly higher than the impact in case A. There is a tiny positive impact on RUK day visitors in this case.

For domestic consumption the story is different. Both tourism and non-tourism spending are negatively impacted in terms of the mean value that is presented in Sim B, -0.327 and -0.042 respectively. The range of domestic tourism spending reductions can range from -0.581 to -0.073 depending on the elasticity values that are assigned. However, in all cases the overall tourism spending reduction is largely driven by the fairly substantial decrease in overnight spending, the mean value being -2.027, the range being between -3.848, the most negative value and -0.184 the most positive value. The mean value is slightly less than it was in Sim A. This is due to the leakage impact from the Government demand injection.

3.5.1.3 Sim (Simulation) C

Table 3.3 Sim C - Summary statistics of an accommodation tax where government spending is endogenous to the model, where there is a balanced budget

	Mean	Min	Max	SD
GDP	-0.021	-0.023	-0.020	0.001
Consumer Price Index	0.071	0.070	0.071	0.000
Employment	-0.014	-0.014	-0.014	0.000
Nominal Gross wage	-0.038	-0.039	-0.037	0.001
Government spending	0.075	0.073	0.077	0.001
Government Revenue	0.075	0.073	0.077	0.001
Household spending	-0.074	-0.075	-0.073	0.001
Non-tourist spending	-0.061	-0.074	-0.049	0.008
Dom. Tourism Total	-0.344	-0.596	-0.092	0.150
Dom. Day spending	0.056	-0.570	0.686	0.270
Dom. Overnight visitors	-2.044	-3.862	-0.204	0.957
RUK day tourist spending	0.013	0.013	0.013	0.000
RUK overnight spending	-1.773	-1.774	-1.773	0.000
International overnight	-1.773	-1.774	-1.773	0.000
Tourism tax revenue	80.861	80.677	81.049	0.097

Notes: GDP – Gross Domestic Product

Table 3.3 shows the results for Case C, where government spending is endogenous to the model and is dependent on revenues that are collected from all tax revenues, including the accommodation tax. This means that when a new tax is imposed, like the accommodation tax, this will have an impact on other government revenues from other taxes in the short run and in the long run, government expenditures will readjust to account for the new revenue stream. This is why the change in government revenues is smaller in Sim C than in Sim B.

For Sim C, we will begin by analysing the key macroeconomic variables. Given that the elasticities have no real bearing on the macroeconomic variables for the analysis of Case C, we will focus exclusively on the mean results. Like in Sim A and Sim B, the accommodation tax negatively impacts GDP, employment and wages, -0.021, -0.014, and -0.038, respectively.

Since the government has a balanced budget in this setting, the government expenditures are increased by the same amount as the government revenues are increased, 0.074 and

0.074. In the model when the government has a balanced budget revenues minus expenditures must equal zero which they do, in this simulation.

The accommodation tax negatively impacts inbound overnight categories (-1.773), more than Sim A (-1.764) but less than Simulation B (-1.784), following the same trends as the macroeconomic variables. There is a small positive impact on RUK day tourist spending, 0.013.

In terms of domestic spending, there is a negative impact on both non-tourism spending and tourism spending, 0.061 and -0.344, respectively. This culminates in a total household spending reduction of -0.074, given that these components make up the household spending variable.

The mean impact of the Scottish day visitors' spending is positive (0.056), again due to the substitution towards day visitors' spending as a result of the tax. However, just like in Sim A and Sim B, there are combinations of elasticities that produce a negative result on day visitors spending. For Scottish Overnight visitors, there is a negative mean impact (2.044) caused by the accommodation tax; again, this is a more significant impact on domestic overnight tourists than inbound overnight tourists (-1.773). A comparison of Sim A, B and C are shown in the appendix in Table 7.1.

3.5.2 Sectoral results

In addition to the macroeconomic results, the sectoral results are key to showing which sectors are positively impacted by policy changes and which sectors are negatively impacted. It is important for Governments and policymakers to understand the sectoral changes that a given policy will induce. The sectoral changes in this Chapter are presented through the analysis of percentage changes in GVA.

Table 3.4 Percentage changes in GVA for each sector for Sim A, Sim B, and Sim C

	Sim A	Sim B	Sim C
Agriculture	-0.024	-0.053	-0.038
Mining	0.051	-0.007	0.023
Food, drink and tobacco	0.011	-0.027	-0.007
Textiles, leather, wood and paper	0.002	-0.031	-0.013
Chemicals	0.031	0.002	0.017
Rubber, plastic, cement and iron	0.039	-0.010	0.016
Computer, electrical and transport equipment	0.041	-0.003	0.020
Electricity, gas and water	0.003	0.001	0.002
Construction	0.002	-0.019	-0.008
Wholesale and retail	-0.056	-0.077	-0.066
Land Transport	-0.049	-0.077	-0.062
Water Transport	-0.075	-0.122	-0.098
Air Transport	-0.001	-0.033	-0.016
Post and Transport services	0.020	-0.003	0.009
Accommodation	-1.278	-1.295	-1.285
Food & Beverage services	-0.511	-0.520	-0.516
Telecommunications	-0.096	-0.104	-0.099
Computer and information services	0.058	0.000	0.031
Financial services	0.018	-0.012	0.004
Real estate	-0.057	-0.038	-0.048
Professional services	0.034	-0.010	0.013
Research and Development	0.036	-0.012	0.013
Public administration	0.010	0.179	0.090
Education	0.009	0.076	0.040
Health	0.004	0.177	0.086
Recreational Services	-0.102	-0.081	-0.092
Other	-0.054	-0.043	-0.049

Figure 3.3 Sectoral impacts of 5% accommodation tax in Sim A, Sim B, and Sim C

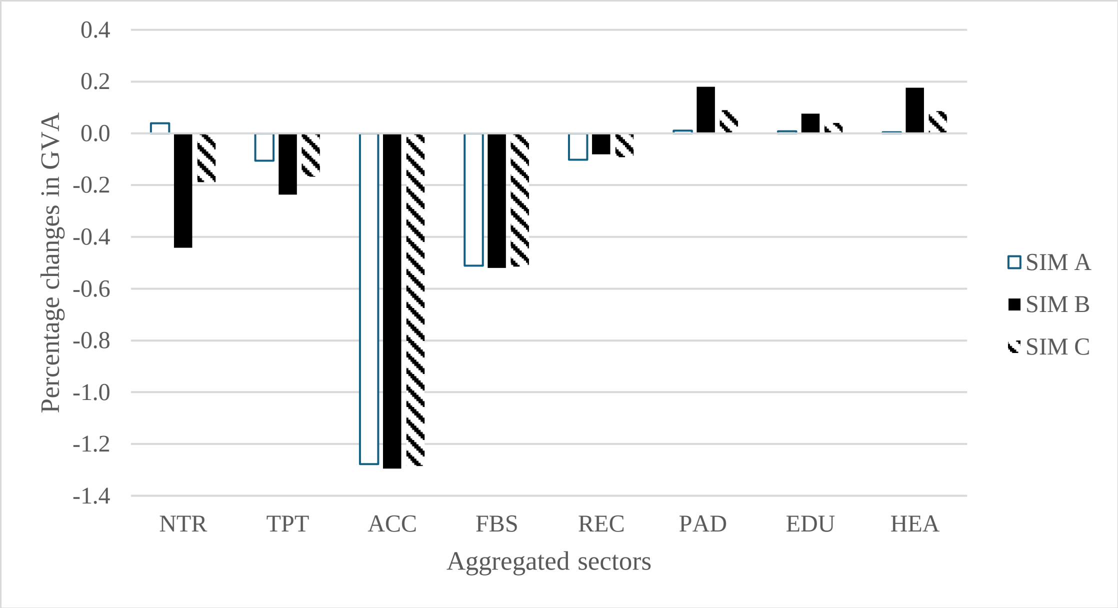


Table 3.4 and Figure 3.3 shows the sectoral impacts of the 5% accommodation tax through the lens of percentage changes in GVA. The results shown here are the mean sectoral changes of the 900 different combinations of elasticities used throughout this Chapter.

For presentation purposes, the 27 sectors that are presented in the SAM for this model have been aggregated in the figure above to 8 sectors. The sectoral aggregation in Figure 3.3 is as follows: Non-tourism (NTR) is all sectors that are non-tourism, non-public; Transport (TPT) is an aggregate of the land transport sector, water transport, Air transport; Accommodation (ACC); Food and Beverage services (FBS); Recreational services (REC). These are the sectors where tourism spending is intensive. In addition to this we present the sectors in which government spending is intensive: (PAD) Public Administration, Education (EDU) and Health (HEA). These are presented as these are the sectors that benefit from a government demand injection, the sectors where public spending is intensive.

The sectoral spending results are interesting when comparing the cases Sim A, Sim B and Sim C, given the differences in how government revenues are used in the model. In terms of the sectors where tourism spending is intensive such as the Accommodation sector (ACC), the Food and Beverage sector (FBS), and Recreational services (REC), there are similar negative impacts in all cases negative impacts in all cases. This is an expected result because this is the sector where the tax is implemented. It is also interesting to see that it is clear from the table that the Accommodation and the Food and Beverage services sector are complements and why these can be aggregated together in some analyses, for example, Manente & Zanetti (2010). In the same way that Simulation B was the extreme case in terms of the macroeconomic results here, it is also the most negative case when it comes to the GVA changes in sectors where tourism spending is intensive. For example, in the accommodation sector Sim B has a -1.295 change in GVA in the accommodation sector compared with Sim A -1.278, and Sim C -1.285. as shown in

Table 3.4.

The opposite is true for sectors where Government (public) spending is intensive, such as Health, Education and Public Administrations, where depending on the Government spending setting that is used, there are positive impacts in terms of GVA in these sectors. Given that Simulation B is the case where the accommodation tax only is re-spent throughout the economy as a government demand shock then the most positive changes in GVA are in Simulation B. In Health, there is a 0.177 change in case, compared to Simulation A, where there is a 0.004 change in GVA and Simulation C, where there is a 0.086 change. There is so little change in GVA in Sim A because there is no re-spending of revenues in Government demand shocks. Whereas in Sim B and Sim C, there is re-spending of revenues, and the revenues are being spent in sectors where Government spending is intensive.

3.6 Sensitivity Analysis

One of the sensitivity checks that we do in the model is to change the Consumer Price Index (CPI_t) variable used in the regional bargaining closure to the adjusted Consumer Price Index[20] (CPI_t^*). This allows us to understand if the way that the CPI is calculated has an important impact on the macroeconomic variables in the model and at the sectoral level.

The labour market closure chosen for the initial simulations detailed in the results section is the regional bargaining closure, where the wage that the labour force receives is directly related to its bargaining power.

In methodology, we describe the equation used for the regional bargaining labour market closure. I repeat the equation below for clarity.

$$\ln\left[\frac{w_t}{cpi_t}\right] = \omega - \varepsilon \ln(u_t) \qquad 3.19$$

[20] The difference in how these variables are calculated are discussed in the appendix

As an alternative to this, we use the adjusted CPI, which, as mentioned above, is defined in the appendix. The equation for the labour market closure that is used in this part of the sensitivity analysis is defined in the following equation:

$$\ln\left[\frac{w_t}{cpi_t^*}\right] = \omega - \varepsilon \ln(u_t) \qquad 3.20$$

By changing this equation, we can assess the impacts of the 5% accommodation tax in Sim A, Sim B and Sim C and which direction the results change as a result.

3.6.1 Key economic variables

Table 3.5 Comparison of the mean results of the sensitivity analysis with the initial below is a comparison between the mean results with the adjusted CPI for Sim A, Sim B, and Sim C and the initial mean results of Sim A, Sim B and Sim C. It also presents the mean results for key economic variables and tourism spending aggregates.

Table 3.5 Comparison of the mean results of the sensitivity analysis with the initial results

%Δ from baseline (long-run)	Sensitivity Analysis			Initial results		
	SIM A	SIM B	SIM C	SIM A	SIM B	SIM C
Gross Domestic Product	-0.058	-0.039	-0.052	-0.030	-0.012	-0.021
Consumer Price Index	0.073	0.091	0.078	0.062	0.080	0.071
Nominal Gross wage	-0.031	- 0.028	-0.014	-0.066	-0.007	-0.038
Government expenditure	0.000	0.160	0.065	0.000	0.145	0.075
Government Revenue	0.053	0.092	0.065	0.056	0.095	0.074
Household spending	-0.097	-0.060	-0.086	-0.091	-0.054	-0.074
Scottish non-tourist	-0.084	-0.047	-0.074	-0.079	-0.042	-0.061
Dom. Tourism Total	-0.368	-0.335	-0.358	-0.360	-0.327	-0.344
Scottish Day spending	0.033	0.066	0.043	0.040	0.074	0.056
Scottish Overnight	-2.067	-2.035	-2.058	-2.059	-2.027	-2.044
RUK day spending	0.011	-0.009	0.005	0.023	0.002	0.013
RUK overnight spending	-1.776	-1.796	-1.782	-1.764	-1.784	-1.773
International overnight	-1.776	-1.796	-1.782	-1.764	-1.784	-1.773
Tourism tax revenue	**80.838**	**80.844**	**80.841**	**80.861**	**80.861**	**80.861**

The results in the sensitivity analysis show that even with the change in the CPI variable in the regional bargaining equation, the 5% accommodation tax, the impacts on key macroeconomic variables like Gross Domestic Product, Nominal Gross wage and Household spending are negative in all cases.

As can be seen from Table 3.5 The results are more negative than the initial results. For example, if we look at the GDP results in Sim A for the sensitivity analysis compared to Sim A for the initial results, -0.058 and 0.030, respectively, this trend is repeated across all variables and all cases. The reason for this is that when you use the adjusted CPI, the changes in demand for the tourism categories will have more of a bearing on the macroeconomic variables because of the nested nature of the calculations (see appendix).

In terms of the macroeconomic variables, Sim A is the most negative case, and Sim B is the least negative case in the same order as it was in the initial results. Again, this is to be expected because, for Sim A, the revenues from the tourism tax are taken from the economy and are not re-spent throughout the economy. Effectively, the economy loses £80.84 million in this case. In Sim B, the tax revenues from the accommodation tax are only re-sent throughout the economy, so what is generated from the tourism tax is spent throughout the rest of the economy as a government demand injection.

For the tourism spending categories, the mean results are more negative in the sensitivity analysis in comparison to the initial results. For example, for the Scottish overnight visitors shown in Table 3.5, the accommodation tax has -2.067, -2.035, and -2.035, for Sim A, Sim B, and Sim C, respectively. For day visitors the results are less positive for Scottish day visitors and RUK day visitors in the sensitivity analysis compared to the initial results. If we look at Sim B for example then then for the Scottish day visitors spending, there is a 0.066 change, and for the RUK day visitors, there is a small negative change of -0.009. This change in the CPI has made, in this case, the RUK day visitors go from a small positive change in the initial result to a small negative change in the Sensitivity analysis results.

Overall, key macroeconomic variables and tourism spending variables have a (small) negative impact on each other. The results are broadly similar but more negative in the sensitivity analysis than in the initial findings. This shows that the extremity of the results depends on the combination of elasticities used and how the CPI variable is used.

3.6.2 Sectoral Results

Table 3.6 compares the sectoral mean GVA results to the sectoral mean GVA results. A general finding from the sectoral results using the adjusted CPI compared to the initial results is that the results are slightly more negative. There are some sectors in which there are small positive changes from the accommodation tax, like in the computer, electrical and transport equipment, or the mining sector (for cases A and C) from the initial results, but the change in CPI used makes the result a small negative result. On the whole, though, the change in CPI makes the results more negative, in all instances.

Table 3.6 Comparison of the mean results of the sensitivity analysis sectoral results with the initial results

Sectors	SIM A - CPI	SIM B - CPI	SIM C - CPI	Sim A	Sim B	Sim C
Agriculture	-0.05	-0.08	-0.06	-0.02	-0.05	-0.04
Mining	0.01	-0.05	-0.01	0.05	-0.01	0.02
Food, drink and tobacco	-0.02	-0.06	-0.03	0.01	-0.03	-0.01
Textiles, leather, wood and paper	-0.03	-0.07	-0.04	0.00	-0.03	-0.01
Chemicals	0.00	-0.03	-0.01	0.03	0.00	0.02
Rubber, plastic, cement and iron	0.00	-0.05	-0.01	0.04	-0.01	0.02
Computer, electrical and transport equipment	0.00	-0.04	-0.01	0.04	0.00	0.02
Electricity, gas and water	-0.02	-0.03	-0.02	0.00	0.00	0.00
Construction	-0.04	-0.06	-0.04	0.00	-0.02	-0.01
Wholesale and retail	-0.09	-0.11	-0.10	-0.06	-0.08	-0.07
Land Transport	-0.09	-0.12	-0.10	-0.05	-0.08	-0.06
Water Transport	-0.11	-0.16	-0.13	-0.08	-0.12	-0.10
Air Transport	-0.04	-0.07	-0.04	0.00	-0.03	-0.02
Post and Transport services	-0.02	-0.04	-0.03	0.02	0.00	0.01
Accommodation	-1.32	-1.34	-1.33	-1.28	-1.30	-1.29
Food & Beverage services	-0.54	-0.56	-0.55	-0.51	-0.52	-0.52
Telecommunications	-0.13	-0.14	-0.13	-0.10	-0.10	-0.10
Computer and information services	0.02	-0.04	0.00	0.06	0.00	0.03
Financial services	-0.01	-0.04	-0.02	0.02	-0.01	0.00
Real estate	-0.07	-0.06	-0.07	-0.06	-0.04	-0.05
Professional services	-0.01	-0.05	-0.02	0.03	-0.01	0.01
Research and Development	-0.01	-0.05	-0.02	0.04	-0.01	0.01
Public administration	0.00	0.17	0.05	0.01	0.18	0.09
Education	-0.02	0.05	0.00	0.01	0.08	0.04
Health	0.00	0.17	0.05	0.00	0.18	0.09
Recreational Services	-0.13	-0.11	-0.12	-0.10	-0.08	-0.09
Other	-0.08	-0.07	-0.08	-0.05	-0.04	-0.05

3.7 Discussion

Tourism spending is an important part of the Scottish economy, and it has been highlighted as a potential growth area for Scotland. With more tourism-related growth comes more negative externalities associated with tourism activity. One way in which governments can mitigate the externalities caused by tourism is to implement a tax tourism tax. Intuitively speaking a tourism tax does two things: (1) generally speaking it will reduce demand for tourism in some capacity, hence reducing the externalities that are associated with tourism and (2) the governments are able to raise revenues and then re-spend the revenues throughout the economy to help to mitigate some of the externalities, through spending on the public sectors, or to improve and maintain public infrastructure. An example of a type of tourism tax that could be implemented in Scotland is modelled in the Chapter in the form of a 5% accommodation tax.

The aim of this Chapter is to analyse the impacts of a hypothetical 5% accommodation tax using a tourism-specific CGE model coined AMOSTRAVEL. This tax is applied to all overnight visitors, both domestic and inbound. There are two main perspectives that the results are shown: (1) the economy-wide impacts of the tax and the change in GVA that the tax causes at the sectoral level and (2) the impacts on the tourism spending categories. In addition, we analyse how the way in which the government revenues are collected and re-spent impacts the economy-wide impacts and the results for each of the tourism spending categories.

The results show that the implementation of an accommodation tax has economic consequences that should be considered, especially in the context of Scotland. Across all of the simulations for the main results and the simulations in the sensitivity analysis, the accommodation tax has a negative impact on the key economic variables, such as GDP, nominal wage rate and household consumption. The extent of this negative impact is dependent on some variables. First, the way the Government re-spends the tourism tax revenues, and second, the combination of elasticities that are applied to each of the tourism spending categories.

The three scenarios use three different government budget equations. Specifically, the three government budget equations impact how the revenues raised by the accommodation tax are re-spent throughout the economy.

Across all simulations, Sim A, where the government spending is fixed and the revenues are collected and then not re-spent throughout the economy, is the most negative. The revenues are removed from the economy; it is the equivalent of the revenues being spent in another country.

