The use of Multi-Sectoral Models in evaluating the Macroeconomic impacts of reduced Household Consumption of Sin Goods: The Case of Alcohol Consumption in Scotland

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Declaration

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 an examination, which has led to the award of a degree.

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Abstract

Health policy goals across the world have sought to reduce the household consumption of alcohol and have attempted various methods to try to achieve this goal such as alcohol duties and price floors. Economies that have a high dependence on the alcohol production industry worry about the potential negative economic impact of a reduced level of household consumption. This thesis explores the usefulness of multi-sectoral economic modelling approaches in identifying the potential economic impacts of changes in household consumption and taxes on alcohol.

The multi-sectoral economic modelling approaches that are used for such purpose in this thesis include Input-Output (IO) models and Computable General Equilibrium (CGE) models. The use of these models helps in providing an ex-ante overview of the economic implications of increased alcohol taxes in an economy. In particular, a CGE model can contribute to quantifying the impact of policies aimed at reducing levels of household consumption of sin goods through the inclusion of health side implications. This thesis studies the use of IO and CGE models in assessing the economic impacts of alcohol policy.

First, an IO model is used to analyse system-wide impacts of reducing Scottish household alcohol consumption and increased alcohol duties, following Connolly et al. (2019). The gross and net impacts of these policies are found by accounting for increased household and government spending in non-alcohol sectors. The results indicate that the gross impact of increased alcohol duties is negative. Despite this, accounting for increased government spending shows that the net impact is positive. A drawback is noted within the IO framework, which is that they do not endogenously determine prices and wages in the economy due to a fixed supply-side constraint. This chapter shows that the scope for using IO models in analysing the economic impacts of alcohol policy is limited due to a passive supply-side constraint.

This leads us to employ a CGE model to further analyse the impacts of alcohol duties. With an active supply-side, CGE models can endogenously determine prices and wages, and thus, may be better suited to assess these economic impacts. The scenarios in this analysis follow Wada et al. (2017) in increasing the level of alcohol duties by 5p per unit. Gross and net impacts are assessed by recycling the raised taxes through higher local government spending.

The gross results show that increasing alcohol duty would have a negative economic impact on the economy. Net results, however, show that through increased government spending, the short-run economic impact is less negative than the gross case, while the long-run economic impact is still negative. Further, since CGE models have an active supply side, the results produced have more detail in terms of impacts on prices, employment, and investment. These results show that a CGE model is more suitable to study the economic impacts of alcohol consumption. However, another drawback that is noted is that the positive health benefits of reducing alcohol consumption are not incorporated into these results.

Finally, the premise that positive health benefits of reduced alcohol consumption lead to increased labour productivity is economically quantified. It is found that alcohol-associated labour productivity accounts for 0.423% of the total labour productivity in Scotland. Through this, we find the level of increase in labour productivity required to offset the gross and net impacts of increased alcohol duties. The results show that alcohol-associated labour productivity is not sufficient to offset the negative impact of gross results. However, the net impacts can be overcome, as an increase in labour productivity leads to higher employment in the long run, given that local governments recycled these taxes through higher spending.

Thus, the use of CGE models in analysing the economic impacts of sin goods is found to have merit, in line with the recommendations of WHO (2009, 2010). The incorporation of changes in labour productivity within the analysis conducted through a CGE model is found to provide a good framework in the analysis of reduced alcohol consumption. It is also noted that these models have the potential to study not only alcohol but also other sin goods that exist in the economy such as tobacco and sugar.

In all, we are able to use multi-sectoral economic modelling approaches in quantifying the economic impacts of policies curbing the consumption of a sin good. We are further able to develop a framework for analysing the sin goods by incorporating the positive health impacts of the reduced level of consumption. The case of alcohol in Scotland also shows the economic impacts of reducing alcohol consumption in an economy that has a high dependence on producing the sin good and, further, informs the debate on alcohol policy in a regional context.

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Chapter 1: An Introduction and a guide to the thesis

The primary aim of this thesis is to investigate the potential macroeconomic impacts arising from reduced household alcohol consumption in Scotland. Before assessing the macroeconomic impacts, the nature and structure of the alcohol sector in Scotland is assessed. The primary aim of this thesis is motivated by the commitment of the Scottish Government to reduce the level of alcohol consumption, thereby reducing alcohol-related harm in the society and economy. The Scottish Government, in association with National Health Service (NHS) Scotland, has made commitments to boost the productivity of the Scottish labour market and to promote healthier attitudes towards the consumption of alcohol (Scottish Government, 2019a).

At the present level of alcohol consumption, Scotland ranks in the top 25 countries in the world in terms of alcohol consumption (WHO, 2015). In 2015, the average weekly alcohol consumption per capita in Scotland was over 20.8 units of pure alcohol[1] (MESAS, 2017). In comparison, the average weekly alcohol consumption per capita in England & Wales was 17.4 units of pure alcohol. However, the maximum level of weekly alcohol consumption per capita as recommended by the NHS (2018b) is 14 units of pure alcohol. This translates to over-consumption of alcohol by over 30% in Scotland. Since the Scottish Government is a devolved government within the United Kingdom, it currently does not have the powers to set or change alcohol duties. The limited powers of the Scottish Government mean they do not have the complete fiscal toolset to deal with the distinctly higher alcohol consumption in the country.

The World Health Organisation (2018) associates alcohol consumption with several different health consequences including diseases of the heart, liver, and even cancer. Their analysis also acknowledges that economies suffer losses to labour productivity due to the consumption of alcohol.

[1] Drinkaware (2019) defines 1 unit of alcohol as 10ml or 8g of pure alcohol. An average 175ml glass of wine contains 12% pure alcohol, which equates to 21ml of pure alcohol or 2.1 units.

The Scottish Government has most recently demonstrated its commitment to reduce this level of alcohol consumption through the introduction of Minimum Unit Pricing (MUP) implemented by the Scottish Government in May 2018, whereby the government has set a price floor on each unit of alcohol. Other policies also in place in the Scottish alcohol market are the time-restricted sale of alcohol introduced in 2010, whereby alcohol can only be sold between the hours of 10 am and 10 pm, and 'Challenge 25' introduced in 2011, whereby individuals who look below the age of 25 are required to produce ID for purchasing alcohol and tobacco (Scottish Government, 2019b).

A direct consequence of increased alcohol consumption is increased health risks and even premature mortality. In the year 2018, alcohol mortality in Scotland was found to be four times higher than in 1981. Men were found to be twice as susceptible to alcohol-specific deaths compared to women. Moreover, those living in the most deprived areas of Scotland were at five times higher risk of alcohol-related morbidity and mortality. Thus the problems relating to alcohol consumption are spread throughout Scottish society with the most deprived taking on a great burden (Scottish Health Survey, 2020).

While alcohol consumption in Scotland is high, the industry also has an important place in the economy of Scotland. One of the primary exports of Scotland is Scotch Whisky. In 2019, Scotch exported to the rest of the world (including the Rest of the UK) was valued at £4.70 billion (SWA, 2019). For reference, the total value of exports from Scotland in that year was £85 billion. The economic contributions of the alcohol industry in Scotland extend further to the generation of employment in the manufacturing and service sector, as well as in its contribution to tax collections. Thus, the alcohol sector is integral to the economy of Scotland, so much so, that it is one of the "Growth sectors"[2] identified by the Scottish Government in its economic strategy.

[2] Scottish Government defines "Growth Sectors" as those sectors where "Scotland has a comparative advantage". (Scottish Government, 2020b)

Given that the alcohol industry is important for the economy, a key concern in implementing policies to reduce alcohol consumption is that doing so would have negative consequences for the alcohol industry and the wider economy (SWA, 2017). However, the literature on alcohol consumption and the economy is widely unified in its view that a reduction in alcohol consumption would not extensively harm the economy, given that alcohol misuse is accounted for (Connolly et al., 2019; Oxford Economics, 2016). Thus, the question arises to what extent reducing alcohol consumption affects the economy upon taking into alcohol misuse.

In this thesis, the macroeconomic impacts of reducing the high level of alcohol consumption in Scotland is investigated through the use of an Input-Output (IO) model and a Computable General Equilibrium (CGE) model. These models are used to explore the potential macroeconomic impacts of reduced alcohol consumption resulting from various policies.

The analysis of reduced alcohol consumption is further extended through the incorporation of health impacts of reduced alcohol consumption by the inclusion of labour productivity changes of reduced absenteeism[3] and presenteeism[4].

Thus, it is the contention of this thesis that the macroeconomic impacts of reducing the levels of consumption of sin goods can be comprehensively studied through the use of a CGE model, and this analysis should include the assessment of reduced economic costs of consuming sin goods.

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[3] Absenteeism denotes absence from paid work, causing a loss in productivity.

[4] Presenteeism denotes being at paid work, but not performing up to the optimal productive capacity.

1.1 The framework for the assessment of alcohol consumption

One of the barriers that the Scottish Government is faced with is the fear of loss of economic activity due to reduced alcohol consumption. Alcohol production and consumption are major sectors for the economy and an employer of workers. A reservation in implementing policies to reduce alcohol consumption is that they may have an impact on the economy of Scotland.

Traditionally, the literature on the consumption of sin goods has often focussed on the positive health impacts of reduced alcohol consumption (Klatsky et al., 1977; Saunders et al., 1993; Bell et al., 2017). Very few studies have assessed the economic impacts of the alcohol sector (Connolly et al., 2019; Oxford Economics, 2016). In this thesis, the use of IO and CGE models is employed to show the way alcohol policy could be analysed in the future by measuring the positive economic impacts of the improved health outcomes. Thus, economic models offer a unique perspective on this debate.

The positive implications of reduced alcohol consumption include increases in demand for goods and services from alternative sectors as well as increases in labour productivity from lower consumption. These mechanisms are incorporated in future chapters to show the true impacts of falling alcohol consumption. The increase in demand from alternative sectors is shown using the mechanism of “consumption switching” where goods and services from alternative sectors see demand increases when households reduce spending on alcohol. Connolly et al. (2019), in their assessment of the economic impacts of reducing the consumption of alcohol, have taken into consideration this switching behaviour of households.

Consumption of sin goods can cause the creation of negative externalities. The consumption of alcohol poses several negative externalities in economic terms, such as stress on the healthcare systems of the country and loss in economic productivity of the labour force. When alcohol policy is assessed, often, the focus is on the health of the consumers of alcohol, which, while is important to study, does not find the overall economic impact of the policy. These impacts include a double dividend for the economy in terms of switching consumer spending to other sectors or increased government spending along with increasing the labour productivity of the workforce.

In 2007, the misuse of alcohol resulted in losses worth £2.25 billion to the Scottish economy. The economic costs of losses due to absenteeism and presenteeism were estimated at £376.5 million (Scottish Government, 2010). These losses mean that the labour productivity of the economy faces serious impacts.

Within this thesis, a key contribution is a proposed framework to analyse the macroeconomic impacts of reducing the consumption of sin goods. The modelling framework takes into consideration the shift in consumer and government spending from the alcohol consumption sectors to other sectors in the economy. Also incorporated are the improved health outcomes modelled through improved labour productivity changes.

Alongside these modelling contributions, the use of the case study of Scotland allows for showing the economic implications of policy in a dynamic fiscal regime. The economic strategy of Scotland includes improving "*productivity and competitiveness*", "*increasing labour market participation*" and stimulating "*population growth*" (Scottish Government, 2009; p.8). The former two of these three goals are affirmatively achieved in due course of this thesis.

1.2 IO and CGE modelling

To study alcohol policy, in the past, various approaches have been adapted. These include macro-econometric models and regional economic models which use a combination of general equilibrium and econometrics.

Several studies have used econometric approaches to measure the impacts of policy to drive down alcohol consumption and its implications on health. Brennen et al (2014) and Brennen et al (2015) use an econometric model to find the impact of MUP on the level of alcohol consumption by moderate and heavy drinkers. These studies focus on the usefulness of alcohol policies on the level of consumption and health consequences of this reduced consumption. However, very few studies have examined the macroeconomic impact of reduced alcohol consumption, specifically for Scotland.

Previously, an IO model has been used by Connolly et al. (2019) to study the economy-wide impacts of changes in alcohol consumption through taxes in the UK. Apart from this, the Regional Economic Model Inc. (REMI) has been used to study sin goods including alcohol and sugary drinks. REMI is an economic forecasting tool that comprises elements from various modelling approaches including Input-Output, General Equilibrium, Econometrics and Economic Geography. Wada et al. (2017) use this model to find the impact of higher alcohol taxes on employment in various American states. These two papers are key in the literature on analysing the economic impacts of reducing alcohol consumption through macroeconomic modelling.

In keeping with both papers mentioned above, it can be argued that the missing link of economy-wide implications of the falling consumption can be better captured using a modelling framework that captures the linkages between the household consumption from alcohol sectors and the wider economy. Using a model with general equilibrium would be able to capture these linkages. In particular, multisectoral macroeconomic models that interlink industries to capture economy-wide impacts could capture the macroeconomic impacts of reduced alcohol consumption.

In this thesis, two main models are used to examine the economic impacts of alcohol consumption. These include an IO model and a CGE model. The studies conducted by Connolly et al. (2019) and Wada et al. (2017) are key papers in the literature and have been replicated in this thesis through IO and CGE models.

IO tables are a set of accounts that contain sector disaggregated data. These tables can be used to better understand the structure and composition of the economy. However, these IO tables can also be used as a macroeconomic model by linking them to linear equations. Thus, an IO model is a multi-sectoral model that captures linkages between sectors. The linear equations within the IO model can be solved to show various backward and forward linkages within the IO model (Miller & Blair, 2009). The IO model set-up is described in detail in chapter 4, while their use is employed as a set of accounts in chapter 3 in explaining the role of alcohol in the Scottish economy.

Within an IO model setup, exogenous demand shocks can be applied, and the linear equations can then be solved to examine the potential economic consequences of the applied demand shock. Within the IO model, the supply-side is passive. This implies that the changes propagated through the model are not subject to supply-side constraints such as availability of capital and labour, as well as estimation of prices and wages.

An IO model can be utilised to calculate some macroeconomic indicators such as GDP, employment and output[5]. When an exogenous shock is applied, a change to these macroeconomic indicators can be noted, alongside changes in sectoral compositions of these variables.

[5] These multipliers and effects are explained in detail in Chapter 4.

Another advantage of using an IO model is that the mechanism of consumption switching can be incorporated in IO models where reduced household demand from one sector may be substituted with increased household demand for other sectors, albeit exogenously. As mentioned before, a key contribution of this thesis is to incorporate consumption switching while analysing the macroeconomic impacts of reduced alcohol consumption.

IO models, since they use IO tables as the calibration, can be aggregated and disaggregated, which makes them highly adaptable in capturing the effects of any specific sector. For example, in this thesis, the alcohol consumption sectors have been disaggregated. A description of this disaggregation is presented in chapter 4. Thus, an IO model may be appropriate to analyse the economic consequences of reduced alcohol consumption.

In policy, IO models have been used extensively to model changes in demand in specific sectors while examining macroeconomic changes. This has been performed in several studies such as by McNicoll (1980) for the oil sector and Frechtling & Horwath (1999) for the tourism sector amongst other studies. Incorporating consumption switching into an IO model is also performed while examining some policies, such as by Eiser & Roberts (2001) while examining the impacts of afforestation and by Connolly et al. (2019) while examining the alcohol sector. These studies are explained in detail in chapter 4, where the study by Connolly et al. (2019) is also replicated for Scotland. Thus, IO models hold a prominent place in the examination of sectoral policy.

However, the production structure within an IO model does not account for labour productivity. This means that improved health outcomes of reducing alcohol consumption cannot be incorporated into an IO model. To address this question, we use an alternative model to assess macroeconomic impacts.

Another model that is widely used to analyse the impacts of changes in demand is a CGE model. CGE models are widely used to analyse policy by various governments and institutions around the world such as the Scottish Government and the U.K. Government (The Scottish Government, 2014; HMRC, 2013). Organisations such as the World Bank also use CGE modelling in their analysis of policies (World Bank, 2011).

Developed from IO models, CGE models are also multi-sectoral in their setup. A CGE model uses data from IO accounts along with data on transfers between governments and households in the form of a Social Accounting Matrix (SAM). Thus, a SAM is built from IO tables. The specific CGE model used in this analysis is an AMOS (A Micro-macro model of Scotland) model which was built by the team at the Fraser of Allander Institute (FAI) at the University of Strathclyde.

The CGE model has various features that make it suitable to analyse changes in demand. Like an IO model, CGE models allow for several economic sectors to interact with one another. However, unlike in IO models, CGE models depend on general equilibrium theory with flexible prices (Rose, 1995). These multi-sectoral interactions are particularly useful while measuring demand changes in alcohol consumption sectors since these shocks could affect alcohol producers and suppliers and their future spending and investment decisions. Additionally, decreases in demand for alcohol could also lead to demand substitutions to other sectors. Changes in demand for alcohol may have positive and negative implications for other sectors, and analysing these important relationships provides a better understanding of potential impacts.

As with IO models, CGE models allow for aggregating and disaggregating sectors with varying level of detail in the analysis of specific sectors. Within our modelling setup, we aggregate the economy into 18 sectors, including 2 alcohol consumption sectors. The SAM built for this thesis is an alcohol disaggregated version which was built from Scottish IO tables for 2014, as used in chapter 4. This SAM is further described in chapter 5.

Production within the AMOS model uses a combination of capital and labour, adjusted by labour productivity. This allows us to exogenously change the level of labour productivity. This feature is especially important in this thesis since the improved health outcomes are assumed to make positive labour productivity improvements. This is a key contribution of this thesis.

The model is also able to offer different choices of specifications. In terms of policy foresight, it possible to alter whether households and firms would have the foresight of the policy. Also given is the choice between allowing for migration and disallowing it. This further helps streamline the setup of simulations to provide appropriate results.

Given the usefulness of IO and CGE frameworks for policy analysis, the choice of research methods used in this thesis is appropriate for the analysis of potential economic consequences.

1.3 Structure of the thesis and contributions

The structure of this thesis is described below. The contributions of each chapter are also described. The thesis consists of a total of seven chapters.

Chapter 2 sets out the backdrop of this thesis by discussing the concept of decentralisation. The case of Scottish devolution is explained in detail, alongside the fiscal powers of the Scottish Government. In the context of reducing alcohol consumption in Scotland, the powers of the Scottish Government to frame policies is important to discuss. The literature on the concept of sin taxes is then discussed in general. It is found that the optimal sin tax is designed with two objectives – to reduce the consumption of the sin good, and to offset the negative costs generated by their consumption. This is also the specific rationale for alcohol duties. The literature on the health consequences of alcohol consumption finds that several ailments are linked to high levels of alcohol consumption. Following this, the specific nature and working of alcohol duty in the United Kingdom are laid out.

The primary contribution of chapter 2 is to establish the context in which the reduction in alcohol consumption is discussed in this thesis. It is found that the fiscal powers of Scotland do not extend to changing the alcohol duties in the country. Given the primary nature of alcohol duty to reduce alcohol consumption, the differing levels of consumption in Scotland and England & Wales could imply that differing policy approaches may be needed to tackle the issue. A key focus of this chapter is on the alcohol policies in Scotland and the use of alcohol duties to reduce alcohol misuse and resulting harm. Thus, this chapter helps in better understanding the results that are found in chapters 4, 5 and 6.

Chapter 3 specifically defines the alcohol production and consumption sectors for this thesis. A historical overview of alcohol consumption and policies is discussed to find which policies have been implemented in Scotland to curb consumption in the past, and the level of success achieved by them. We analyse the consumption and production of alcohol in Scotland to help us better define the alcohol sectors. Also included in this analysis is the contribution of the alcohol sector to employment, trade and tax collections in Scotland.

To explain the size and scope of the alcohol sector, we analyse data from various sources. It is found that the alcohol sector is a major contributor to the economy in terms of production, exports and employment. In all, 12,329 FTE jobs are supported through alcohol manufacturing, while 35,551 FTE jobs are supported through alcohol sales in Scotland. It also contributes significantly to tax collections in the UK. Alcohol duty worth £961 million was collected in 2014-15 from alcohol sales in Scotland. The current market players of the alcohol sector show what type of firms operate in the present-day economy. This chapter helps in understanding the size and scope of the alcohol sector in Scotland and how effective policies have been in tackling the problems of alcohol consumption in the past.

This chapter conducts an in-depth analysis of the alcohol sector in Scotland. This is especially important since the Scottish alcohol sector is a major export sector for the UK. The role of this chapter in this thesis is to show the size of the alcohol sector. Given its contributions to the Scottish economy, a reduction in alcohol consumption could harm the economy.

The model used in Chapter 4 is an IO model. While IO tables were used as a set of accounts in chapter 3, their use is employed as a model in chapter 4. The chapter starts with an overview of IO models and their historical prevalence in the economic modelling of policy and non-police cases. These models have been in use for several decades and have developed drastically over this time with various extensions making them more effective in analysing sectoral changes in a macroeconomic setup. The literature on the use of IO models shows its popularity in modelling policy, along with the reasons it may be considered optimal when compared to other types of macroeconomic frameworks. Consumption switching is also explored in the literature to see how reductions in alcohol consumption can lead to the redirection of household budgets.

Since the aim of this thesis to find the economic impacts of reduced alcohol consumption, the alcohol consumption sectors are identified and disaggregated within the IO tables. Alcohol consumption sectors include the off-trade and on-trade sectors. The alcohol off-trade sector refers to the consumption of alcohol from wholesale outlets for consumption at home. The alcohol on-trade sector refers to the consumption of alcohol sold by licensed premises including bars, pubs and restaurants and through accommodation. These disaggregations are explained further in chapter 4. A full list of all 101 sectors in the disaggregated IO model is available in Appendix A.

A key paper in this literature is identified, which is Connolly et al. (2019). This paper has analysed alcohol consumption in the UK through an IO model and included the switching behaviour in their analysis. In this chapter, two main scenarios are analysed through the use of the IO table. These include a 10% reduction in alcohol consumption from each of the consumption sectors, along with a 10% increase in the level of alcohol duty in Scotland. Gross and net results are formulated for both the scenarios through switching household consumption and government spending of raised alcohol duties. The simulated reduction is 10% since this is the level of reduction in consumption recommended by WHO (2013).

In the initial simulations, the reduction in household alcohol spending is kept isolated without any changes to the consumption of other goods and services from other sectors. These gross results indicate that a reduction in consumption of alcohol could have negative consequences for the economy, all other factors kept constant. Specifically, we find that the aggregate GDP could fall by £157.74m (-0.13%) given a reduction in alcohol consumption by the level recommended by the WHO (2013). Alongside this, employment could be expected to fall by 4600 FTE (-0.20%). Following this, the scenario is simulated with the inclusion of consumption switching to find net impacts, where a reduction in alcohol demand is supplemented by an increase in household spending in other sectors of the economy. We find that with consumption switching, the GDP can be expected to increase by £2.95m (0.00%), while employment can be expected to fall by 1785 FTE (-0.08%).

Similarly, the economic impacts of an increase in alcohol duty by 10% are also found. To find gross impacts, the increased tax revenue is not recycled as increased government spending, while in the net case, this recycling is assumed to take place. Gross impacts find a reduction in GDP by £23.80m or 0.02% and employment by 738 FTE (-0.03%). Net impacts are more optimistic, as GDP rises by £81.35m (0.07%) and employment rise by 1489 FTE (0.04%).

The primary contribution of chapter 4 is the incorporation of consumption switching in the estimation of the potential macroeconomic impacts of reduced alcohol consumption. While this has been conducted for the UK before by Connolly et al. (2019), this thesis uses an IO model for Scotland.