Sim B is the simulation across all three where there is the smallest change from the baseline in terms of the macroeconomic results. Here, the revenues from the accommodation tax are collected by the Government, and those exact revenues are shifted throughout the economy as a government demand shock; the rest of the Government spending is fixed. This simulation isolated the impacts of the accommodation tax revenues alone.

At the sectoral level, in this case, you can see that as a result of the accommodation tax causes a reduction in demand in sectors where tourism spending is intensive, and then in the cases where the re-spending of the tourism tax revenue is a Government demand injection, the sectors where Government spending is intensive, the public sectors like education health and public administration, are positively impacted by the revenues of the accommodation tax, as they are spent as a government demand injection. However, there is less of a positive impact on the public sectors in terms of percentage changes in GVA from the baseline, than the negative impacts on the tourism sectors, which raises the question of the importance of employment and GVA in some sectors compared to others.

An important point that has been addressed in this Chapter is that the results are partially dependent on the combination of elasticities of substitution used when it comes to domestic tourism demand. In the model, because of the nested nature of which household consumption has been designed, the consumers have two choices to make. Whether to consume tourism or non-tourism, if they choose to consume tourism, then they have a choice between whether to consume the day visitors spending bundle or the overnight visitor spending bundle. These decisions are heavily dependent on the elasticity of substitution assigned.

One of the key objectives of this Chapter is to capture the economy-wide implications of how a policy targeted at overnight visitors impacts day visitors' spending. There is an understanding that there would be a negative impact on overnight visitors spending, but the impact on day visitors previous to the study is unclear in the case of Scotland. We see from the results that there are cases where the accommodation tax can actually have a positive impact on domestic day visitors' spending. This happens when the elasticity value between tourism and non-tourism is low, meaning that regardless of any price change, consumers will still choose to consume the tourism bundle AND, where the elasticity of substitution value between day visitors and overnight visitors is high, meaning that any price change to one of the bundles will have a significant impact on the substitution to the alternative bundle.

However, to our knowledge, no elasticity of substitution values has been found for these specific elasticities in Scotland. Hence, we overcome this issue by testing 900 different combinations of elasticities. This shows to which extent the elasticities impact each of the variables that we assess.

What do this novel methodology and these results mean in the context of the tourism industry and academic literature? First, the novel methodology developed and used in this Chapter allows the analysis of tourism heterogeneity. The AMOSTRAVEL model has been extended to analyse two types of tourism heterogeneity: inbound vs. domestic tourism spending and day visitors vs. overnight tourism spending. The model allows us to target taxes to specific tourism categories and collect revenues as a result from specific categories. To allow the analysis of this tourism heterogeneity we include five tourism spending categories and a non-tourism spending category: two domestic categories, day visitors and overnight visitors and three inbound categories, RUK day visitors and overnight visitors and International overnight visitors.

In this context, this allows us to understand the different ways in which taxes aimed at tourists impact inbound and domestic tourists differently. This highlights the importance of including an analysis of domestic tourism spending as well as inbound spending, as highlighted by Biagi et al. (2017). In general, the domestic tourism overnight categories are more negatively impacted by the accommodation tax than the inbound overnight tourism categories. This is in line with Gooroochurn & Sinclair (2005) finding that inbound tourists are less responsive to price changes than domestic tourists. In addition to this, domestic tourists in the model context are also impacted by the general price increase caused by a new tax being implemented. Household spending and income are forced down, and then so is the demand for overnight tourism. In the case of inbound tourists in the model context, they are not impacted by the wage rate and employment decreases by the accommodation tax and are, therefore, less impacted by the accommodation tax.

Another objective of this Chapter was to understand and include the difference in spending between day visitors spending and overnight visitors spending, like Murillo et al. (2013). They recognise that day visitors and overnight visitors consume different things. For example, a significant proportion of overnight visitors spend on accommodation, whereas day visitors do not. We include the disaggregation between day visitors and overnight and our results show that in the case of accommodation taxes, there are significant differences in how they are affected, and therefore including this level of heterogeneity is useful for the analysis of results but also could be useful for policymakers to consider in the future in shaping changes to Scottish tourism policy.

As with all models, there are limitations – some of which can be addressed by future research. Firstly, there is a lack of knowledge or literature on the elasticity values that are required in this model for substitution between the tourism consumption bundles. Future research could work toward identifying what these values are. There is research that includes elasticity values for inbound tourism in Scotland (Chen et al., 2022) that have been included in the model but none for domestic tourism.

Another limitation in the model is the assumption that the rest of the UK overnight spending category and the International overnight spending category are the same, i.e., the inbound overnight categories have identical spending patterns. Understanding the differences between the two types of tourists could improve this. However, this would be extremely challenging given the data collection that would be required to carry out such work.

In this Chapter we have incorporated substitution between the domestic consumption categories. Another potential extension to the model would be to incorporate the same level of substitution between RUK day visitors and RUK overnight visitors, depending on some value of elasticity of substitution, for example. This could be modelled in the same way as the substitution between the domestic spending categories.

Lastly, the national accounts data used in this framework include accommodation aggregated, which comprises various different types of accommodation, some more expensive than others. If there was a more in-detail aggregation of the accommodation sector, then when a tax is applied, it might be that a tourist shifts to a cheaper form of accommodation, from a five-star hotel to a three-star hotel, for example. Or from an "Air BnB" to camping. Again, there is potential here for future work to be developed to build on the model created and developed for the purposes of this chapter.

3.7.1 Policy implications

It is important that there is a recognition that the that this accommodation tax has different policy implications for different end users such as the Government, tourism bodies, tourism businesses and tourists themselves.

For Governments, an accommodation tax provides an opportunity to expand the tax base without raising the tax burden on residents; there is more income generated by the Government, which can be spent on essential public resources. However, in all cases presented the accommodation tax causes an economic contraction. In a context where there is "overtourism", some Governments will be willing to accept a small contraction if it means that the strain on public services and other resources decreases through a reduction in tourism demand. In the case where the tourist demand is not affected by the tax, then there is a contribution to the public budget to help internalise some of the negative externalities associated with tourism activity.

Tourism bodies and businesses will likely be averse to any policies that will reduce tourism demand. This is due to the fact that there could be jobs lost and, therefore, a reduction in the "attractiveness" of the specific destinations for tourists. However, if the Government re-spent the tax revenue generated on improving tourism infrastructure and investment into tourism (Adedoyin et al., 2023) then taxes such as this could be positive for tourism bodies.

3.8 Conclusion

To conclude, in this Chapter, we have attempted to examine the impacts of tourism tax on a small regional economy using a tourism-extended computable general equilibrium (CGE) model. To do this, we have extended the AMOS CGE framework to develop AMOSTRAVEL by incorporating tourism heterogeneity, amongst other things. Another key characteristic of this framework is that it allows substitution between domestic consumption categories to reflect price changes in consumption bundles as a result of a policy change. In addition, this framework allows us to assess a wide range of tourism-specific policies. In this chapter, we assess a hypothetical 5% accommodation tax. For example, when a tax is targeted at overnight visitors, tourists can switch between consuming the overnight "bundle" to consuming the day visitor "bundle" or switch from consuming tourism to non-tourism.

These extensions and special treatment of tourism consumption allow us to contribute to the literature in three ways which were set out in the introduction. To recap, the first contribution was to allow us to analyse impacts on inbound vs domestic tourist spending from changes in policy. The second contribution was to include a disaggregation between day visitors' spending and overnight spending and recognise the impact of a tax that is targeted at overnight visitors on day visitors, too. Third, given the fact that there is limited evidence on the elasticity of substitution values between the domestic tourism consumption bundles, we add a methodology that can, in some part, overcome these challenges by testing a wide variety of combinations of elasticities of substitution.

The results from the framework show that in all government budget equations used, there is a difference in impact between the impact on domestic visitors' change in demand and in the inbound visitors' change in demand as a result of the implementation of the tax. Hence, highlighting the value of including this level of heterogeneity within the framework. In general, domestic (overnight) tourists are more impacted by the tax on accommodation than inbound tourists, which is in line with Biagi et al. (2017). In addition, Gooroochurn & Sinclair (2005) claim that inbound tourists are less responsive to price changes, they are more inelastic, than domestic tourists. The results shown in the analysis are also in line with that.

Another key objective of the study is to capture the economy-wide implications of how a policy targeted at overnight visitors can affect day visitors, similar to what Murillo et al. (2013) investigate in their research. Hence, we introduce a partial equilibrium characteristic into a general equilibrium framework. The AMOSTRAVEL framework allows us to analyse the results of a policy shock at the economy-wide level, the sectoral level and at the tourism demand level. We incorporate substitution possibilities and disaggregation into household consumption, tourism spending and non-tourism spending. We aggregate further to include domestic day visitors spending vs domestic overnight spending. We find that there is an impact on day visitors' spending as a result of the accommodation tax in all cases. Where this impact is positive or negative depends on the combination of elasticities that are used.

The third contribution is that we introduce an addition to the methodology to overcome the lack of data on the specific elasticities that are required for this analysis. We test 900 different combinations of elasticities and then present the summary statistics of the results in the form of mean, min, max and standard deviation. We find that in terms of the key macroeconomic variables, the combinations of elasticities have no impact. On the other hand, when it comes to the domestic consumption categories, the combinations of elasticities that are applied have a significant impact on the result.

In addition, we include a sensitivity check, which used an adjusted CPI. We find that changing the way that the Consumer Price Index is modelled from standard to adjusted makes the results at the macro level and the sectoral level slightly more negative, but the impact of changing this is very small.

Finally, overall, we find that an accommodation tax would, in any case, cause a contraction in the economy. However, implementing a tax such as this would overall reduce demand for tourism and hence reduce the externalities caused by tourism consumption. By implementing the tax, the tourists, in some way, can contribute to the public budget and support improved infrastructure and investment in public services. The results from this analysis could be used in policymaking for the tourism industry in Scotland in the future. Given tourism's importance to the Scottish economy, policymakers can find a balance between tourism growth but also reducing externalities caused by tourism activity.

4 Chapter 4 – Reducing emissions through fiscal interventions and the impacts on tourism spending and the economy

4.1 Introduction

There has recently been growing concern about the environmental consequences of tourism. While many governments identify the sector's economic importance, there is increasing concern about its environmental impact. As well as a significant economic industry across the world, tourism accounted for around eight per cent of global GHG emissions, including transport and aviation emissions (WTTC, 2023)[21]. A significant negative externality, therefore, of tourism activity is the associated environmental consequences, such as those from the operation of tourism businesses and the travel choices of tourists. One way that governments can intervene to reduce environmental damage is by introducing changes in policy and legislation, such as taxes. A classic Pigouvian perspective on externalities would suggest that introducing a price for a negative externality would cause it to become internalised, and so align private (business/individual) actions with societal optimum.

Government interventions to mitigate the environmental costs of tourism activities through tourism-targeted fiscal policies, or "tourism taxes" are widely studied in the economics literature (Adedoyin et al., 2023; Buckley, 2011; Do Valle et al., 2012; Dwyer et al., 2021). There are a variety of taxes that can be referred to as tourism taxes due to the spending made by tourists (Gooroochurn & Sinclair, 2005), from Casino taxes to visitor attraction taxes. These taxes can be levied on businesses or consumers. Tourism taxes reduce the emissions associated with tourism in various ways (Meng et al., 2021). First, and most obviously, by increasing the price of tourism, they would reduce demand for tourism and, therefore, reduce the level of emissions associated with tourist activity. Second, increasing the price of specific elements within consumption could encourage a substitution of consumption away from emissions-intensive tourism activities to less

[21] In this report it also outlines that there is an aim to cut tourism emissions by half in the next decade

intensive consumption. An (unrecycled) increase in tax would be expected to raise prices, lead to lower demand, and therefore have negative economic impacts overall. The emissions consequences of such a fiscal intervention are, however, unclear.

One way to assess the whole economy and environmental impacts of fiscal policies on tourism demand is to use Computable General Equilibrium (CGE) models. CGE models are a useful tool in the assessment of fiscal policies because of the strong economic theory fundamental to CGE models (De Quatrebarbes et al., 2016) and that they take into account the relationships and interactions between all agents in the economy, including government (Lemelin & Suvard, 2022). Furthermore, CGE models can be highly disaggregated depending on the research question in terms of production – i.e., the number of different sectors included – and/or consumption – i.e., the number of different categories of consumption, including tourism categories – (Hosoe et al., 2010). Lastly, the dataset that the CGE models use can be extended depending on the research question, including emissions data (e.g., Bergman, 2005; Li et al., 2021).

Despite this, "economic assessments of environmental and climate change impacts related to the tourism industry appear underrepresented in the CGE literature" (Wickramasinghe & Naranpanawa, 2023, p.1660). From the limited CGE literature to date on fiscal interventions aimed at tourism, Gago et al. (2009) find that both specific (a 10% tax on accommodation) and general (an increase in VAT) tourism taxes have positive impacts on government revenues without harming the macroeconomy. They argue that of the two taxes modelled, the indirect VAT tax "may be a more feasible, equitable and neutral way to obtain tax revenues from tourism activities" (Gago et al., 2009, p.381). A similar result occurred in Forsyth et al. (2013), who found that an increase in "Passenger Movement Charge" – a departure tax paid by travellers leaving Australia – produces a contraction in the tourism industry but a positive impact on the Australian economy as a whole. In this segment of the literature, the authors focus on the economic impact of the changes in policy and mention that there would be an environmental impact but no quantification of what the environmental impact is.

There is also a small literature on the use of CGE modelling for the environmental impact[22] of policies targeted at tourism consumption (e.g., Alvarez-Albelo et al. (2017), and Zhang & Zhang (2019)). These papers focus on the emissions from the activity of international tourists and find that these environmental taxes reduce tourism activity more than in other sectors, despite not being specifically targeted at tourists. In addition, these papers examine the direct emissions from industrial activity.

This Chapter aims to explore the following question: what are the economic and emissions impacts of alternative fiscal interventions aimed at tourism consumption in Scotland? Specifically, we develop an environmental extension of the AMOSTRAVEL CGE model from Chapter 3, to explore the economy-wide and environmental impacts of simulations of three hypothetical taxes. The AMOSTRAVEL model has a detailed disaggregation of tourism demand in Scotland. The environmental impacts are captured through an emissions extension in which we add emissions from industries and consumption so that we can trace the emissions impact on tourism spending by category under each policy. In each simulation, we do not recycle the revenue raised by the new hypothetical tax and hold revenues from the tax constant so that the economic and emissions impacts can be compared.

Specifically, we examine the economic and emissions consequences of three hypothetical taxes:

- an accommodation tax – levied on overnight tourism (and so directly impacts the consumption of domestic and inbound visitors staying overnight).
- a land transport tax – is applied to domestic tourists, tourists from the rest of the UK and also non-tourist consumption.
- a fuel sales tax – all tourist consumption categories including tourist and non-tourists.

[22] Environmental policy is "primarily concerned with how to govern the relationship between humans and the natural environment in a mutually beneficially environment" (Benson & Jordan, 2015, p. 116)

We make two contributions to the existing literature. First, we extend the CGE literature on the economic and environmental impacts of taxes which impact on tourism directly or indirectly, examining the case of a small open regional economy, Scotland. There are relatively few examples of environmentally extended CGE models which have been used to analyse how environmental taxes impact tourism demand and emissions (i.e. Dwyer et al., 2013; Meng & Pham, 2017; Meng et al., 2019).

Second, in the AMOSTRAVEL model – with a detailed breakdown of different categories of tourism consumption – we develop a novel environmental extension in which we widen the scope of emissions typically considered in tourism-focused CGE models, including both industrial emissions (those from the use of energy in production of goods and services by industries) as well as consumption emissions, specifically those from energy use in private transport consumption. This lets us include and see the impact of policies directed at tourism not only from the changing emissions from industries use of energy but also from changes in tourism and non-tourism consumption of fuel. This novelty allows us to explore in greater detail policies which impact on different categories of tourism and move beyond a focus of many of the papers in this area to date on international tourism. Domestic tourism is an extremely important and significant proportion tourism demand and so, in turn, will contribute a significant proportion of the emissions associated with tourism activity. We therefore generate a wider view on the changes in emissions coming from the introduction of tourism taxes.

Our illustration of the economic and emissions consequences of fiscal interventions aimed at tourism uses the case of Scotland, which is relevant for a number of reasons. A concern for protecting the environment has led the tourism industry and policymakers to focus on promoting sustainable tourism (Scotland Outlook 2030, 2023). This also addresses tourists concern and eagerness to engage in responsible tourism. In addition, Scotland has set itself an ambition to be net zero by 2045, requiring targeted interventions to reduce emissions in the country.

Furthermore, new legislation going through the Scottish Parliament is giving local authorities the power to raise tax locally from tourism consumption partially in response to the negative environmental consequences of tourism consumption in popular areas of the country and concerns about "overtourism".

The remainder of this Chapter is structured as follows. Section 4.2 is a literature review. Section 4.3 discusses the methodology and describes the specific environmental extensions of the AMOSTRAVEL model. Section 4.4 presents the simulation strategy, and how we introduce the disturbances to our CGE model, while economic and environmental results are presented in Section 4.5. A sensitivity analysis in Section 4.6 shows how our economic and environmental results are affected by alternative values of key elasticities. Lastly, Section 4.7 discusses the results and provides the conclusion.

4.2 Literature review

In recent years, a growing number of studies have analysed the relationship between tourism and the environment, given government, policymakers, and tourists' interest in reducing emissions and undertaking less environmentally damaging tourism behaviours.

There has been a variety of research that has assessed the impacts of environmental policies, mainly aviation taxes and carbon taxes (Usman & Alola, 2023), on tourism demand using a variety of different econometric techniques. For example, Alvarez-Albelo et al. (2017) develop a simple static model to represent the transfer of tourism spending from the origin country to the destination country. Seetaram et al. (2014) developed an autoregressive lag model to understand the income, price, and tax elasticities in relation to the UK Air Passenger Duty, which is a tax levied on all outbound tourists from the UK. Seetaram et al. (2018) use a contingent valuation method to understand passengers' changes in willingness to pay given the same UK Air Passenger Duty. A general finding from the literature on aviation taxes is that whilst aviation taxes present an opportunity to increase government revenue through taxation, they have little impact on tourism demand and, therefore, emissions associated with tourism.

In addition, a variety of techniques have been used to investigate the impacts of levying a carbon tax on tourism demand, for example, by Palmer & Riera (2003) & Zhang & Zhang (2019). These taxes are applied across all consumption categories in the respective economies, and they find that carbon taxes encourage emissions reductions, and the most significant reductions are in tourism industries. It is important to note that whilst the carbon tax did initiate reductions in emissions, it also caused a reduction in demand for tourism industries and, therefore, harmed the tourism sector.

CGE models have been used to investigate the impacts of taxes on tourism (Forsyth et al., 2019; Gago et al., 2009; Gooroochurn & Sinclair, 2005; Ihalanayake, 2013; Thirawat & Ponjan, 2016) and much smaller literature that uses environmentally extended CGE models for their analysis (Dwyer et al., 2013; Meng & Pham, 2017; Meng et al., 2021). Gago et al. (2009) find that general tourist taxes reduce externalities from tourist activity by increasing government revenues without hampering the wider economy's performance. Ihalanayake (2013) found that the implementation of a tourism tax, specifically an increase in Passenger Movement Charge levied on international tourists, causes a contraction in international tourism demand but has a positive impact on the economy as a whole. Gooroochurn & Sinclair (2005) use a CGE model to assess a variety of taxes that impact tourists and suggest that taxing international tourism is a potential solution to raising government revenues whilst shifting the tax burden to non-residents. All of these papers show that through the implementation of tourism taxes, there is an implied reduction in externalities that are associated with tourism activity. However, the environmental impact is not quantified. In addition, these papers are primarily focused on the taxation of international tourists and do not account for the impacts of tourism taxes on domestic tourists.

There is a much smaller literature on fiscal policies that has used environmentally extended CGE models (Dwyer et al., 2013; Meng et Pham, 2017; Meng et al., 2021). These papers are focused on the changes in tourism demand as a result of a change in environmental policy to the economy and are not specifically focused on the changes in tourism policy. The environmental extensions to these CGE models allow the quantification of the emissions impacts of these policies. Dwyer et al. (2013) use a model that includes "a detailed accounting GHG component" (Dwyer et al., 2013, p.116), stating that this addition is rare in CGE models, and calculating emissions using direct emission by industry. Meng & Pham (2017) use an environmentally extended Social Accounting Matrix (SAM), which includes three different types of emissions: stationary emissions, activity emissions and consumption emissions. They extend the SAM to capture the emissions impact, whereas we extend the CGE model to capture emissions in line with tourism demand disaggregation, substitution impacts and macroeconomic effects. In their extension, there is an aggregate household, so domestic tourism emissions cannot be disaggregated from non-tourism emissions.

4.3 Model and Data

For this analysis, two key components of the model allow for the analysis of the environmental and economic impact of a range of tourism taxes. First, the detailed AMOSTRAVEL tourism CGE model allows for the economic analysis of a variety of policies, which is described in Chapter 3. The AMOSTRAVEL framework includes extensive details on tourism spending categories and is able to capture the analysis of a wide variety of disturbances, including changes in demand and fiscal policies, capturing the impacts on different tourism categories, sectors of the economy and the economy as a whole.

To recap the AMOSTRAVEL includes tourism heterogeneity in two ways. It allows the analysis of tourism disturbances on inbound and domestic categories by the inclusion of three inbound categories: RUK day visitors, RUK overnight, and international overnight, and two domestic categories: day visitors and overnight visitors.

Within the domestic tourism spending categories, we incorporate substitution at two levels (see Figure 3.1 Tourism-specific nested consumption). First, there is incorporated substitution between tourism and non-tourism bundles. In the model, households make decisions based on which bundle maximises their utility. This decision is based on the elasticity of substitution values assigned. If the household chooses the tourism consumption bundle, then it has a choice whether to consume the day visitors bundle or the overnight visitors' bundle. As we saw in Chapter 3, if an accommodation tax is implemented, there is a substitution between overnight visitors and day visitors. Each of the categories are modelled in bundles such that when the price of a good is increased the price of the whole bundle is increased i.e. there is no sectoral substitution.

In addition, and crucial to this Chapter, is the environmental extension of the model, which allows us to capture and quantify the existing relationships between industries and consumption categories with energy use and emissions. There are two types of emissions incorporated in this environmental extension: emissions from fuel use in sectors, which we term "industrial emissions", and emissions from fuel use in private consumption, which we term "consumption emissions". Note that these are equivalent to the terms used here in industrial emissions used in Meng & Pham (2017) as activity emissions. Second, we also include the consumption of direct fuel use by each tourism category, referred to by Meng et al. (2017) as consumption emissions. We add to this by capturing the changes in emissions from households (tourism and non-tourism) and for both day visitors and overnight for domestic and inbound tourism. Meng & Pham. (2017) capture stationary emissions, which are defined as combustion by any type of fuel, including kerosene from airplanes. We do not capture emissions from air travel.

Here, we use the AMOSTRAVEL described in Chapter 3; therefore, the Social Accounting Matrix data comes from the Scottish national accounts in 2017 (Scottish Government, 2020). We use emissions data from 2019 because this reflects the current emissions in the economy more closely than the emissions generated in the years of the pandemic. The reason for the disparity in years is that we keep the economic dataset consistent for all chapters so that the results can be easily compared and the current emissions data is relevant to the current emissions.

4.3.1 Industrial emissions

The first component of emissions we include are those which come from fuel use in sectors. The Scottish Government produce emissions on an inventory basis – aligned with IPCC inventory categories and in CO2 equivalents, in 2019 these were shown as 47.8

$MtCO_2e$[23] (Scottish Government, 2023) of which 33.5 MTC02 are directly from Carbon dioxide. These include air travel emissions and emissions from methane in agriculture. In our methodology we capture 17.3 MTCO2 from industrial emissions and 5.3 MTCO2 from emissions from private fuel use which captures a significant amount of the CO2 reported in the Scottish emissions inventories.

However, the Scottish emissions inventories data cannot be used directly for our purposes as these do not map directly to sectors as presented in the aggregation of the economic accounts, as alluded to above.

To overcome this challenge, we start by using environmental data from the UK Government and the UK Environmental Accounts published by the ONS (ONS, 2019). This data is disaggregated into emissions by economic sector for 104 sectors. In addition, the emissions from six different fuels are presented: Coal, Natural Gas, Petrol, Diesel, Fuel Oil and Gas Oil. Of course, this emissions data is for the UK rather than Scotland, so we need to adjust it for our purposes.

First, we map 104 UK sectors to the 98 sectors of the Scottish IO table, so that the aggregation of energy by industry matches with the Scottish sectors as given in the Scottish economic accounts. Second, we calculate energy use-output coefficients for each UK sector, using output figures from the 2019 UK Input-Output table (ONS, 2023). These show the amount of energy by fuel type per £1million of output in 2019 for that sector. Next, we multiply each UK energy use-output coefficient by the output of that sector in Scotland to get energy use by sector by fuel type in Scotland.

Finally, we multiply each sector's use of each fuel type by (UK) kgCO2 per Tonne emissions conversion factors to get Scottish emissions by sector and by fuel type for 2019. One critical assumption here is that, for each sector, fuel consumption per unit of output is identical in Scotland as for that sector in the UK as a whole. Using this process, we obtain an estimate of total CO2 emissions from fuel use in industries in Scotland in 2019 of 17,255 $ktCO_2$ which is 47.3% of the emissions that are present in the IPCC greenhouse

[23] https://www.gov.scot/binaries/content/documents/govscot/publications/statistics/2021/06/scottish-greenhouse-gas-statistics-1990-2019/documents/scottish-greenhouse-gas-emissions-2019/scottish-greenhouse-gas-emissions-2019/govscot%3Adocument/scottish-greenhouse-gas-emissions-2019.pdf

inventory. This disparity is because we do not consider emissions from aviation or agriculture.[24]

[24] This equates to 7.97% of CO_2 emissions from industries in the UK as a whole.

4.3.2 Consumption emissions

In our environmental extension for AMOSTRAVEL, we include emissions from private transport. i.e., the emissions attributed to each of the tourism and non-tourism consumption categories are the fuels consumed in the use of private transport in Scotland. We will see later that this addition allows us to add changes in emissions due to changes in fuels used for private consumption.

The process of adding consumption emissions starts by assigning emissions intensities to energy used directly in private transport by each of the tourism spending categories. We start with the total emissions from cars and motorcycles in the Scottish Government Greenhouse Gas (GHG) emissions inventory (Scottish Government, 2019). The total CO_2 emissions from energy used in cars and motorcycles were 5355.79 $ktCO_2$.

The next step is to assign these emissions to each of the appropriate consumption categories: non-tourism spending (NT^d), Scottish day visitors spending (DV^d) , Scottish overnight spending (ON^d), RUK day visitors spending (DV^{ruk}), RUK overnight spending (ON^{ruk}), and International Overnight spending[25] (ON^{int}). As we are allocating emissions from private transport, it is appropriate for us to use the breakdown of spending on petrol/diesel by category. Spending on fuels is included within purchases from the "Retail" sector and not disaggregated further. We, therefore, identify the total amount of spending by each consumption category on the retail sector, subscript "ret" directly from the national accounts constructed in Chapter 3, and take that category's share of spending by all consumption categories to allocate their share of emissions from private transport in Scotland. These shares are given in the first column of Table 3.1, while the resulting emissions from each category of consumption in the base year (2019) are given in the final column.

Table 4.1 represents the initial emissions that come from each of the consumption categories fuel use. From this, we can gather that most emissions from fuel use are attributable to the domestic consumption categories, non-tourism, day visitors and overnight visitors, approximately 94%. The rest of the emissions from private transport

[25] Each of the consumption categories are defined and described in Chapter 2.

are attributable to the inbound (non-domestic) tourism categories. Therefore, our industrial emissions and consumption emissions sum up to 22,611 KtCO2, or roughly 47.3% total CO_2 emissions from fuel use in Scotland.

Table 4.1 Consumption emissions from private transport assigned to tourism categories, 2019.

		Share of spending on retail across consumption categories (%) **	Emissions attributed to each category, $KtCO_2$
Domestic	Non-tourism	86.43	4629.14
	Day visitors	6.33	339.16
	Overnight visitors	1.01	53.95
Non-domestic	RUK Day visitors	2.06	110.07
	RUK Overnight visitors	1.87	100.06
	International Overnight visitors	2.30	123.41
	Total	100.00	5355.79

Notes: Author’s calculations

Using these assumptions and data described in 4.4.1 we construct 27-sector emissions from fuel use for each of the fuel types represented in the accounts. This is displayed in Table 4.2 below.

Table 4.2 27 sector aggregated emissions from industrial emissions by fuel type, KtCO2

No.	**Sectors**	**Coal**	**Natural Gas**	**Petrol**	**Derv**	**Fuel Oil**	**Gas Oil**	**Total**
1	Agriculture	0.0	33.0	2.0	97.8	7.5	610.0	**750.3**
2	Forestry Planting and Forestry Harvesting	0.0	0.0	2.7	8.2	0.0	28.6	**39.5**
3	Fishing and Aquaculture	0.0	0.0	2.1	2.2	20.5	524.6	**549.4**
4	Coal & ignite	4.9	1.7	0.0	2.1	0.0	8.3	**17.0**
5	Oil and gas extraction etc	0.0	178.2	0.2	11.7	3.0	84.8	**277.8**
6	Food processing	5.5	351.5	1.5	63.4	0.7	2.7	**425.3**
7	Alcohol and Soft drinks production	10.1	550.3	3.3	37.9	1.7	8.3	**611.6**
8	Textiles, wood and paper	18.6	269.7	2.7	69.7	0.2	5.8	**366.7**
9	Coke, petroleum & petrochemicals	161.0	268.7	0.7	5.1	1.8	2.7	**440.0**
10	Other chemicals, robber plastics etc	144.5	490.3	2.5	81.9	3.1	6.1	**728.4**
11	Computers, electronics and other manufacturing	1.9	201.5	3.6	97.1	6.7	6.3	**317.0**
12	Electricity	499.4	5931.3	1.3	28.7	0.0	28.6	**6489.3**
13	Gas	0.0	245.3	0.2	2.3	0.0	0.0	**247.8**
14	Water and waste	0.0	16.1	2.2	139.0	0.0	11.8	**169.1**
15	Construction	0.0	121.5	61.2	395.1	0.0	196.3	**774.1**
16	W & R	0.0	81.1	20.1	352.0	0.0	15.4	**468.6**
17	Retail excluding vehicles	0.0	109.8	8.5	169.5	0.0	1.9	**289.7**
18	Land transport	2.1	8.8	128.7	1172.0	0.0	154.1	**1465.7**
19	Other transport	0.0	8.4	3.5	9.3	501.5	197.5	**720.3**
20	Support and post	0.5	26.4	3.5	78.7	7.2	76.6	**192.9**
21	Accommodation	0.0	91.2	0.3	1.4	1.5	1.8	**96.2**
22	Food and Beverage services	0.1	126.2	1.8	8.9	3.6	3.2	**143.8**
23	Services	0.0	241.9	27.0	150.8	1.4	8.3	**429.3**
24	Public Administration & Defence	1.5	210.6	7.1	73.1	2.3	73.7	**368.4**
25	Education & Health	1.8	677.3	3.0	18.9	6.1	4.0	**711.0**
26	Creative, cultural and recreational services	0.1	67.3	2.8	16.2	1.4	2.4	**90.2**
27	Other	0.0	48.9	2.3	23.8	0.6	0.3	**75.9**
	Total	**852.1**	**10357.0**	**294.8**	**3116.7**	**570.7**	**2064.1**	**17255.4**

Source: Author's calculations, No. – Aggregated sector number, DERV – Disel for Road vehicles.

Table 4.2 above shows the sectoral breakdown of industrial emissions using the methodology described above. We can see that natural gas is where most of the emissions come in terms of industrial emissions, 10,357 KtCO2. 57% of these emissions come from the electricity sector. At the sectoral level, using the methodology that is described for calculating industrial emissions the electricity sector is where most of the emissions are coming from i.e. the industrial activity that is used to produce electricity. In addition to this the land transport sector is another large emitter relative to the other sectors presented in Table 4.2, 1,465.7. This is largely driven by emissions from diesel road vehicles (DERV). Land transport is an important industry for the tourism industry in Scotland given its geographical size and the ease of which you can travel the country.

4.3.3 Modelling changes in emissions

To understand the changes in each of the fuel types, we link changes in emissions by sector and by category to changes in purchases as noted in the AMOSTRAVEL economic model by sector and category, respectively. We first aggregate the full set of environmentally extended IO accounts for Scotland to the same level of sectoral detail as the AMOSTRAVEL model, i.e., 27 sectors. However, the sectoral disaggregation in this Chapter is slightly different from Chapter 3 to account for an in-detail analysis of the energy sectors as shown in Table 4.2.

For Industrial emissions, we map each emissions intensity from fuel type to purchases of the outputs of different sectors as per Table 4.3. From our CGE model, changes in the purchases by each industrial sector are then used to quantify the change in emissions for that sector as a whole. This allows us to quantify the change in emissions from each sector as the sum of changes in absolute emissions associated with that sectors purchase of each energy good as an intermediate input. Petrol and diesel are linked to the retail sector, as purchases of these fuels are within the Retail sector as noted earlier.

Table 4.3 Linking fuel type to economic sector

Fuel Type	*Economic Sector*

Coal	Sector 4[26]: Coal & Ignite
Gas	Sector 13: Gas
Petrol	Sector 17: Retail (excl. vehicles)
Diesel	Sector 17: Retail (excl. vehicles)
Fuel Oil	Sector 9: Coke, petroleum & petrochemicals
Gas Oil	Sector 9: Coke, petroleum & petrochemicals

For Consumption emissions, we have emissions from private transport in the base year which we link to purchases of the output of the retail sector. In each simulation therefore, we will see (percentage) changes in spending by retail by each category and be able to calculate a change in emissions for each consumption category. Absolute changes in consumption emissions will be aggregated with the changes in Industrial emissions in each simulation, to report overall changes in emissions from fuel use.

This methodology, therefore, allows us to capture emissions from the fuel used in private transport, which is an important part of the emissions from tourist activity. In addition, this methodology allows us to understand the ways in which each fiscal intervention affects each of the different consumption categories, helping policymakers understand the emissions and economic impacts of such policies.

4.4 Simulation Strategy

In this Chapter, we undertake three simulations, each relating to a different hypothetical new tax aimed at tourists, either directly or indirectly. In all simulations, other elements of the AMOSTRAVEL model are unchanged. For instance, in each we assume that there is no migration, and therefore, the unemployment rate changes as a result of the shock rather than the size of the labour force changing. Second, we assume that wages are determined by a wage curve, following Blanchard and Oswald (1994) and that changes in the wage rate are relative to workers' bargaining power. When there is excess demand for labour the size of the labour force is increased through increased participation. Third, for all simulations that are presented in this Chapter, we hold government expenditure constant, so that additional revenues from the tax receipts are not returned to the economy.

[26] These sector numbers refer to the aggregated sector number in Table 4.2

We do not impose a balanced government budget constraint, so there is no consequence for government spending of reduction in tax revenues from economic contractions in each case. The simulations therefore allow us to analyse and compare the economic and emissions effects that arise purely from the hypothetical taxes.

The three simulations that we analyse are: (1) an Accommodation tax, (2) a Land transport tax, and (3) a Fuel sales tax. Simulation 1 is the accommodation tax introduced and analysed from an economic perspective in Chapter 2, which we can now extend to the impacts on emissions. Specifically, this is a 5% increase in the price paid for accommodation by overnight visitors. The revenue which this policy raises for the Government becomes the target amount that is raised by each of Simulation 2 and Simulation 3 in turn, so we can directly compare the economic and emissions results.

Simulation 2 is a new tax which increases the output price of the Land transport sector, which includes all buses and trains. This is introduced as an increase in price in the Land transport sector.

$$CPI_{t,d}^{dv} = \sum_{i} \frac{PQ_{i,t} \cdot (1 + \tau_{ltr}^{tr}) \cdot Q_{i,t=0,d}^{dv}}{PQ_{i,t=0} \cdot Q_{i,,t=0,d}^{dv}} \qquad 4.1$$

$$DV_{t,d} = \left(\gamma^{\rho^{tr}} \cdot (\alpha^{tr}) \cdot \frac{CPI_{t}^{tr}}{CPI_{t,d}^{dv}} \right)^{\frac{1}{1-\rho^{tr}}} \cdot TR_{t,d} \qquad 4.2$$

The example above shows how the land transport tax is modelled in AMOSTRAVEL. The example in equation 4.1 and 4.2 is an example of how the land transport tax is applied to day visitors. It is also applied to overnight visitors for the RUK and domestic, as well as the non-tourist consumption bundle. In the same way as the accommodation tax is modelled the price increase in the land transport sector is first fed through the relevant CPIs for the specific category. The price of commodity ($PQ_{i,t}$) is multiplied by 1 plus the land transport tax rate τ_{ltr}^{tr} multiplied by the demand for day visits $Q_{i,t=0,d}^{dv}$. This is divided by the initial price of land transport multiplied by the initial demand for day visits. This is fed through to the CES day visitors equation in equation 4.2.

This simulation impacts all of the consumption categories presented in the model, as they all purchase from Land transport to varying degrees. The tax rate is set to hold revenue constant in each Simulation and is equivalent to a 0.7% tax rate.

Simulation 3 is a new tax rate that increases the output price of the retail sector, capturing fuel purchases. This will an impact on all the consumption categories that are presented in the model, both domestic and non-domestic tourists, as well as non-tourism consumption. As with Simulation 2, this tax rate is set to ensure that the new tax raises the same as is raised under Simulation 1 and is equivalent to a 4.1% increase in tax rate.

4.5 Results

4.5.1 Aggregate economic and emissions results across three simulations

The headline economic results are set out in Table 4.4. The left-hand column lists the key macroeconomic variables, while each column shows the long-run percentage changes from the baseline under each simulation in turn. The target revenue for the taxes in each case is presented in the last row in this table and confirms that revenues from these taxes are the same in each case (i.e., £93.64 million). We can note that, despite the same amount being raised, each simulation has quite different economic impacts.

Table 4.4 Aggregate economic impacts under each simulation, % changes from base unless otherwise stated, long run

	Accommodation tax	Land transport tax	Fuel sales tax
Gross Domestic Product (GDP)	-0.03	-0.01	-0.01
Employment	-0.03	-0.01	-0.01
Nominal Gross Wage	-0.08	-0.02	-0.03
Investment	-0.03	-0.01	-0.02
Households spending	-0.10	-0.07	-0.07
Consumer Price Index (CPI)	0.05	0.08	0.08
Domestic Tourist spending	-0.14	-0.08	-0.10
Scottish non-tourist spending	-0.10	-0.07	-0.07
Scottish Day visitors spending	0.68	-0.09	-0.13
Scottish Overnight visitors spending	-3.58	0.01	0.06
RUK Day visitors spending	0.03	-0.11	-0.21
RUK Overnights visitors spending	-1.95	-0.06	-0.12
International tourist spending	-1.94	-0.06	-0.12
Tourism Tax Revenue (£m)	93.64	93.64	93.64

Notes: Author's calculations

Tourism tax revenues are captured differently for each tax. As accommodation taxes are applied exclusively to overnight tourists, the revenue is calculated from the overnight tourists' spending on accommodation. For the land transport tax, the revenues are calculated from the domestic and UK change in spending categories spending on land transport. The fuel sales tax is calculated by summing the change in spending of all consumption categories spending in the retail sector.

In terms of macroeconomic impacts, we note that the GDP and employment effects in all simulations are negative. Simulation 1, the accommodation tax, —where the tax is levied on overnight stays—has a reduction in these two variables that is around three times larger than both Simulation 2 and Simulation 3.

A sees the largest increase in the price of overnight tourism of the three Simulations. Note that spending by overnight visitors falls in this Simulation both for Scottish (-3.58%) and non-Scottish tourism consumption (1.95% and 1.94% for RUK and International, respectively). The reduction in Overnight spending is larger for the Scottish Overnight category as Scottish households can substitute the now more expensive Overnight visitor spending in favour of Day visitor spending, which rises by 0.68%. Overall, spending by Scottish non-tourist spending falls by the largest amount in Simulation 1, and there is the largest fall in total tourist spending.