Very little research has been conducted to create a modelling setup that can find macroeconomic impacts of reduced alcohol consumption with a general equilibrium model. One key paper in this literature is found to be by Wada et al. (2017). While quantitative studies do exist in the realm of measuring policy effectiveness to reduce the consumption levels, and in finding the level of health improvement at the macroeconomic level, the literature review finds a gap where the macroeconomic quantification of these consequences has not been conducted. This appears to, therefore, be a gap where multisectoral modelling frameworks can contribute to the literature.

In Chapter 5, various modelling choices are discussed and analysed. CGE models are found to be the best choice of model for analysing macroeconomic impacts of reduced alcohol consumption since they can simultaneously look at consequences for the economy of shocks on the demand side and the response of the supply side. CGE models relax the passive supply-side constraints seen in IO models. Additionally, CGE models incorporate labour productivity in the production process. These features allow us to extend the analysis performed in chapter 4. The next section introduces CGE models in general. The history of CGE models is presented and then showcased as an extensive overview of CGE models including components and strengths & weaknesses.

Following this, the specific CGE model used in this thesis, the AMOS model is explained in detail, and key relationships in the model are shown. These relationships are represented in the form of a set of equations, which is shown in Appendix B. While these equations have been developed over time with the Fraser of Allander Institute, they are essential in the model which produces the results presented in this chapter.

A key paper identified in the literature of the application of CGE models in analysing the economic impacts of alcohol consumption is that of Wada et al. (2017). This paper uses the REMI model to find the employment impacts of reduced alcohol consumption in various American states and finds that upon recycling increases tax collections from higher alcohol taxes, there exists a positive employment impact. Thus, this paper is replicated for Scotland in Chapter 5.

The modelling strategy adopted to find the economic impacts of changes in alcohol consumption is then explained. In line with Wada et al. (2017), the scenarios carried out in chapter 5 include an increase in the duties on alcohol without and then with recycling the raised taxes as local government spending. These simulations are carried out in a controlled setup. As mentioned in the previous section, the model offers different choices when it comes to controlling policy foresight and migration. The results are also tested for sensitivity to these assumptions.

The results are, thus, able to uncover key linkages of the alcohol sector with the rest of the economy. These are extensively explained in chapter 5. Through the use of the AMOS model, we find that an increase in alcohol taxes without recycling as government spending would mean that the GDP can be expected to fall by £14.18m, while employment would fall by 241 FTE in the short run. When the raised taxes are recycled, the GDP falls by £6.80m, while employment reduces by 80 FTE in the short run. However, the long-run impacts are found to be more negative since the GDP falls by £41.61m, while employment falls by 686 FTE. Thus, this chapter shows that the advantage of using a CGE model is an active supply-side response in a macroeconomic modelling framework. This is a key contribution of Chapter 5. However, Wada et al. (2017) do not report long-run impacts. This analysis finds that the impacts are negative in the long run.

While the use of CGE models in studying alcohol consumption is shown to be effective in chapter 5, the analysis conducted is still unable to uncover the economic consequences of improvements in health that come with reduced consumption of alcohol. These health consequences are essential in showing the true economic impacts of reduced alcohol consumption. This brings us to chapter 6 where the health consequences are explained and modelled. As seen in chapters 2 and 3, alcohol consumption has several negative health externalities. However, the one thing that binds together these negative health externalities is a reduction in the productive capacity of the economy. It is assumed that improvements to the health of individuals due to reduced consumption of alcohol would have a positive impact on their ability to perform at their peak productive capacity. This increase in productive capacity is therefore used as a tool to measure the positive health outcomes of reduced alcohol consumption.

The elements of productive capacity associated with alcohol consumption include absenteeism and presenteeism. Estimations of these contributors to losses in productive capacity are carried out. These are quantified and presented in chapter 6. Thus, absenteeism and presenteeism are simulated in chapter 6.

The simulations carried out in this section include an increase in alcohol-associated labour productivity arising from presenteeism and absenteeism. With these results, it is possible to show what level of increase in alcohol-associated labour productivity would be required to offset any negative economic impacts of a reduction in alcohol consumption. These results are therefore able to comprehensively analyse the economic implications of changes in alcohol consumption. When it is assumed that no government revenue is recycled, adding back all the lost labour productivity due to alcohol consumption would increase the GDP by £531.32m, while employment would rise by 39 FTE. This level of productivity improvement is not enough to offset the gross impacts of increasing alcohol duties.

However, we find that when there is a recycling of tax revenue through government spending in the economy, adding back all the lost labour productivity due to alcohol consumption, the GDP of Scotland can be expected to increase by £720.78m, while employment is expected to increase by 4189 FTE. Through this, we find that labour productivity would need to increase by 0.0692% to completely offset the negative impacts of reduced alcohol consumption seen in the net impacts of chapter 5. These results show that recycling of government revenue through local government spending is the key to offsetting the negative economic impacts of higher alcohol duties.

The use of CGE models in the research field of alcohol policy is shown to be effective, and the applicability of similar models to tackle other sin goods is then discussed. The chapter is, thus, able to show a way of making a comprehensive analysis of alcohol and other similar sin goods.

The main contribution of this chapter is the inclusion of positive health outcomes of reduced alcohol consumption within a CGE framework. To our knowledge, no other study has used a CGE model to analyse the reduction of negative externalities associated with lower consumption of a sin good. This is the unique contribution of this thesis.

In all, the thesis provides a systemic way to analyse the consumption of sin goods that have negative externalities under a consistent framework of a CGE model. The use of this framework may be used in the analysis of other sin goods as well as in other regions. Alongside the modelling contributions, the thesis also contributes to a better understanding of the relationship between alcohol consumption in Scotland and its impact on the Macroeconomy of the region. This thesis has implications for policymakers across the world, in the area of framing policies to reduce alcohol consumption, and indeed consumption of other sin goods.

Chapter 2: Devolution in Scotland as a specific case study of Subnational Taxation Issues

2.1 Introduction

As briefly discussed in chapter 1, Scotland faces the problem of high alcohol consumption. To combat this issue, the Scottish Government may use a variety of tools. These include social and fiscal policies. The focus of this chapter is on fiscal policies to reduce alcohol consumption. However, one concern is that since the administration of Scotland is not fully devolved, these tools may not be available to the Scottish Government. This brings us to the need for devolution of alcohol-related fiscal policy to the Scottish Government. The Scottish Government has previously mentioned that it is committed to getting alcohol duty to be devolved (Scottish Government, 2011).

The case of Scottish devolution is a complex one. A long history of Scottish-English relations has led to the current devolved status of Scotland. However, devolution is a complicated issue and each case of devolution is different.

The focus of this chapter is on using a review of literature and data to inform the debate on alcohol taxes and their devolution in Scotland. This enables us to set the context for the use of models to analyse the macroeconomic impacts of alcohol consumption in Scotland.

In this chapter, we start by analysing the definitions and types of decentralisation. We find that decentralisation can be of several types and these vary by the level of autonomy of powers. The case of Scotland is then discussed. This is done through a historical analysis of the process of devolution in Scotland. The structure of governance in Scotland is also discussed.

We then understand what fiscal powers are devolved to the Scottish Government. Following this, we turn our focus to sin taxes in general. We analyse literature to better understand the rationale for sin taxes and alcohol taxes in particular. We then investigate the structure of alcohol taxes in Scotland

and the United Kingdom. Since the aim of this thesis is to better understand the macroeconomic impacts of reducing alcohol consumption, it is important to understand the difference in tax powers between Scotland and the UK as this has implications on the macroeconomic impacts of various alcohol tax policies within Scotland.

2.2 The Concept of Devolution

In the literature surrounding the distribution of economic powers, the concept of decentralisation has been discussed widely. The term decentralisation refers to the delegation of fiscal powers to local governments to change taxes and manage expenditure (Prud'Homme, 1995). Pure decentralisation is an economic model where no transfers take place between local government and central government, and the local government is allowed to be responsible for fiscal decisions (Prud'homme, 1995).

Decentralisation has various forms. These include – deconcentration (where fiscal powers are redistributed amongst various levels of the central government), delegation (where fiscal powers are allocated to semi-autonomous bodies), and devolution (where a transfer of fiscal power and resources takes place to subnational governments) (Prud'Homme, 1995, p.2).

Across the world, various forms of decentralisation have defined the creation and distribution of powers at subnational levels (Agrawal, 1999). Additionally, Manor (1999) points out that decentralisation, to be effective, must have a combination of three essential elements – democratic, fiscal and administrative.

However, while the elements mentioned are the important elements of decentralisation, Agrawal (1999) argues that the dimensions of a region that better represent these elements are actors, powers and accountability. They say that without understanding who the actors of the decentralised region, the powers that these actors possess along with methods of accountability, it is hard to understand the extent of decentralisation of a region.

2.2.1 The Case of Scottish Devolution

From the discussion above, it is clear that the case of Scotland is that of devolution of fiscal powers (Rodriguez-Pose & Gill, 2005). The history of the Scottish-UK relationship is complex and long. For the review of Scottish devolution, the understanding of this history is imperative. Finlay (2001) states that due to the evolution of public opinion throughout two referendums in 1979 and 1997, the historical perspectives of the relationship between the two countries is important to discuss when studying Scottish devolution.

Alcohol's role in Devolution: A Historical tour

Meisch (2013) argues that the literature on Scottish devolution does not sufficiently attempt to explain the historical perspective. However, most of the literature in this subject area only focuses on the history between 1979 and 1997. It is important to note here that years after the signing of the Treaty of Union (1707), Scottish MP's and British ministers regularly disagreed and claims were made that vital aspects of the treaty were not being honoured (Hanham, 2020).

Davidson (2003, p. 191) points at five main breaches to the Treaty of Union that harmed Scottish society. One of these five breaches is listed as the increase in the taxes on malt in 1713. Lenman (1980) states that there are three reasons that this would have breached the treaty. The first was that the treaty explicitly discharged Scotland from having to finance the War of Spanish Succession. However, it was argued that the situation in which this tax was created, the intent was to collect tax to fund the War of Spanish Succession that was ongoing from 1701. Secondly, the treaty agreed upon said that taxes on malt would not be levied in wartime. However, with an ongoing war, this was also a breach of the treaty. Lastly, the treaty spoke of a fair apportionment of taxes. With the annual value of the barley crop used in malt production in Scotland being a fraction of that of England, it was argued that an equal tax on malt In England and Scotland breached this point in the treaty as well (Lenman, 1980). In all, a direct breach of the fiscal terms of the treaty which was already unpopular with the Scottish public led to anguish in the Scottish society.

Scottish politicians, in the House of Lords and Commons, challenged the breach of the treaty. They proposed the dissolution of the treaty due to the breach. However, the bill was defeated in both houses since Scotland did not enjoy a majority in either house. This was, though, enough for the government to withdraw the malt taxes, and thus a reversal of the breach of the treaty (Davidson, 2003).

This did not prevent an uprising. In 1715, the Scottish public under Jacobite leadership rebelled against the treaty and the union. Davidson (2003) points out that this rebellion had the potential to succeed, if not for low support from the southern lowlands, along with the questionable leadership that was not able to persist onwards towards victory.

Several other attempts at Jacobite uprisings were also made in 1719 and 1745 which had much to do with rebelling against the English crown. These uprisings continued up until 1746 (Davidson, 2003). Despite the failed attempts of these rebellions, they continued and manifested into the "Home Rule Movement" for the first time in 1853. This movement asked for a separate Scottish Parliament, a key milestone of devolution. However, since the Irish demand for home rule garnered more attention, and it was thought that Scottish interests were widely ignored due to this (Devine, 1990).

Another uprising through the 1880s took place. A pro-devolution campaign was run unsuccessfully. Despite its failure, to appease Scotland, the government created a position of Secretary for Scotland in 1885 (Levitt, 1992). This position saw powers being transferred including law & order, welfare and education. This was a big milestone in the history of Scottish devolution.

While larger calls for home rule were still made from time to time, the agenda of Scottish home rule was put on the backburner since the government of the day was not in favour of it. This changed with the liberal government coming to power in 1906. The Scottish Home Rule bill was eventually debated upon in 1913 after the successful passage of the Irish Home Rule bill was passed in 1912. This was interrupted by the start of the World War at the time.

After the war concluded, the parliament voted in favour of the creation of the government of Ireland, and a free Irish state was established. This had no implications for Scotland since the Scottish Home Rule bill was not passed yet. Added pressure from a period of depression following the war dominated the politics of the time. Following another intense call for home rule, a step was then taken to further the liberal promise, and this led to the elevation of the Scottish secretary to the position of Secretary of State and was included as a full-time member of the Prime Minister's cabinet in 1926 (Levitt, 1992).

Through the 1920s and early years of the 1930s, several different political organisations were formed. These included the right-wing Scottish Party and the left-wing National Party. These two parties eventually merged in 1934 to form the Scottish Nationalist Party or SNP. The mission for home rule was then spearheaded by this united political organisation. A leader of this organisation, John MacCormick proposed a petition advocating home rule in Scotland. This was the start of the Scottish covenant movement (Levitt, 1998).

The Scottish covenant movement gathered much attention in the 1940s. The petition gathered nearly two million signatures (the population of Scotland as per the census in 1951 was 5.1 million, Levitt, 1998). However, soon after this, public interest in the movement dissipated. In fact, by 1954, the Royal Commission on Scottish Affairs reported that most Scottish people supported the Union (Balfour, 1954). The reasons for the dissipation in interest were unclear. Mitchell (1996) mentioned that this could be due to a lack of "political sophistication" on the part of the actors to unite in the face of opposition. Instead, the left-wing and right-wing factions of the SNP resorted to infighting.

Post the erosion of interest in the 1950s, the following decade marked a change in direction for the United Kingdom since the process of decolonisation of several colonies across Africa began. Through this, the nationalist sentiment grew in Scotland (Glass, 2012). In 1968, two prominent events led to an increased interest in devolution. These were the Conservative leader's declaration in support of Scottish Devolution (Pentland, 2015), alongside the Labour Prime Minister's move in establishing the Kilbrandon Commission to explore devolution in Scotland (Wilson, 2017).

The findings of the Kilbrandon Commission (1973) suggested the creation of a Scottish justice system and a Scottish Parliament. Despite strong political support from the Labour government and the SNP, a referendum was seen as the democratic way of deciding on devolution. This was due to differences in opinion within labour as well as the SNP. A referendum was scheduled for 1979. One condition for the success of the referendum was set as 40% of the electorate had to be in favour of devolution. Although 52% voted in favour of devolution, a low voter turnout meant that the referendum had failed (Perman, 1980).

Consecutive conservative governments opposed any change to the structure of the union. These included the governments of Margret Thatcher and John Major. The general elections of 1997 saw the Scottish devolution becoming a key issue in the election. Tony Blair had declared earlier that a referendum would be held on the issue and two questions would be asked of the Scottish electorate – one on the establishment of a Scottish Parliament and the other on tax-varying powers of said Scottish Parliament. Both of these returned positive results and Scottish devolution was achieved in 1997 and thus, in 1998 the Scottish parliament was re-established for the first time since 1707 when the then parliament of Scotland ratified the Treaty of Union (Pattie et al., 1998). The

Scottish Act of 1998 gives powers to the Scottish Parliament as well as the Scottish Executive and listed the policy areas where the Scottish Parliament could not exercise powers over. Thus, the policy areas that were not listed were devolved to the Scottish Parliament (Mitchell, 1999).

After the election of 2007 when SNP, a pro-independence party, won the elections, the possibility of an Independent Scotland was floated. Unionist parties established the Calman Commission which favoured the status quo (Calman, 2009). However, to avoid a Scottish Independence referendum, the Scotland Act, 2012 was passed that gave added fiscal powers to the Scottish Parliament, including the devolution of stamp duty and landfill tax. Despite this, the calls for independence did not stop, and the Edinburgh Agreement was signed in October 2012 for an independence referendum in 2014. The results of this referendum returned in favour of the unionists and Scotland remained a part of the UK (Masetti, 2019).

Post this independence referendum, the Smith Commission was announced by then Prime Minister David Cameron, which recommended complete devolution of income tax, assignment of half of the VAT proceeds and other taxes to be devolved (Smith, 2014). As the UK was a part of the EU at the time, VAT could not be devolved since, under the EU rules, the variation of VAT rate would be inadmissible. This commission's findings led to the passage of the Scotland Act of 2016 (McLean, 2019).

In terms of alcohol, the Scottish Act of 1998 gave way to the devolution of alcohol licencing. This act gave powers to the Scottish Government to enact the Licensing (Scotland) Act of 2005 and 2010. These legislations gave powers to Scottish local authorities to license the sale of alcohol through licensing boards (Scottish Government, 2018).

One of the main aims of the alcohol licensing policy in Scotland is "protecting and improving public health" (Scottish Government, 2018, p. 2). Under this aim, the Scottish Government has further passed and enacted the Alcohol (Minimum Pricing) (Scotland) Act, 2012. This policy enforces that alcohol is sold at a minimum price per unit as prescribed by Scottish ministers. This minimum price was set at 50p per unit of alcohol by the Scottish Government. In effect, a price floor exists on the sale of alcohol in Scotland. These policies have been enacted due to the devolution of alcohol licensing under the Scotland Act (1998).

While all the powers devolved under the Scotland Act of 2016 are not currently devolved yet, the powers of the Scottish Parliament in framing Fiscal policy have been extended considerably since the devolution referendum of 1997.

Thus, the history that entailed the issue of Scottish devolution is long. Several different events, rebellions and referendums led to the Scottish devolution in its current form. The historical analysis has shown the complex case of Scottish devolution and its fiscal powers.

2.2.2 The Current Administrative Structure of the UK and Scotland

In its current form, Scotland is a region under the administration of the United Kingdom. The Scottish parliament has certain powers as discussed in the section above. These powers include fiscal and administrative policy areas.

On the fiscal front, several taxes are devolved to the Scottish parliament and the Scottish Government. These include the landfill tax, stamp duty and the power to create new taxes. Apart from this, the Scottish parliament also has powers to alter the rates of income tax. These powers are elaborated in section 2.3.3.

The taxes not devolved to Scotland are collected by the HMRC, while devolved taxes are collected by Revenue Scotland. Taxes collected by HMRC are pooled together and redistributed to the subnational governments in the United

Kingdom in the form of a block grant. This block grant, alongside the devolved tax collections, form the revenue of the Scottish Government and forms the basis for the Scottish Budget. The allocation of the block grant to the devolved nations in the UK is conducted through the use of the Barnett formula.

The Barnett formula has been used to determine any changes to the block grant received by Scotland since devolution, should the Scottish parliament choose to make changes to the tax rates determined by the UK government. This implies that a reduction in income tax in Scotland through the exercise of the powers of Scotland Act (2016) would mean an impact on the block grant received. Since the Block grant is a significant contributor to the Scottish budget, changes to the income tax rates would have repercussions on other government spending.

Apart from fiscal policy, the Scottish Government also has jurisdiction over the areas of health and social care, justice and policing, agriculture, forestry and fisheries, environment, tourism, and so on. Through these powers, the Scottish Parliament has devolved the NHS or the National Health Service in Scotland, schools, and the justice system amongst other public services.

In all, the Scottish Government has various social and fiscal powers but is not authorised to make decisions on non-devolved matters.

2.2.3 Fiscal Powers of the Scottish Parliament

As seen in section 2.3.1, the passage of the referendum in 1997 saw the devolution of powers to a Scottish parliament. This was done through the passage of the Scotland Act (1998). As per the referendum result, the Scottish Parliament was also given tax varying powers. However, these powers were not absolute. Various commissions including the Calman Commission and the Smith Commission have contributed to the current standing of fiscal powers of the

Scottish Parliament. Successive acts have been passed to further devolve taxes including the Scotland Act (2012) and the Scotland Act (2016).

In the context of fiscal powers, the various taxes that the Scottish Government has control over are Income tax, Landfill Tax and Stamp Duty. Apart from these taxes, the Scottish Parliament also has access to the power to create new taxes and decentralise them to local government bodies.

While Income Tax in Scotland is not devolved, the Scottish Parliament has some control over the income tax collected from Scotland by the HMRC. (Scottish Government, 2020e). The powers of the Scottish Parliament to set the Income Tax rates have changed through the passage of successive Scotland Acts. The Scotland Act of 1998 gave very limited powers to the Scottish Parliament. The tax rate could only be adjusted 3% over or under the tax rate set by the UK government. This very limited power was never exercised. Scotland Act (2012) gave higher flexibility and allowed the Scottish Government to adjust income tax rates by 10% over and under the tax rates set by the UK government. However, this added power was also not exercised.

The Scotland Act (2016) has given additional powers to the Scottish Parliament. These include the ability to set income tax bands and rates on non-savings non-dividend income. These taxes will then be collected by the HMRC and then paid to the Scottish Government. Given in the tables below are the income tax bands and the corresponding tax rates in Scotland, and the rest of the UK.

Bands	Band Name	Rate
Up to £12,500	Personal Allowance	0%
Over £12,500 - £14,549	Starter Rate	19%
Over £14,549 - £24,944	Scottish Basic Rate	20%
Over £24,944 - £43,430	Intermediate Rate	21%
Over £43,430 - £150,000	Higher Rate	41%
Above £150,000	Top Rate	46%

Table 2.1: Scottish Income Tax Bands and Rates for 2019-20
Source: Scottish Government, 2020e

Bands	Band Name	Rate
Up to £12,500	Personal Allowance	0%
Over £12,501 - £50,000	Basic Rate	20%
Over £50,001 - £150,000	Higher Rate	40%
Above £150,000	Additional Rate	45%

Table 2.2: British Income Tax Bands and Rates for 2019-20
Source: HMRC, 2020

It is seen in the tables above that the Scottish Parliament has exercised the powers given by the Scotland Act (2016). Additional tax bands have been introduced. Very little research has been conducted on the impacts of these additional tax bands on the economy of Scotland, given that it may have implications on the block grant received by Scotland.

Another tax power given to Scotland through the passage of the Scotland Act (2012) is the Landfill Tax. This tax is imposed on the operators of landfills for the dumping of waste materials. The purpose of this tax is to discourage the excessive production of waste, finding alternatives to landfills and an attempt to create a circular economy (Scottish Government, 2020c).

In practice, the Landfill tax was devolved through the passage of the Landfill Tax (Scotland) Act, 2014. The Scottish Government now collects the tax from operators of landfills. The tax is charged at two different rates – a standard rate and a reduced rate. The standard rate is currently set at £94.15 per tonne and the reduced rate at £3 per tonne. Certain materials that qualify for the reduced rates include rocks, minerals, furnace slags and so on. These are included in the reduced rate since they have a low level of pollution (Scottish Government, 2020c).

Replacing the UK wide Stamp Duty Land Tax (SDLT), the Land and Building Transaction Tax (LBTT) was devolved to the Scottish Parliament as per Scotland Act (2012). It was replaced through the passing of the Land and Buildings Transaction Tax (Scotland) Act, 2013. The tax is paid when a transaction occurs over the sale or lease of properties including land and buildings. The Scottish parliament has the powers to set the rate of the tax and create relevant tax bands. It has exercised this power and replaced the SDLT completely. The Scottish Government has also provided various reliefs, especially beneficial for first-time buyers (Scottish Government, 2020c).

Apart from the taxes discussed above that the Scottish parliament has powers to adjust, or have been devolved, some other taxes also exist that may be allocated to the Scottish Budget. These include assigned VAT revenue and local government taxes.

As per the Scotland Act (2016), half of all VAT raised in Scotland is assigned to Scotland. This implies that the first 10p of the VAT for every pound spent in Scotland would be sent back to Scotland, and 2.5p for products with the reduced rates (Scottish Government, 2020f). The VAT rates in the UK are set at a standard rate of 20%. Certain products have a reduced rate of 5%. In terms of alcohol products, VAT is levied on all alcoholic beverages at the standard rate of 20%.