We find that the results of Simulations 2 and 3 are qualitatively similar to each other, and they differ from those of Simulation 1. In Simulations 2 and 3, we see a larger increase in CPI overall, with modest reductions in spending by each non-Scottish tourism category as well as Scottish day visitor spending. In each, we find a small increase in spending on Scottish overnight visitor spending, albeit tourism spending falls in both these simulations as well. This is linked to the fact that both of these taxes cause a slight reduction in the price of accommodation in the long run. Therefore, the price of the overnight bundle, in the case of simulations 2 (land transport tax) and 3 (the fuel sales tax), is relatively less expensive than the day visitor bundle and, hence, a very small substitution toward overnight spending in these cases. In these simulations the less pronounced reductions in non-Scottish tourism spending mean that there is a smaller reduction in incomes to Scottish households, with smaller reductions in Scottish non-tourist spending compared to Simulation 1.

We see that the economic results under each of these Simulations are influenced by the degree of substitution between tourism spending, which is determined by the selected elasticities of substitution. In Section 4.6, we test how sensitive our findings are to the selected elasticities. The degree to which this substitution happens is dependent on the elasticities of substitution that are used. This will be explored in the sensitivity analysis section.

Table 4.5 Aggregate emissions impacts under each simulation, % changes from baseline, long run

	Accommodation tax	Land transport tax	Fuel sales tax
Total (Industry plus Consumption) emissions	-0.03	-0.02	-0.02
Industrial emissions	0.01	-0.01	-0.01
Consumption emissions	-0.16	-0.08	-0.07

4.5.2 Sectoral economic results across three simulations

Table 4.6 Sectoral changes in output, percentage changes from base, long run

	Accommodation tax	Land transport tax	Fuel sales tax
Agriculture	-0.054	-0.023	-0.025
Forestry Planting and Forestry Harvesting	-0.047	-0.006	-0.010
Fishing and Aquaculture	0.006	0.004	0.003
Coal & ignite	0.012	-0.014	-0.012
Oil and gas extraction etc	0.056	0.016	0.018
Food processing	-0.017	-0.009	-0.010
Alcohol and Soft drinks production	0.020	0.008	0.008
Textiles, wood and paper	0.004	-0.002	-0.002
Coke, petroleum & petrochemicals	0.046	0.012	0.014
Other chemicals, robber plastics etc	0.034	0.007	0.008
Computers, electronics and other manufacturing	0.032	0.006	0.007
Electricity	-0.030	-0.017	-0.017
Gas	-0.015	-0.012	-0.012
Water and waste	-0.011	-0.008	-0.008
Construction	0.009	-0.002	-0.002
W & R	0.000	-0.005	-0.005
Retail excluding vehicles	-0.143	-0.054	-0.059
Land transport	-0.063	-0.117	-0.022
Other transport	-0.026	-0.018	-0.089
Support and post	0.011	0.002	0.002
Accommodation	-1.620	-0.066	-0.112
Food and Beverage services	-0.428	-0.071	-0.101
Services	-0.010	-0.015	-0.014
Public Administration & Defence	0.003	-0.001	-0.001
Education & Health	-0.002	-0.008	-0.007
Creative, cultural and recreational services	-0.123	-0.036	-0.043
Other	-0.068	-0.050	-0.049

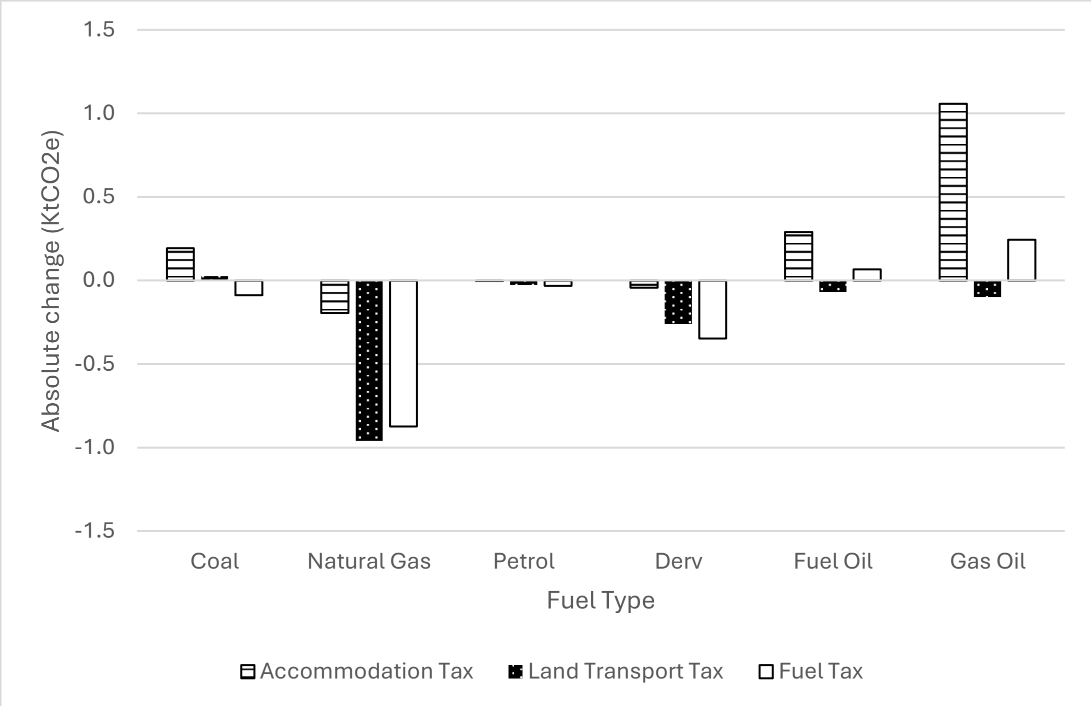
Notes: Author's calculations

Table 4.6 shows the sectoral changes for output from the three taxes that are assessed in this chapter. From the accommodation tax you can see that there is a more negative impact in output in accommodation and food and beverage sectors relative to other sectors. In simulations 2 and 3 the tourism sectors, accommodation and the food and beverage sectors are impacted more than the other sectors by the taxes but to a lesser degree than the accommodation tax.

4.5.3 Emissions results by fuel type: Industrial emissions

Figure 4.1 illustrates the absolute changes in industrial emissions under each Simulation from the baseline measured in KtCO2e of each of the six fuel types: Coal, Natural Gas, Petrol, Diesel (DERV), Fuel Oil and Gas Oil.

Figure 4.1 Absolute change in industrial emissions by fuel type under each simulation, absolute changes from base, KtCO2



There are three main points to note from Figure 5.1. First, we see that the small increase in Industrial emissions in Simulation 1 is not driven by increases in consumption of each fuel type. Emissions from Natural gas, Petrol and Diesel fall slightly. However, we find increases in emissions from Coal, Fuel Oil and Gas oil. The changes in emissions from fuel use are driven by the shift away from Accommodation sector – and its output falling, requiring fewer inputs to be purchased– to the inputs purchased by sectors where Day visitors spending is concentrated, such as Agriculture, Aquaculture and Fishing, and Other transport, which are relatively fuel-intensive. For Agriculture. Fishing and Aquaculture and Other transport the total emissions from these sectors are heavily attributed to Gas Oil. These sectoral changes are shown in the appendix.

Second, recall from Table 3.4 that in Simulations 2 and 3 that Industrial emissions fall. We see from Figure 5.1 that this is primarily driven by reductions in emissions from natural gas, with emissions from this fuel falling by 0.959 MtCO2e and 0.874 MtCO2e for Simulations 2 and 3 respectively. For Simulation 2, much of the reduction in emissions from natural gas is due to the reduction in natural gas usage in the Electricity sector. For Simulation 3, while the change in natural gas used in electricity consumption only 58% of the change is attributed to the electricity sector. Sectors such as alcohol and soft drinks production and education and health also can be attributed the reductions in emissions from natural gas as a result of the fuel tax.

Third, Simulation 3 has the largest absolute change in industrial emissions, -1.38 KtCO2, followed by the fuel tax and the accommodation tax. However, these policies have a very small impact on industrial emissions.

4.5.4 Emissions results by fuel type: Consumption emissions

Figure 4.2 shows the results for each simulation of the changes in Consumption emissions by each consumption category from the baseline measured in KtCO2 of each of the six fuel types: Coal, Natural Gas, Petrol, Diesel (DERV), Fuel Oil and Gas Oil. Figure 4.2 shows the % changes from the base values, while Figure 4.3 shows the absolute changes, in KtCO2.

Figure 4.2 Changes in emissions from private transport, % changes from base

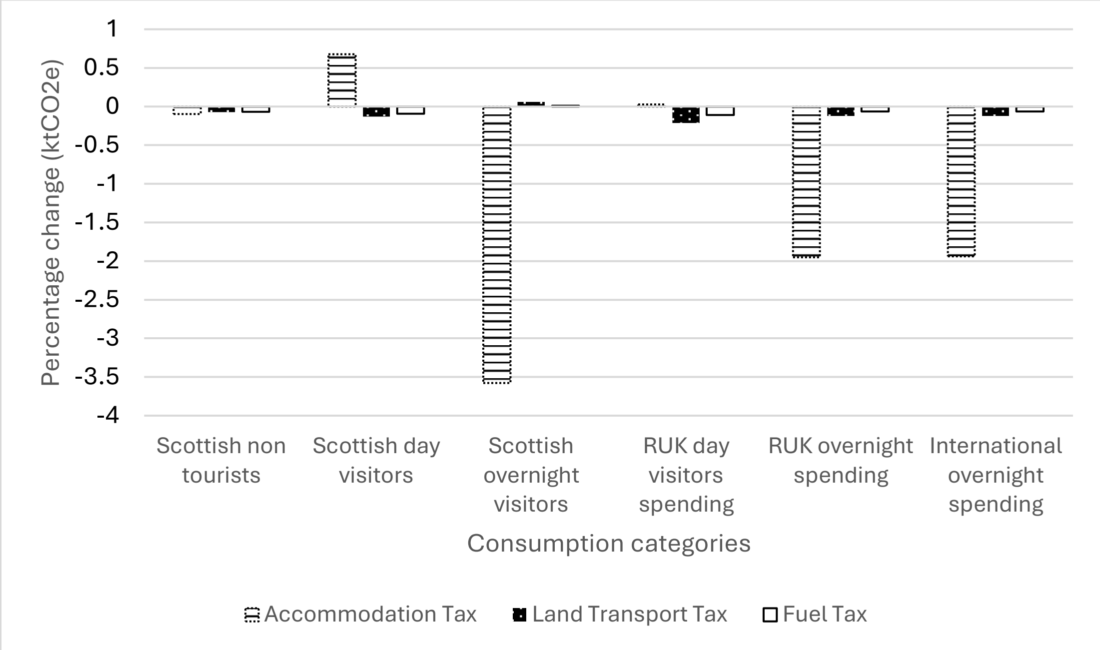
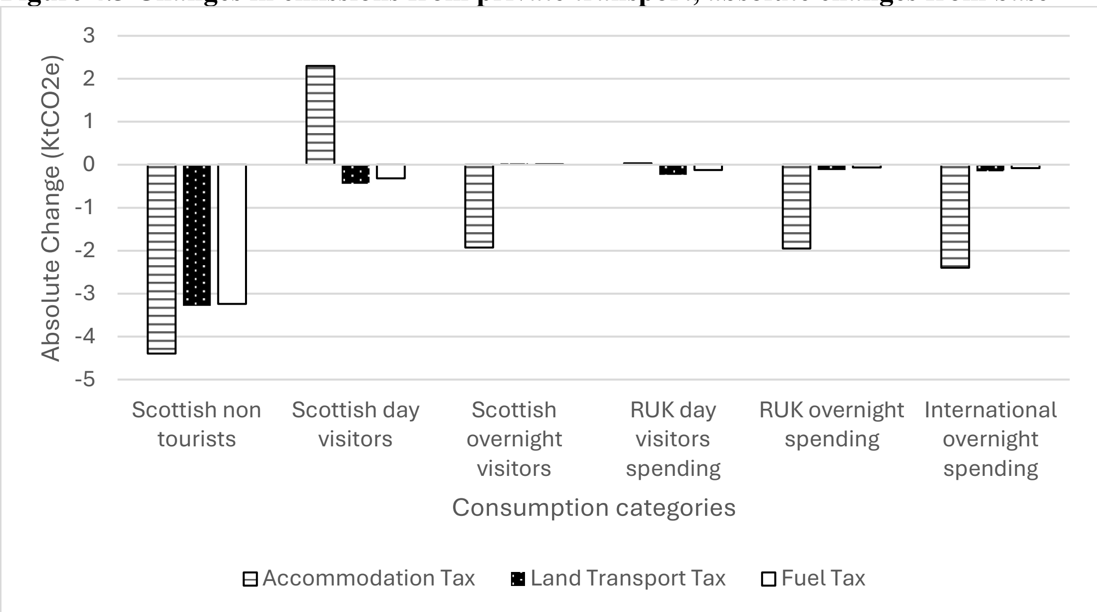


Figure 4.3 Changes in emissions from private transport, absolute changes from base



We can see that for Simulation 1, each of the three overnight categories see a reduction in Consumption emissions. The percentage changes in reduction in Consumption emissions (Figure 4.2 match the reduction in demand for each of the consumption categories (see Table 4.3) as at the sectoral level, each tourism consumption category is modelled in bundles, i.e. where there is an increase in the price of accommodation, then the price of the whole bundle is increased, with demand for each element in the tourism bundle changing by the same proportion. In the case of Scottish non-tourist spending there are small negative impacts from private transport emissions. This is due to the fact that as a result of all taxes the consumer price index is increased and hence, there is a negative impact on non-tourism emissions.

Figure 4.3 shows the absolute changes in emissions from private transport for each of the consumption categories that are presented in the model. Domestic non-tourists have the most emissions from private transport associated with them out of the consumption categories that are represented in the model. Hence despite there being small percentage changes in Figure 4.2, the absolute changes are relatively large compared to the other tourism categories.

4.6 Sensitivity Analysis

We saw in Chapter 3 that elasticities of substitution within the model has an impact on the economic results for the analysis of the Accommodation tax. In this Chapter, we are interested in the extent to which this is also true for the emissions findings examining the case of Simulation 1. We thus illustrate the sensitivity of our emissions in the case where only Scottish residents are able to substitute between day and overnight visitor spending as well as between tourism and non-tourism spending. We have already seen from Chapter 3 that alternative values for elasticity of substitution in this case can result in an accommodation tax increasing by Scottish day visitors spending, through substituting away from the more expensive Overnight visitor spending.

In this sensitivity analysis we choose two elasticities of substitution and alternative values to those used in the simulations carried out earlier in this Chapter. Firstly, we undertake sensitivity to the value of the elasticity of substitution between day visitors and overnight consumption by Scottish (domestic) households. In the simulations reported so far, we have taken a value of 2.2 for this elasticity. In the sensitivity carried out here, we take as extreme values of 0.2 and 3 for this parameter informed by the literature.

Secondly, we undertake sensitivity to the value of the elasticity of substitution between tourism and non-tourism consumption by Scottish (domestic) households. In the simulations reported so far, we have taken a value of 0.5 for this elasticity. In the sensitivity carried out here, we take as extreme values of 0.2 and 3 for this parameter, informed by the literature.

Firstly, we know from Chapter 3 that the combinations of elasticities of substitution values have a significant impact on day visitors' demand. What we mean by this is that for domestic day visitors spending, depending on the combinations of elasticities used the accommodation tax can have both a positive and negative impact. For clarity, and as a reminder this is shown in Table 7.2**.**

Table 4.7 Percentage changes in industrial emissions with different combinations of elasticities of substitution, % changes from base

		Elasticity of substitution between tourism and non-tourism		
		0.2	**0.5**	**3**
Elasticity of substitution between day visitors and overnight spending	**0.2**	0.008%	0.008%	0.011%
	2.2	0.008%	0.008%	0.011%
	3	0.008%	0.008%	0.011%

Table 4.7 shows percentage changes in industrial emissions as a result of an accommodation tax from Simulation 1 with different combinations of elasticities. We see that the elasticity of substitution between day visitors and overnight visitor spending does not impact the industrial emissions. Conversely, the elasticity between tourism and non-tourism does have an impact. Given that non-tourists have more emissions attributed to them than tourists then it makes sense that the more likely the substation to non-tourist consumption as a result of the tax the higher the industrial emissions. The absolute value of the reductions in emissions from the accommodation tax are shown in Table 4.8 below.

Table 4.8 Changes in industrial emissions with different combinations of elasticities of substitution, absolute changes from base, Kt CO2

		Elasticity of substitution between tourism and non-tourism		
		0.2	**0.5**	**3**
Elasticity of substitution between day visitors and overnight spending	**0.2**	1.289	1.295	1.833
	2.2	1.299	1.300	1.854
	3	1.320	1.410	1.917

Lastly, for the sensitivity analysis section we look at the impact of different combinations of elasticity of substitution on emissions from private transport shown in Table 4.9below. As the elasticity between day visitors and overnight visitors increase, there is a much more likely substitution between overnight and day visitors, the percentage change in emissions becomes more positive (less negative). However, as the elasticity between tourism and non-tourism increase then the changes in emissions from private transport become more negative.

Table 4.9 Changes in Consumption emissions with different combinations of elasticity of substitution, % changes from base

		Elasticity of substitution between tourism and non-tourism		
		0.2	**0.5**	**3**
Elasticity of substitution between day visitors and overnight spending	**0.2**	-0.172%	-0.179%	-0.192%
	2.2	-0.162%	-0.167%	-0.179%
	3	-0.155%	-0.169%	-0.175%

4.7 Conclusion

4.7.1 Policy Implications

This research raises some interesting policy questions. Mainly the importance of understanding the environmental consequences of changes to fiscal policies targeted at tourists. Of the three hypothetical taxes that are analysed here the accommodation tax has the largest reduction in emissions but also the most negative economy-wide impact. However, implementing the accommodation tax simultaneously reduces economy-wide emissions, which is essential for any policy decision as all policies should be directed at achieving net zero targets directly or indirectly. Furthermore, it helps to internalise some of the other negative externalities associated with tourism, such as putting pressure on public services without contributing to the public budget. The accommodation tax reduces tourism demand, which counters 'overtourism' whilst shifting the tax burden onto non-residents.

4.7.2 Conclusion

One way in which governments might intervene to reduce the environmental externalities associated with tourism is by implementing taxes that are targeted at tourists. There are a large variety of taxes that can be understood as a tourism tax, ranging from an accommodation tax to a casino tax (Gooroochurn & Sinclair, 2005). While there is a significant economic literature on the impact of fiscal interventions aimed at tourism, there is a much more limited literature using Computable General Equilibrium models to examine the economic as well as environmental impacts of such policies. CGE models are particularly useful for this analysis as these allow the understanding of the aggregate as well as sectoral economic impacts, and sectors have very different energy use and thus emissions. Such models can also allow for the comparison of the economic and emissions impacts of fiscal policies targeted on specific purchases, such as Accommodation.

In this Chapter, we have analysed the economic and emissions impacts of three alternative fiscal interventions, each of which raises the same amount of revenue for the government, allowing us to compare the economic and emissions consequences of each simulation. In doing so, we find that the simulation with the most negative economic impact is also that which produces the largest fall in emissions, principally an Accommodation tax. Alternative simulations such as a levy on Land transport or on Fuel sales, lead to smaller reductions in economic activity, and slightly smaller reductions in emissions. Our results show that despite – holding the amount of tax revenue each raises constant – there are different results of all three taxes in terms of the impact on the wider economy, the effects on the tourism categories, and the emissions changes in terms of both Industrial emissions and Consumption emissions.

In terms of the economic impact, the Accommodation tax has around three times a more negative impact on the economy than the other two taxes examined. There could be a variety of reasons for this. One of the most obvious reasons for this is the fact that that type of tax targets a specific type of tourism, and therefore, there is a significant reduction in demand for the overnight categories that are represented in this model. There is less of a negative economic impact on the other taxes. These taxes are more general taxes and, therefore, apply to all consumption categories that are represented in the model. This finding is in line with Gooroochurn & Sinclair (2005) and Gago et al. (2009), who suggest that the most efficient way to raise tax revenue from tourists is by implementing a general tax, a tax that affects everyone and passing the tax burden on tourists.

In terms of emissions, our results show that in all simulations, emissions fall. With our distinction between Industrial emissions – from fuel use in industry – and Consumption emissions – related to private transport by tourism and non-tourism consumption categories – we find that the Land transport tax and the Fuel sales tax led to a reduction in Industrial emissions whilst these (slightly) rise under the Accommodation tax. This is due to the fact that there is substitution away from overnight tourism spending in response to this tax, and toward more emissions-intensive activity. The consumption bundles that are associated with day visitors spending and non-tourism spending are more emissions intensive collectively than Overnight spending.

This Chapter makes two contributions to the existing literature. First, we extend the literature on the economic and emissions impacts of fiscal interventions, and their impact on the tourism industry and wider economy. We examine three different fiscal interventions which impact on both tourism and non-tourism activities in different ways and show the economic and emissions impacts. In doing so, we explore three alternative fiscal interventions which impact directly or indirectly on domestic and inbound tourism (Gooroochurn and Sinclair, 2005). Specifically, our Simulation 1 relates to an Accommodation tax directly impacts on Overnight tourism – both domestic and inbound visitors – while Simulations 2 and 3 impact on tourism and non-tourism categories directly.

Second, we develop a novel methodology to calculating emissions impacts from fiscal interventions in a CGE model by including industrial emissions as well as emissions from private fuel consumption by each of the tourism categories and also for non-tourism consumption. This is important as a significant proportion of emissions from tourism relate to private transport, and these are ignored in analysis which focus only on industrial emissions. As the disaggregation of the AMOSTRAVEL model – described in Chapter 2 – allows for the quantification of the economic impact of fiscal interventions on different tourism consumption activities with an economy, this addition for the direct emissions from tourism expenditure is important. Domestic tourism is an extremely important and significant proportion of Scottish tourism demand and in turn direct emissions by domestic and non-domestic tourism represents a significant proportion of the emissions from tourism activity in Scotland. Indeed, from Industrial emissions alone, we might conclude that an Accommodation tax would lead to an increase in emissions – due to the substitution by domestic residents away from Overnight spending and towards Day visitor spending– however when we include the change in emissions from Consumption this result changes, and overall emissions fall.

4.7.3 Future research

There is a potential to extend this research in two main ways. As well as including industrial and domestic consumption emissions this research could include inbound emissions, mainly associated with the type of travel that is used and the emissions associated with the travel choices. This would allow researchers to understand the more broad emissions “intensities” associated with each type of tourist consumption that is included in the model.

Second we assume for industrial emissions that Scotland has identical patterns of energy use by fuel type as the rest of the UK. A Scottish specific energy use inventory by industrial sector could be created to add to the existing dataset and methodology that is used in this research.

5 Conclusion

In conclusion, tourism makes an important economic contribution to regional economies. As such, it is important that economists are able to offer advice on the impacts of policies aimed at tourists both at the sectoral level and the economy-wide level. In addition to this, as we have seen throughout the thesis, different policies have different impacts across categories of tourism spending, i.e. day visitor's vs overnight visitors or inbound vs domestic tourism spending. The frameworks that we have developed allow us to contribute to such policy debates on the future sustainability of tourism policy.

Chapter 2 used IO modelling to understand the impacts of a tourism subsidy, specifically a 5% reduction in Value Added Tax to the accommodation sector. The key contributions of this chapter to the literature are to account for the costs associated with the change in fiscal policy at a regional level; a subsidy has a cost to the government. Other studies that have analysed tourism subsidies using IO have assumed that there is no cost to the regional government as a result of a tourism subsidy being imposed. Through using the IO methodology, Chapter 2 shows that recognising this cost reduces economic activity across all key macroeconomic variables that are assessed. Hence, not including this cost would mean that the positive impacts of a tourism subsidy would be inflated to some degree. The net effect of policy interventions such as a VAT reduction to the accommodation sector would depend on the increase in tourism spending as a result of the policy intervention. We repeat this analysis in a model with disaggregated spending across different tourism categories. This involves disaggregating the non-resident spending vector in the Scottish national accounts for the inbound tourism sectors and disaggregating the household spending vector to develop vectors for domestic tourism spending. The benefits of disaggregation in this case are represented by showing that to offset the GVA lost from Government spending there are different increases in spending that are required. Hence, the subsidy has different impacts on different tourism spending categories, and this would be omitted without such detail on the category's tourism consumption.

Chapter 3 develops a tourism-extended Computable General Equilibrium (CGE) model AMOSTRAVEL. In recent decades, there are multiple examples of CGE models being utilised to understand changes in tourism demand due to changes in policy or a variety of other factors. A Social Accounting Matrix is the dataset that is usually adopted as the "backbone" of the data set for a CGE model. These are heavily reliant on economic accounts and, as described in Chapter 2, have limited detail on different categories of tourism demand. In addition, tourism spending is often assumed to be the changes in non-resident spending, which misses out on domestic tourism spending. Domestic tourism spending is generally a large proportion of total tourism spending. Chapter 3 describes a methodology to address some methodological issues associated with previously constructed (tourism-specific) CGE models.

Firstly, we address these problems by using the disaggregated national accounts developed in Chapter 2 and incorporate them into a tourism extended Social Accounting Matrix. Using conventional utility functions that reflect the price-sensitive behaviour of both domestic and inbound tourists, we incorporate the categories into AMOSTRAVEL. We highlight the added value of our disaggregation through a variety of different tourism-specific simulations, specifically a 5% tax on accommodation. The methodological advances that we make here and the model in general can be used as a guide to make policy decisions toward the tourism sector.

Chapter 4 assesses the environmental implications of three different hypothetical taxes that will affect tourism spending to some degree. Taxes toward tourists, as seen in Chapter 3, will have a negative impact not only on overall tourism demand but also on key economic indicators like GDP and Employment. However, increasingly tourists are becoming aware of the environmental implications associated with their tourism consumption. Hence, in Chapter 4 we analyse the emissions impacts of three policies aimed at tourists through environmental extensions to AMOSTRAVEL.

We introduce a methodological novelty by including industrial emissions (emissions relating to the industries in the national accounts) as well as a portion of consumption emissions (emissions relating to the consumption categories that are presented in the model). We find that there are varying economic impacts of the three taxes; the accommodation tax is the most negative and has the largest environmental (emissions) reductions of the three taxes. The results from Chapter 4 raise some interesting questions about the balance between benefiting the economy and benefiting the environment.

5.1 Future research

There is potential for extending there AMOSTRAVEL framework further in future research to give more in-detail analysis on tourism spending at a regional level. Specifically, there are three potential extensions that would be useful for the tourism sectors.

First, household and income disaggregation. Jobs in the tourism industry are viewed as low-skilled and low-paid, which tourism industries around the world are attempting to change these perceptions. However, there may be positive distributional impacts from developing the tourism industry that are not captured in the frameworks developed throughout the thesis (e.g. Kronenberg & Fuchs, 2022). These distributional impacts have been incorporated in CGE model (e.g. Figus et al., 2017) but not in the context of tourism spending. Therefore, this is a potential area of future research for AMOSTRAVEL.

Second, the AMOSTRAVEL uses national accounts data and therefore is limited to the regional level of analysis. However intra-national tourism is important in the UK context and a model that includes UK regions would be an interesting extension. This would be especially interesting given the ongoing discussions about implementing tourism taxes at the regional level.

Third, as mentioned in chapter 3 a limitation of AMOSTRAVEL is that we have an aggregated accommodation sector and could be extended to include a disaggregation of accommodation as in Romero and Tajeda (2011), for example. Hotels are very different from campsites but use the same SIC codes in national accounts. Policies targeted at specific types are not captured in AMOSTRAVEL and substitution between consuming different types of accommodation are not captured. Future work could incorporate these into AMOSTRAVEL.

6 References

Adebayo, T.S., Akadiri, S.S., Asuzu, O.C., Pennap, N.H., Sadiq-Bamgbopa, Y., 2023. Impact of tourist arrivals on environmental quality: a way towards environmental sustainability targets. Current Issues in Tourism 26, 958–976. https://doi.org/10.1080/13683500.2022.2045914

Adedoyin, F.F., Seetaram, N., Disegna, M., Filis, G., 2023. The Effect of Tourism Taxation on International Arrivals to a Small Tourism-Dependent Economy. Journal of Travel Research 62, 135–153. https://doi.org/10.1177/00472875211053658

Ahlert, G., 2008. Estimating the Economic Impact of an Increase in Inbound Tourism on the German Economy Using TSA Results. Journal of Travel Research 47, 225–234. https://doi.org/10.1177/0047287508321197

Akkemik, K.A., 2012. Assessing the importance of international tourism for the Turkish economy: A social accounting matrix analysis. Tourism Management 33, 790–801. https://doi.org/10.1016/j.tourman.2011.09.002

Alfano, V., De Simone, E., D'Uva, M., Gaeta, G.L., 2022. Exploring motivations behind the introduction of tourist accommodation taxes: The case of the Marche region in Italy. Land Use Policy 113, 105903. https://doi.org/10.1016/j.landusepol.2021.105903

Álvarez-Albelo, C.D., Hernández-Martín, R., Padrón-Fumero, N., 2017. Air passenger duties as strategic tourism taxation. Tourism Management 60, 442–453. https://doi.org/10.1016/j.tourman.2016.12.002

Antonakakis, N., Dragouni, M., Filis, G., 2015. How strong is the linkage between tourism and economic growth in Europe? Economic Modelling 44, 142–155. https://doi.org/10.1016/j.econmod.2014.10.018

Archer, B., 1978. Domestic tourism as a development factor [WWW Document]. https://doi.org/10.1016/0160-7383(78)90007-5

Arguea, N.M., Hawkins, R.R., 2015. The rate elasticity of Florida tourist development (aka bed) taxes. Applied Economics 47, 1823–1832. https://doi.org/10.1080/00036846.2014.1000519

Balaguer, J., Cantavella-Jordá, M., 2002. Tourism as a long-run economic growth factor: the Spanish case. Applied Economics 34, 877–884. https://doi.org/10.1080/00036840110058923

Banerjee, O., Cicowiez, M., Moreda, A., 2019. Evaluating the Economic Viability of Public Investments in Tourism. Journal of Benefit-Cost Analysis 11, 101–130. https://doi.org/10.1017/bca.2019.32

Barron, G.N., Kerr, B., Wood, R.C., 2001. Arguing For and Against Tourism Taxation: Insights from the Scottish Context. Scottish Affairs 37 (First Serie, 72–87. https://doi.org/10.3366/scot.2001.0054

Bashir, M.F., Ma, B., Bilal, Komal, B., Bashir, M.A., 2021. Analysis of environmental taxes publications: a bibliometric and systematic literature review. Environ Sci Pollut Res 28, 20700–20716. https://doi.org/10.1007/s11356-020-12123-x

Bergman, L., 2005. Chapter 24 CGE Modeling of Environmental Policy and Resource Management, in: Handbook of Environmental Economics. Elsevier, pp. 1273–1306. https://doi.org/10.1016/S1574-0099(05)03024-X

Biagi, B., Brandano, M.G., Pulina, M., 2017. Tourism taxation: A synthetic control method for policy evaluation. International Journal of Tourism Research 19, 505–514. https://doi.org/10.1002/jtr.2123

Blanchflower, D.G., Oswald, A.J., 1994. The Wage Curve. MIT Press.

Bonham, C.S., Gangnes, B., 1996. Intervention analysis with cointegrated time series: the case of the Hawaii hotel room tax. Applied Economics 28, 1281–1293. https://doi.org/10.1080/000368496327831

Briassoulis, H., 1991. Methodological issues: Tourism input-output analysis. Annals of Tourism Research 18, 485–495. https://doi.org/10.1016/0160-7383(91)90054-F

Buckley, R., 2011. Tourism and Environment. Annu. Rev. Environ. Resour. 36, 397–416. https://doi.org/10.1146/annurev-environ-041210-132637

Calero, C., Turner, L.W., 2020. Regional economic development and tourism: A literature review to highlight future directions for regional tourism research. Tourism Economics 26, 3–26. https://doi.org/10.1177/1354816619881244

Cardenete, M.A., Guerra, A.-I., Sancho, F., 2017. Applied General Equilibrium, Springer Texts in Business and Economics. Springer Berlin Heidelberg, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-54893-6

Carrascal Incera, A., Fernández, M.F., 2015. Tourism and income distribution: Evidence from a developed regional economy. Tourism Management 48, 11–20. https://doi.org/10.1016/j.tourman.2014.10.016

Chen, J.L., Li, G., Liu, A., Morgan, N., n.d. Review of Evidence of Elasticities Relevant to Tourism in Scotland.

Chen, J.L., LI, G., Wu, D.C., Shen, S., 2019. Forecasting Seasonal Tourism Demand Using a Multiseries Structural Time Series Method [WWW Document]. https://doi.org/10.1177/0047287517737191

Connolly, Kevin, 2021. 2017 Social Accounting Matrix for Scotland. https://doi.org/10.15129/3A388B44-9EC5-4818-999E-D11BE1BED9C0

Croes, R., Rivera, M., 2016. Tourism's potential to benefit the poor: A social accounting matrix model applied to Ecuador - Robertico Croes, Manuel A. Rivera, 2017 [WWW Document]. URL https://journals.sagepub.com/doi/full/10.5367/te.2015.0495?casa_token=dVWFbnpxGBoAAAAA%3Al_suds8rQV2WJmZ0q2G0SsFm9vIy9Z9YOziTb_mRRC48kjg3Pd9MtooL2xDUH93qNBA2I3QjbMI (accessed 10.29.22).

Dalir, S., Mahamadaminov, A., Olya, H.G., 2021. Airbnb and taxation: Developing a seasonal tax system. Tourism Economics 27, 365–378. https://doi.org/10.1177/1354816620904894

de Quatrebarbes, C., Boccanfuso, D., Savard, L., 2016. Beyond representative households: The macro–micro impact analysis of VAT designs applied to Niger. Economic Modelling 57, 76–92. https://doi.org/10.1016/j.econmod.2016.03.018

Dixon, P.B., Jorgenson, D.W., 2013. Introduction, in: Handbook of Computable General Equilibrium Modeling. Elsevier, pp. 1–22. https://doi.org/10.1016/B978-0-444-59568-3.00001-8

do Valle, P.O., Pintassilgo, P., Matias, A., André, F., 2012. Tourist attitudes towards an accommodation tax earmarked for environmental protection: A survey in the Algarve. Tourism Management 33, 1408–1416. https://doi.org/10.1016/j.tourman.2012.01.003

Dodds, R., Butler, R., 2019. The phenomena of overtourism: a review. International Journal of Tourism Cities ahead-of-print. https://doi.org/10.1108/IJTC-06-2019-0090

Durán-Román, J.L., Cárdenas-García, P.J., Pulido-Fernández, J.I., 2021. Tourists' willingness to pay to improve sustainability and experience at destination. Journal of Destination Marketing & Management 19, 100540. https://doi.org/10.1016/j.jdmm.2020.100540

Dwyer, L., 2015. Computable general equilibrium modelling: an important tool for tourism policy analysis. Tour. hosp. manag. 21, 111–126. https://doi.org/10.20867/thm.21.2.1

Dwyer, L., Forsyth, P., Dwyer, W., 2020. Tourism economics and policy, 2nd Edition. ed, Aspects of tourism texts. Channel View Publications, Bristol ; Blue Ridge Summit, Pennsylvania.

Dwyer, L., Forsyth, P., Madden, J., Spurr, R., 2000. Economic Impacts of Inbound Tourism under Different Assumptions Regarding the Macroeconomy. Current Issues in Tourism 3, 325–363. https://doi.org/10.1080/13683500008667877

Dwyer, L., Forsyth, P., Spurr, R., 2022. Evaluating tourism's economic effects: new and old approaches [WWW Document]. https://doi.org/10.1016/S0261-5177(03)00131-6

Dwyer, L., Forsyth, P., Spurr, R., 2012. Wither Australian Tourism? Implications of the Carbon Tax. Journal of Hospitality and Tourism Management 19, 15–30. https://doi.org/10.1017/jht.2012.18

Dwyer, L., Forsyth, P., Spurr, R., Hoque, S., 2013. Economic Impacts of a Carbon Tax on the Australian Tourism Industry. Journal of Travel Research 52, 143–155. https://doi.org/10.1177/0047287512461568

Emonts-Holley, T., Ross, A., Swales, J., 2014. A social accounting matrix for Scotland. Fraser of Allander Economic Commentary 38, 84–93.

Filimonau, V., Dickinson, J., Robbins, D., 2014. The carbon impact of short-haul tourism: a case study of UK travel to Southern France using life cycle analysis. Journal of Cleaner Production 64, 628–638. https://doi.org/10.1016/j.jclepro.2013.07.052

Fletcher, J.E., 1989a. Input-output analysis and tourism impact studies. Annals of Tourism Research 16, 514–529. https://doi.org/10.1016/0160-7383(89)90006-6

Fletcher, J.E., 1989b. Input-output analysis and tourism impact studies. Annals of Tourism Research 16, 514–529. https://doi.org/10.1016/0160-7383(89)90006-6

Forsyth, P., Dwyer, L., 2002. Market Power and the Taxation of Domestic and International Tourism. Tourism Economics 8, 377–399. https://doi.org/10.5367/000000002101298197

Forsyth, P., Dwyer, L., Spurr, R., Pham, T., 2014. The impacts of Australia's departure tax: Tourism versus the economy? Tourism Management 40, 126–136. https://doi.org/10.1016/j.tourman.2013.05.011

Freightling, D.C., 2010. THE TOURISM SATELLITE ACCOUNT | Elsevier Enhanced Reader [WWW Document]. https://doi.org/10.1016/j.annals.2009.08.003

Gago, A., Labandeira, X., Picos, F., Rodríguez, M., 2009. Specific and general taxation of tourism activities. Evidence from Spain. Tourism Management 30, 381–392. https://doi.org/10.1016/j.tourman.2008.08.004

Galindo, L.M., 2018. Potential consequences of a CO2 aviation tax in Mexico on the demand for tourism. Potential consequences of a CO2 aviation tax in Mexico on the demand for tourism 241–264. https://doi.org/10.19272/201806702003

Goh, C., Law, R., 2002. Modeling and forecasting tourism demand for arrivals with stochastic nonstationary seasonality and intervention. Tourism Management 23, 499–510. https://doi.org/10.1016/S0261-5177(02)00009-2

Gomes, S., Lopes, J.M., 2023. Insights for Pro-Sustainable Tourist Behavior: The Role of Sustainable Destination Information and Pro-Sustainable Tourist Habits. Sustainability 15, 8856. https://doi.org/10.3390/su15118856

Gooroochurn, N., Thea Sinclair, M., 2005. Economics of tourism taxation: Evidence from Mauritius. Annals of Tourism Research 32, 478–498. https://doi.org/10.1016/j.annals.2004.10.003

Hara, T., 2008. Quantitative Tourism Industry Analysis: Introduction to Input-Output, Social Accounting Matrix Modeling, and Tourism Satellite Accounts. Routledge, London. https://doi.org/10.4324/9780080887999

Hayashi, F., 1982. Tobin's Marginal q and Average q: A Neoclassical Interpretation. Econometrica 50, 213–224. https://doi.org/10.2307/1912538

Holzner, M., 2011. Tourism and economic development: The beach disease? Tourism Management 32, 922–933. https://doi.org/10.1016/j.tourman.2010.08.007

Hosoe, N., Gasawa, K., Hashimoto, H., 2010. Textbook of computable general equilibrium modeling: programming and simulations. Palgrave Macmillan, Basingstoke.