In terms of local government taxes, the Scottish Parliament has the responsibility to set policy for local taxes. These include council taxes and business rates or non-domestic rates. These taxes are collected by local authorities such as the local councils. Councils also have the authority to introduce new taxes on tourism and workplace car parking.

2.3 Sin Taxes and Alcohol Policy

The central premise of this thesis is to analyse the macroeconomic impacts of reducing alcohol consumption. In a broad sense, this thesis proposes the use of a modelling framework to analyse the macroeconomic impacts of reducing the consumption of sin goods. Various taxes have been used by governments around the world to curb the consumption of sin goods. We analyse some of these methods in this section.

2.3.1 The use of interventions in reducing consumption

The use of policy to tackle the issues caused by the misuse of alcohol may be done through two main methods – the use of fiscal policy and the use of the social policy. Both of these policy routes have been extensively researched in literature, and the results show positive impacts of the use of a variety of policy initiatives. In this section, we discuss the level of success achieved through both policy routes across the world and their impact on health parameters.

In general, a sin tax is applied to goods which create economic costs on their consumption. This is to say that when consumed, there is a negative impact on society. These include impacts such as poorer health outcomes and environmental degradation (Haavio & Kotakorpi, 2011).

In cases where the consumption of the good causes negative impacts, policymakers use sin taxes to correct the distortions. When individuals value their utility and the overconsumption is not caused by addiction, sin taxes can improve the welfare of the consumers (Kotakorpi, 2008).

Specifically, excise taxes can be used to internalise the externalities caused by sin goods (Chaloupka et al., 2019). With excise taxes, either ad valorem taxes or specific taxes may be used by the government. An ad valorem tax would be applied to the price of the product, while a specific tax may be applied based on the volume and constituents of the product (Chaloupka & Powell, 2019). In most countries, a combination of ad valorem and specific taxes are used to internalise specific externalities. In the UK, the ad valorem tax applied is VAT, while the specific taxes applied on sin goods include alcohol duty, tobacco duty and sugar taxes.

In any case, the use of sin taxes as prescribed by Cecil (1920) yields a double dividend to the economy. These are a reduction in the consumption of the good, along with a collection of duty to offset the negative externalities associated with the good. This is the main rationale for alcohol duties to be levied.

However, Haavio & Kotakorpi (2011) find that the effectiveness of sin taxes is sub-optimal when applied as a uniform tax. This is due to the unproportioned weight that is carried by individuals who consume sin goods moderately and does not have a justified impact on reducing the consumption of heavy consumers. This is often due to the self-control problems of heavy consumers. They do not reduce their consumption even when high sin taxes are present and shift their spending from other goods to fund the consumption of the sin good. A wide view exists within addiction literature that for a sin tax to be optimal, it must target binge consumption and not moderate consumption.

The rationale for sin taxes can be divided into three main categories: Social control, cost-recovery and revenue-raising. In terms of social control, the use of a sin tax is employed to curb the consumption of a good that is harmful to the public. As an example, cigarette smoking is considered to cause harm to not only their consumers but also to other members of the public (Liu, 2016).

This causes the consumption to create a social cost, which can be recovered through the sin tax. However, often, sin taxes are used as a mechanism to raise revenue by governments. In the US, the aggregate tax collections from tobacco sales were $23 billion in 2006, and increased to $32 billion in 2010, without a significant increase in the consumption of tobacco over this time period (Liu, 2016.)

Thus, sin taxes can be used by governments to reduce the consumption of good with negative societal implications, and the revenue from these taxes should be used in cost-recovery mechanisms.

Throughout the literature on alcohol consumption, a key observation is that price has a strong impact on the level of consumption of alcohol. In this regard, the main relationship uncovered is that an increase in the price level causes a reduction in alcohol consumption. A meta-analysis of 112 studies on alcohol consumption including countries such as New Zealand, Canada and the USA showed this relationship (Wagenaar et al., 2009). A highly significant relationship was found between price measures and the level of sales of alcohol. The study further showed that the impact of price rises was also felt on heavy consumers of alcohol, albeit at a lower magnitude. The results are indicative of the effectiveness of pricing tools such as alcohol taxes in reducing consumption levels.

Further from a meta-analysis, individual cases of the effectiveness of alcohol consumption have also been examined in the literature. The use of minimum unit pricing and uniform volumetric taxation in tackling high consumption levels in Australia was examined by Jiang et al. (2020). It was found that both policies would have a significant impact in reducing the levels of alcohol consumption. In their study, the use of price elasticities was used to model the impacts on consumption levels.

While the literature in this field is unified in finding that pricing is a key mechanism in reducing alcohol consumption (WHO, 2014), there lay divisions on the way it can be used. In order to target pricing policies on heavy drinkers, MUP has been found to be effective in ensuring that light and moderate drinkers are not disproportionately burdened with increased taxes (Meier et al., 2009) in England and Wales.

In a social context, several studies have also found that when alcohol taxes were increased at a low rate, the level of alcohol consumption was found to increase as well. In Canada, when alcohol duties were raised nominally in the years 2000 to 2004, it was found that alcohol consumption increased. Conversely, a sudden significant increase in alcohol tax in Ireland in 2003 had an impact on not only reduced deaths from alcohol-related illnesses, but also a fall in consumption level. Thus, the rationale for using alcohol taxes doesn't limit to reducing consumption, but goes further in a social context as the health benefits of such a reduction are also felt. These health benefits are discussed in depth in section 2.3.3 as well as chapter 7.

Further, Rabinovich (2009) found that a reduction in the affordability of alcohol had a strong impact on not just a reduction in alcohol consumption, but also preventing alcohol-related harm. They advocated the use of pricing policies to target a reduction in risky consumption behaviours. This study was able to find a linkage between alcohol consumption and health-related harms.

While sin taxes, specifically alcohol duties, have been shown to have an impact on consumption levels through various methods such as case studies of policies in different countries as well as meta-studies on price elasticities of alcohol, it is also acknowledged that non-price mechanisms such as information campaigns have also been employed to reduce consumption in the past.

In their analysis of literature looking at the impact of mass media campaigns on reducing alcohol consumption, Young et al. (2018) find six studies that draw a statistical analysis to find if such a relationship exists. A majority of these studies found no statistical significance of information campaigns on reducing alcohol consumption (Flynn et al.. 2006; Kypri et al., 2005; Karlsson et al., 2005; Barber & Grichting, 1990; Wallack & Barrows, 1983). Only one study found a reduction in consumption levels (Barber et al., 1989). The study concluded that overall, there was very little evidence that information campaigns have an impact on reducing consumption levels.

Despite this, governments have used information campaigns in the past as a tool to attempt to reduce consumption levels. In Scotland, various campaigns have been run that attempt to do this, such as the inclusion of information on the packaging of alcoholic beverages, information campaigns run by the NHS as well as other non-governmental organisations.

On the social front, curbing the sale of alcohol at specific times has been used by several governments in the world to reduce the occurrence of binge drinking. The literature on this view is divided. Analysing this policy in the Diadema, Brazil, Duailibi et al. (2011) found a reduction in the number of murders when alcohol sales were restricted beyond 11 pm. It was found that alcohol consumption reduced, along with a reduction in the level of crime.

Curbing the sale of alcohol on Sunday in Canada was withdrawn in 1997. Carpenter & Eisenberg (2009) found that with the restrictions in place, alcohol consumption was higher on Saturdays and caused high levels of binge drinking. Conversely, upon the withdrawal of this policy, it was seen that there was a substitution in alcohol consumption, which increased on Sundays between 7% and 15% but resulted in a lower level of alcohol consumption on Saturday, with no significant change in the total level of consumption.

Extending opening hours of bars and restaurants have also shown similar evidence in England and Wales. A study by Green et al. (2014) found that when closing hours of on-trade establishments was liberalised, the level of automobile accidents reduced dramatically. This was due to increased time taken by individuals to drink, rather than binge drinking. However, the paper also mentions that it has not analysed the impact on the total level of consumption.

Alternative evidence does show a reduction in the level of on-trade alcohol consumption since the enactment of this policy in 2005 (MESAS, 2017).

Strong evidence has been found on the linkages of alcohol consumption and the price level of alcohol, as well as alcohol consumption and the development of health conditions. It is also found that time restrictions on alcohol sales had a mixed response to reducing the social costs of alcohol misuse.

In this thesis, while we do not attempt to examine the impact of policies on consumption levels, we rather focus the thesis on examining the macroeconomic impacts of some such policies that may be introduced by governments around the world.

2.3.2 The Economic rationale for Alcohol Duty

The use of fiscal policy has been employed widely in attempts to control consumption by the government around the world. Policies in the fiscal realm range from the use of standard alcohol duties differentiated on categories and alcohol content, to policies discarding categorisation and focussing on alcohol content (Uniform Volumetric Taxation), to the establishment of price floors (Minimum Unit Pricing). The main aim of all these policies is to reduce alcohol-related harm in society.

However, the collection of alcohol duties also has an economic argument of offsetting the negative externalities associated with alcohol consumption. This is to say that consumers of alcohol cause some social and economic problems within society, and these have a cost associated with it. Alcohol duties are collected to offset these costs to society (Pogue and Sgontz, 1989).

A view exists within the literature on alcohol duties that the burden of this duty is unfairly placed on moderate drinkers who do not cause extensive harm to society, as heavy drinkers do. They call for alcohol duties to be placed on heavy drinking (Cnossen, 2007).

Another argument that challenges the alcohol duty structure in the UK is that alcohol categories such as beer, wine, spirits and cider should not be treated differently (Crooks, 1989; Cnossen, 2007). The health community is unanimous in its view that the harm from consuming alcoholic beverages comes from the volume of pure alcohol consumed.

This is accepted widely within the UK, as the NHS considers one unit of alcohol as 10 ml of pure alcohol and suggests that no more than 14 units be consumed in a week (NHS, 2018). However, alcohol duties do not follow this principle. The implication that a large quantity of weak drinks is just as harmful as a small number of strong drinks is ignored. The economic argument on this front is that duty should be levied solely based on the alcohol level in a drink, disregarding the type of beverage (Crooks, 1989; Cnossen, 2007).

Another important point is that alcohol duties are often not used to offset the negative externalities of alcohol consumption and are not used for further helping alcohol abusers in reducing their alcohol consumption (Smith, 2005). These duties may be levied with the intent of reducing negative externalities but there is no evidence to support the use of the duty collected in this regard.

Arguments can be made in favour of, and against various alcohol duty systems, but the rationale of all systems remains to reduce alcohol misuse and cover the costs of negative externalities, which is the double dividend of sin taxes as described by Cecil (1920).

In all, it is seen that the use of alcohol duties has been justified through the double dividend yielded through the duty. However, the issues of alcohol misuse are faced in each country based on the level of consumption.

2.3.3 Alcohol Policy and its Health Consequences

As was discussed in the previous section, the rationale for implementing policies to reduce consumption of sin goods comes from their role in causing societal harm. Key societal harm of alcohol consumption is noted to be its negative health consequences (WHO, 2010). In assessing the global disease burden, alcohol ranks third as a risk factor (Lim et al., 2012). Such consequences are discussed in this section.

Various health problems have been related to excessive consumption of alcohol. Numerous types of heart conditions have been found to be associated with alcohol misuse. The risk of developing coronary heart disease is one such condition. It is found that increased alcohol consumption may lead to premature mortality, and the risk is found to increase with age. Zhao et al. (2017) find that non-drinkers have a much lower risk of developing the disease compared to low-volume drinkers. However, when the results are disaggregated by age, cohorts, where the mean age was over 55 and were drinkers, were found to be at a much higher mortality risk compared to younger cohorts.

Similar effects are also found when brain health is considered. Welch (2017) finds that even moderate drinkers are at a greater risk of developing changes in the brain leading to diseases such as dementia. Moderate drinkers were defined as people consuming between 7 and 21 units of alcohol in a week. Non-drinkers and light-drinkers were found to have a significantly lower risk of developing changes in the brain leading to dementia.

Alcohol is also found to be a leading cause of the increased risk of developing certain types of cancers. Consuming more than 1 unit of alcohol in a day could lead to increased risks of developing cancers (Kunzmann et al., 2018). Age was found to be an important factor as well, with older adults being the most susceptible to the risk of developing cancer. Ethanol, which is the main component of alcoholic beverages, is considered to be a carcinogenic substance (WCRF, 2019). Cancers of the liver, mouth, colon, oesophagus and breast have been found to have a causal dependence on alcohol consumption (Baan et al., 2007).

Several gastrointestinal diseases are also known to have been caused by alcohol consumption. Liver cirrhosis is a leading cause of death globally (Lopez et al., 2014). The linkage between liver cirrhosis and alcohol consumption is abundantly noted in medical literature, so much so, that about half of all deaths caused by liver cirrhosis in 2012 were attributed to alcohol consumption and misuse (WHO, 2019). Similarly, pancreatitis has also been found to have strong linkages to alcohol consumption, as it plays a significant role in transitioning from acute to chronic pancreatitis (Sankaran et al., 2015).

Short-term health impacts are found to be worse in individuals who binge drink. Binge drinking is heavy episodes of drinking at a stretch, often associated with young adults (Kuntsche et al., 2017). These include blackouts, nausea, hangovers and memory loss. It is also found that such a drinking pattern could lead to a high risk of alcohol poisoning and related mortality. Increased chances of unprotected sexual activity is also a consequence of this and could lead to STI's such as HIV. Another consequence associated with binge drinking is the prevalence of driving under the influence, which may lead to harm to one's self and others (Kuntsche wt al., 2017).

Apart from physical health, mental health is also adversely affected by alcohol consumption. A range of mental illnesses covered under that broad medical term "Major depressive disorders" have been found to be associated with heavy drinking (Kessler et al., 1997). The medical reasons for this are related to changes in neural activities in the brain. However, the prevalence of mental health disorders is high among heavy drinkers. Moreover, it is noted that continued alcohol misuse has strong linkages with worse outcomes for patients suffering from mental health conditions. These include a higher risk of injury, death, or suicide (Sullivan et al., 2005).

While several negative outcomes have been noted relating to the misuse of alcohol, there exist limited diseases that may have positive outcomes from consuming alcohol. In all of these cases, it is noted that consuming alcohol in small quantities could be beneficial. These diseases include diabetes mellitus, hypertension, and ischaemic stroke (Rehm et al., 2017). However, such positive impacts have not yet been widely established through meta-studies. As limited data is available in this specific area, the impacts of these potentially positive impacts have not been modelled previously.

In all, the literature points widely towards harm caused by the consumption of alcohol. It is noted that riskier alcohol consumption patterns include heavy drinking and binge drinking. These are both found to have adverse health impacts on individuals. These negative impacts are further discussed in chapter 6, where the discussion is taken further to discuss how these could be measured in economic analyses, as is being conducted in this thesis.

2.4 Nature and Working of Alcohol Duty in the UK and Scotland

Within the UK, the taxes on alcohol are controlled by the UK government. The sale of taxes involves the levy of two taxes. These include VAT, which is an ad valorem tax; and alcohol duty which is a specific tax. As previously explained, the Scottish Government is committed to getting alcohol duty to be devolved.

In this section, we find that the nature of alcohol duty in the UK is the same in all the countries. However, since the level of consumption is different in the constituent countries, this alcohol duty may need to be used differently to internalise externalities in Scotland.

In the UK, the duty on alcohol is levied by the union government as set out in the Alcohol Liquor Duties Act, 1979. The rates of duty on alcohol are based on the category of product. Alcohol is divided into four categories to determine which rate is to be levied by the HMRC. These categories are Beer, Wine, Cider and Spirits. The rate of levy also depends on the content of alcohol in the product. This means that products which have a high percentage of alcohol would be taxed at a high rate. The rate depends on the percentage of alcohol in the beverage. Tax brackets are created based on the volume of alcohol, and duty must be paid at the relevant rate per percentage of alcohol in the beverage. The list of alcohol duties is presented in Table 2.3.

The calculation of alcohol duty is described by HMRC (2019a). They describe that alcohol becomes liable for duty on the production of alcohol. However, the duty only becomes payable once the alcohol crosses a duty point. This is to say that the premises on which the alcohol is produced are the zone where no duty is to be paid. Once the beverage leaves the premises (unless it is lost, in which case duty is payable when the alcoholic beverage is considered to be lost), the duty becomes payable to HMRC.

As an example of the calculation of alcohol duty, if a brewery produces 360 cases of 24 cans of beer at 440ml each, with an alcohol percentage of 5.6%, then the alcohol duty that would be liable would be calculated as follows:

24 cans x 440 ml = 10.56 litres per case

10.56 litres x 360 cases = 3801.6 litres of beer

3801.6 litres x 5.6% = 21288.96 litre%

21288.96 litre% x £0.1908 = £4061.93

The alcohol duty being paid by the brewery, in this case, is £4061.93, which comes to about 47 pence per can of beer. Thus, it is seen that alcohol duty is a duty that is levied on the production of alcohol. This duty is payable by the manufacturer to the HMRC.

Alcohol Category	Strength	Duty per litre for each % of alcohol
Beer		
Beer	More than 1.2%, up to 2.8%	8.42p
Beer	More than 2.8%, up to 7.5%	19.08p
Beer	More than 7.5%	24.77p
Cider		
Still	More than 1.2%, less than 6.9%	40.38p
Still	At least 6.9%, up to 7.5%	50.71p
Still	More than 7.5%, less than 8.5%	61.04p
Sparkling	More than 1.2%, up to 5.5%	40.38p
Sparkling	More than 5.5%, less than 8.5%	288.10p
Wine		
Still	More than 1.2%, up to 4%	91.68p
Still	More than 4%, up to 5.5%	126.08p
Still	More than 5.5%, up to 15%	297.57p
Still	More than 15%, up to 22%	396.72p
Sparkling	More than 5.5%, up to 8.5%	288.10p
Sparkling	More than 8.5%, up to 15%	381.15p
Spirits (In £/litre of pure alcohol)		
Spirits	Any	£28.74

Table 2.3: Alcohol duty rates in the UK
Source: HMRC (2019a)

Apart from alcohol duty, VAT is also levied on the sale of alcohol in Scotland. This is levied on all categories of alcohol products at the standard rate of 20%. As seen in section 2.3.3, half of the VAT levied in Scotland is allocated to the Scottish block grant.

Thus, the duty on alcohol in the UK is not devolved. This means that the Scottish Parliament neither has the responsibility, nor the power to set and adjust alcohol duties. These duties are administered centrally and collected by the HMRC. They are then redistributed to the countries through the Barnett formula as a part of the block grant. The consumption of alcohol in countries plays no role in the redistribution of alcohol duty. However, there is a large disparity in the consumption patterns of alcohol within the UK. This disparity is discussed in detail in chapter 3.

2.5 Conclusions

In this chapter, the use of literature and data has been employed to contextualise the macroeconomic analysis of alcohol consumption in Scotland. Since the powers of taxation are limitedly devolved in Scotland, the issues that arise from this are that the Scottish Government does not have the complete set of fiscal tools to reduce alcohol consumption in the country.

The literature on devolution found that devolution is a complex term. We were able to show that the level of devolution of the region depends on three main characteristic – actors, powers and accountability. It was also found that the level of devolution was determined by the powers granted to the actors of the region, alongside reduced upward accountability. Governments were found to have a higher degree of devolution where the accountability lay directly with the electoral process.

It was in this context that the history of Scottish devolution was discussed. It was found that the demand for Scottish devolution is not new and has its roots in the Treaty of Union of 1707. The many requests and uprisings of Scotland over three centuries led to the creation of the Scottish Parliament in 1998. The actors of this parliament, the Members of the Scottish Parliament (MSPs) were then given fiscal powers, along with a low level of upward accountability. This led to the establishment of Scotland as a country with a high degree of devolution.

The fiscal powers of the Scottish parliament along with the fiscal structure of block grant were discussed. It was found that very few taxes have been devolved to Scotland. Of the powers devolved through the various Scotland Acts (1998, 2012, 2016), only two taxes have effectively been devolved. Recently, the Scottish Government also took up the powers to create new income tax bands and set income tax rates for Scotland, different from the rates in the rest of the UK. The process of uptake of other fiscal powers is still ongoing.

In the framework of alcohol, it was seen that alcohol taxes include VAT and alcohol duty. The Scottish Government is committed to getting the alcohol duty to be devolved (Scottish Government, 2011). The nature and working of alcohol duty in the UK were discussed. While policies such as Minimum Unit Pricing have been implemented by the Scottish Government, further devolution of alcohol duties would mean that the government would have the fiscal levers to attempt to reduce alcohol consumption. The macroeconomic impacts of fiscal policies on the alcohol consumption sectors can, therefore, be expected to differ based on the devolution of powers. The differences in the expected impacts of various policies, depending on various scenarios of devolution are discussed in chapter 5.

A discussion on the literature on alcohol taxes and their impact on reducing consumption and health problems was conducted. It was seen that a direct correlation exists between the use of pricing policies and reduced levels of consumption. It was also found that a reduction in alcohol consumption had positive impacts on reducing various health problems. It was shown that high levels of alcohol consumption have negative economic externalities.

This chapter helped show that fiscal policies have been used to successfully tackle alcohol consumption problems in different parts of the world. For the reduction of alcohol consumption, a wide range of fiscal tools may be required that are unavailable to the Scottish Government. The devolution of alcohol duties may help in providing the Scottish Government with these fiscal levers.

However, what was not found was the economic impact of reducing alcohol consumption in Scotland. The next chapter will focus on finding the role of alcohol in the Scottish economy. This is essential to find the expected linkages within the economy, and thus to form the basis for macroeconomic analysis of reducing alcohol consumption.

Chapter 3: Economic Role of Alcohol Production and Consumption

3.1 Introduction

As briefly discussed in the previous chapter, the Scottish alcohol industry is complex. Various policies aimed at reduced alcohol consumption have been tried in Scotland historically. This makes the case of Scotland particularly interesting as alcohol is consumed in Scotland in larger quantities than in the rest of the United Kingdom. Adults in Scotland consumed about 19.6% more alcohol in 2015 than in England and Wales (MESAS, 2017). These statistics make a worrying case for the level of consumption in Scotland. It is important to understand how alcohol is integrated into the economy of Scotland.

The focus of this chapter is to better understand the alcohol industry in Scotland. It is important to do so since this allows us to not only better shape the simulations that are carried out in future chapters, but also to better understand the results of such simulations. A historical overview of alcohol policies in Scotland is conducted to understand the policies that have been implemented and their effectiveness. Also analysed is the discontinuity between policies in Scotland and England. Current alcohol policies are also discussed in this chapter.

The analysis of the alcohol industry is done by first defining the alcohol sectors for this study. An analysis of alcohol production finds that the two main alcohol production sectors in Scotland are “Spirits and Wine” and “Beer and Malt”. However, we find that alcohol is sold to consumers through other channels. These include the “alcohol off-trade” and the “alcohol on-trade” sectors. The alcohol off-trade sector sells alcohol through the wholesale channel, while the alcohol on-trade sector sells alcohol through the accommodation sector, and through bars, pubs and restaurants. Further analysis of the alcohol sectors finds that alcohol plays an important role in the economy of Scotland in terms of employment generation, trade and tax collections. In all, we find that this is a key “growth” sector in the Scottish economy.

3.2 History of Alcohol Consumption and Policy in Scotland

In chapter 2, we saw that alcohol played an important role in the devolution of Scotland from the UK. However, historic alcohol policies in Scotland were not studied. To better understand the reasons for high alcohol consumption in Scotland, it is important to note how policy has evolved in this field. Thus, this section helps to understand how integrated alcohol is to the economy of Scotland.