Ihalanayake, R., 2013. Tourism taxes and negative externalities in tourism in australia: A CGE approach. COC 10, 200–214. https://doi.org/10.22495/cocv10i4c1art4

Inchausti-Sintes, F., 2020. The macroeconomic consequences of quality improvement policies in advanced tourism-led economies. Current Issues in Tourism 23, 3073–3092. https://doi.org/10.1080/13683500.2019.1679094

Jones, C., Munday, M., 2004. Evaluating the Economic Benefits from Tourism Spending through Input-Output Frameworks: Issues and Cases [WWW Document]. https://doi.org/10.1080/0269094042000203063

Khanal, B.R., Gan, C., Becken, S., 2014. Tourism Inter-Industry Linkages in the Lao PDR Economy: An Input—Output Analysis. Tourism Economics 20, 171–194. https://doi.org/10.5367/te.2013.0255

Kim, H.J., Chen, M.-H., Jang, S. "Shawn," 2006. Tourism expansion and economic development: The case of Taiwan. Tourism Management 27, 925–933. https://doi.org/10.1016/j.tourman.2005.05.011

Klijs, J., Ormond, M., Mainil, T., Peerlings, J., Heijman, W., 2016. A state-level analysis of the economic impacts of medical tourism in Malaysia. Asian-Pacific Economic Literature 30, 3–29. https://doi.org/10.1111/apel.12132

Krishnaswamy, J., 1979. The Economic Impact of Tourism. Tourism Recreation Research 4, 19–23. https://doi.org/10.1080/02508281.1979.11014970

Kronenberg, K., Fuchs, M., 2022. The socio-economic impact of regional tourism: an occupation-based modelling perspective from Sweden. Journal of Sustainable Tourism 30, 2785–2805. https://doi.org/10.1080/09669582.2021.1924757

Kweka, J., Morrissey, O., Blake, A., 2003. The economic potential of tourism in Tanzania. Journal of International Development 15, 335–351. https://doi.org/10.1002/jid.990

Law, A., De Lacy, T., Lipman, G., Jiang, M., 2016. Transitioning to a green economy: the case of tourism in Bali, Indonesia. Journal of Cleaner Production, Special Volume: Sustainable Tourism: Progress, Challenges and Opportunities 111, 295–305. https://doi.org/10.1016/j.jclepro.2014.12.070

Lecca, P., McGregor, P.G., Swales, J.K., 2013. Forward-looking and myopic regional Computable General Equilibrium models: How significant is the distinction? Economic Modelling 31, 160–176. https://doi.org/10.1016/j.econmod.2012.11.010

Lemelin, A., Savard, L., 2022. What do CGE models have to say about fiscal reform? Economic Analysis and Policy 74, 758–774. https://doi.org/10.1016/j.eap.2022.04.003

Li, G., Zhang, R., Masui, T., 2021. CGE modeling with disaggregated pollution treatment sectors for assessing China's environmental tax policies. Science of The Total Environment 761, 143264. https://doi.org/10.1016/j.scitotenv.2020.143264

Li, K.X., Jin, M., Shi, W., 2018. Tourism as an important impetus to promoting economic growth: A critical review. Tourism Management Perspectives 26, 135–142. https://doi.org/10.1016/j.tmp.2017.10.002

Liu, A., Kim, Y.R., Song, H., 2022. Toward an accurate assessment of tourism economic impact: A systematic literature review | Elsevier Enhanced Reader [WWW Document]. https://doi.org/10.1016/j.annale.2022.100054

Lundie, S., Dwyer, L., Forsyth, P., 2007. Environmental-Economic Measures of Tourism Yield. Journal of Sustainable Tourism 15, 503–519. https://doi.org/10.2167/jost713.0

Mahadevan, R., Amir, H., Nugroho, A., 2017. Regional impacts of tourism-led growth on poverty and income inequality: A dynamic general equilibrium analysis for Indonesia. Tourism Economics 23, 614–631. https://doi.org/10.5367/te.2015.0534

Making the case for supporting broad energy efficiency programmes: Impacts on household incomes and other economic benefits - ScienceDirect [WWW Document], n.d. URL https://www.sciencedirect.com/science/article/pii/S0301421517305888?via%3Dihub#s0015 (accessed 7.17.24).

Manente, M., Zanette, M., 2010. MACROECONOMIC EFFECTS OF A VAT REDUCTION IN THE ITALIAN HOTELS & RESTAURANTS INDUSTRY. Economic Systems Research 22, 407–425. https://doi.org/10.1080/09535314.2010.526927

Manrique-de-Lara-Penatea, C., Gallego, M.S., Valle, E., 2022. The economic impact of global uncertainty and security threats on international tourism [WWW Document]. https://doi.org/10.1016/j.econmod.2022.105892

Martins, L.F., Gan, Y., Ferreira-Lopes, A., 2017. An empirical analysis of the influence of macroeconomic determinants on World tourism demand. Tourism Management 61, 248–260. https://doi.org/10.1016/j.tourman.2017.01.008

Mayor, K., Tol, R.S.J., 2007. The impact of the UK aviation tax on carbon dioxide emissions and visitor numbers. Transport Policy 14, 507–513. https://doi.org/10.1016/j.tranpol.2007.07.002

Meng, B., Lee, M.J., Chua, B.-L., Han, H., 2022. An integrated framework of behavioral reasoning theory, theory of planned behavior, moral norm and emotions for fostering hospitality/tourism employees' sustainable behaviors. International Journal of Contemporary Hospitality Management 34, 4516–4538. https://doi.org/10.1108/IJCHM-02-2022-0151

Meng, S., Pham, T., 2017. The impact of the Australian carbon tax on the tourism industry. Tourism Economics 23, 506–522. https://doi.org/10.5367/te.2015.0514

Meng, S., Pham, T., Dwyer, L., Grant, B., 2021. Carbon Price Impacts on the Chinese Tourism Industry. Journal of Travel Research 60, 370–383. https://doi.org/10.1177/0047287520903111

Meng, S., Siriwardana, M., 2017. Assessing the Economic Impact of Tourism. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-319-40328-1

Meng, W., Xu, L., Hu, B., Zhou, J., Wang, Z., 2016. Quantifying direct and indirect carbon dioxide emissions of the Chinese tourism industry. Journal of Cleaner Production 126, 586–594. https://doi.org/10.1016/j.jclepro.2016.03.067

Mihalic, T., 2020. Conceptualising overtourism: A sustainability approach. Annals of Tourism Research 84, 103025. https://doi.org/10.1016/j.annals.2020.103025

Mikulić, J., Vizek, M., Stojčić, N., Payne, J.E., Čeh Časni, A., Barbić, T., 2021. The effect of tourism activity on housing affordability. Annals of Tourism Research 90, 103264. https://doi.org/10.1016/j.annals.2021.103264

Moutinho, V., Costa, C., Bento, J.P.C., 2015. The impact of energy efficiency and economic productivity on CO2 emission intensity in Portuguese tourism industries. Tourism Management Perspectives 16, 217–227. https://doi.org/10.1016/j.tmp.2015.07.009

Munjal, P., 2013. Measuring the Economic Impact of the Tourism Industry in India Using the Tourism Satellite Account and Input—Output Analysis - Poonam Munjal, 2013 [WWW Document]. URL https://journals.sagepub.com/doi/abs/10.5367/te.2013.0239 (accessed 11.1.22).

Murillo, J., Vayà, E., Romaní, J., Suriñach, J., 2013. How Important to a City are Tourists and Day-Trippers? The Economic Impact of Tourism on the City of Barcelona. Tourism Economics 19, 897–917. https://doi.org/10.5367/te.2013.0225

ONS, 2023. UK input-output analytical tables, industry by industry: 2019 - Office for National Statistics [WWW Document]. URL https://www.ons.gov.uk/releases/ukinputoutputanalyticaltablesindustrybyindustry2019 (accessed 7.16.24).

ONS, 2022. Energy use: fossil fuels by fuel type - Office for National Statistics [WWW Document]. URL https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsfuelusebytype (accessed 5.15.23).

ONS, 2019. UK Environmental Accounts - Office for National Statistics [WWW Document]. URL https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/ukenvironmentalaccounts/2019 (accessed 6.9.23).

Oosterhaven, J., Fan, T., 2006. Impact of international tourism on the Chinese economy. International Journal of Tourism Research 8, 347–354. https://doi.org/10.1002/jtr.582

Palmer, T., Riera, A., 2003. Tourism and environmental taxes. With special reference to the "Balearic ecotax." Tourism Management 24, 665–674. https://doi.org/10.1016/S0261-5177(03)00046-3

Pambudi, D., McCaughey, N., Smyth, R., 2009. Computable general equilibrium estimates of the impact of the Bali bombing on the Indonesian economy. Tourism Management 30, 232–239. https://doi.org/10.1016/j.tourman.2008.06.007

Peng, B., Song, H., Crouch, G., 2019. A meta-analysis of international tourism demand forecasting and implications for practice. [WWW Document]. https://doi.org/10.1016/j.tourman.2014.04.005

Ponjan, P., Thirawat, N., 2016. Impacts of Thailand's tourism tax cut: A CGE analysis. Annals of Tourism Research 61, 45–62. https://doi.org/10.1016/j.annals.2016.07.015

Reis, H., Rua, A., 2009. An Input–Output Analysis: Linkages versus Leakages. International Economic Journal 23, 527–544. https://doi.org/10.1080/10168730903372323

Robaina-Alves, M., Moutinho, V., Costa, R., 2016. Change in energy-related CO2 (carbon dioxide) emissions in Portuguese tourism: a decomposition analysis from 2000 to 2008. Journal of Cleaner Production, Special Volume: Sustainable Tourism: Progress, Challenges and Opportunities 111, 520–528. https://doi.org/10.1016/j.jclepro.2015.03.023

Rodenburg, E., 1980. The effects of scale in economic development: Tourism in Bali [WWW Document]. https://doi.org/10.1016/0160-7383(80)90003-1

Romero, I., Tejada, P., 2011. A multi-level approach to the study of production chains in the tourism sector. Tourism Management 32, 297–306. https://doi.org/10.1016/j.tourman.2010.02.006

Scottish Government, 2022. Growth sector statistics [WWW Document]. URL http://www.gov.scot/publications/growth-sector-statistics/ (accessed 6.20.24).

Scottish Government, 2021. Government Expenditure & Revenue Scotland (GERS) 2021-22 [WWW Document]. URL https://www.gov.scot/publications/government-expenditure-revenue-scotland-gers-2021-22/ (accessed 7.15.24).

Scottish Government, 2020. Supply, Use and Input-Output Tables [WWW Document]. URL https://www.gov.scot/publications/about-supply-use-input-output-tables/ (accessed 7.17.24).

Seetaram, N., Song, H., Ye, S., Page, S., 2018. Estimating willingness to pay air passenger duty. Annals of Tourism Research 72, 85–97. https://doi.org/10.1016/j.annals.2018.07.001

Seetaram, N., Song, H., Page, S., 2014. Air Passenger Duty and Outbound Tourism Demand from the United Kingdom [WWW Document]. URL https://journals.sagepub.com/doi/10.1177/0047287513500389 (accessed 1.23.23).

Shaffiullah, M., Okafor, L.E., Khalid, U., 2018. Determinants of international tourism demand: Evidence from Australian states and territories - Muhammad Shafiullah, Luke Emeka Okafor, Usman Khalid, 2019 [WWW Document]. URL https://journals.sagepub.com/doi/full/10.1177/1354816618800642?casa_token=-0YEjhlQZ9AAAAAA%3AFeItz9DOJLOn1TE7TBSAKUODJdm_1s602Ai43A0OiB0G9phBa8KyZhSt3OlA-PPHsFaPwc2sOpQ (accessed 10.29.22).

Shahbaz, M., Bashir, M.F., Bashir, M.A., Shahzad, L., 2021. A bibliometric analysis and systematic literature review of tourism-environmental degradation nexus. Environ Sci Pollut Res 28, 58241–58257. https://doi.org/10.1007/s11356-021-14798-2

Sinclair, M.T., 1998. Tourism and economic development: A survey. The Journal of Development Studies 34, 1–51. https://doi.org/10.1080/00220389808422535

Song, H., 2021. A Critique of Tourism-Led Economic Growth Studies [WWW Document]. https://doi.org/10.1177/00472875211018514

Song, H., Li, G., 2008. Tourism demand modelling and forecasting—A review of recent research. Tourism Management 29, 203–220. https://doi.org/10.1016/j.tourman.2007.07.016

Song, H., Seetaram, N., Ye, S., 2019. The effect of tourism taxation on tourists' budget allocation. Journal of Destination Marketing & Management 11, 32–39. https://doi.org/10.1016/j.jdmm.2018.12.001

Song, H., Witt, S.F., Li, G., 2008. The Advanced Econometrics of Tourism Demand. Routledge, New York. https://doi.org/10.4324/9780203891469

Sun, Y.-Y., 2014. A framework to account for the tourism carbon footprint at island destinations. Tourism Management 45, 16–27. https://doi.org/10.1016/j.tourman.2014.03.015

Sun, Y.-Y., Pratt, S., 2014. The Economic, Carbon Emission, and Water Impacts of Chinese Visitors to Taiwan: Eco-efficiency and Impact Evaluation. Journal of Travel Research 53, 733–746. https://doi.org/10.1177/0047287513517420

Towa, E., Zeller, V., Achten, W.M.J., 2019. Input-output models and waste management analysis: A critical review | Elsevier Enhanced Reader [WWW Document]. https://doi.org/10.1016/j.jclepro.2019.119359

Tsai, K.-T., Lin, T.P., Lin, Y.-H., Tung, C.-H., Chiu, Y.-T., 2018. The Carbon Impact of International Tourists to an Island Country. Sustainability 10, 1386. https://doi.org/10.3390/su10051386

Tsukui, M., Ichikawa, T., Kagatsume, M., 2017. Repercussion effects of consumption by domestic tourists in Tokyo and Kyoto estimated using a regional waste input–output approach. Economic Structures 6, 1. https://doi.org/10.1186/s40008-017-0061-3

UK Government, 2022. Greenhouse gas reporting: conversion factors 2022 [WWW Document]. GOV.UK. URL https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022 (accessed 5.15.23).

UNWTO, 2024. International Tourism to Reach Pre-Pandemic Levels in 2024 [WWW Document]. URL http://www.unwto.org/news/international-tourism-to-reach-pre-pandemic-levels-in-2024 (accessed 6.20.24).

UNWTO, 2022. Glossary of tourism terms | UNWTO [WWW Document]. URL https://www.unwto.org/glossary-tourism-terms (accessed 12.9.22).

UNWTO, 2021. UNWTO | World Tourism Organization a UN Specialized Agency [WWW Document]. URL https://www.unwto.org/ (accessed 12.7.22).

Usman, O., Alola, A.A., 2023. How do environmental taxes influence the effect of tourism on environmental performance? Evidence from EU countries. Current Issues in Tourism 26, 4034–4051. https://doi.org/10.1080/13683500.2022.2157706

Vergori, A.S., 2017. Patterns of seasonality and tourism demand forecasting [WWW Document]. URL https://journals.sagepub.com/doi/full/10.1177/1354816616656418?casa_token=5av_bJv74NEAAAAA%3AUhHFQ0b1XtRp-LUFCGppiQTZ15c0plJ7H2VidoWCus2cRT7hVmi9eF4qSlTFJ02DkRSsb69Lgmfxbw (accessed 10.28.22).

Visit Britain, 2015. Introduction to tourism [WWW Document]. VisitBritain. URL https://www.visitbritain.org/introduction-tourism (accessed 12.8.22).

Wang, S., Hu, Y., He, H., Wang, G., 2017. Progress and Prospects for Tourism Footprint Research. Sustainability 9, 1847. https://doi.org/10.3390/su9101847

Wickramasinghe, K., Naranpanawa, A., 2022. Systematic literature review on computable general equilibrium applications in tourism. Tourism Economics 28, 1647–1668. https://doi.org/10.1177/13548166211006988

WTTC, 2022. Travel & Tourism Economic Impact | World Travel & Tourism Council (WTTC) [WWW Document]. URL https://wttc.org/research/economic-impact (accessed 12.7.22).

Wu, Liu, Fu, Sing, Liu, 2018. Developing a Web-based regional tourism satellite account (TSA) information system [WWW Document]. https://doi.org/10.1177/1354816618792446

Zha, J., Shao, Y., Li, Z., 2019. Linkage analysis of tourism-related sectors in China: An assessment based on network analysis technique. International Journal of Tourism Research 21, 531–543. https://doi.org/10.1002/jtr.2280

Zhang, J., 2021. Impacts of the emissions policies on tourism: An important but neglected aspect of sustainable tourism. Journal of Hospitality and Tourism Management 47, 453–461. https://doi.org/10.1016/j.jhtm.2021.02.006

Zhang, Zhang, 2019. Carbon tax, tourism CO2 emissions and economic welfare | Elsevier Enhanced Reader [WWW Document]. https://doi.org/10.1016/j.annals.2017.12.009

7 Appendix

7.1 Chapter 2 Appendix

One of the advantages of using CGE models is that they allow us to analyse how changes to the price of commodities through a shock affect demand in the economy. CGE models are innately price-sensitive.

In the standard AMOS model, the Consumer Price Index, CPI_t, is calculated as per the below equation.

$$CPI_t = \sum_i \frac{PQ_{i,t} \cdot (Q_{i,t=0}^{hh})}{PQ_{i,t=0} \cdot \left(Q_{i,t=0}^{hh}\right)} \qquad 7.1$$

Here, $PQ_{i,t}$ is the price of commodity i within the model and $Q_{i,t=0}^{hh}$ is the initial value of household demand. Hence the CPI is the sum of the change in the price of the commodities.

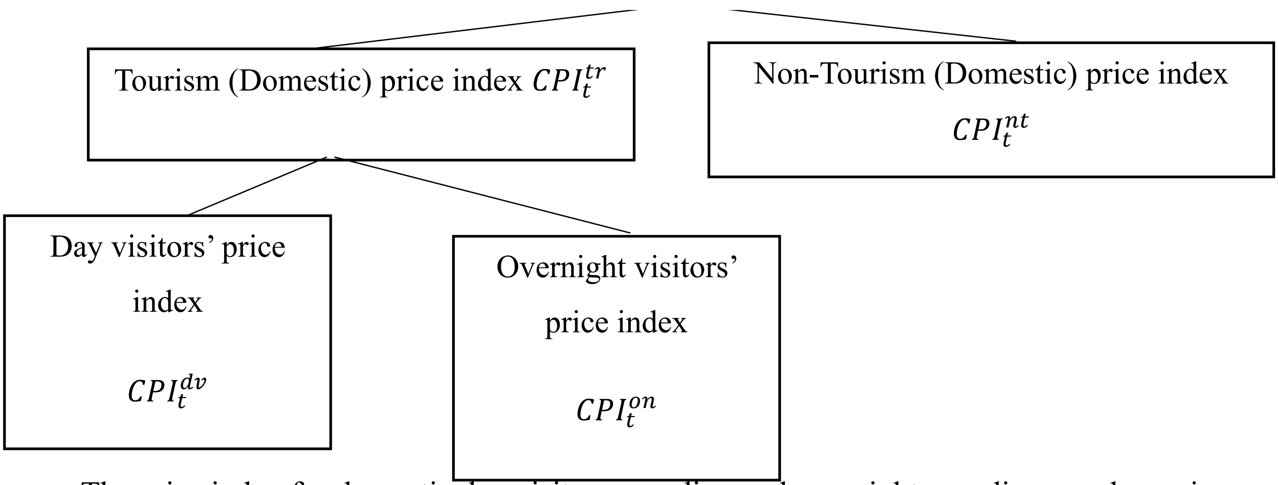
However, because there is a disaggregation of household demand within the economy into tourism day visitors spending, tourism overnight visitor spending and non-tourism spending. Hence the standard way of calculating the standard CPI within the economy is shown in the equation below:

$$CPI_t = \sum_i \frac{PQ_{i,t} \cdot (Q_{i,t=0}^{h,nt}, Q_{i,t=0}^{h,dv}, Q_{i,t=0}^{h,on})}{PQ_{i,t=0} \cdot \left(Q_{i,t=0}^{h,nt}, Q_{i,t=0}^{h,dv}, Q_{i,t=0}^{h,on}\right)} \qquad 7.2$$

Equation 7.2 is an extended version of the standard CPI that is shown in equation 7.1. CPI_t is the sum of the price of commodities multiplied by the sum of the share of consumption that is associated with non-tourism, $Q_{i,t=0}^{h,nt}$, day visitors spending, $Q_{i,t=0}^{h,dv}$, and overnight spending, $Q^{h,on}_{i,t=0}$, divided by the price of commodity multiplied by the share of consumption for all of the household consumption choices within the model[27].