While the earliest recorded date of Alcohol production in Scotland is disputed, records of modern breweries and distilleries date back to at least 800 years (Belhaven, 2017). Alcohol has been of historical importance through, both, the golden and dark ages of monarchy, through wars and celebrations, from at least 1147 by King Stephen. Through these times, Scotland went through peaks and troughs in its demand for alcohol, with beer and whisky being the two cornerstones of Scottish alcohol history.

Soon after alcohol was known as a popular good, taxes were imposed on it. The first instance of informal alcohol taxation in Scotland dates back to the rule of King Edward I in 1303 when imports of wine were taxed in exchange for safe passage of ships. However, official taxation was not established until 1642 (Dean, 2002).

Alcohol was available so freely that it was even supplied as a standard to troops in wars, with rural Scotland having open access to it (Dean, 2002). Over time, it was a common commodity like any other food or drink. Grocers stocked alcohol like any other consumable. This cheap and uncontrolled way of escaping from the harsh climate of Scotland became so ingrained at the heart of Scottish culture that it became an everyday affair for most Scotsmen (Nelson, 2005).

3.2.1 Alcohol policies from Period: 1642-2000

Alcohol Policy has seen a considerable amount of change in the history of Scotland. Policies were often enacted specifically to a region within the United Kingdom (Dean, 2002). There were, therefore, differences in laws between the countries of the UK.

An overview of different alcohol policies in Scotland and England & Wales is shown in Table 3.1 below.

Year	England & Wales	Scotland
1552	Ale Houses Act (1551) was enacted to control the law and order situation. This allowed Justices of Peace to shut down any establishment that would cause problems. All ale houses needed to be licensed by the appropriate magistrate.	
1642		First instance of laws governing alcohol in Scotland by the monarchy.
1707	Act of Union to merge England and Wales with Scotland was passed. This lead to stronger calls for Scotland to brought under the same laws of England and Wales that were introduced before this.	
1713		First attempt to introduce tax on Whisky in Scotland – Failed
1725		Second attempt to introduce tax on Whisky in Scotland – Successful, but with riots
1750	Due to a boom in the consumption of gin in the country through the early 1700s, taxes on gin were introduced and tripled. The Act of 1750 introduced a £10 licence for premises that sold gin.	
1751	Tax rates were stabilized and made equal for England and Scotland to overcome the problem of smuggling alcohol from Scotland to England.	
1756		Scotland was included in the Ale Houses Act (1551), which meant licensing was necessary for all establishments serving beer in Scotland as well.
1803	The taxes on Whisky production were increased from £2 annually to £162. This was an 8000% increase in taxes and led to a rise in illegal distilleries.	
1825	The Inland Revenue Act was enacted which required all public houses which served alcohol and grocers who sold alcohol to obtain licences to do so.	

1828	The Drummond Act of 1828 set out that licensing authority in each Burgh made up of a bench of magistrates would issue licences for that Burgh, and Justices of Peace had the authority to issue licences in Counties.	
1853		Due to the higher consumption of alcohol in Scotland, the Forbes Mackenzie Act was enacted which paved the way for differential licences for off-trade and on-trade establishments. A new “off-trade only certificate” was introduced.
1862		Alcohol could now only sold in from Monday to Saturday between the hours of 8 am and 11 pm, and a complete ban on-trade on Sunday. Additionally, residents and police were now allowed to lodge their reservations about licenses with the magistrate to restrict newly issued licenses.
1887		The opening hours were further amended and restricted to 10 pm from the previous 11 pm.
1900 to 1935	The taxes on spirits were progressively increased since spirit consumption was higher than beer consumption during this time.	
1913		A plebiscite was conducted on whether alcohol should be banned in Scotland but was defeated.
1950	Alcohol sales in shops on Sunday were restricted.	
1962		The Licensing (Scotland) Act (1962) was enacted that changed the timings of alcohol sales in both on-trade and off-trade. The new on-trade timings were from 11 am to 3 pm, and 5 pm to 10 pm from Monday to Saturday and 12:30 pm to 2 pm and 6 pm to 9 pm on Sundays. Off-trade stores were not allowed to sell on Sundays.
1970		Off-trade timings were changed from 11 am to 11 pm from Monday to Saturday, and 12:30 pm to 11 pm on Sundays.
1994	Alcohol sales on Sunday were allowed again.	

Table 3.1: Historical Overview of major changes in alcohol policy in England & Wales and Scotland.
Source: Author's illustration of the reviewed literature

The history of alcohol policy in Scotland began a long time before 1642, but since alcohol taxes were first set up in this year, this is where we begin the journey on alcohol policy. While important in contextualising modern day alcohol policy, it is also important to explicitly talk about the alcohol policy in the current fiscal regime. These are discussed in the following sections.

Taxes in Britain were first set up in the rule of King Charles I. The exact year of these taxes being implemented is unknown since the king ruled without a parliament till 1640. However, Scotland was brought under the king's administration in 1642. Thus, alcohol taxes were first introduced in Scotland this year. The taxes of this time were levied to pay for the English Civil war of 1641, and not due to social harm (Crooks, 1989).

The first instance of tax to offset social harm comes in the year 1750 when the country faced a crisis with over-consumption of gin. At this point, the average consumption of alcohol in England was about 25.6 litres of pure alcohol per capita[6]. This led to a tax being levied on all alcohol, apart from Whisky in Scotland (Crooks, 1989). Following this tax, consumption fell to a fourth by 1758.

In 1713, the parliament tried to introduce a tax on whisky in Scotland. However, due to a backlash, this was withdrawn, but only to be re-proposed in 1725 by Walpole, the first Prime Minister of Britain. This time, Scotland saw massive riots, famously, the Malt tax riots of Glasgow.

While alcohol production in Scotland started much earlier, the industry was first brought under government societal regulation in 1756. This was the first time that the sale of alcohol needed licenses. The main reason for these licensing laws to be enacted came from the disorder that became a regularity at public houses ("pubs"). In England and wales, these laws were already in force through the Ale Houses Act of 1552 (Tanner, 1922). Scotland was later included through the Act passed in 1756 (Nicholson Committee, 2003). In England and Wales, Justices of Peace, the courts which handled small cases, were appointed to control the sale

[6] In context, the level of alcohol consumption in Scotland in 2015 was 10.8 litres of pure alcohol per capita (MESAS, 2017), and this has been regarded as a high level of alcohol consumption by the Scottish Government.

of alcohol in alehouses depending on the local public order situation. However. In Scotland, all establishments serving alcohol had to have licenses issued by the magistrates.

The limitation of this law was that only beer was included in this act and other alcohols like whisky, gin, and brandy were not included. However, this seeming limitation was not a problem at the time. This comes from the fact that it was Ale that was consumed in the public houses. It wasn't until the 19th century when whisky became a drink to be consumed in a social setting in the "saloons" (Dean, 2002).

The difference in licensing policy for different classes of alcohol brings out some very interesting observations on how alcohol was consumed at the time (Nichols, 2012). The colonisation of exotic lands resulted in a range of flavours coming back to Scotland, and indeed, all of Britain. By the early 1700s, Britain faced the "Gin Craze" as it was called then. Due to the lack of taxes on the commodity as opposed to low, but significant taxes on beer and whisky, gin had become popular with the poorer sections of the society (Warner, 2002). Additionally, gin was promoted for consumption as an alternative to the French brandy by the monarchy due to the religious differences between the two countries and growing aggression between them. In the 1700s, the economy of Britain boomed, and this allowed the consumption of gin to spread through the society unleashing a "craze" for gin. Through the years, all types of alcohol were included in the licensing policy. The gin craze was controlled by first introducing taxes on gin and then tripling them in 1750 (Nichols, 2012).

Tax rates on alcohol were stabilised and made equal for England and Scotland in 1751, to combat the smuggling of Alcohol to England from Scotland. From 1788 to 1823, the tax on whisky production was increased by 8000%, from an annual tax of £2 to £162. This gave rise to illegal distillation, where many modern-day whisky companies, such as Glenlivet, operated illegally (Glenlivet, 2019).

There were no significant changes in alcohol policy and regulation until 1825 when grocers needed to obtain a public house licence to continue selling drink due to the Inland Revenue act (Nichols, 2012). Over time, it was no longer on-trade that was the problem. Off-trade alcohol was causing more public disruption than on-trade given that on-trade was regulated heavily with licenses (Nichols, 2012). Another change that followed was that instead of individual magistrates issuing licenses burghs, or boroughs as we now know them, had licensing authorities made up of magistrates. This centralised the process of acquiring licences in each borough. However, establishments in the counties of Scotland and England continued to receive their licenses from the Justices of peace (Nichols, 2012). This was set out in the Home Drummond Act of 1828 (Tanner, 1922).

By 1853, there was a perception that Scotland consumed higher amounts of alcohol, though all of Britain was battling high levels of consumption. England was, however, resistant to change, and no policy seemed to pass the parliament to amend alcohol policy south of the border. Therefore, Scotland came to be used as an experiment: In 1853, for the first time, different licenses were issued based on the type of sale in Scotland. This was done through the Forbes Mackenzie Act. Till now, shops could sell alcohol only with pub licences. Now, shops could acquire “off-trade only certificates” to sell in-store (Nichols, 2012).

Another big policy in the act was restrictive sales. Alcohol could only be sold between 8 am and 11 pm in stores from Monday to Saturday, with a ban on Sunday. Age restrictions were put in for the first time as well, with under-14-year-olds unable to buy alcohol. Drunk or inebriated customers could also no longer buy alcohol. This Act was further amended in 1862 where the police and residents could now restrict new licenses issued in their areas by lodging their reservations with the magistrates. Another change was made in 1887 in the Hours of Closing (Scotland) Act, which restricted the time to 10 pm instead of the previous 11 pm. This set of laws saw the birth of Scotland’s alcohol policy as we know it today (Dean, 2002).

All these restrictions caused Scotland to consume slightly lesser alcohol per capita as compared to England. Scotland was said to be the case study for England. However, it was found that Scotland consumed more spirits per capita than England while consuming far lesser beer per head (Tanner, 1922). Despite this, historical data for beer consumption in Scotland is not available. Spirits were taxed at a higher rate. In the early 1900s, until about 1935, alcohol consumption fell sharply in Scotland and the policies were said to be doing quite well (Nichols, 2012). While official figures are not available, this decline was evident in the fall of spirit consumption from 1900 to 1935 according to Wilson (1940). This is evident in Figure 3.1.

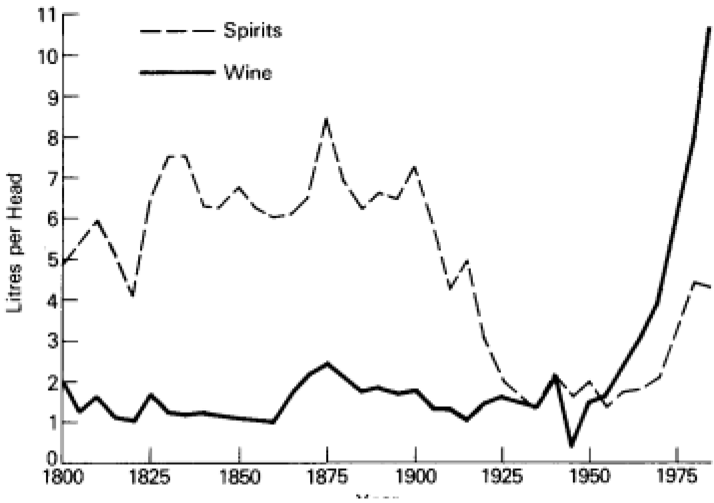


Figure 3.1: Average Scottish Alcohol Consumption per capita (1800-1975)
Source: Alcohol Consumption and taxation, IFS (1989)

A commission was set up by the British government to check alcohol consumption in England, called the Peel Commission (House of Commons, 1899). This commission recommended that fewer licenses be approved in England. This commission also recommended the 8 am to 11 pm times in Scotland overturning the 1887 law. As a result, Scotland received a new law which was the 1903 Licensing (Scotland) Act; while England got its law which was the 1904 Licensing Act in England. The English law sought fewer licenses to be issued to reduce the density of outlets selling alcohol. Scotland's law focussed on re-limiting the hours of sale of alcohol (Nichols, 2012).

A 1913 plebiscite on whether alcohol sales should be banned completely in Scotland was also carried out which was defeated. Complete prohibition did not catch momentum due to political defeats of the Liberal party which ran on this platform in 1895 (Nichols, 2012).

Only a few new laws saw the day of light in the early 1900s. Public houses were put on time restrictions as well, along with a ban on alcohol sale on Sundays, although hotels could serve alcohol to their guests. All licenses were made one-year licenses and were granted to individuals rather than to establishments. The three different forms of license became stricter in implementation. Apart from these laws, the policy remained unchanged. Alcohol consumption stayed at very low levels through Scotland till the mid-1900s. This was due to the effects of the wars, good policy in place, and low-income levels.

Due to the low levels of alcohol consumption, Scotland decided to uplift restrictions on the timings of the sale of alcohol. However, The Licensing (Scotland) Act of 1962 restricted the timings of alcohol sale in stores and public houses. The opening hours were now 11 am – 3 pm, and 5 pm to 10 pm, and lifted the ban on Sundays with reinstated timings of 12:30 pm to 2 pm and 6 pm to 9 pm. However, off-trade was not allowed on Sundays. Thus, the on-trade alcohol policy and taxation were relaxed in 1962, but this made off-trade less attractive. This was done to prevent street drinking (Nichols, 2012). The wine was still purchased in stores and the wine consumption soared in the 1960's increasing per capita consumption.

In the 1970s a report commissioned by the British government suggested that off-trade be deregulated to increase tax revenues (Nichols, 2012). This report also increased hours of off-trade and changed it from 11 am to 11 pm on weekdays, and 12:30 pm to 11 pm on Sundays. This report said that with increasing prosperity, Britain can expect to see increased spending on Alcohol. This was seen as a view to promoting the alcohol industry since manufacturing boosted heavily in this period as well (Scotch and Whisky Association, 2017).

One big debate that arose in the UK dealt with licensing. A committee headed by Dr Christopher Clayson, in their report said that magistrates were licensing alcohol establishments based on their assessments on the need for the society, and there was no guidelines set. This problem was not addressed then, although it was recommended that a licensing board is established and elected. It wasn't until 2005 that Scotland tried to address this through the Licensing (Scotland) Act (Nichols, 2012).

Thus, alcohol policy and taxation, as we know it today has been impacted heavily by past policies, and these should form an important precedent for future policy as well.

3.2.2 2000's onwards

The recent form of Alcohol policy in Scotland is determined by past policies. Certain aspects of alcohol policy have been devolved from the United Kingdom to Scotland, where the country makes its policies to deal with curbing consumption. The minimum drinking age is set at 18, irrespective of place of consumption. Legally, there is no restriction on alcohol sponsorship, but the advertising of alcohol is restricted. Health warning labels are not required on alcoholic products by law, but the alcohol industry agreed with the UK government in 2011 to add the warning labels on the packaging (Blackwell et al, 2018).

Alcohol consumption in Scotland is regulated using various government policies such as time restrictions on off-trade purchases through the Alcohol etc. (Scotland) Act, 2010. Most of the policies that were set up historically still stand.

The major changes are that Alcohol can be sold in on-trade establishments until much later, with varying timings depending on the type of licence held by an establishment that was set out in the Alcohol (Scotland) Act of 2005.

The standard alcohol license in Scotland is dependent on postcodes and the type of establishments an individual is working in since alcohol licenses are issued to individuals and not venues. While some postcodes do not allow for a license to be issued for sales past midnight, others can stay open till 3 am, or 4 am with special permission from a magistrate. Off-trade timings are set from 10 am to 10 pm.

As was discussed in chapter 2, on the fiscal front, alcohol is taxed in the same way across the United Kingdom. Alcohol duty is levied on all alcohol, but the rate of duty depends on the type of alcohol being purchased. Four different classes of alcohol are set out by the HMRC as per the Alcohol Liquor Duties Act, 1979. These include – Beer, Spirits, Wine and Cider, and the duties of these categories were discussed in chapter 2.

Since alcohol duties have not been devolved, they are directly collected by the HMRC and redistributed as a port of the block grant. In 2013-14, the Scottish share of alcohol duty revenue was £972m (9.43% of total UK alcohol duty), while the total alcohol duty revenue in the UK was £10,308m. In 2014-15, the Scottish share of alcohol duty revenue was £961m (9.20% of total UK alcohol duty), and the total alcohol duty revenue in the UK was £10,449m (Scottish Government, 2016b). Additionally, alcohol is also subject to the regular VAT rate of 20% (HMRC, 2019a).

A key change in alcohol policy in Scotland came as recently as 2018 when the Minimum Unit Pricing (MUP) was enacted. While this law was passed in 2012, it faced a legal battle by the alcohol industry but was eventually held to be permissible. This policy has placed a price floor on the sale of alcohol. The price floor is decided by the Scottish Parliament and is currently at £0.50 per unit of alcohol (Scottish Government, 2018).

In all, policies in Scotland that deal with alcohol consumption include social policies as well as fiscal policies, with the introduction of policies such as Minimum Unit Pricing and Challenge 25. These are both aimed at reducing the consumption of alcohol in Scotland. The Scottish Government has thus, been attempting to frame a policy that effectively deals with the issue of alcohol misuse, thereby reducing alcohol consumption. The policy of age-restricted sales of alcohol has been found to be effective in reducing alcohol consumption in underage populations, reducing the likelihood of them from becoming heavy drinkers later on in their life (Jones et al., 2011; Babor et al., 2010; Spoth et al., 2008; Ker & Chinnock, 2008).

As MUP is a relatively new policy, very little analysis has been conducted that shows the impact this has had on the levels of consumption, in Scotland. However, O'Donnell et al. (2019) and Robinson et al. (2020) have found in their initial assessments of the policy that households in Scotland have reduced their purchasing of alcohol. This reduction was found to be the largest in those households that consumed the highest proportion of alcohol. Thus, keeping in mind that the aim of the policies has been on reducing the level of alcohol consumption, the focus of this thesis is on the macroeconomic impacts of reducing this level of consumption.

3.3 Defining the alcohol sector in the Scottish context

As mentioned in the previous sections, alcohol has played a key role in the Scottish economy historically. In the current context, alcohol continues to play an important role in the Scottish economy. Due to its important role, it is necessary to define the alcohol sector in Scotland. The Scottish Government has designated the food and beverages industry, and specifically the alcohol production sector as a "growth sector" (Scottish Government, 2020b). This means that Scotland has a comparative advantage in this sector.

Alcohol consumption and production sectors have seen sea changes over the past decade in terms of policy. As seen in the sections above, both fiscal and social policy has been subject to changes. In this section, the production and consumption sectors of alcohol are identified and analysed.

To better define the alcohol sector, we must look at how alcohol is produced and consumed in Scotland. To understand this, alcohol-related data is gathered from a variety of sources. These sources include the Scottish Government, the World Health Organisation (WHO), the Office for National Statistics (ONS), HMRC, Business Register and Employment Survey (BRES), and Monitoring and Evaluating Scotland's Alcohol Strategy (MESAS). The data helps us to find the prominence of alcohol in the economy and society in Scotland.

3.3.1 Production

The importance of Alcohol in Scottish society can be displayed through the celebration of Alcohol through trails of Whisky distilleries and breweries of beer across the country. Numerous tourists visit the country for these trails, highlighting the prominence of Alcohol in Scotland.

The production of alcohol in Scotland is given into two sectors of the IO tables – "Spirits and Wine" and "Beer and Malt".

The Gross Value Added by the manufacturing sector as a proportion to total output averages at 38.57%. This ratio for Spirits and Wine is 56.34% and beer and malt is at 41.2%. It is worthy to note that the ratio is the fourth highest amongst all manufacturing industries after Pharmaceuticals, Print and publishing, and Repair and maintenance of machinery. This has increased drastically from the 1990s when the industry was considered a 'medium' value-added sector. The increase can be attributed to the increased levels of production of alcohol, alongside higher alcohol taxes.

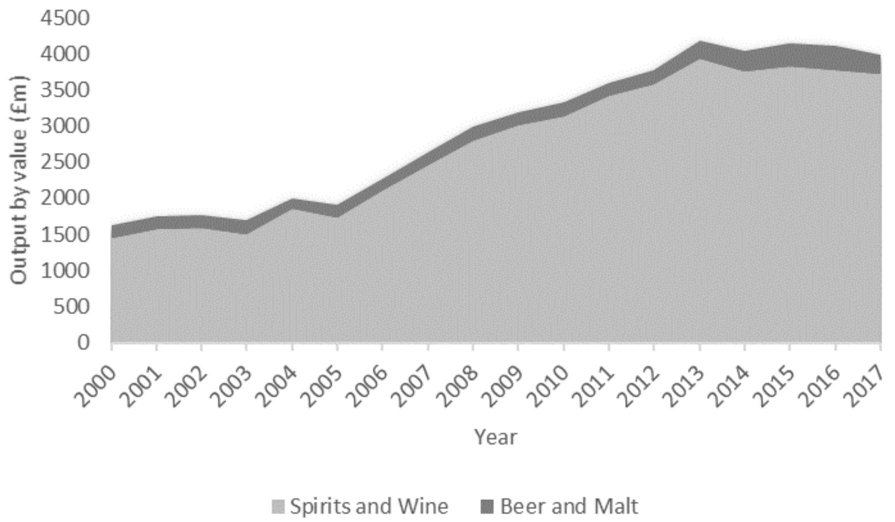


Figure 3.2: Production of alcohol in Scotland from 2000 to 2017 (in real prices, 2015 is the base year)
Source: Input-Output tables for Scotland (Scottish Government, 2020g)

As is noted from Figure 3.2, the value of manufactured spirits and wine in Scotland has increased by over 157.14% from 2000 to 2017, while the manufacture of beer and cider has increased by just over 54.97%, primarily to meet the high foreign demand. This increase in the manufacturing of alcohol, especially spirits, is driven by the increase in global demand for Scotch whisky.

The Scotch Whisky Association (SWA) has data published on the volume of Scotch whisky produced in Scotland. This data is presented in the chart below. It is seen that the volume of production peaked in 2008. It has been at a consistently lower level since 2012. While no specific explanation is provided for this low level of Scotch production, it is important to note that the volumes presented in the chart below denotes the volume of whisky that has matured from casks and not the volume of whisky that was produced and put into casks.

In terms of whisky, the value of whisky exports reached £4.7bn in 2018. This accounts for an overwhelming majority of all food and drinks exports from Scotland, and 21% of all food and drink exports from the UK. The production of whisky is also integral to attracting tourism to Scotland, with about £85m being spent at visitor centres of distilleries in 2019 (SWA, 2020). The contribution of Scotch whisky to total UK exports was 1.3% of total exports in 2018 (O'Connor, 2019).

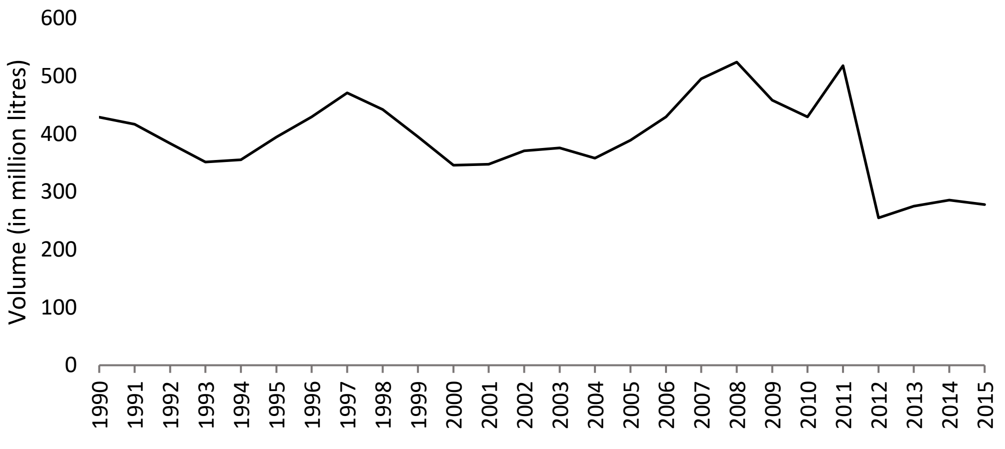


Figure 3.3: Volume of Scotch whisky produced in Scotland, 1990 to 2015 (in million litres)
Source: Scotch Whisky Association, 2017

In all, it is seen that in value terms, the level of production of alcohol in Scotland in the year 2014 was £4,078 million. This translates to over 1.75% of the total output of the economy. It is clear from this analysis that the main alcohol manufacturing sectors in Scotland are “Spirits and Wine” and “Beer and Malt” within the IO tables.

As is expected from increased levels of production, the level of employment in the alcohol manufacturing industry has also increased. Particularly in the past few years, there have been large increases in employment in the distilling of spirits. Just in the year 2018, the level of employment in the spirits production sector increased by 25% year-on-year (BRES, 2019).

Of the 32 local authorities in Scotland, 23 of them have distilleries in them. This accounts for about 72% of the local authorities. Moray has the highest concentration of distilling businesses, with 50 of the 280 Scottish distilling businesses located here. The highlands have the second-highest number of distilling businesses at 30. The city of Edinburgh has seen the highest growth rate in the number of businesses from 5 business in the year 2000 to 15 businesses in the year 2019 (BRES, 2019). Stirling and Perth are also being considered growth hotspots (O’Connor, 2019). The main products of distilleries in Scotland include Scotch Whisky and Gin.

However, when it comes to the concentration of employment in the local authorities, Glasgow city has the highest number of jobs at 1500 of the 10000. About 53.5% of all jobs from the distilling sector are located in the 5 local authorities – Glasgow city, Moray, Fife, North Lanarkshire and West Dunbartonshire. In all, it is found that 9 out of 10 distilling jobs in the UK are Scottish (O’Connor, 2019). This places a greater emphasis on the need to analyse the subnational nature of the alcohol industry in Scotland and its differences from the rest of the United Kingdom.

While distilling spirits is an integral part of alcohol manufacturing in Scotland, so is the brewing industry. This industry has shown a large growth in the past 3 years, with an increase of 150% in the level of employment in 2018, compared to previous years. 15% of total employment from brewing in the UK comes from

Scotland. Aberdeenshire is the main centre for the brewing industry in Scotland, while the highlands and Glasgow are prominent centres for employment in the industry as well (O'Connor, 2019).

Both the industries – Distilling and brewing are important in the Scottish economy and have high employment multiplies as is seen in the proceeding chapters. It is seen that the alcohol manufacturing industry is very important to the Scottish economy, and any changes to consumption taxes have impacts on the production sectors as well, which need to be kept in mind while changes to fiscal policy are considered.

3.3.2 Consumption

A primary source for data on consumption is the MESAS alcohol database. This data is split into two categories based on place of sale and consumption – off-trade and on-trade.

Changes from 2000 to 2019 show that the total volume of pure alcohol being sold to each adult in Scotland has stayed widely consistent and has reduced from 10.9 litres per adult to 9.9 litres per adult. This number peaked in 2005 and 2007 at 11.7 litres per adult. However, when this data is disaggregated by type of sales, it is noted that on-trade alcohol consumption has fallen from 4.4 litres of pure alcohol per adult to 2.7 litres per adult. Since the prices of on-trade alcohol have increased from £0.71 in 2000 to £1.96 in 2019 in real terms. This difference of £1.25 per unit explains the reduction in on-trade alcohol consumption.

In the Scottish off-trade sector, the real price of alcohol has increased by £0.23. However, since the on-trade sector prices have increased by a much larger percentage, there is an increase in the volume of alcohol being sold in the off-trade sector from 6.5 litres of pure alcohol per adult in 2000 to 7.2 litres of pure alcohol per adult in 2019.

Thus, the prices of alcohol have increased over time in real terms, although the trend in total alcohol consumption has shown a slight reduction between 2000 and 2019.

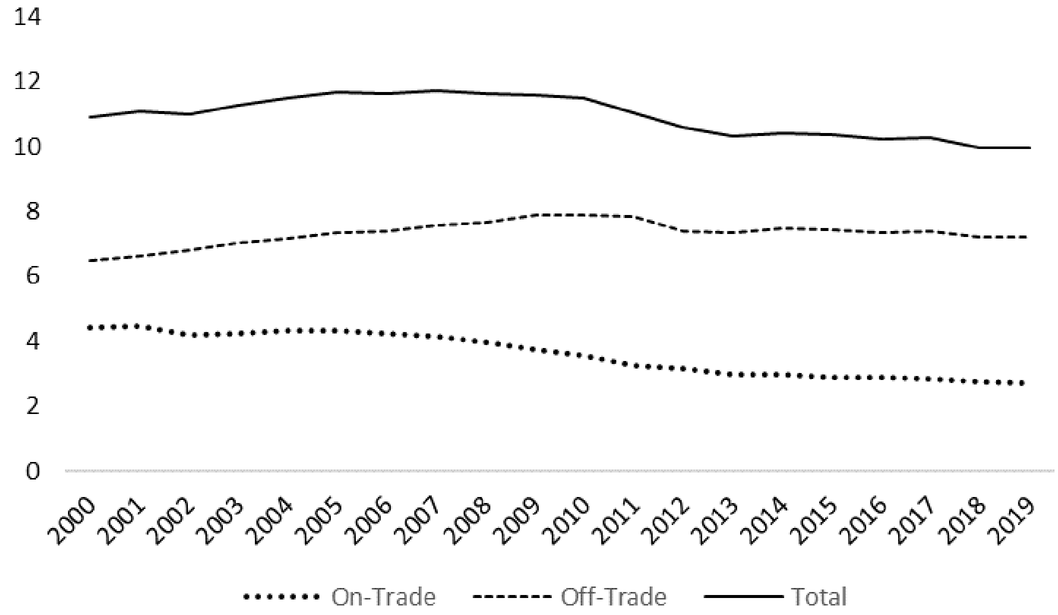


Figure 3.4: Volume of pure alcohol consumed per adult per year in litres, 2000 to 2019
Source: MESAS, 2020

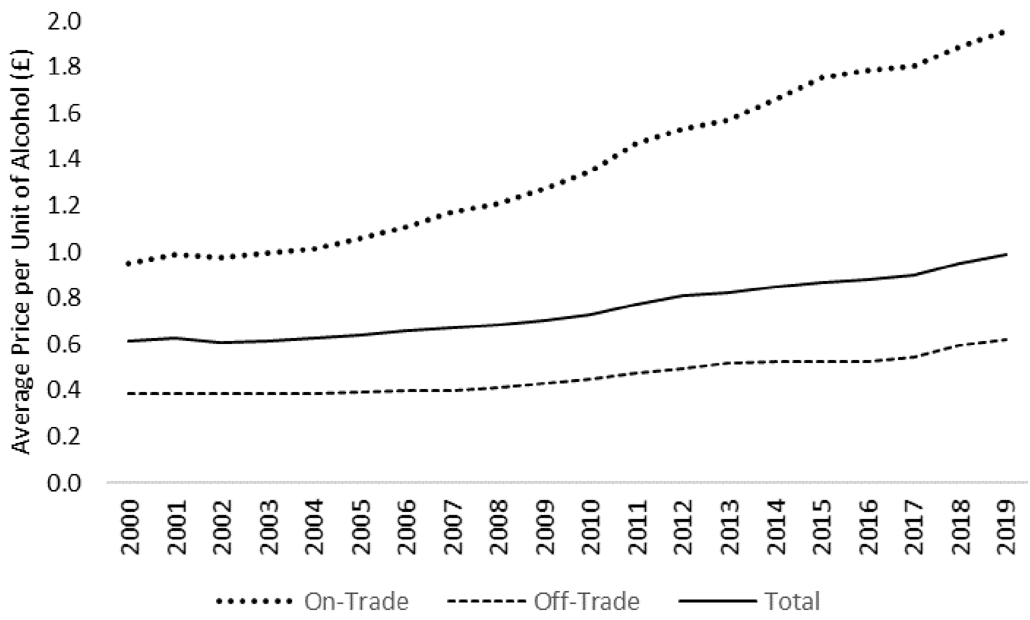


Figure 3.5: Price per unit of alcohol in pounds, 2000 to 2019 (in real prices, 2015 is the base year)
Source: MESAS, 2020

As noted in chapter 2, the composition of consumption of alcohol is very different for countries within the UK. Within the UK, alcohol is consumed in England, Wales, Scotland and Northern Ireland. However, detailed data on the consumption of alcohol in detail is not available for Northern Ireland. The data for England and Wales is also only available in a combined format (MESAS, 2017).

The data for alcohol consumption shows that the consumption in Scotland for all types of alcohol in volume terms is 9.9 litres of pure alcohol per adult in 2019. The same value for England and Wales is 9.1 litres of pure alcohol per adult in a year. The disparity in this number is a difference of 0.8 litres of pure alcohol per adult in a year. This translates to 80 additional units of alcohol per adult in a year.

Breaking down the data shows that while Scotland and England and Wales have similar levels of alcohol consumption in the on-trade sector at 2.7 litres of pure alcohol per adult in a year, the level of consumption in the off-trade sector is much larger. While in England and Wales, an average adult consumes 6.5 litres of pure alcohol in a year, this figure is at 7.2 litres of pure alcohol in Scotland. The disparity in the figures is 0.7 litres of pure alcohol, which indicates that the level of consumption of alcohol from wholesale outlets for consumption at home in Scotland is higher than in England and Wales.

The data described above is shown in the table below. It is seen that in the on-trade sector, where Scotland and England and Wales have similar levels of alcohol consumption, Scottish people have different preferences for different types of alcohol. This trend is even more magnified while looking at off-trade differences.

Alcohol Class	Off-Trade		On-Trade	
	England and Wales	Scotland	England and Wales	Scotland
Spirit	1.8	2.4	0.4	0.6
Wine	2.4	2.7	0.4	0.5
Cider	0.6	0.4	0.3	0.2
Beer	1.8	1.7	1.6	1.4

Table 3.2: Level of alcohol consumption in the off-trade and on-trade sectors by the class of alcohol (in litres of pure alcohol per adult per year)
Source: MESAS, 2020

While the MESAS (2020) data shows the level of alcohol consumption in Scotland, disaggregated by type alcohol and location of the sale of alcohol, it does not elaborate upon who the alcohol is being consumed by. In order to better understand the problem of alcohol consumption in Scotland, data from the Scottish Health Survey (2020) is looked at. This data is able to showcase the divide in consumption between various age groups, gender, location and consumption habits.

Within the general population, it is seen that 24% of the population indulged in hazardous or harmful consumption of alcohol, while 16% were non-drinkers. People living in the most deprived regions of Scotland were more likely to be drinkers compared to those living in the least deprived regions. However, those living in the least deprived regions were more likely to be hazardous or harmful drinkers (Scottish Health Survey, 2020).

A stark gender divide was also seen in the likelihood of individuals consuming alcohol in harmful ways. It was seen that men were less likely to be non-drinkers. Of the drinkers, men were found to be twice as likely to be consuming alcohol at hazardous or harmful levels (Scottish Health Survey, 2020). Further, men were found to consume almost twice the number of units of alcohol (16.1 units) as women (8.9 units) in a week, on average.

Men in the age group of 45-54 were found to be the group that consumed the highest weekly average level of alcohol at 18.5 units. For women, this age group was 16-24, who drank 11.6 units of alcohol per week, on average. However, men in the age group of 55-64 were most likely to be hazardous or harmful drinkers (36%), while for women, this was in the age group of 45-54 (22%) (Scottish Health Survey, 2020).

It was also found that between 36,000 and 51,000 children in Scotland lived with a parent or guardian who was consuming alcohol in ways that could be harmful or hazardous. Scotland also has one of the highest rates of underage alcohol consumption in the world (Scottish Health Survey, 2020).

It is clear from the above data that Scotland faces a problem in terms of alcohol consumption levels. However, alcohol duties are set by the British government centrally. IAS (2017) shows that the level of changes in alcohol duties has been reducing since 2012 as seen in Figure 3.6. From the figure below, it is seen that alcohol duties remain largely unchanged from 1995 to 2008. The alcohol duty escalator of 2008 meant that the duty would increase by a certain value above inflation every year. This was done to tackle the increasing affordability of alcohol (IAS, 2017). However, after requests and lobbying by the alcohol industry, in particular, beer manufacturers, this duty escalator was eliminated in 2014.

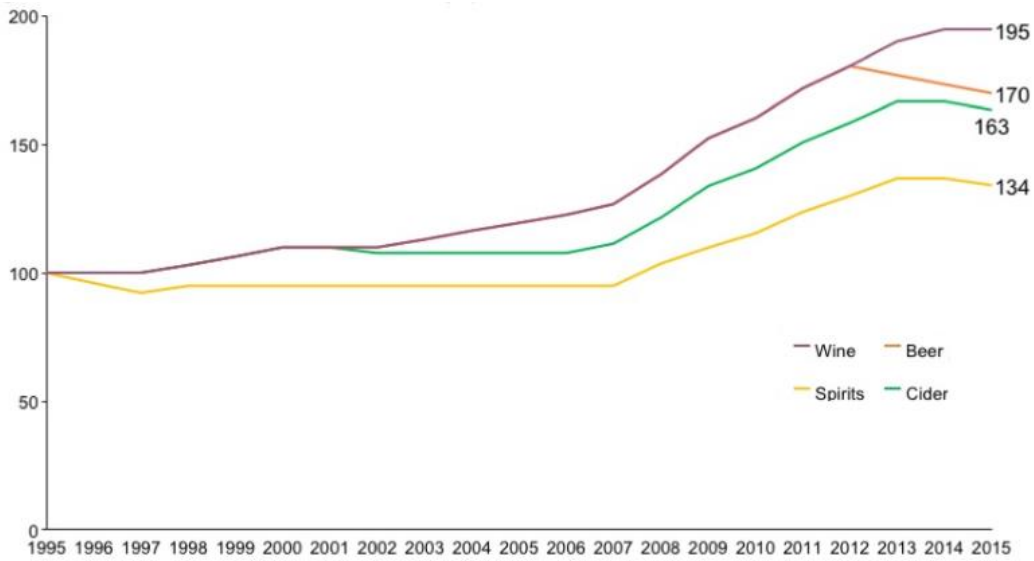


Figure 3.6: UK alcohol duty rate by beverage category, 1995-2015, Indexed, 1995 = 100
Source: IAS (2017), HMRC (2016)

It is clear from the above analysis of data that there is a considerable difference in the consumption patterns in Scotland and the UK.

When looking at alcohol consumption within IO tables, we look at the demand from the two main alcohol production sectors – Spirits and Wine, and Beer and Malt. Demand from the two sectors is quite different in their compositions.

Intermediate demand only makes up 1.8% of the total demand for Spirits and Wine. Most of this is in the food and beverages service industry along with accommodation as a part of the on-trade demand. However, intermediate demand makes 21.8% of the total demand for beer and malt. The most dependent sectors are, again, Food and beverages and Accommodation, making up the on-trade consumption. This is primarily due to differential demand patterns for the different classes of alcohol. A notable point here is that most of the final demand for “Spirits and Wine” is for export purposes, as seen in the figure below.

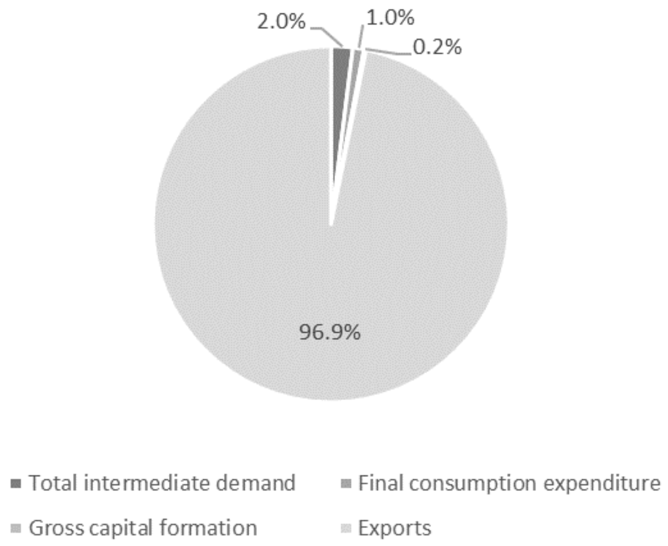


Figure 3.7: Composition of Demand for Spirits and Wine
Source: Input-Output tables for Scotland (Scottish Government, 2020g)

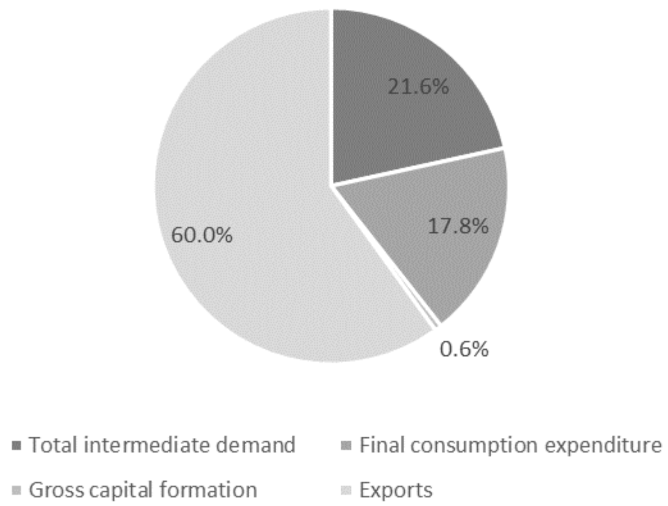


Figure 3.8: Composition of demand for Beer and Malt
Source: Input-Output tables for Scotland (Scottish Government, 2020g)

The household demand from the alcohol production sector has seen changes since 2000. The intermediate consumption of both, spirits and wine, and beer and malt has fallen by 55-60%. Household demand has also fallen in spirits and wine from £158.86m to £150.84m in real terms, and beer and malt have fallen from £38.86m to £35.72m in nominal terms. The fall in demand is much greater in real terms.

Figure 3.9: Total household consumption from alcohol production sectors in value from 2000 to 2017 (in real prices, 2015 is the base year)
Source: Input-Output tables for Scotland (Scottish Government, 2020g)

While Figure 3.9 shows that in value terms, household alcohol consumption from alcohol production sectors in 2014 was £150.5 million in basic prices, this is vastly smaller than the volumetric data on alcohol consumption by MESAS (2017) who find that total household spending on alcohol in 2014 was £3956.5 million in real terms.

However, we know that alcohol is not sold mainly by the alcohol production sector, but by off-trade and on-trade establishments. Off-trade of alcohol is a part of other sectors such as wholesale, and on-trade of alcohol takes place through bars, pubs and restaurants, and through accommodation, which are in the food and drink service sector within the IO tables. To find the alcohol consumption within IO tables, we must look to disaggregate the alcohol consumption sectors. This disaggregation is described in chapter 4 since we are looking to find the economic impact of reducing this level of household alcohol consumption.

Thus, we find that alcohol consumption in Scotland takes place through the off-trade and on-trade channels. Thus, these are considered to be the two alcohol consumption sectors and have been disaggregated from the IO tables in chapter 4.

3.4 Economic role of the alcohol sectors in the Scottish Economy

In the previous section, we found that alcohol production takes place in the Scottish economy through the “Spirits and Wine” and “Beer and Malt” sectors. We also found that alcohol consumption takes place within the Scottish economy through the alcohol “off-trade” and “on-trade” sectors. In this section, we see how these sectors play an important role in the Scottish economy. Since the alcohol sector is classified as a growth sector in Scotland, it is important to highlight the role it plays in the economy.

3.4.1 Employment

The Scottish alcohol sectors support several part-time and full-time jobs. As per BRES (2019), the total number of jobs supported through alcohol production and consumption in Scotland in 2014 was nearly 111,000 jobs including part-time and full-time jobs.

BRES (2019) finds that about 20800 jobs are supported by the alcohol production sectors in Scotland. Figure 3.10 shows that the manufacturing of spirits provides the highest number of jobs. Also notable is that wine is not manufactured in Scotland. Cider manufacturing also has a very small number of jobs. Also notable is that the supply chain of all the categories of alcohol supports a large number of jobs. Figure 3.11 shows the total number of jobs provided by the alcohol consumption sector. It is shown that on-trade, which is sales in bars, pubs, and restaurants require the highest amount of labour, while production requires relatively fewer jobs. Off-trade, which is the sale of alcohol in wholesale outlets, is another important employment generator on the supply-side.

Figure 3.10: Total number of jobs in each process of the alcohol production sectors
Source: BRES, 2019

Figure 3.11: Total number of jobs in each process of the alcohol consumption sectors
Source: BRES, 2019

It is also important to note the nature of jobs generated by each of these classes. The nature of jobs here is the proportion of full-time jobs in each of the sections of the supply is analysed, as shown in Figure 3.12. This shows that while Wholesale, Supply Chain, and Production have a high proportion of full-time jobs, off-trade and on-trade have very small ratios. Thus, part-time jobs are a big provision of the alcohol sector, especially to young people, who are more likely in such positions.

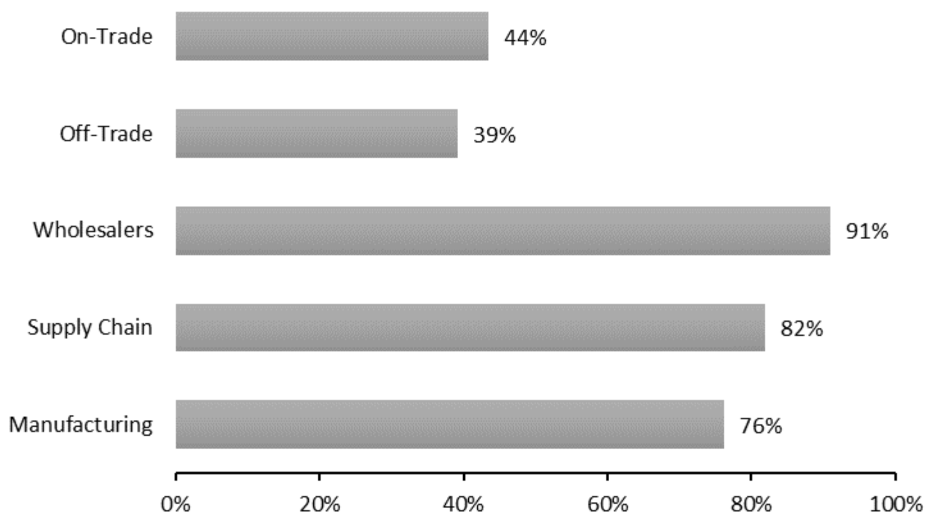


Figure 3.12: Proportion of jobs that are full-time within the supply chain of alcohol in Scotland
Source: BRES, 2019

Upon adjusting the total number of jobs in the alcohol production and consumption sectors, the Scottish government (2020g) finds the FTE or Full-Time Equivalent number of jobs. This is used with IO tables as well. The level of FTE employment in the Spirits and Wine sector in 2019 was at 10,000 jobs. This figure for the Beer and Malt sector was 2,500 jobs. The disaggregation of the alcohol service sector of the on-trade sector reveals that 31,000 FTE jobs were available in this sector. Similar disaggregation for the alcohol off-trade sector showed that 4600 FTE jobs were available in this sector.