The way that household consumption is modelled within the economy, we incorporate substitution possibilities between the consumption bundles. Modelling the Consumer Price Index within the economy in the way shown in the above equations does not allow us to analyse the impacts of the substitution between consumption bundles in the model, because of price changes. Given that each of the consumption bundles has a separate price attached to it, we model the CPI in the same way as the consumption bundles.

Figure 7.1 Nested price index within AMOSTRAVEL



The price index for domestic day visitors spending and overnight spending are shown in the two equations below:

$$CPI^{d,dv}_{t} = \sum_{i} \frac{PQ_{i,t} \cdot Q^{d,dv}_{i,t=0}}{PQ_{i,t=0} \cdot Q^{d,dv}_{i,t=0}} \qquad 7.3$$

[27] $(Q^{h,nt}_{i,t=0}, Q^{h,dv}_{i,t=0}, Q^{h,on}_{i,t=0})$ is equal to total (domestic household) consumption within the model

$$CPI_t^{on} = \sum_i \frac{PQ_{i,t} \cdot (1 + \tau_i) \cdot Q_{i,t=0}^{h,on}}{PQ_{i,t=0} \cdot Q_{i,t=0}^{h,on}} \quad 7.4$$

In both equations the CPI is calculated through multiplying the price of commodity $PQ_{i,t}$ by the share of consumption that is associated with day visitors spending $Q_{i,t=0}^{h,dv}$ and overnight visitor spending $Q_{i,t=0}^{h,on}$ respectively divided by the initial price and sectoral share of consumption for the consumption bundle.

In equation 7.4 $(1 + \tau_i)$ represents the tax rate that is applied to accommodation. Day visitors do not consume accommodation hence the tax rate does not appear in the day visitors CPI equation.

A price index for non-tourism spending is also required in this case and this is defined in the following equation:

$$CPI_t^{nt} = \sum_i \frac{PQ_{i,t} \cdot Q_{i,t=0}^{h,nt}}{PQ_{i,t=0} \cdot Q_{i,t=0}^{h,nt}} \quad 7.5$$

When the price of day visitors spending and/or domestic overnight spending is increased, then a required specification of the model is that the price change is reflected and fed through to the price index of the domestic tourism consumption, CPI_t^{tr}.

$$CPI_t^{tr} = \frac{\left(CPI_t^{dv} \cdot DV_{t=0}\right) + \left(CPI_t^{on} \cdot ON_{t=0}\right)}{TR_{t=0}} \quad 7.6$$

Day visitors' consumption and overnight visitors consumption are denoted $DV_{t=0}$ and $ON_{t=0}$ respectively. $TR_{t=0}$ is demand for total tourism spending. These are the aggregates of the sectoral shares that are assigned $Q_{i,t=0}^{h,dv}$ and $Q_{i,t=0}^{h,on}$ and these will be denoted as DV_t and ON_t in the following paragraphs. Equation 7.6 shows that the price index for total domestic tourism spending is dependent on the price and demand for each of the domestic categories.

The price change in the total spending bundle therefore must be reflected in the CPI for the whole economy and hence in the model we calculate the CPI in an unconventional way. The reason that this is unconventional is because the CPI is calculated through in a nested fashion, where the change in the day visitors or overnight consumption bundle, is fed into the tourism price index and into the CPI presented mathematically in the equation below:

$$CPI_t^* = \frac{(CPI_t^{tr} \cdot TR_{t=0}) + (CPI_t^{nt} \cdot NT_{t=0})}{C_{t=0}} \qquad 7.7$$

The general CPI for the economy is a function of the price and demand for tourism and non-tourism. The baseline level of consumption in the economy without a shock being applied is equal to tourism consumption and non-tourism consumption. This allows any price changes from the domestic tourism bundles to be reflected in the general price for the overall economy.

Table 7.1 Comparison of mean values of Sim A, Sim B and Sim C

Macroeconomic variables	SIM A	SIM B	SIM C
Gross Domestic Product	-0.030	-0.012	-0.021
Consumer Price Index	0.062	0.080	0.071
Employment	-0.024	-0.003	-0.014
Nominal Gross wage	-0.066	-0.007	-0.038
Government expenditure	0.000	0.145	0.075
Government Revenue	0.056	0.095	0.074
Household Consumption	-0.091	-0.054	-0.074
Scottish non-tourist consumption	-0.091	-0.042	-0.061
Tourist consumption	-0.091	-0.327	-0.344
Scottish Overnight visitors	-2.059	-2.027	-2.044
Scottish Day visitors spending	0.040	0.074	0.056
RUK day tourist spending	0.023	0.002	0.013
RUK overnight spending	-1.764	-1.784	-1.773
International overnight	-1.764	-1.784	-1.773
Tourism tax revenue	80.861	80.861	80.861

Table 7.2 Impacts of 5% accommodation tax on Scottish day visitors spending from simulation A

		Tourism / Non-Tourism elasticity																													
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Scottish day / overnight elasticity	0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.6	-0.6	-0.6
	0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.6
	0.3	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
	0.4	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5
	0.5	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5
	0.6	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5
	0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4
	0.8	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4
	0.9	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4
	1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4
	1.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
	1.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3
	1.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3
	1.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3
	1.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
	1.6	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
	1.7	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
	1.8	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
	1.9	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
	2	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
	2.1	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
	2.2	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	2.3	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	2.4	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
	2.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
	2.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
	2.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	2.8	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
	2.9	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1
	3	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2

7.2 Chapter 3 Appendix

Table 7.3 Absolute changes is industrial emissions from accommodation tax

	Coal	**Natural Gas**	**Petrol**	**Derv**	**Fuel Oil**	**Gas Oil**	**Total change in emissions by sector**
Agriculture	0.00	0.00	0.00	0.00	0.00	0.33	**0.33**
Forestry Planting and Forestry Harvesting	0.00	0.00	0.00	0.00	0.00	0.02	**0.02**
Fishing and Aquaculture	0.00	0.00	0.00	0.00	0.01	0.25	**0.25**
Coal & Ignite	0.00	0.00	0.00	0.00	0.00	0.01	**0.01**
Oil and gas extraction etc	0.00	-0.01	0.00	0.00	0.00	0.04	**0.03**
Food processing	0.00	-0.01	0.00	-0.01	0.00	0.00	**-0.01**
Alcohol and Soft drinks production	0.00	-0.06	0.00	-0.01	0.00	0.00	**-0.06**
Textiles, wood and paper	0.01	0.01	0.00	0.00	0.00	0.00	**0.01**
Coke, petroleum & petrochemicals	0.02	-0.03	0.00	0.00	0.00	0.00	**-0.01**
Other chemicals, robber plastics etc	0.04	0.02	0.00	0.00	0.00	0.00	**0.06**
Computers, electronics and other manufacturing	0.00	0.00	0.00	-0.01	0.00	0.00	**0.00**
Electricity	0.12	-0.15	0.00	0.00	0.00	0.01	**-0.02**
Gas	0.00	-0.01	0.00	0.00	0.00	0.00	**-0.01**
Water and waste	0.00	0.00	0.00	-0.01	0.00	0.01	**-0.01**
Construction	0.00	0.01	0.00	0.00	0.00	0.11	**0.12**
W & R	0.00	0.01	0.00	0.00	0.00	0.01	**0.01**
Retail excluding vehicles	0.00	0.02	0.00	0.01	0.00	0.00	**0.03**
Other land transport	0.00	0.00	0.00	0.02	0.00	0.09	**0.11**
Other transport	0.00	0.00	0.00	0.00	0.26	0.10	**0.36**
Support and post	0.00	0.00	0.00	0.00	0.00	0.04	**0.05**
Accommodation	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Food and Beverage services	0.00	0.01	0.00	0.00	0.00	0.00	**0.01**
Services	0.00	0.01	0.00	-0.01	0.00	0.00	**0.01**
Public Administration & Defence	0.00	-0.02	0.00	-0.01	0.00	0.03	**0.00**
Education & Health	0.00	-0.01	0.00	0.00	0.00	0.00	**-0.01**
Creative, cultural and recreational services	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Other	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Total	**0.19**	**-0.20**	**0.00**	**-0.04**	**0.29**	**1.06**	**1.30**

Table 7.4 Absolute change in industrial emissions from land transport tax

	Coal	Natural Gas	Petrol	Derv	Fuel Oil	Gas Oil	**Total change in emissions by sector**
Agriculture	0.00	-0.01	-0.00	-0.02	-0.00	-0.13	**-0.15**
Forestry Planting and Forestry Harvesting	0.00	0.00	-0.00	-0.00	0.00	-0.00	**-0.00**
Fishing and Aquaculture	0.00	0.00	0.00	0.00	0.00	0.05	**0.05**
Coal & Ignite	-0.00	-0.00	0.00	-0.00	0.00	-0.00	**-0.00**
Oil and gas extraction etc	0.00	0.04	0.00	0.00	0.00	0.02	**0.06**
Food processing	-0.00	-0.02	-0.00	-0.00	-0.00	-0.00	**-0.02**
Alcohol and Soft drinks production	0.00	0.07	0.00	0.01	0.00	0.00	**0.08**
Textiles, wood and paper	0.00	0.01	0.00	0.00	0.00	0.00	**0.01**
Coke, petroleum & petrochemicals	0.04	0.05	0.00	0.00	0.00	0.00	**0.09**
Other chemicals, robber plastics etc	0.02	0.06	0.00	0.01	0.00	0.00	**0.10**
Computers, electronics and other manufacturing	0.00	0.02	0.00	0.01	0.00	0.00	**0.04**
Electricity	-0.04	-0.80	-0.00	-0.00	0.00	-0.00	**-0.84**
Gas	0.00	-0.02	-0.00	-0.00	0.00	0.00	**-0.02**
Water and waste	0.00	-0.00	-0.00	-0.00	0.00	-0.00	**-0.00**
Construction	0.00	0.00	0.00	0.02	0.00	0.01	**0.03**
W & R	0.00	-0.00	0.00	0.01	0.00	0.00	**0.01**
Retail excluding vehicles	0.00	-0.06	-0.00	-0.09	0.00	-0.00	**-0.16**
Other land transport	-0.00	-0.00	-0.02	-0.17	0.00	-0.02	**-0.21**
Other transport	0.00	-0.00	-0.00	-0.00	-0.07	-0.03	**-0.09**
Support and post	0.00	0.00	0.00	0.01	0.00	0.01	**0.02**
Accommodation	0.00	-0.10	-0.00	-0.00	-0.00	-0.00	**-0.10**
Food and Beverage services	-0.00	-0.12	-0.00	-0.01	-0.00	-0.00	**-0.13**
Services	0.00	-0.03	-0.00	-0.01	-0.00	-0.00	**-0.04**
Public Administration & Defence	0.00	0.01	0.00	0.00	0.00	0.00	**0.02**
Education & Health	0.00	-0.02	-0.00	-0.00	-0.00	-0.00	**-0.02**
Creative, cultural and recreational services	-0.00	-0.03	-0.00	-0.01	-0.00	-0.00	**-0.03**
Other	0.00	-0.02	-0.00	-0.01	-0.00	-0.00	**-0.03**
Total	**0.03**	**-0.96**	**-0.03**	**-0.26**	**-0.07**	**-0.10**	**-1.38**

Table 7.5 Absolute change in industrial emissions from fuel sales tax

Sectors	Coal	Natural Gas	Petrol	Derv	Fuel Oil	Gas Oil	**Total changes in emissions by sector**
Agriculture	0.00	0.00	0.00	-0.01	0.00	0.08	**0.06**
Forestry Planting and Forestry Harvesting	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Fishing and Aquaculture	0.00	0.00	0.00	0.00	0.00	0.06	**0.06**
Coal & Ignite	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Oil and gas extraction etc	0.00	-0.02	0.00	0.00	0.00	0.01	**-0.01**
Food processing	0.00	-0.03	0.00	-0.01	0.00	0.00	**-0.04**
Alcohol and Soft drinks production	0.00	-0.06	0.00	-0.01	0.00	0.00	**-0.07**
Textiles, wood and paper	0.00	-0.02	0.00	-0.01	0.00	0.00	**-0.03**
Coke, petroleum & petrochemicals	-0.02	-0.03	0.00	0.00	0.00	0.00	**-0.05**
Other chemicals, robber plastics etc	-0.01	-0.03	0.00	-0.01	0.00	0.00	**-0.05**
Computers, electronics and other manufacturing	0.00	-0.02	0.00	-0.01	0.00	0.00	**-0.03**
Electricity	-0.05	-0.51	0.00	0.00	0.00	0.00	**-0.56**
Gas	0.00	-0.02	0.00	0.00	0.00	0.00	**-0.02**
Water and waste	0.00	0.00	0.00	-0.02	0.00	0.00	**-0.02**
Construction	0.00	-0.01	-0.01	-0.04	0.00	0.03	**-0.03**
W & R	0.00	0.00	0.00	-0.04	0.00	0.00	**-0.04**
Retail excluding vehicles	0.00	0.00	0.00	-0.02	0.00	0.00	**-0.02**
Other land transport	0.00	0.00	-0.01	-0.12	0.00	0.02	**-0.11**
Other transport	0.00	0.00	0.00	0.00	0.06	0.02	**0.08**
Support and post	0.00	0.00	0.00	-0.01	0.00	0.01	**0.00**
Accommodation	0.00	-0.01	0.00	0.00	0.00	0.00	**-0.01**
Food and Beverage services	0.00	-0.01	0.00	0.00	0.00	0.00	**-0.01**
Services	0.00	-0.02	0.00	-0.02	0.00	0.00	**-0.04**
Public Administration & Defence	0.00	-0.02	0.00	-0.01	0.00	0.01	**-0.03**
Education & Health	0.00	-0.06	0.00	0.00	0.00	0.00	**-0.06**
Creative, cultural and recreational services	0.00	0.00	0.00	0.00	0.00	0.00	**-0.01**
Other	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Total	**-0.09**	**-0.87**	**-0.03**	**-0.35**	**0.07**	**0.24**	**-1.03**

7.3 The Mathematical Presentation of AMOSTRAVEL

Note: The model is based on Lecca et al. (2013) with tourism extensions, these equations reflect that.

Prices

$$PM_{i,t} = \varepsilon_t \cdot PWM_i \cdot (1 + MTAX_i) \tag{A.1}$$

$$PE_{i,t} = \varepsilon_t \cdot PWE_i \cdot (1 - TE_i) \tag{A.2}$$

$$PX_{i,t} = PQ_{i,t} \tag{A.3}$$

$$PQ_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PM_{i,t} \cdot M_{i,t}}{R_{i,t} + M_{i,t}} \tag{A.4}$$

$$PIR_{j,t} = \frac{\sum_i VR_{i,j,t} \cdot PR_{j,t} + \sum_i VI_{i,j,t} \cdot \overline{PI}_j}{\sum_i VIR_{i,j,t}} \tag{A.5}$$

$$PY_{j,t} \cdot a_j^Y = \left(Pr_{j,t} \cdot \left(1 - btax_j - sub_j - dep_j\right) - \sum_i a_{i,j}^V PQ_{j,t} \right) \tag{A.6}$$

$$UCK_t = PINV_t \cdot (ir + \delta) \tag{A.7}$$

$$PC_t = \frac{\sum_i PQ_{i,t} \cdot \left(DV^d + ON^d + NT^d\right)}{\sum_i PQ_{i,t=0} \cdot \left(DV^d + ON^d + NT^d\right)} \tag{A.8}$$

$$w_t^b = \frac{w_t}{(1 + sscee + sscer) \cdot (1 + ire)} \tag{A.9}$$

(A.10)

$$wage\ setting \begin{cases} RB \rightarrow\ ln\left[\frac{w_t^b}{PC_t}\right] = \beta - \mu \cdot ln(u_t) \\ NB \rightarrow\ w_t = w_{t=0} \\ FWRB \rightarrow \frac{w_t}{cpi_t} = \frac{w_{t=0}}{cpi_{t=0}} \end{cases}$$

$$rk_{j,t} = PY_{j,t} \cdot \delta_j^k \cdot A(\xi_{j,t})^{\varrho_j} \cdot \left(\frac{Y_{j,t}}{K_{j,t}}\right)^{1-\varrho_j} \quad \textbf{(A.11)}$$

$$PINV_t = \frac{\sum_j PQ_{j,t} \cdot \sum_i KM_{i,j}}{\sum_i \sum_j KM_{i,j}} \quad \textbf{(A.12)}$$

$$CPI_t^{ruk,dv} = \frac{\sum_i PQ_{i,t} \cdot DV_t^{ruk}}{\sum_i PQ_{i,t=0} \cdot DV_t^{ruk}} \quad \textbf{(A.13)}$$

$$CPI_t^{ruk,on} = \frac{\sum_i PQ_{i,t} \cdot ON_t^{ruk}}{\sum_i PQ_{i,t=0} \cdot ON_t^{ruk}} \quad \textbf{(A.14)}$$

$$CPI_t^* = \frac{(CPI_t^{tr} \cdot TR_{t=0}) + (CPI_t^{nt} \cdot NT_{t=0})}{C_{t=0}} \quad \textbf{(A.15)}$$

$$CPI_t^{int,on} = \frac{\sum_i PQ_{i,t} \cdot ON_t^{int}}{\sum_i PQ_{i,t=0} \cdot ON_t^{int}} \quad \textbf{(A.16)}$$

$$CPI_t^{nt} = \frac{\sum_i PQ_{i,t} \cdot NT_{(t=0)}}{\sum_i PQ_{i,t=0} \cdot NT_{t=0}} \quad \textbf{(A.17)}$$

$$CPI_t^{tr} = \frac{\left(CPI^{d,dv} \cdot DV_{t=0}\right) + \left(CPI^{d,on} \cdot ON_{t=0}\right)}{TR_{t=0}} \quad \textbf{(A.18)}$$

$$CPI_t^{d,dv} = \frac{\sum_i PQ_{i,t} \cdot DV_t^{d,dv}}{\sum_i PQ_{i,t=0} \cdot DV_t^{d,dv}} \quad \textbf{(A.19)}$$

$$CPI_t^{d,on} = \frac{\sum_i PQ_{i,t} \cdot DV_t^{d,on}}{\sum_i PQ_{i,t=0} \cdot DV_t^{d,on}} \quad \textbf{(A.20)}$$

Production technology

$$X_{i,t} = min\left(\frac{Y_{i,t}}{a_i^Y};\frac{V_{i,j,t}}{a_{i,j}^V}\right) \tag{A.21}$$

$$Y_{i,t} = a_i^Y \cdot X_{i,t} \tag{A.22}$$

$$V_{i,t} = a_{i,j}^V \cdot X_{i,t} \tag{A.23}$$

$$Y_{i,t} = A(\xi_{i,t}) \cdot \left[\delta_i^k K_{i,t}^{\rho_i} + \delta_i^l L_{i,t}^{\rho_i}\right]^{\frac{1}{\rho_i}} \tag{A.24}$$

$$L_{j,t} = \left(A(\xi_{j,t})^{\rho_i} \cdot \delta_j^l \cdot \frac{PY_{j,t}}{w_t}\right)^{\frac{1}{1-\rho_j}} \cdot Y_{j,t} \tag{A.25}$$