3.4.2 Trade

To investigate the trade from the alcohol industry, alcohol production sectors are analysed. The two alcohol production sectors perform very differently even in terms of exports. While only 15% of Scottish spirit exports go to the rest of the U.K., 46% of beer exports are to the U.K. Spirits are mainly exported to the rest of the world (84.5%). Thus, the demand of U.K. markets and world markets jointly influence the beer and malt sector, while world exports alone are key to the demand for spirits. It is important to mention that wine production is at near-zero levels in Scotland (ABS, 2016).

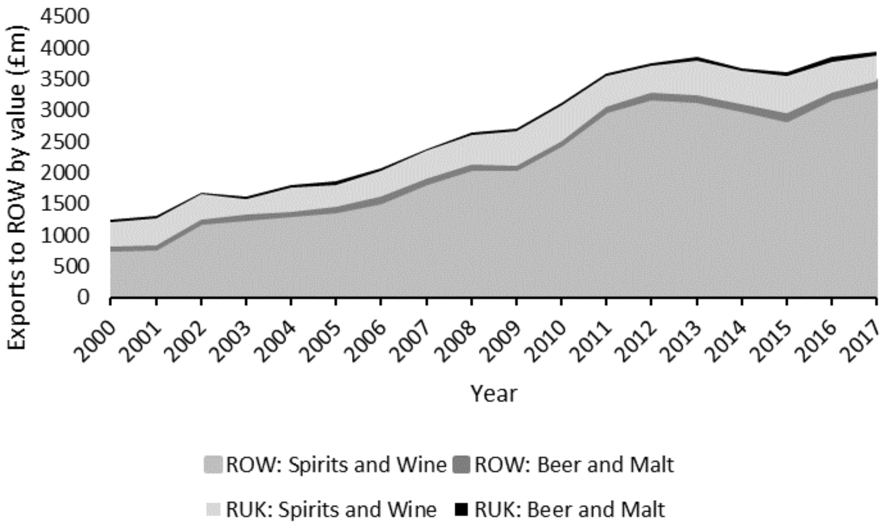


Figure 3.13: Export of alcohol from Scotland to Rest of UK (RUK) and Rest of the World (ROW) from 2000 to 2017 (in real prices, 2015 is the base year)
Source: Input-Output tables for Scotland (Scottish Government, 2020g)

Main markets for export from Scotland include the U.S.A., E.U., Canada, Japan, and Australia (HMRC, 2016). Of this, 44% by share of the volume is exported to the U.S.A. Exports saw a huge boost from 1995-2000, especially for spirits like Gin and Vodka. Since 2000, alcohol exports have steadily grown every year, apart from a small decline from 2003 to 2004. This increase in the level of exports from the alcohol sectors makes for a viable alternative to falling electronics exports and the highly volatile petroleum markets.

The composition of demand for Spirits and Wine (Figure 3.7) and the composition of demand for Beer and Malt (Figure 3.8) show a clear trend for high dependencies on exports and a low percentage of consumption of domestic produce. While Scotch (Whisky produced in Scotland) is the main export of Scotland's Alcohol sector, Wine is the main import. Imports in "Beer and malt" can be attributed to the demand for various brands.

3.4.3 Tax Contributions

Given the high levels of consumption of alcohol seen in the above section, and the relatively high tax rates that apply to alcohol, it is easy to show that the government also receives high levels of taxes from alcohol.

According to GERS (2017), the Government of the United Kingdom received £961 million worth of alcohol duties from sales and consumption of alcohol in Scotland in the financial year 2014-15. This accounts for just about 9.2% of alcohol duty collected from across all the countries in the UK. Since the population of Scotland only accounts for 8.3% of the population of the UK (Scottish Government, 2016b), it is again evident that the consumption of alcohol in Scotland exceeds consumption elsewhere in the UK. The alcohol sector of Scotland contributed £1.76bn in VAT and excise duty to U.K. government revenues in 2014. The primary contributor to this is distilled alcohol such as Scotch whisky, which is exported in high quantities as seen above.

While the Scottish Government (2015) has been seeking to devolve alcohol taxes from London, it has been unsuccessful thus far. Due to this, the Scottish Government does not receive alcohol duty raised from consumption in Scotland. It does, however, receive 50% of all VAT collected from the sale of all goods in Scotland, and thus, receives 50% of VAT from alcohol production and sale in fiscal transfers from the United Kingdom.

3.4.4 Market players and structure

The sections above have shown the levels of consumption and production of alcohol in Scotland. They have also shown the levels of employment generated, the contribution to exports as well as taxes. However, the structure of the sector in the markets of Scotland are not yet clear.

In Scotland, several local and global firms participate in the alcohol industry. This allows for a complex market structure within the sector. As compared to England, particularly, London, fewer firms are headquartered in Scotland. This allows them to pay corporation taxes in England, since corporation tax is neither currently decentralised nor set to be decentralised.

There exist several vertical linkages in the industry. The agricultural raw material is generally grown by farmers specialising in different crops. Thus, the supply chain for different firms remains similar for producers of each class of alcohol. It is also true that in some cases, raw material passes through third parties before reaching the firms. For example, malting is a process that is generally done through third parties to produce whisky. Sales are also closely knit as neither brands, nor classes of alcohol are sold in exclusive outlets in both, off-trade and on-trade. The market place is defragmented to this extent.

Horizontal integration or mergers and acquisitions with industry is dynamic for the alcohol industry. Smaller firms have been acquired by large brands in recent years. Heineken has attempted and succeeded in boosting production by buying ‘Scottish & Newcastle’ in 2010, which was previously partially owned by Carlsberg. In 2012, Diageo purchased a majority stake in United Spirits, India’s Alcohol Giant. The wave of mergers and acquisitions in the alcohol industry has certainly hit the Scottish markets.

A recent change in the Scottish markets has been a growth of small brewers and distillers who sell locally produced alcoholic beverages. This section of the market has seen its profits grow over the past decade. In 2018, SME manufacturers saw their profits grow by 7.2%, compared to 3.1% in 2013. Some such firms include Brewdog, Warner Edwards, Camden Town and Sipsmith. These have become significant players in their respective markets. Another trend in this section of the market is that young consumers are more willing to pay higher for locally produced alcoholic products than ever before.

In the alcohol market, the concentration of small and micro firms (less than 50 employees) is much higher than medium and large firms. In terms of spirit distilling, about 79% of the firms are small, while 83.3% of firms in the brewing industry are small (BRES, 2019).

Each class of alcohol also has an association that works in its interest. This has been essential in driving policy changes in Scotland. Such associations give sectors higher bargaining power. It also brings in a higher level of structure to the market as firms that compete in the market seek to hedge against instability.

Barriers to entry in the alcohol industry in Scotland are quite high, given high capital intensity in the production process and sales. A high level of competition amongst large firms in prominent markets curbs new firms from entering. In Scotland, local companies such as Tennent's compete with large global firms. However, smaller firms are starting to establish themselves in niche markets such as artisanal beers. These firms can, however, compete at a regional level and are unable to reach global markets due to the economies of scale.

3.5 Conclusions

This chapter has highlighted the size and scope of the alcohol sector in Scotland. A historical analysis of alcohol policy in the country is compiled through a review of the literature. It is seen that various policies have been tried and these policies have seen varying degrees of success. These policies have been instrumental in leading us to the alcohol policies that are presently enacted in Scotland.

To better understand the definition of alcohol sectors in Scotland, data regarding alcohol production and consumption is analysed. This analysis finds that the alcohol production sectors in the Scottish economy are “Spirits and Wine” and “Beer and Malt”. The alcohol consumption sectors are found to be “Off-trade” and “On-trade”. It is found that the consumption of alcohol by households takes place through these consumption sectors, and these need to be disaggregated from the IO tables for future analyses in chapters 4, 5 and 6. A primary highlight is that alcohol is a key manufacturing sector in the economy. The high level of production of alcohol has been primarily to export Scottish alcohol such as Scotch whisky. Another highlight that is noted is that local demand for alcohol has seen increases over the past two decades.

Given that the alcohol sector is a growth sector in Scotland, we find the extent to which alcohol contributes to the economy. This is done through analysing employment, trade and tax contributions. This data shows that the alcohol sectors play a crucial role in the economy of Scotland by contributing to employment and tax revenues. A primary highlight here is that the on-trade alcohol sector contributes greatly to employment in the economy. However, this employment is mainly part-time. The off-trade alcohol sector is slightly better at providing full-time employment. However, the production sector provides the most full-time employment. Another key result that was found was that there are large variances in the level of consumption between the different countries in the United Kingdom.

Various macroeconomic models can be employed to analyse the economic impacts of a reduction in alcohol consumption in Scotland. In this chapter, we have seen the economic importance of alcohol production and consumption. Questions on how the economy can be expected to be impacted by a reduction in alcohol consumption consistent with government policies are the focus of the next chapter. The next chapter focuses on using the IO tables as a multi-sectoral economic model and dwells into an ex-ante analysis of reduced alcohol consumption.

Chapter 4: Evaluating the economic impacts of demand-side disturbances in the alcohol sector using an IO Model

4.1 Introduction

The previous chapter gives us an insight into the alcohol sector of Scotland. This analysis showed that the alcohol sector is important in the Scottish economy. Chapter 2 elucidated the rationale for implementing policy to reduce alcohol consumption. These two chapters point towards a complicated relationship between the economy and alcohol. A reduction in the demand for alcohol could have negative impacts on the economy, but a high level of alcohol consumption could have a negative impact on the health of individuals in society. The Scottish Government is committed to reducing alcohol consumption within the region (Scottish Government, 2010). Thus, it is important to study the implications for the economy of this lower consumption of alcohol. The system-wide economic impacts of a fall in demand for alcohol can be studied through multi-sectoral modelling. A model to study such economic impacts must be robust in measuring demand-side responses, as well as supply-side effects. This chapter aims to use one such model, the IO model, to study the economic impacts of falling alcohol demand.

Demand-side changes can be well modelled using IO tables. Historical background on the development of such models provides us with the necessary insight into why these models are useful. Since IO models have not been used extensively to study the impacts of changes in alcohol consumption, the contribution of this chapter extends to identifying the strengths and weaknesses of IO models in such modelling. The process of transforming IO tables from a set of accounts into a model is elaborated upon in this section. The model created in this study uses economic principles such as elasticities and price impacts of policies which are externally modelled and fed into the IO model, showcasing potential demand-side impacts of fiscal policy on the alcohol sector in Scotland.

This model is further enhanced by the inclusion of a consequence of falling demand in one sector – household consumption switching. We define consumption switching as the redistribution of consumption from one sector of the economy to alternative sectors. In our study, a reduction in household consumption in the alcohol sector is redistributed as increased household consumption in alternative sectors of the economy.

A small number of studies have used consumption switching with IO models. A key paper in this literature is Connolly et al. (2019), who study the economic and health outcomes of a reduction in alcohol consumption for the UK through an IO model. This paper is replicated within this chapter, to test the strengths and weaknesses of the IO model built by us. Being able to replicate their results for Scotland would demonstrate the credibility of the IO framework created in this chapter, and allow us to use this for further analyses through CGE models.

Following Connolly et al. (2019), two main policies are assessed within this chapter – a change in the consumer tastes fuelled by an information campaign resulting in lower alcohol consumption, and a reduction in alcohol consumption due to higher alcohol duties. To find these macroeconomic impacts, we disaggregate the alcohol consumption sectors into off-trade and on-trade. This allows us to find disaggregated impacts of a fall in consumption in both sectors individually. To estimate the net impacts, a reallocation of spending is also simulated to non-alcohol products and government expenditure, where appropriate. This allows us to note the potential impact of changes in household and government consumption.

Thus, using a multi-sectoral macroeconomic model such as an IO model for finding the impacts of falling alcohol consumption in Scotland is one of the contributions of this chapter. Replicating UK wide impacts for Scotland highlights the resilience of the model used in this chapter, and justifies its use for further modelling in the following chapters. Incorporating net impacts of the policies analysed through switching household and government consumption is key to estimating the expected macroeconomic impacts of said policies.

This chapter starts with a brief discussion on the historical evolution of economic modelling, and the origins of IO tables and modelling in section 4.2. Section 4.3 then explains how IO tables can be used as a set of accounts and as a macroeconomic model. This sets the stage for the uses of IO tables in economic modelling, through a multiplier analysis. Section 4.4 highlights the key literature on the use of IO models in analysing economic policy. The set-up that is used to analyse the economic impacts is elaborated in section 4.5. The results are then discussed in section 4.6 for reductions in alcohol consumption through two policy options. These results make clear the necessity to include consumption switching. The strengths and weaknesses of IO modelling are further highlighted and discussed in section 4.7. Thus, this chapter finds the use of IO models in analysing the impacts of reducing the consumption of sin goods such as alcohol.

4.2 A historical perspective of Input-Output concepts

The conceptual framework behind IO tables originates with the analytics in economics when the French economist Francois Quesnay published his work titled "Tableau Economique", translated to Economic Table in English (Eltis, 1975). The main concept put forward by Quesnay was the distribution of capital to produce a revenue of a certain amount is split into two categories: Productive expenditures, or the expenditure on raw materials to produce output; and sterile expenditures, or the expenditure of the industry on other avenues such as housing, employment, interest on capital, and so on (Monroe, 1923). While the tableau did not attribute expenditure by sectors, it brought forth the idea that when production takes place, there is an impact on the wider economy as there is a transfer of capital between sectors (Quesnay, 1766). The main concept that stems here is that sectors are interdependent on one another (Sy, 2013). Another very important input from these tables is an early attempt to represent the various processes of the economy in a systemic format.

Long after Quesnay's attempt to represent the economy in a tabular format emerged various theories and discussions about equilibrium in the economy. Cournot published "Researchers on the Mathematical Principles of the theory of Wealth" in 1838 which used mathematical equations in modelling an economy (Fisher, 1960). Using this work as a base, Leon Walras came up with a theory, which stated that if all markets in an economy were in a state of equilibrium apart from one, then this market would also have to be in a state of equilibrium. This meant that an economy, which was constituted of several markets, would be in a state of equilibrium if the excess demands of some markets were compensated for by the dearth of demand in the other markets. Therefore, if all but one market were in a state of equilibrium, then the assumption of general equilibrium would only be true if the last market was also innately in a state of equilibrium.

Inspired and impressed by the work of Quesnay, Marx approached the Tableau with some changes, which stemmed from his view of society (Marx, 1963). While Quesnay had included labour costs as a "sterile expenditure", Marx believed that labour was not sterile but Productive expenditure. He reclassified the expenditures into two categories – Class I represented "Production of the means of subsistence" and Class II represented "Means of Production" (Kurz & Salvadori, 2000). A representation of the Tableau as described by Quesnay is shown in Figure 4.2. He used a system of equations to represent his version of an economy with two sectors and created a tabular way of presenting this, although it was still not a matrix at this stage, which was later created by Leontief. Some problems arose in his explanation of how prices should be calculated in the economy, derived from the profits. He suggested a two-step process to determine prices, where profit would be calculated in value terms and then divided to find prices. This is not possible since prices and profits need to be calculated simultaneously.

Despite the flaws of Marx's model (Kurz & Salvadori, 2000), it was instrumental in inspiring the IO table due to its combination of a system of equations and tabular representation of the economy.

Leontief was the economist who presented IO tables as we know them. His concepts were also based on the theories of Quesnay and Walras (Foley, 1998). He started out building the IO models in his doctorate thesis as a two-sector model, where all economic processes such as production, consumption and distribution were combined. He also wrote mathematical equations that represented the model. This multi-sector model was the first time that a matrix was used to embody the economy. It was based on the circular flow model of the economy, which he said was the fundamental objective of the model (Akhabbar & Lallement, 2010).

The model, as represented in Figure 4.1, shows four sectors of the economy – A, B, C, and D. Leontief explained that while sectors A and B jointly input into the production of Sectors C and D, Sectors C and D also input into sectors A and B. Thus, it was his interpretation that "(A+B) and (C+D) exist simultaneously" (Leontief, 1928). This gave the roots for classifying goods as inputs and outputs. Theoretical and empirical developments of the IO framework won Leontief the Nobel Prize in 1973 (Dietzenbacher & Lahr, 2004).

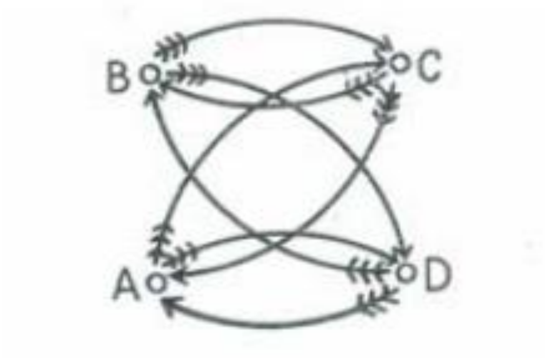
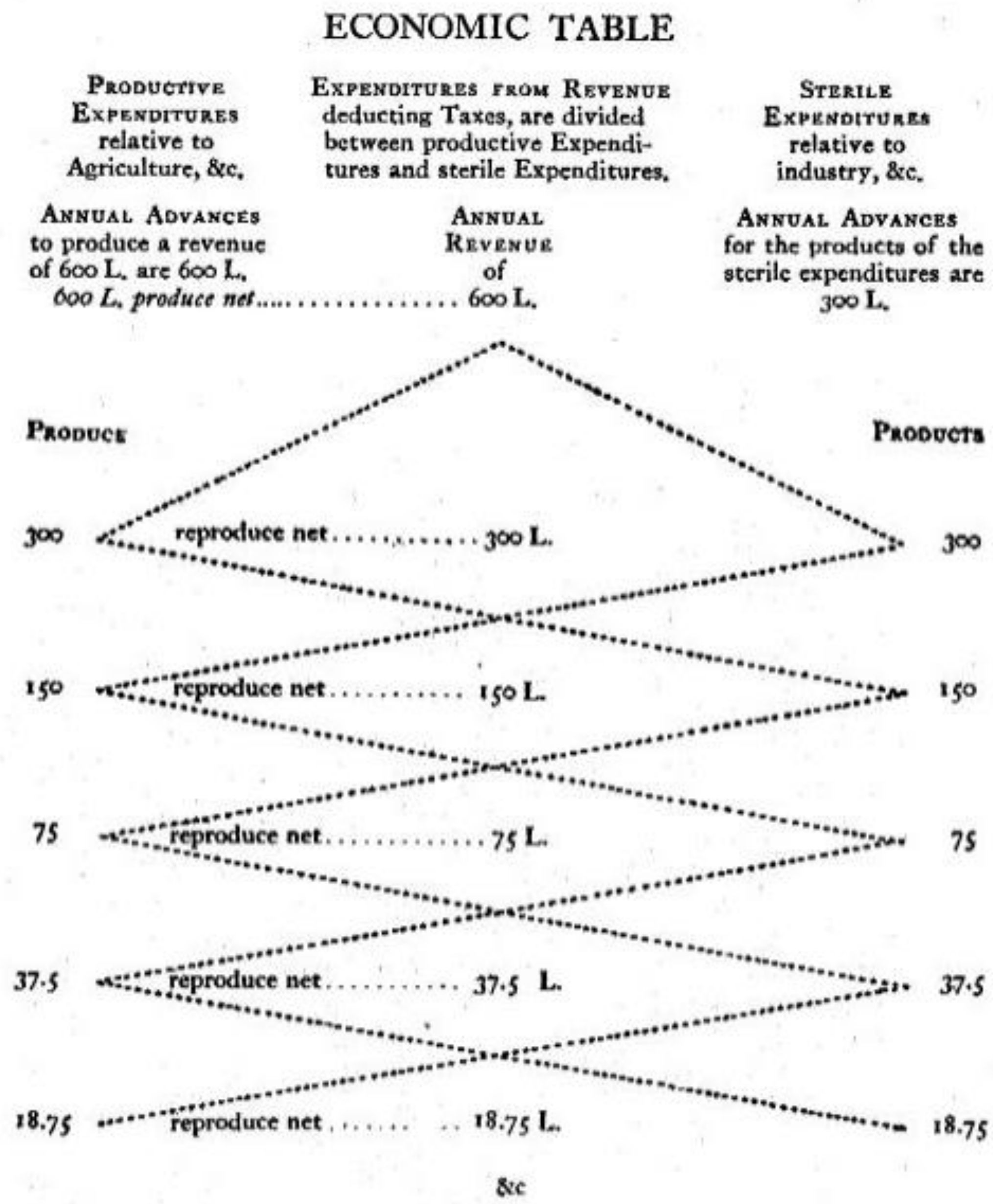


Figure 4.1: Leontief's representation of the circular flow model with 4 sectors
Source: Leontief, 1928

His classification referred to inputs as 'cost goods', or goods that constituted a cost of production; and 'revenue goods' which were sold in the markets to fulfil final demand. This created an assumption of constant returns to scale. Such an assumption means that the production increases at the same rate of increased inputs. A problem associated with this assumption was that substitutability in the factors of production was ignored. The main purpose of this model was to show the usage of goods and services from various sectors into other sectors, and displaying the total production by each sector, thereby finding the monetary value of sales into the final demand. This model came to be known as the IO model which is discussed in the following section.



Total Reproduction ....600 L. of revenue; besides the annual expenditures of 600 L. and the interest on the original advances of the Husbandman, amounting to 300 L., which the land restores. Thus the reproduction is 1500 L., including the revenue of 600 L. which is the basis of the calculation, apart from taxes deducted, and the advances required for its annual reproduction, &c.

Figure 4.2: A simplified representation of 'Tableau Economique'
Source: Arthur Eli Monroe, 1923

4.3 The Concept of Input-Output tables

All economies are comprised of production, consumption and trade of goods and services through their industries, households, and government. These functions need to be understood by the government to fulfil their economic obligations to the society they serve. To be able to do this, there must be some systems of national and regional accounts available to the government to create checks and balances in the economy. It is these systems that would eventually promote the holistic growth of the economy.

The functions mentioned above are linked with one another through various mechanisms. This creates a circular flow in the economy. This circular flow can be presented in the form of two basic economic concepts – Inputs and Outputs. Inputs are those factors that go into the economy for the processes of value addition. The resulting products after the value additions are the Outputs. Inputs and Outputs interact with one another through the various industries or sectors of the economy since the output of some sectors are inputs of some other sectors (Miller & Blair, 2009). This forms the basis of IO Tables. Other functions such as trade, taxes and so on are also included in these tables to include all the components of national accounting. This finally creates a set of numbers that can be used as national accounts.

These national accounts are comprehensive given they are done in a systematic sector-wise manner. This allows for the accounts to be modelled in response to various, potential and actual, external and internal changes that may affect the economy, thus giving the potential to the field of economic modelling. IO tables have a very large application in the field of economic modelling. While they can be used directly as a set of accounts or for modelling purposes, they also hold the potential to be used indirectly in other models. An application of this will be seen in Chapter 5 of this report as well, where IO tables are used as a set of accounts for data collection in the creation of Computable General Equilibrium models. Thus, the array of applications of IO models make them indispensable in the field of economic modelling.

The IO framework has two main uses – Economic Accounting and Economic Modelling. It can be used as a system of economic accounting of the factors of the production process such as cost structures, employment and income. This is done by presenting monetary flows through the economy by measuring exports, imports, local consumption, intermediate consumption, and output. It is also a great tool to examine changes in the structure of the economy over time. The IO framework is also very important for its use in economic modelling and is the basic framework in models such as general equilibrium modelling. We discuss the use of IO tables as a set of accounts in section 4.3.1 and as a framework for economic modelling in section 4.3.2.

4.3.1 Input-Output Tables as a Set of Accounts

One of the primary uses of IO tables is as a set of accounts for the Government. This is a practice that has been going on since the 1970s since when the European Union countries have used this system. The latest update to this form of accounting was in 2010.

This section elaborates on how this system of national accounts is carried out. This will be done through illustrations and discussions on the features and linkages in the set of accounts. Through this section, the aim is to display the basic structure of IO tables and their use in understanding the structure of an industry.

There are three main components of this system of accounting, namely supply tables, use tables, and a derivation of these, an Industry-by-Industry table. The supply and use tables are derived from inputs and outputs of the economy and are used to make several different types of analysis.

The supply tables are created from the output of the economy. Since this table contains information about which products are manufactured by which industries, these tables are used to demonstrate the relationships within the industry (Miller & Blair, 2009). It presents in basic monetary terms the industry's output in the year. The other side of the accounts is given by the Use tables. These tell us the consumption of products by the components of the economy including the intermediate demand and final demand in purchasers' prices. The final demand is split into household demand, central and local governments' demand (Hewings & Jensen, 1987). Combinations and transformations of these matrices give use the IXI matrix discussed in the following section (Miller & Blair, 2009).

There are some integral differences in the valuation of supply and use tables. While the value of supply tables is assessed in terms of basic prices, the valuation of Use tables is done in terms of purchasers' prices. This brings the need to convert the prices to have a comparable set of accounts (Eurostat, 2010). This is done by adjusting the supply tables for taxes along with trade and transport margins, and subsidies. This treatment converts them from basic prices to purchasers' prices.

A very important element that is pertinent to this study is the tax. While talking about the sale of goods and services in the economy, the taxes paid are indirect, as they are not paid to the government directly by the consumer. Since these taxes vary from product to product, different types of indirect taxes must be added to give this figure. These include VAT or Value-Added Taxes while considering goods and services. Some special goods have differential taxes such as tobacco, alcohol, etc. Excise duty must be paid on special goods such as gasoline. Customs duty must be paid on traded goods as well (EY, 2015). In sharp contrast, while taxes are paid by consumers and/or manufacturers and/or traders, the government also does sometimes give monetary benefits to the industry in the form of subsidies. These benefits may be given to producers or importers. They are treated in the exact opposite manner of taxes, i.e., they are subtracted. Thus, the IO tables use the terminology of "Taxes minus subsidy".

Since value addition is the result of production, its value is recorded in basic prices. This implies that it is the value that is added through the production processes. Its arithmetic of calculation is done by subtracting 'Intermediate Consumption' which is valued at producers' prices from the net output of the industries, which is valued at basic prices.

Another important adjustment made in the tables is that of trade. Trade is accounted for as imports and exports in supply and use tables respectively. These are to be reconciled using two mechanisms (Eurostat, 2010). In the Use tables, the exports of locally produced goods are recorded as a negative expense, or in simpler terms, an income for the supplier, and the converse mechanism is used for the purchaser.

It is not just at the industrial level, but also at the individual level. Non-residents purchase goods and take them out of the country while residents bring goods purchased externally to the country (Hewings & Jensen, 1987). These are also adjusted while calculating and adjusting the imports and exports. Mechanisms of VAT refunds on exports and customs paid on imported good are, thus, also adjusted.

The next step in the system of accounting is to calculate the Gross Domestic Product or GDP. The GDP of the country can be calculated in three different ways. These are using the production approach, the income approach and the expenditure approach. All three methods are supposed to give us the same results. The production approach uses total outputs at basic prices, total intermediate inputs at purchasers' prices and taxes less subsidies. The income approach uses compensation of employees, taxes and subsidies on production, Gross operating surplus and taxes less surplus on products. The Expenditure approach uses household final consumption, government final consumption, gross capital formation, exports and imports.

IXI tables have a section of additional information which is directly extracted from the use tables. The information given is as follows: Gross fixed capital formation, Stocks of fixed assets, and Labour inputs by industry. This information is essential for analytical purposes including but not limited to the fields of sectoral employment, inventory management practices in industries, productivity management, and so on. Thus, the above sets out how supply and use tables can be combined to create the all-important IXI matrix which, as Leontief meant it to be, is used for economic modelling in the following sections.

4.3.2 Input-Output Tables as Economic models

The Supply and Use tables discussed above are tables that give us a lot of accounting information for the economy and are a very important starting point for economic analysis and modelling. This section will expand on the analytical function of IO analysis. It then develops and explains these uses and goes on to discuss their economic modelling potential.

The IXI tables that are available from the Scottish Government (2017) can be used for economic analysis. To do this, we use algebraic math of matrices as explained by Leontief (1940). It is essential to understand and learn this mathematical operation to completely understand this form of economic analysis.

The first step in economic analysis using IO tables is to understand the context of the problem being addressed and transforming the tables accordingly. Consider, for example, measuring the impact of an internal event on the domestic market. We would need to convert the supply and use tables in terms of basic prices since import and export data might give us misleading results.

However, this would differ from case to case, and is a situation the researcher must judge.

The Scottish IO tables have the IXI matrix showing the intermediate demand, the total final demand, and the total output. These three key elements help in the formulation of an IO model which can be used to simulate changes in sectoral demand (or demand shocks) through the economy (Miller & Blair, 2009). Let the total final demand be Y, and the total output is X. Under the assumptions of the IO table, total outputs are equal to the total inputs.

Therefore, Total Output = Intermediate demand + Final demand

For each sector with "i" Input sectors and "j" output sectors, intermediate demand =x_{ij}.

From the above statements,

$$X_j = x_{ij} + Y_i \qquad \text{... (1)}$$

a_{ij} is an Input-Output coefficient which can be defined as $a_{ij} = x_{ij}/X_j$.

Thus, $x_{ij} = a_{ij} \cdot X_j$. Equation (1) can be rewritten as follows.

$$X_j = a_{ij} \cdot X_j + Y_i$$

$$Y_i = X_j - a_{ij} \cdot X_j$$

$$Y_i = \left(1 - a_{ij}\right) \cdot X_j$$

In Matrix form, $Y = (I - A) \cdot X$

$$X = (I - A)^{-1} \cdot Y \qquad \text{... (2)}$$

Thus, it seems that the total output matrix, X can be determined using the Input-Output coefficient matrix and the final demand matrix. The set of accounts has all the data available, and equation (2) holds.

When a demand shock is being modelled into this table, there is a change in the final demand matrix. This change in the final demand matrix translates into a change in the total output, constrained by the Input-Output coefficients, as in equation (3).

$$\Delta X = (I - A)^{-1} \cdot \Delta Y \qquad \text{… (3)}$$

4.3.2 Multipliers in Input-Output models

While the section above shows how changes in demand have effects on the total output of the sector, the tool of the multiplier can be used to examine the implications of this change on the other parts of the economy. Based on the level of impact being analysed, multipliers can have two types – Type 1 and Type 2 (Leontief, 1938; Miller & Blair, 2009). These are both discussed in this section. Additionally, based on the impact being analysed, an endless array of multipliers can be created, of which some which are relevant to this study are discussed.

Leontief type 1 multipliers are measures of the effect that is felt by the economy when the final demand for product changes. These are direct and indirect effects multipliers. Consider the example of an increase in demand for a sector in the economy. When demand increases, the sector increases production. This is the direct effect felt. To meet this demand, the sector will need to increase its intermediate demand which impacts other industries in the sector's supply chain, and the supply chains of the sectors thereof. This effect on the supply chain of the sector is explained as an indirect effect. Thus, Leontief type one multipliers measure the direct and indirect effects felt on the economy (Clark, 2010).

Leontief type 1 multipliers display supplier linkages since they only measure direct and indirect effects. The supply chain of goods is the primary target of this type of multiplier. The main concept is that as demand for one product increases, there is a change in supply to meet this demand which impacts economic activity. There is also a change in economic activity in complementary industries to meet the changed input demands of the main industry being analysed. Thus, type 1 multipliers include GDP and output.

To find the type 1 multipliers, a Leontief Type 1 matrix is used. This is made using the following formula.

$$L_1 = (I - A)^{-1} \cdot A \qquad \text{... (4)}$$

Leontief type 2 multipliers refer to induced effects in addition to the direct and indirect effects. Induced effects are those effects that result from direct and indirect effects. Take the case of labour markets. When the demand for a product changes, the impact is felt not only on the production but also on the labour markets. Since there is a change in the demand for labour as well, wages are set to be affected. These wages again depend on the supply in the labour market. The changing wages would again, influence the final demand and increased disposable incomes would stimulate consumption. The final demand is again, set to be readjusted, causing a direct and indirect impact on the economy. This effect is known as an induced effect (Department for the Economy, 2014).

To find the type 2 multipliers, a Leontief Type 2 matrix is used. This is made using equation 5 below. The difference in this equation from equation 4 is that the A matrix, in this case, includes an endogenized household consumption sector to find the induced effect.

$$L_2 = (I - A)^{-1} \cdot A \qquad \text{... (5)}$$

As explained, type 2 multipliers measure not just the direct and indirect effects, but also the induced effects. However, there is one assumption of this type of multiplier. As wages change, there is a likelihood that consumers would change as well in response. This is considered to not happen while measuring induced effects. This assumption does limit the robustness of type 2 multipliers (Gretton, 2013). They are, in any case, more grasping of the economic effects than the type one multipliers, which are likely to undervalue economic effects (Department for the Economy, 2014). To measure the additional induced impact, the flow of money into households must be assessed. This is done by simply including households as an additional sector supplementary to the rest of the Industry-by-industry matrix.

There are several different Type 1 and Type 2 multipliers, and these multipliers are specific to each sector within an IO model. The calculation of 4 of these multipliers that are used in this thesis is explained below, as shown by the Scottish Government (2017).

1. Output Multipliers – This multiplier is a measure of the sum of all the outputs that are produced domestically in the economy to produce one extra unit of output.

   Type 1 multiplier: $\sum_{\mathrm{i}} L_{1_{\mathrm{ij}}}$

   Type 2 multiplier: $\sum_{\mathrm{i}} L_{2_{\mathrm{ij}}}$

   (where $L_1$is the Leontief type 1 matrix and L_2 is the Leontief type 2 matrix.)

2. Employment multiplier – This multiplier measures how much employment increases in the whole economy if the final demand

increases enough to create an additional Full-Time employment position in one industry.

Type 1 multiplier: $\sum_{\mathrm{i}}(\mathrm{w_i} L_{1_{\mathrm{ij}}})/\mathrm{w_j}$

Type 2 multiplier: $\sum_{\mathrm{i}}(\mathrm{w_i} L_{2_{\mathrm{ij}}})/\mathrm{w_j}$

(where $L_1$is the Leontief type 1 matrix, L_2 is the Leontief type 2 matrix and w is the ratio of income from employment to total output.)

3. Income Multipliers – This multiplier measures how much the income from employment would change for the whole economy if there was a £1 increase in income from employment in one sector.

Type 1 multiplier: $\sum_{\mathrm{i}}(\mathrm{v_i} L_{1_{\mathrm{ij}}})/\mathrm{v_j}$

Type 2 multiplier: $\sum_{\mathrm{i}}(\mathrm{v_i} L_{2_{\mathrm{ij}}})/\mathrm{v_j}$

(where $L_1$is the Leontief type 1 matrix, L_2 is the Leontief type 2 matrix and v is the ratio of income from employment to total output.)

4. GDP multiplier – This multiplier measures how much the Gross Value Added to the whole economy would change if there was a £1 increase in the GDP in one sector.

Type 1 multiplier: $\sum_{\mathrm{i}}(\mathrm{g_i} L_{1_{\mathrm{ij}}})/\mathrm{g_j}$

Type 2 multiplier: $\sum_{\mathrm{i}}(\mathrm{g_i} L_{2_{\mathrm{ij}}})/\mathrm{g_j}$

(where $L_1$is the Leontief type 1 matrix, L_2 is the Leontief type 2 matrix and g is the ratio of income from employment to total output.)

Leontief Type 1 and Type 2 multipliers help us better analyse the linkages within the economy and greatly help in measuring economic impacts. To contextualise these multiplier effects, let’s look at an example. Harris (1997) conducted a study on the economic impacts of the University of Portsmouth in 1994. This study employed the Input-Output methodology as described above to find type 1 and type 2 multipliers of output, employment and income. This study found the type 1 and type 2 output multipliers to be 1.24 and 1.73 respectively. This meant that for every £1 that the university spent, 24p-73p was spent in the economy of Portsmouth in terms of indirect or induced effects. Similarly, the University also had between 1029 and 1490 indirect and induced Full-time jobs attributed to it, apart from the 1885 full-time jobs it directly created. This study is representative of how multipliers can be used to find the indirect and induced economic effects using IO analyses.

4.4 Uses of Input-Output models in the field of economic policy

As seen in the above sections, IO tables can be used to examine changes in policies. This type of method is very flexible since it is essentially a set of mathematical equations which can be rewritten in several ways to yield a range of different results. Being a region-specific model, several different countries have their version of the IO tables for economic modelling. Various models exist that model multiple regions in the world, such as the World Input-Output Database (WIOD) exists that contains IO tables for 43 countries. Owing to EU law, all EU countries produce IO tables as a set of accounts that can be modelled. Similarly, the United States has a multi-region IO table known as the RIMS II which can be used to model policies. Being so widely available, IO models can be used to model a wide range of policy in many economic regions are the world.

The IO model for the United States was used by Frechtling & Horvath (1999) to examine the impact of tourism expenditures on the local economy of Washington, D.C. In this version of IO models, a countrywide IXI matrix forms the mainframe that supplies information for a regional direct requirements table (Frechtling & Horvath, 1999). This matrix is a subset of the national IXI matrix and shows the ability of each of the local sectors in meeting the local demand through location quotients.

In the case of sectors that need to "import" from the rest of the United States, the location quotient would be below 1, and vice versa (BEA, 1997). It is this matrix that is transformed to create the $(I - A)^{-1}$ the matrix in equations (2) and (3) in the previous sections. The study uses the BEA table of 471 industries to find six sectors that contribute to the tourism industry. The multipliers for these sectors are found, and multiplied with the tourism expenditure in each of these industries, along with gross trade margins to find the output, earnings and employment effects of tourism in Washington DC in these industries. While this study does not explicitly study demand shocks, it makes clear that IO tables can be used to find implications of demand originating from a very specific part of the economy.

Similarly, McNicoll (1980) uses IO models to find the impact of a specific sector on the local economy of the Shetland Islands. The study tries to find the impact of the employment generated by the then newly discovered oil industry in Shetland. He found very little direct impact generated by the oil industry on the local economy. He found that traditional industries employed only about 2% of the oil-generated revenues. As opposed to this, 80% of this revenue was in the service sectors. This implies that there was very little direct impact on the oil industry, but the indirect and induced impacts were much greater. He attributed this to the fact that oil was not indigenously sold in Shetland. This study has used IO modelling to show the impacts of the export of a natural resource on the local economy in terms of employment generation, and changes in income.

While Frechtling & Horvath (1999) measure the impact of the tourism industry in supporting local industry, they do not go far enough in modelling a scenario where tourism expenditure falls. The impacts of this falling demand in tourism cause income levels to fall according to the paper, but this has implications on the household budgets as well. Similarly, McNicoll's study does not elucidate the impact of increased household budgets after the establishment of the oil sector in Shetland. He quantifies the impact on the service and traditional sectors, which are both positive, but the implications of this on household budgets and changing consumer behaviour is not elucidated. The next study hopefully tries to include switching in consumption.

Eiser & Roberts (2001) attempt to find the employment and output effects of changing patterns of afforestation in Scotland. A shift from coniferous plantations to broadleaf and native species is considered. This research starts with disaggregating the IO tables using a survey to break down the forest sector by woodland type. Using IO tables and multipliers, the study finds that the shift from coniferous plantations to broadleaf species could be better for the economy in terms of output and employment, as higher inputs are required in the process. The study goes on to say that the average agricultural land, when converted to native woodland, could yield higher economic benefits. The study is successful in showing the importance of considering switching from one form one sector to another is important while talking about demand-driven policy since there needs to be a reallocation of spending by households.

IO models have also been used in analysing the economic impacts of sin goods such as tobacco and sugary drinks. However, their use has been widely limited to showing the importance of specific sectors.

Oxford Economics (2016) have made use of an Input-Output model for the UK to find the economic impacts of the alcohol industry in the British economy. They do so by finding the contributions of various elements of the beer and pub trade and find direct, indirect and induced impacts of the industry. The report is primarily used to highlight the contributions of the sector to the economy. Based on this report, the British Beer and Pub Association (BBPA) argues that reductions in alcohol taxes can increase the economic contributions of the sector. However, the report does not explicitly model a reduction in tax while highlighting the contributions of the industry. It also does not look to find the negative health impacts of alcohol consumption.

Similarly, a study by EY (2013) studies the economic impact of wine and spirits in the British economy and calls for the duty escalator on alcohol to be dropped in order to boost the alcohol industry. This study uses an IO model to analyse the importance and contributions of wine and spirits in the economy. This study was widely used by the WSTA to campaign to drop the duty escalator, which was abolished shortly after in the 2015 budget (Sheron & Gilmore, 2016).

Firmansyah et al. (2018) use an Input-output model to show that an investment of 1 million rupiahs into the tobacco sector would increase the GDP and employment in the economy of the region. This increase in employment would be greater if the same investment was targeted to 10 food production sectors with the highest labour force multipliers. The paper recommends that the government focus investment on the tobacco sector. However, this paper takes a very simplistic view and does not take into consideration the negative impacts of the tobacco industry. Additionally, the results are quite straightforward as we expect the employment to be higher when the investment is targeted to sectors with the highest labour force multipliers.

However, an important element missing from the above studies is that of consumption switching.

As previously mentioned, a key paper in this literature is Connolly et al. (2019). In their analysis of the economic impacts of policy-induced reductions in alcohol consumption, Connolly et al., (2019) use the alcohol disaggregated IO model of the UK. Their IO model has disaggregation which is replicated in this thesis, and are based on on-trade and off-trade alcohol consumption. The analysis finds the gross and net impacts of policy-driven reductions in alcohol consumption. It is found that the gross impacts of a reduction in consumption would have negative economic consequences.

However, when the reduction in consumption from alcohol sectors is substituted with increased consumption in other sectors, the results show positive impacts on the policy of increased alcohol duty. Furthermore, they find that when alcohol duties are used to reduce alcohol consumption, there is no trade-off between health outcomes and employment. This trade is evident when the reduction in alcohol consumption is not driven by increased taxes (Connolly et al., 2019). This is primarily because the increased taxes are recycled into the economy, and this has a positive economic impact. While this study is similar to the model in this chapter, our analysis in this thesis goes beyond the IO model and extends this through adopting a CGE framework. Additionally, the analysis of this chapter focuses heavily on the mechanisms and linkages of the alcohol consumption sectors.

In all, the use of IO models has been widely employed in various fields. Analyses of sin goods have also been conducted through IO models. While some studies have focussed on the contributions of the alcohol sectors, others have extended their analysis to include the negative health effects and the ensuing economic consequences. A comprehensive analysis of sin goods, thus, should extend to include elements of consumption switching, reallocation of taxes, and positive health consequences.

4.5 Simulation Strategy

As seen in chapter 3, alcohol consumption in Scotland is above the national average for the UK (MESAS, 2017). The Scottish Government has expressed its concern in this regard and has taken steps to reduce this consumption. These policies are bound to have some macroeconomic impact on the Scottish economy. This chapter examines the economic impacts of two policy options that may be used to reduce alcohol consumption. Following Connolly et al. (2019), this section aims at showing how an Input-Output model could be used to examine falling alcohol demand in Scotland.

The IO tables have available information about the alcohol manufacturing industry and are disaggregated into two separate sectors. Both of these sectors constitute different types of alcohol produced in Scotland. However, the tables do not have disaggregated data about alcohol consumption. Alcohol consumption takes place through off-trade and on-trade sectors as explained in previous chapters. Since both avenues have different consumer behaviour related to them, it is important to include detail about these sectors. The disaggregation of these sectors is elucidated in the section below.

4.5.1 Disaggregation of alcohol consumption sectors

While the standard published IO tables for Scotland may be used to model changes in alcohol production, it is not possible to use these tables to model changes in consumption. However, this problem is overcome through the disaggregation of these sectors within the IO framework. This allows us to run more targeted simulations. As mentioned in earlier sections, alcohol consumption can take two forms – off-trade and on-trade. Off-trade consumption takes place when alcohol is bought from stores and prepared to be consumed directly by the consumer. On-trade consumption takes place when the consumer visits an establishment to consume alcohol, such as a bar, pub, club, or restaurant. To further analyse the alcohol sector, these two types of alcohol consumption have been disaggregated from the IO tables for this section.

On-trade consumption has been disaggregated from the ‘accommodation’ sector (SIC 55) and the ‘food & beverage service’ sector (SIC 56). Off-trade consumption is disaggregated from the ‘wholesale – excluding vehicles’ sector (SIC 46).

The standard Scottish IO table contains 98 sectors. Of these, there exist two alcohol manufacturing sectors – SIC 11.01-.04 which represents the manufacturing of Spirits and Wine, and SIC 11.05-.06 representing Beer and Malt. The consumption of alcohol is primarily captured through off-trade and on-trade in ‘wholesale – excluding vehicles’, ‘accommodation’, and, ‘food and beverage service’ sectors.

The disaggregation of alcohol consumption from the above-mentioned sectors requires additional data to make accurate disaggregations. For the disaggregations of on-trade consumption, the BBPA handbook provides data on the inputs of the food and beverage sector. Using this data, it is possible to say the proportions of inputs required for alcoholic beverage service. MESAS (2017) publishes an alcohol sales dataset that shows the value and volume of alcohol consumption through off-trade and on-trade sectors. HMRC (2016) and the Scottish Government (2016b) data on alcohol duty receipts and VAT receipts are also used in the disaggregation of the IXI matrix. HMRC (2017) data on trade statistics has also been used in the disaggregation process.

Some assumptions also have to be made in the disaggregation process, where data is not available. Since data for consumption by non-resident households is not available, this is disaggregated in the same proportions as the original IXI matrix.

The process of disaggregation involves disaggregating both, the rows and columns. Thus, the result is a matrix of an increased dimension, but summing up to the same values as before the disaggregations. In this model, the number of sectors increases from 98 sectors to 101 sectors. These are further described in Appendix A.

For the disaggregation of output given in the rows of the IO table, the primary assumption is that since alcohol is a final product, it is not used in the intermediate production of other products. To calculate the final demand, data is gathered on the value of alcohol for each of the alcohol consumption sectors. This is done through data from MESAS (2017) which includes the volume of alcohol consumed along with prices of alcohol by alcohol type. These figures are used to calculate the alcohol sales from the Scottish wholesale industry. This data is also used to calculate the alcohol sales from the accommodation and food and beverage service industry along with the data found within the BBPA handbook. A key assumption that is made in this calculation is that households and tourists consume alcohol at the same sales percentage as the original aggregated IO sector.

In terms of the inputs shown in the columns of the IO table, the disaggregation is carried out based on the type of industry. In the wholesale sector, since different products are sold through the same network on the same premises, the sales value of alcohol compared to other goods sold was used as the basis for disaggregation. However, for the food and beverage and accommodation industry, the disaggregation was based on the cost of running the premises as well as the value of alcohol sold compared to the value of other items sold such as food and entertainment. This provides an overview of the inputs involved in the sale of alcohol as a product to consumers.

The IO tables are published in basic prices, and thus the values of the above inputs and outputs are converted to basic prices through the use of data on the alcohol duties in the UK from HMRC (2020) and the VAT levied on alcohol, which, as discussed in chapter 3 is the standard rate of VAT at 20%.

All the alcohol consumed within Scotland is not locally produced, and a sizeable portion is imported from the rest of the UK and the rest of the world. This means that the disaggregation of the imports also is carried out. This is done through the use of data from HMRC on the value of alcohol imported as well as data from the BBPA handbook on the alcohol sold in establishments.