Trade

$$VV_{i,j,t} = \gamma_{i,j}^{vv} \cdot \left[\delta_{i,j}^{vm} VM_{i,t}^{\rho_i^A} + \delta_{i,j}^{vir} VIR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \tag{A.26}$$

$$\frac{VM_{i,j,t}}{VIR_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vm}}{\delta_{i,j}^{vir}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \tag{A.27}$$

$$VIR_{i,j,t} = \gamma_{i,j}^{vir} \cdot \left[\delta_{i,j}^{vi} VI_{i,t}^{\rho_i^A} + \delta_{i,j}^{vr} VR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \tag{A.28}$$

$$\frac{VR_{i,j,t}}{VI_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vr}}{\delta_{i,j}^{vi}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \tag{A.29}$$

$$TV_{j,t} = \sum_i VV_{i,j,t} \tag{A.30}$$

$$TVR_{j,t} = \sum_{i} VR_{i,j,t} \tag{A.31}$$

$$TVI_{j,t} = \sum_{i} VI_{i,j,t} \tag{A.32}$$

$$TVM_{j,t} = \sum_{i} VM_{i,j,t} \tag{A.33}$$

$$E_{i,t} = \bar{E}_i \cdot \left(\frac{PE_{i,t}}{PQ_{i,t}}\right)^{\sigma_i^x} \tag{A.34}$$

$$M_{i,t} = \sum_{j} VI_{i,j,t} + \sum_{j} VM_{i,j,t} + \sum_{h} QHM_{i,t}^{nt} + QHM_{i,t}^{dv} + QHM_{i,t}^{on} + +QGM_{i,t} + QVI_{i,t} + QVM_{i,t} \tag{A.35}$$

$$CA_t = \sum_{i} M_{i,t} \cdot PM_{i,t} - \sum_{i} E_{i,t} \cdot PE_{i,t} + \varepsilon_t \cdot \left(\sum_{dngins} \overline{REM}_{dngins} + \overline{FE}\right) \tag{A.36}$$

$$R_{i,t} = \sum_{j} VR_{i,j,t} + \sum_{h} QHR_{i,t}^{nt} + QHR_{i,t}^{dv} + QHR_{i,t}^{on} + QVR_{i,t} + QGR_{i,t} + TR_{i,t}^{reg,n} \tag{A.37}$$

Domestic Institutions

$$YNG_{dngins,t} = d_{dngins}^{L} \cdot w_t \cdot \sum_{i} L_i + d_{dngins}^{K} \cdot rk_{i,t} \cdot \sum_{i} K_i + d_{dngins}^{h} \cdot rh_{i,t} \cdot \sum_{i} H_i + \sum_{dnginsp} TRSF_{dngins,dnginsp,t} + PC_t \cdot TRG_{dngins} + \varepsilon_t \cdot REM_{dngins} \tag{A.38}$$

$$TRSF_{dngins,dnginsp,t} = PC_t \cdot \overline{TRSF}_{dngins,dnginsp} \tag{A.39}$$

$$SAV_{dngins,t} = mps_{dngins} \cdot YNG_{dngins,t} \tag{A.40}$$

$$C_t = \sum_{dngins \in \langle HH \rangle} YNG_{dngins,t} - \sum_{dngins \in \langle HH \rangle} SAV_{dngins,t} - HTAX_t - TRTAX_t \sum_{dngins} \sum_{h} TRSF_{dngins,h,t} \quad \textbf{(A.41)}$$

Consumption equations

(A.42)

$$C_t = \gamma^c \left(\alpha^c \cdot TR_t^{\rho^c} + (1-\alpha^c) \cdot NT_t^{\rho^c} \right)^{\frac{1}{\rho^c}} \quad \textbf{(A.43)}$$

$$NT_t^d = \left(\gamma^{tr^{\rho^{tr}}} \cdot (1-\alpha^c) \cdot \left(\frac{cpi_t}{cpi_t^{nt}} \right) \right)^{\frac{1}{1-\rho^{tr}}} \cdot C_t \quad \textbf{(A.44)}$$

$$TR_t^d = \left(\gamma^{tr^{\rho^{tr}}} \cdot (\alpha^c) \cdot \left(\frac{cpi_t}{cpi_t^{tr}} \right) \right)^{\frac{1}{1-\rho^{tr}}} \cdot C_t \quad \textbf{(A.45)}$$

$$ON_t^d = \left(\gamma^{d^{\rho^d}} \cdot (1-\alpha^{tr}) \cdot \left(\frac{cpi_t^{tr}}{cpi_t^{on}} \right) \right)^{\frac{1}{1-\rho^d}} \cdot TR_t \quad \textbf{(A.46)}$$

$$DV_t^d = \left(\gamma^{d^{\rho^d}} \cdot (\alpha^{tr}) \cdot \left(\frac{cpi_t^{tr}}{cpi_t^{dv}} \right) \right)^{\frac{1}{1-\rho^d}} \cdot TR_t \quad \textbf{(A.47)}$$

$$QH_{i,t} = L_i^{qh} \cdot NT_t^d \quad \textbf{(A.48)}$$

$$Q_{i,t}^{dv} = L_i^{dv} \cdot DV_t^d \quad \textbf{(A.49)}$$

$$Q_{i,t}^{on} = L_i^{on} \cdot ON_t^d \quad \textbf{(A.50)}$$

$$QHM_{i,t}^{nt} = \left(\left(\gamma_i^{qh}\right)^{\rho_i^c} \cdot \delta_i^{qhm} \cdot \frac{PQ_{i,t}}{PM_{i,t}} \right)^{\frac{1}{1-\rho^c}} \cdot QH_{i,t} \tag{A.51}$$

$$QHM_{i,t}^{dv,on} = \left(\left(\gamma_i^{qh^{dv,on}}\right)^{\rho_i^c} \cdot \delta_i^{qhm,tr} \cdot \frac{PQ_{i,t}}{PM_{i,t}} \right)^{\frac{1}{1-\rho^{tr}}} \cdot Q_{i,t}^{dv,on} \tag{A.52}$$

$$QHIR_{i,t}^{nt} = \left(\left(\gamma_i^{qh}\right)^{\rho_i^c} \cdot \delta_i^{qhir} \cdot \frac{PQ_{i,t}}{PIR_{i,t}} \right)^{\frac{1}{1-\rho^c}} \cdot QH_{i,t} \tag{A.53}$$

$$QHM_{i,t}^{dv,on} = \left(\left(\gamma_i^{qh^{dv,on}}\right)^{\rho_i^c} \cdot \delta_i^{qir,tr} \cdot \frac{PQ_{i,t}}{PIR_{i,t}} \right)^{\frac{1}{1-\rho^{tr}}} \cdot Q_{i,t}^{dv,on} \tag{A.54}$$

Government equations

(A.55)

$$GY_t = (DSHR_{GOV,CAP}KY_t + \sum_i IBT_{i,t} + \sum_i IMT_{i,t} + HTAX_t + ETAX_t + CTAXTOT_t + \boldsymbol{TRTAX_t} + TINVT_t + +SAM_{IBT,TR^{ruk,ON}} + SAM_{IBT,TR^{ruk,DV}} + SAM_{IBT,TR^{INT,ON}} + SAM_{IBT,stock} + \sum_{fins} SAM_{IBT,fins} + \sum_i SUBSY_{i,t} + \sum_{fins} SAM_{gov,fins}) \cdot \epsilon_t$$

(A.56)

$$GEXP_t = GEXP_{t=0}$$

(A.57)

$$GEXP_t = GEXP_{t=0} + TRTAX_t$$

(A.58)

$$GOVBAL_t = \sum_i QG_{i,t} \cdot PQ_{i,t} + \overline{GSAV} + PC_t \cdot \sum_{dngins} TRG_{dngins,t} - (d_g^k \cdot \sum_i rk_{i,t} \cdot K_{i,t} + d_g^h \cdot \sum_i rh_{i,t} \cdot H_{i,t} + \sum_i IMT_{i,t} + HTAX_t + \overline{FE} \cdot \varepsilon_t$$

(A.59)

$$QG_{i,t} = \overline{QG}_i$$

(A.60)

$$QG_{i,t} = \gamma_i^g \cdot \left[\delta_i^{gr} \cdot QGR_{i,t}^{\rho_i^A} + \delta_i^{gm} \cdot QGM_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}}$$

(A.61)

$$\frac{QGR_{i,t}}{QGM_{i,t}} = \left[\left(\frac{\delta_i^{gr}}{\delta_i^{gm}}\right) \cdot \left(\frac{PM_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}}$$

(A.62)

$$QV_{i,t} = \sum_j KM_{i,j} \cdot J_{j,t}$$

(A.63)

$$QV_{i,t} = \gamma_i^v \cdot \left[\delta_i^{qvm} \cdot QVM_{i,t}^{\rho_i^A} + \delta_i^{qvir} \cdot QVIR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}}$$

(A.64)

$$\frac{QVM_{i,t}}{QVIR_{i,t}} = \left[\left(\frac{\delta_i^{qvm}}{\delta_i^{qvir}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \qquad \textbf{(A.65)}$$

$$QVIR_{i,t} = \gamma_i^{vir} \cdot \left[\delta_i^{qvi} \cdot QVI_{i,t}^{\rho_i^A} + \delta_i^{qvr} \cdot QVR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \qquad \textbf{(A.66)}$$

$$QVIR_{i,t} = \gamma_i^{vir} \cdot \left[\delta_i^{qvi} \cdot QVI_{i,t}^{\rho_i^A} + \delta_i^{qvr} \cdot QVR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \qquad \textbf{(A.67)}$$

$$\frac{QVR_{i,t}}{QVI_{i,t}} = \left[\left(\frac{\delta_i^{qvr}}{\delta_i^{qvi}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \qquad \textbf{(A.68)}$$

(A.69)

Investments

$$\frac{I_{i,t}}{KS_{i,t}} = \delta^K \cdot \left(\frac{rk_{i,t}}{uck_{i,t}}\right)^{\alpha_i}$$ **(A.70)**

$$J_{i,t} = I_{i,t}\left[1 + \frac{\beta_i}{2} \cdot \frac{I_{i,t}^2}{K_{i,t}}\right]$$ **(A.71)**

(A.72)

Factors accumulation

(A.73)

$$KS_{i,t} = (1-\delta^K) \cdot KS_{t-1} + I_{i,t-1}$$

Short Run

$$KS_{i,t} = KS_{i,t=0}$$

(A.74)

Long Run

$$I_{i,t=LR} = \delta^K \cdot KS_{t=LR}$$

$$LS_t = (1 + nim_t) \cdot LS_{t-1}$$

(A.75)

Short Run

$$LS_t = LS_{t=0}$$

$$nim_t = \varsigma - \nu^u[ln(u_t) - ln\,(\bar{u}^N)] + \nu^w\left[ln\left(\frac{w_t}{cpi_t}\right) - ln\left(\frac{w^N}{cpi^N}\right)\right]$$ **(A.76)**

Equilibrium conditions

$$K_{i,t} = KS_{i,t} \tag{A.77}$$

$$LS_t \cdot (1 - u_t) = \sum_j L_{j,t} \tag{A.78}$$

$$X_{i,t} + M_{i,t} = \sum_j VV_{i,j,t} + \sum_h QH_{i,h,t} + QV_{i,t} + QG_{i,t} + QHK_{i,t} + E_{i,t} \tag{A.79}$$

Inbound Tourism equations

(A.80)

Regional, r and RUK imported shares, m

$$DV_{i,t}^{ruk,reg} = \left(\left(\gamma_i^{rukdvs}\right)^{\rho^{rukdvs},r} \cdot \delta_i^{rukdv,r} \frac{cpi_t^{rukdv}}{cpi_t^{rukdv,r}}\right)^{\frac{1}{1-\rho_i^{rukdv,r}}} \cdot DV_{i,t}^{ruk} \quad \textbf{(A.81)}$$

$$DV_{i,t}^{ruk,m} = \left(\left(\gamma_i^{rukdvs}\right)^{\rho^{rukdvs},r} \cdot \delta_i^{rukdv,m} \frac{cpi_t^{rukdv}}{cpi_t^{rukdv,m}}\right)^{\frac{1}{1-\rho_i^{rukdv,m}}} \cdot DV_{i,t}^{ruk} \quad \textbf{(A.82)}$$

$$ON_{i,t}^{ruk,reg} = \left(\left(\gamma_i^{rukon}\right)^{\rho^{rukon},r} \cdot \delta_i^{rukon,r} \frac{cpi_t^{rukon}}{cpi_t^{rukon,r}}\right)^{\frac{1}{1-\rho_i^{rukon,r}}} \cdot ON_{i,t}^{ruk} \quad \textbf{(A.83)}$$

$$ON_{i,t}^{ruk,m} = \left(\left(\gamma_i^{rukon}\right)^{\rho^{rukon},r} \cdot \delta_i^{rukon,m} \frac{cpi_t^{rukon}}{cpi_t^{rukon,m}}\right)^{\frac{1}{1-\rho_i^{rukon,m}}} \cdot ON_{i,t}^{ruk} \quad \textbf{(A.84)}$$

$$ON_{i,t}^{int,reg} = \left(\left(\gamma_i^{inton}\right)^{\rho^{inton},r} \cdot \delta_i^{inton,r} \frac{cpi_t^{inton}}{cpi_t^{inton,r}}\right)^{\frac{1}{1-\rho_i^{inton,r}}} \cdot ON_{i,t}^{int} \quad \textbf{(A.85)}$$

$$\mathrm{DV}_{\mathrm{i,t}}^{\mathrm{ruk}} = DV_{i,t=0}^{ruk} \cdot \left(\frac{PM_{i,t}}{CPI^{rukdv}}\right)^{\sigma_n^{tr}} \quad \textbf{(A.86)}$$

$$ON_{\mathrm{i,t}}^{\mathrm{ruk}} = DV_{i,t=0}^{ruk} \cdot \left(\frac{PM_{i,t}}{CPI^{rukon}}\right)^{\sigma_n^{tr}} \quad \textbf{(A.87)}$$

$$ON_{\mathrm{i,t}}^{int} = ON_{i,t=0}^{ruk} \cdot \left(\frac{PM_{i,t}}{CPI^{inton}}\right)^{\sigma_n^{tr}} \quad \textbf{(A.88)}$$

Taxes and subsidies

(A.89)

$$IBT_{i,t} = btax_i \cdot X_{i,t} \cdot PX_{i,t} \quad \textbf{(A.90)}$$

$$IMT_{j,t} = \sum_i MTAX_j \cdot VM_{i,j,t} \cdot PM_{i,t} \quad \textbf{(A.91)}$$

$$SUBSY_{i,t} = SUB_i \cdot X_{i,t} \cdot PX_{i,t} \quad \textbf{(A.92)}$$

$$HTAX_t = \sum_h dtr_h \cdot (ssce + sscer) \cdot \sum_j L_{j,t} \cdot w_t \quad \textbf{(A.93)}$$

$$TRTAX_t = \quad \textbf{(A.94)}$$

Glossary

i,j	the set of goods or industries
ins	the set of institutions
$dins$ ($\subset ins$)	the set of domestic institutions
$dngins$ ($\subset dins$)	the set of non government institutions
h ($\subset dngins$)	the set of households
Notes	dv – day visitors, on - overnight visitors, n - inbound, ruk – rest of the uk, int - - international

Prices

$PX_{i,t}$	output price
$PY_{i,t}$	value added price
$PR_{i,t}$	regional price
$PQ_{i,t}$	commodity price
$PIR_{i,t}$	national commodity price (regional + RUK)
$PI_{i,t}$	RUK price
$rk_{i,t}$	rate of return to tangible capital
$rh_{i,t}$	rate of return to intangible capital (knowledge)
w_t	unified nominal wage
w_t^b	after tax wage
$PINV_t$	capital good price
$PINVH_t$	capital knowledge price
uck_t	user cost of physical capital
uch_t	user cost of tangible capital
PC_t	aggregate consumption price
$CPI_t^{ruk,d,int}$	Tourism specific CPI
ε_t	exchange rate

Endogenous Variables

$X_{i,t}$	total output
$R_{i,t}$	Regional supply
$M_{i,t}$	total import
$E_{i,t}$	total export (interregional + international)
$Y_{i,t}$	value added
$A_{i,t}$	scale factor in CES function
$L_{i,t}$	labour demand
$K_{i,t}$	demand of physical capital
$H_{i,t}$	demand of Knowledge
$KS_{i,t}$	physical capital stock
$HS_{i,t}$	knowledge stock
$LS_{i,t}$	labour supply
$VV_{i,jt}$	intermediate inputs
$VR_{i,jt}$	regional intermediate inputs
$VM_{i,jt}$	RUK intermediate inputs
$VIR_{i,jt}$	national intermediate inputs (regional+RUK)
$VI_{i,jt}$	RUK intermediate inputs
$QGR_{i,t}$	regional government expenditure
$QGM_{i,t}$	government expenditure from RUK+ROW
C_t	aggregated household consumption

NT_t	aggregated non-tourist consumption
TR_t	Aggregated tourism consumption
DV_t	Aggregated domestic day visitors spending
ON_t	Aggregated overnight visitors spending
$QH_{i,t}$	total households consumption in sector *i*
$Q_{i,t}^{dv}$	Total domestic day visitors spending in sector i
$Q_{i,t}^{on}$	Total domestic overnight visitors spending in sector i
L^{dv}, L^{on}	Splitting aggregate consumption into sectoral shares
$QHR_{i,h,t}$	regional consumption in sector *i*
$QHM_{i,t}^{dv,on}$	import consumption in sector *i* for domestic day visitors or overnight visitors
$QHM_{i,t}$	import consumption in sector *i*
$TR_{i,t}^{reg,n}$	Inbound tourism regional consumption in sector i (RUK + international)
$QV_{i,t}$	total investment by sector of origin *i*
$QVR_{i,t}$	regional investment by sector of origin *i*
$QVM_{i,t}$	ROW investment
$QVIR_{i,t}$	national investment (REG+RUK)
$QVI_{i,t}$	RUK investment
$QHK_{i,t}$	R&D investment by sector of origin *i*
$I_{j,t}$	investment by sector of destination *j*
$J_{j,t}$	investment by destination *j* with adjustment cost
$R_{j,t}$	R&D investment by sector of destination *j*

$H_{j,t}^{*}$	optimal level of knowledge stock
u_t	regional unemployment rate
nim_t	net in migration
ξ_t	external knowledge spillover
ω_t	import share in the knowledge spillover function
$SAV_{dngins,t}$	domestic non government saving
$YNG_{dngins,t}$	domestic non government income
$TRSF_{dngins,dnginsp,t}$	transfer among *dngins*
$HTAX_t$	total household tax
CA_t	current account balance
$SUBSY_t$	production subsidies
$GOVBAL_t$	government balance

Exogenous variable

$\overline{FSK}_{r,t}$	R&D stock of region *r*
$\overline{REM}_t$	remittance for *dngins*
$\overline{FE}_t$	remittance for the Government
$QG_{i,t}$	government expenditure
$GSAV_t$	government saving

Elasticities:

ρ_j	between knowledge and tangible inputs in sector *j*
σ_i^x	of export with respect to terms of trade
ρ_i^A	in Armington functions
μ	of real wage with respect to unemployment rate
α_j	of acc. rate with respect to the real shadow price
ϑ	of non-excludable *H* with respect to foreign R&D
σ_r^{reg}	elasticity of substitutions of imported import from country *r*
σ_n^{tr}	elasticity of demand for inbound tourism
$\rho^{tr,c}$	Elasticity for tourism and consumption in the CES

Parameters

$a_{i,j}^V$	input output coefficients for i used in j
a_j^Y	share of value added on production
α^c, α^{tr}	Share of household consumption designated to tourism spending, share of tourism consumption designated to day visitors spending
$\delta_j^{k.h,l}$	shares in value added function in sector j
$\delta_{i,j}^{vir,vm,vr,vi}$	shares parameters in Armington function for intermediate goods
$\delta_{i,j}^{qvir,qvm,qvr,qvi}$	shares parameters in Armington function for investment
$\delta_{i,}^{hr,hm}$	shares parameters in Armington function for investment in R&D
$\delta_i^{gr,gm}$	shares parameters in Armington function for Government consumption

$\gamma_{i,j}^{vv,vir}$	shift parameter in Armington functions for intermediate goods
γ_i^f	shift parameter in Armington function for households' consumption
γ_i^g	shift parameter in Armington function for government consumption
γ^c	shift parameter in Armington function for tourism consumption
$\delta^{K,H}$	rate of depreciation for *KS* and *HS*
λ	Speed of adjustment in R&D investment function
β_i	adjustment cost in tangible investment function
$btax_i$	business tax
sub_i	rate of production subsidy
$MTAX_i$	rate of import tax
$YTM_{i,j}$	Yale Technology Matrix
$KM_{i,j}$	physical capital matrix
mps_{dngins}	rate of saving in institutions *dngins*
ssce	rate of social security paid by employees
sscer	rate of social security paid by employer
ire	rate of income tax