In all, the disaggregation of the IO tables to include separate on-trade and off-trade sectors is done using data from a large range of sources based on the method described by Connolly et al. (2018) for the UK. In saying that, this disaggregation has not been done for the alcohol sector of Scotland before. The resulting disaggregated IO table is essential for the modelling performed in this chapter and for the following chapters as well. The disaggregated alcohol consumption sectors within the IO are shown in Figure 4.3 below.

The sectors in the IO tables are then aggregated to 18 sectors. This allows for better comparability to other models used in this thesis in chapters 5 and 6. The aggregations of the tables follow the schema presented in Table 4.1 below.

Sector Code	Sector Names	SIC Classification (2007)
AFF	Agriculture, forestry and fishing	1-3
OTP	Other primaries	5-9, 19-21
FAD	Food and drink	10, 11.07,12
SAW	Spirits and Wine	11.01-04
BAM	Beer and malt	11.05-06
TLW	Textiles, leather and wood	13-18
RCG	Rubber, Cement and glass	22-25
EMO	Electrical, mechanical and other manufacturing	26-33
ETD	Energy transmission and distribution	35
WSW	Water, sewerage and Waste	36-39
CON	Construction	41-43
WRT	Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	45-56
AOF	Alcohol Off-trade	46 – Alcohol
AON	Alcohol On-trade	55, 56 – Alcohol
FIN	Financial services, insurance and services	64-66, 69.2-70, 73, 74, 82
RCO	Real Estate, Communication and other services	58-63, 68-69.1, 71, 72, 75-81, 90-97
EDU	Education and Admin	84-85
HRS	Health, residential care and Social Work	86-88

Table 4.1: Sectoral aggregation of the SAM for CGE modelling
Source: Author’s Aggregations

↓ Sales by industry group ↓	AFF	OTP	FAD	SAW	BAM	TLW	RCG	EMO	ETD	WSW	CON	WRT	AOF	AON	FIN	RCO	EDU	HRS	Total intermediate demand	Final consumption expenditure	Gross capital formation	Exports	Total final demand	Total demand for industry output
AFF	419	4	857	37	5	102	11	4	13	1	28	50	0	0	8	60	10	8	1616	877	87	1882	2846	4462
OTP	58	454	27	9	1	27	90	46	27	8	247	105	1	3	31	110	44	172	1462	627	92	6721	7440	8901
FAD	93	8	270	25	3	10	2	3	1	1	4	156	0	0	16	96	19	38	745	1348	6	3727	5080	5825
SAW	2	2	2	10	1	1	2	4	1	0	5	3	2	39	1	-11	2	2	68	77	12	3625	3713	3781
BAM	0	0	0	20	1	0	0	0	0	0	0	0	0	68	0	-26	0	0	65	61	3	169	232	297
TLW	16	26	54	31	2	439	45	85	5	5	284	78	0	0	82	117	109	49	1426	470	72	2027	2570	3996
RCG	36	176	118	71	33	55	459	513	21	13	680	122	3	3	17	56	94	21	2491	273	248	2286	2807	5299
EMO	98	153	47	48	8	57	104	922	61	20	419	197	1	2	35	147	148	28	2495	822	808	7767	9398	11893
ETD	65	324	103	109	6	132	173	229	3450	37	87	245	5	55	92	220	188	139	5659	2310	70	2360	4740	10399
WSW	26	24	19	21	1	13	16	14	33	225	20	41	1	9	50	57	165	117	852	1405	16	705	2127	2978
CON	82	173	17	17	1	30	20	67	65	53	3740	895	0	38	332	1151	532	83	7295	194	9986	1950	12131	19426
WRT	324	296	335	178	14	194	318	544	124	113	625	3480	117	137	1026	818	627	437	9707	16261	767	9668	26695	36403
AOF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	570	0	22	592	592
AON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1043	0	286	1329	1329
FIN	83	217	75	130	9	83	97	209	140	80	299	858	18	109	1782	1795	497	143	6624	3439	72	12349	15861	22484
RCO	116	238	94	89	6	71	73	413	157	121	978	2214	46	228	2019	4133	1395	811	13200	23073	2126	13587	38786	51986
EDU	7	18	8	16	1	9	14	29	14	22	112	257	2	10	203	1133	1069	78	3001	20069	973	1702	22744	25745
HRS	3	4	1	0	0	3	1	3	2	1	3	9	0	1	30	27	28	746	865	16390	5	92	16487	17352
Total domestic consumption	1429	2117	2030	813	91	1226	1425	3085	4113	700	7531	8710	195	701	5723	9882	4927	2873	57570	89309	15342	70926	175577	233147
Total domestic consumption (Basic)	2658	4349	4231	1744	177	2436	2873	6812	6780	1251	11164	15158	294	828	10698	17136	8917	5085	102591	117989	22887	75072	215948	318539
Taxes less subsidies on products	69	243	24	112	6	55	101	102	372	115	142	563	6	59	688	437	960	480	4534	9258	2647	552	12457	16991
Gross value added	1735	4310	1570	1926	114	1505	2324	4979	3247	1612	8120	20681	293	442	11098	34413	15868	11786	126022					
Total output at basic prices	4462	8901	5825	3781	297	3996	5299	11893	10399	2978	19426	36403	592	1329	22484	51986	25745	17352	233147					

Figure 4.3: The Alcohol disaggregated 18-sector Scottish Input-Output tables for 2014 (in £m)
Source: Scottish Government, 2017; Author’s Calculations

4.5.2 Multiplier Analysis

To better understand the results in the following sections, the multipliers of the sectors in the IO model provide an overview of their contribution to the economy. As explained in previous sections, type 1 multipliers include direct and indirect impacts, while type 2 multipliers additionally include induced impacts. Type 2 multipliers have an additional endogenous household consumption sector to include induced impacts.

Table 4.2 and Table 4.3 show type 1 and type 2 multipliers of all sectors within the IO model respectively. In both types of multipliers, it is seen that the alcohol consumption sectors have relatively lower total output multipliers. This is since these sectors are mainly consumption sectors. In contrast, it can be seen that production sectors including alcohol consumption sectors have higher total output multipliers.

Since the alcohol consumption sectors have a high dependency on labour, it is seen that their employment multipliers are some of the highest across all sectors with only the healthcare sector with high multipliers in this domain. Thus, we can expect to see a large reduction in employment with a fall in alcohol consumption.

In terms of income multipliers, it is seen that in both type 1 and type 2, the alcohol off-trade sector has a much larger multiplier compared to the on-trade sector. This is due to differences in the type of employment and wages between the two sectors, as seen in chapter 3.

Similarly in GDP multipliers, the off-trade sector is seen to have greater multipliers compared to the on-trade sector. Thus, the impact of the off-trade sector on the GDP per pound of reduction in consumption should be higher.

However, as seen in chapter 3, the size of the on-trade sector is much larger. This could mean that the higher GDP impact of the off-trade sector could be dominated by the volume of the on-trade sector.

With consumption switching, another important point here is that should consumption switch from alcohol consumption sectors to alternative sectors with higher multipliers, the overall impact on the economic indicator would be positive, and vice versa.

Sectors	Total Output Multiplier	Income-Output Multiplier	GDP-Output Multiplier	Employment-Output Multiplier
AFF	1.45	0.23	0.60	16.62
OTP	1.33	0.38	0.64	6.79
FAD	1.49	0.32	0.49	10.83
SAW	1.30	0.29	0.65	5.11
BAM	1.42	0.33	0.58	10.12
TLW	1.43	0.36	0.57	9.66
RCG	1.37	0.42	0.61	10.14
EMO	1.35	0.41	0.59	8.62
ETD	1.62	0.19	0.53	3.97
WSW	1.32	0.29	0.71	6.77
CON	1.56	0.43	0.68	12.88
WRT	1.32	0.45	0.74	15.47
AOF	1.43	0.40	0.74	12.21
AON	1.71	0.41	0.71	29.23
FIN	1.34	0.36	0.68	11.45
RCO	1.25	0.32	0.80	11.52
EDU	1.25	0.56	0.76	16.26
HRS	1.22	0.60	0.80	20.32

Table 4.2: Type 1 multipliers for the 18 sector IO model
Source: Author’s Calculations

Sectors	Total Output Multiplier	Income-Output Multiplier	GDP-Output Multiplier	Employment-Output Multiplier
AFF	2.08	0.32	0.77	19.66
OTP	2.35	0.52	0.92	11.70
FAD	2.37	0.44	0.73	15.04
SAW	2.09	0.40	0.87	8.90
BAM	2.31	0.45	0.83	14.41
TLW	2.40	0.49	0.83	14.30
RCG	2.51	0.58	0.92	15.61
EMO	2.46	0.56	0.89	13.94
ETD	2.13	0.26	0.67	6.40
WSW	2.11	0.40	0.93	10.59
CON	2.72	0.59	1.00	18.47
WRT	2.52	0.61	1.07	21.26
AOF	2.52	0.55	1.04	17.44
AON	2.82	0.56	1.01	34.58
FIN	2.32	0.50	0.95	16.17
RCO	2.11	0.44	1.04	15.66
EDU	2.78	0.78	1.17	23.60
HRS	2.83	0.82	1.25	28.09

Table 4.3: Type 2 multipliers for the 18 sector IO model
Source: Author's Calculations

4.5.3 Simulating changes in demand in the IO model

For the creation of the model, data is taken from the Industry X Industry Matrix (IXI matrix). The input of this model is the potential direct change in the output in one or more of the 18 sectors. This direct change is calculated as a percentage of sectoral outputs from the IXI table. The employment is also collected from the IXI table. Since the Scottish IO table does not have employment numbers, these are calculated backwards from the employment-output multiplier that is provided in the published tables. The next step is the calculation of the employment-output coefficients, which is done by dividing the base year employment with the sectoral demand. The direct employment effect is calculated as a product of the employment-output coefficients and the change in output that is simulated.

Income data is also available in the IXI tables. The income-output coefficient is calculated in the same way as the employment-output coefficient. The base year income is divided by the sectoral demand. This income-output coefficient is multiplied with the change in demand to calculate the direct income year.

The base year GDP is calculated by adding the base year income and the gross operating surplus. The GDP-Output coefficient is calculated by dividing the base year GDP by the sectoral demand. The direct GDP effect is a product of the GDP-Output coefficient and the change in demand. All these direct effects show the direct changes in the output in percentage terms on each of the economic factors.

To feed these changes through type 1, the direct effects output matrix is multiplied with a type 1 technical coefficients matrix to create the new Type 1 Output matrix. This shows the type 1 changes in output. The changes in output have a reflective effect on employment, income and GDP as well. These effects are calculated by multiplying the Type 1 change in output with the corresponding direct changes. A similar process is carried out for Type 2 multipliers as well. With the base model created, demand changes can be easily propagated into the IO to find the effects of changes in one or more sectors in the wider economy.

$$\Delta X = (I - A)^{-1} \cdot \Delta Y \qquad \text{… (6)}$$

A change in the final demand, given by ΔY will feed through the Leontief inverse matrix representing the structure of the economy, and show the economic implications on the output of the economy, denoted by ΔX. We use this model to create a demand shock and propagate it through the economy to find its macroeconomic impact. Thus, the process of formulating the appropriate demand shock is to find the change in demand in the alcohol and non-alcohol sectors.

4.5.4 Modelling Strategy

In this chapter, the aim is to show how an IO model may be used to model the changes in demand for alcohol and answer a key question – what macroeconomic impacts can be expected should the consumption of alcohol fall in Scotland, given that it is a key industry within the Scottish economy. Thus far, through literature, we have seen that IO models have the potential to propagate demand shocks and show the macroeconomic impacts that we are looking for. This leads us to strategize using these IO models through two simulation scenarios.

To do this, the level of alcohol consumption in Scotland through the off-trade and on-trade are shocked. As previously mentioned, the data for alcohol consumption for each category of alcohol is available using the MESAS database (2017). This data has been used to disaggregate the level of alcohol consumption within the IO tables and is thus used to calibrate the level of shock in the IO models.

As has been explained before the level of alcohol consumption in Scotland is higher than the recommendation by the NHS. In their Global Action Plan for the prevention and control of non-communicable diseases, the WHO (2013) sets out a target for countries to reduce alcohol-related harm. This target is for countries to reduce harmful alcohol consumption by 10%. Connolly et al. (2019) also motivate their analysis by this target set by the WHO (2013). Thus, this target is used to motivate the analysis conducted in this chapter. To do this, alcohol consumption would need to reduce in both channels of consumption – off-trade and on-trade.

In order to simulate this, it is assumed that there is no change in preference between off-trade and on-trade, as the hypothetical information campaign aims to have a general reduction in alcohol consumption. This means that we run the reduction in consumption by 10% in both sectors. It is assumed here that the fall in the level of alcohol consumption is a result of a hypothetical generalised information campaign, and no fiscal policy is applied. The information campaign that is being simulated in this scenario may be achieved through means such as an education campaign or a public health information drive or advisory. This is done to understand how the economy would react to a fall in overall consumption. The expectation here is that in line with analyses performed by EY (2013), Oxford Economics (2016) and Connolly et al. (2019), the economy would shrink.

However, in the next scenario, we examine the impact of a fiscal policy. Here, we look for the macroeconomic impacts of an increase in the level of alcohol duty in Scotland. A 10% increase in the level of alcohol duty is applied here. The increase in alcohol duty reduces the level of alcohol consumption and raises the level of alcohol duties collected based on the new level of alcohol consumption. The macroeconomic impacts of higher government expenditure are also found.

Therefore, in all, two scenarios that are simulated within the IO model are modelled.

- Scenario 1: Changes in consumer tastes fuelled by an information campaign resulting in lower alcohol consumption; and

- Scenario 2: An increase in alcohol duty resulting in lower alcohol consumption.

4.5.5 Gross and Net Impacts

In both the above-mentioned scenarios, there are changes to the level of alcohol consumption. These changes show the gross impacts of a reduction in alcohol consumption in the Scottish economy. However, as previously mentioned, there are also other impacts of a reduction in alcohol consumption through both scenarios. These are included to find the net impacts of said policy.

In Scenario 1, the gross impacts are found by simulating a reduction in household alcohol consumption by 10%. This reflects the recommendation by WHO (2013). Similarly, in Scenario 2, a 10% increase in alcohol duty results in a fall in alcohol consumption. This is used to find the gross impact of said policy.

The gross impacts of both scenarios are expected to have negative implications for the economy across the board, given a reduction in the level of alcohol consumption by households. These results are subject to the assumption that a reduction in spending on alcohol would not stimulate spending in other sectors.

However, a very critical consequence of falling demand in one or more sectors is the increase in demand in other sectors, as households find alternative forms of spending. Similarly, an increase in the level of duties in a particular sector will also have impacts on the level of government expenditure. Thus, changes in spending patterns and changes to government expenditure are taken into consideration through net impacts. The IO model does not endogenously reallocate the spending when there is a negative demand shock in one sector. This means that the process of switching needs to be performed exogenously.

To perform exogenous switching, a negative demand shock in the alcohol sector is complemented with positive demand shocks in other sectors of the economy in the proportions of the size of household consumption by each sector. This is to say that if a sector commanded 1% of total household consumption, then 1% of the household spending reduced from the alcohol consumption sectors would be allocated to that sector. A similar process is replicated for government spending as well.

In Scenario 1, to estimate the net impacts, a reduction in the demand from the alcohol consumption sectors is complemented with an increase in household consumption from the rest of the sectors of the economy in the same proportions as the base year. To carry out consumption switching, the proportions in which the households consume from the sectors of the IO tables are calculated. Since the value of reallocation is the same as the reduced demand from the alcohol sectors, there is no overall change in the level of household consumption, but a reallocation of household spending.

In Scenario 2, the net impacts are found by increasing the level of government consumption by the calculated increase in government revenue from the increase in alcohol duty. The increased government revenue is allocated to government spending in non-alcohol sectors in their pre-existing shares of total government expenditure.

The gross and net results of the scenarios are reported and discussed in the following section. These results show the need to lay greater emphasis on estimating net impacts while examining changes in demand through an IO model, and for a CGE model used in future chapters.

4.6 Results of changes in demand for alcohol

Two different simulations are carried out with disaggregated IO tables. In these scenarios, we attempt to find gross and net impacts on the economy of Scotland. In scenario 1, we use the IO model to examine the impacts of changes in consumer tastes fuelled by an information campaign, while in scenario 2, we examine the impacts of an increase in alcohol duty. Both scenarios result in lower alcohol consumption and reflect the goal of the Scottish Government to reduce alcohol consumption (Scottish Government, 2009).

4.6.1 Scenario 1: Changes in consumer tastes fuelled by an information campaign

In this scenario, we look for the impacts of a 10% reduction in off-trade and on-trade household alcohol consumption. The assumption here is that a hypothetical general information campaign is successfully used to reduce the overall alcohol consumption in the economy. There is no change in preferences between off-trade and on-trade. These impacts mean that off-trade household alcohol consumption would fall by £56.99m, while on-trade household alcohol consumption would fall by £104.28m in output prices. As explained previously, this reduction in alcohol consumption accounts for gross impacts. Net impacts are calculated by recycling this household spending from alcohol consumption sectors to non-alcohol products. This is done in line with their share of the total household consumption from IO tables.

Gross results from the IO model show that a contraction in demand for alcohol from the off-trade and on-trade sectors would have negative implications for the backward and forward linkages of wholesale sectors, and the economy as a whole.

The direct impact of this reduction in alcohol consumption by households is that the output is seen to fall by £161.27m. This causes a fall in the level of employment by 2871 FTE and the level of income by £39.13m in the alcohol consumption sectors. In all, the direct impact of this reduction in alcohol consumption is a fall in GDP by £58.08m, which accounts for 0.05% of the total GDP.

In Type 1 terms, a fall in the consumption from the off-trade sector indicates a fall in output by £259.85m. About 62% of this output is seen to fall in the alcohol consumption sectors. Also seen is that there is a reduction in the level of employment. Type 1 results indicate a reduction in employment could fall by as much as 3744 FTE. Of this, over 76% of the jobs are directly from the alcohol consumption sectors. The alcohol consumption sectors offer about 35551 FTE. This equates to a reduction of over 8% of employment in the sector.

In type 2 terms, the level of reduction in output is £437.39m. The reduction in output for the alcohol consumption sectors is estimated to be £163.29m through this model. In terms of employment, the reduction in employment is estimated to be 4600 FTE. A reduction of 0.13% in GDP is noted with this reduction in consumption. The gross results of this scenario are reported in the table below.

Effects	Output (£m)	Employment (FTE)	Income (£m)	GDP (£m)
Direct	-161.27	-2871	-39.13	-58.08
Indirect	-98.58	-874	-26.74	-51.78
Type 1	**-259.85**	**-3744**	**-65.87**	**-109.85**
Induced	-177.54	-856	-24.53	-47.89
Type 2	**-437.39**	**-4600**	**-90.39**	**-157.74**

Table 4.4: Scenario 1: Gross Impacts: Direct, Indirect and Induced effects on output, employment, income and GDP

Variable	Type 1 Effects	Type 2 Effects
GDP	-0.09%	-0.13%
Employment	-0.16%	-0.20%
Output	-0.11%	-0.19%
Household Consumption	-0.30%	-0.30%
Investment	0.00%	0.00%
Government Spending	0.00%	0.00%
Exports	0.00%	0.00%
Imports	0.00%	0.00%
Gross Wages	-0.09%	-0.12%
Consumer Price Index	0.00%	0.00%

Table 4.5: Scenario 1: Gross Impacts: Type 1 and Type 2 macroeconomic impacts (%)

In a sectoral disaggregated context, the composition of the reduction in employment is displayed in Figure 4.4. It is seen that the reduction in employment is most pronounced in the alcohol on-trade sector. This is because the on-trade sector is responsible for a majority of the sale of alcohol in value terms. The alcohol off-trade sector also finds itself with lower employment but to a lesser extent. The wholesale and retail sector excluding vehicles and alcohol (WRT) also shows a high level of losses in employment since the alcohol on-trade and off-trade sectors depend on this sector heavily for inputs.

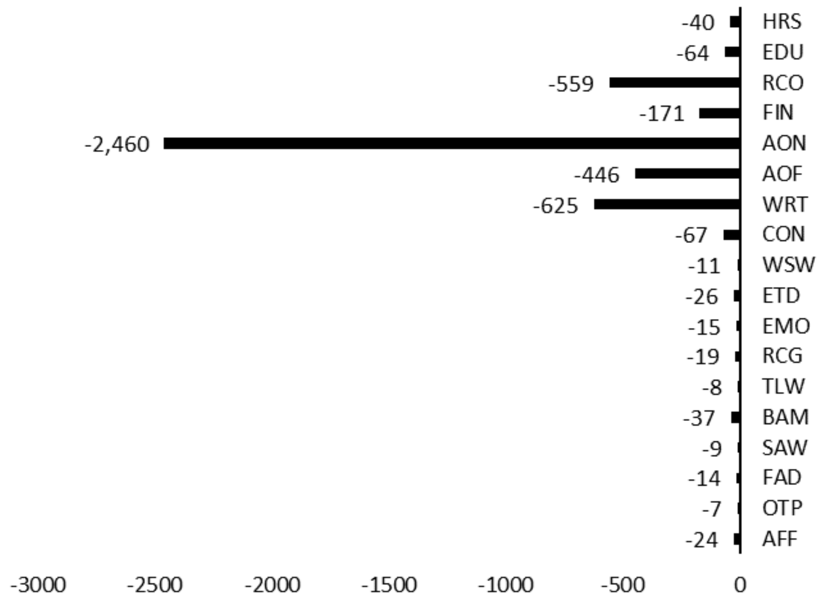


Figure 4.4: Scenario 1: Gross Impacts: Sectoral change in type 2 employment from base period (FTE)
Source: Author's Illustration

While the gross results largely showed a contraction in the economy, we now look at the net impacts. Here, a general reallocation of household spending within the economy is performed in the IO model exogenously, along with a reduction in household spending in the alcohol consumption sectors. The reallocation is performed in the same proportions as the initial household spending by the sectors.

The results are presented in Table 4.6. These results are found to be less negative when compared to those seen in gross impacts. The total level of output in the economy is seen to fall by £64.84m, in contrast to a reduction of £437.39m seen in the gross results. Also noted is there is an overall reduction in employment by 1785 FTE. While a reduction is noted, it is also true that the IO model results without consumption switching showed a reduction of 4600 FTE. Overall, the GDP of the economy is seen to rise by 0.0024%. This expansion, while is small in size, is an indicator that the IO results with consumption switching show positive results than the same scenario without consumption switching.

Effects	Output (£m)	Employment (FTE)	Income (£m)	GDP (£m)
Direct	0.00	-1273	7.05	33.40
Indirect	-48.36	-432	-13.16	-26.00
Type 1	**-48.36**	**-1706**	**-6.11**	**7.40**
Induced	-16.48	-79	-2.28	-4.45
Type 2	**-64.84**	**-1785**	**-8.39**	**2.95**

Table 4.6: Scenario 1: Net Impacts: Direct, Indirect and Induced effects on output, employment, income and GDP

Variable	Type 1 Effects	Type 2 Effects
GDP	0.01%	0.00%
Employment	-0.07%	-0.08%
Output	-0.02%	-0.03%
Household Consumption	0.00%	0.00%
Investment	0.00%	0.00%
Government Spending	0.00%	0.00%
Exports	0.00%	0.00%
Imports	0.00%	0.00%
Gross Wages	-0.01%	-0.01%
Consumer Price Index	0.00%	0.00%

Table 4.7: Scenario 1: Net Impacts: Type 1 and Type 2 macroeconomic impacts (%)

When the losses in employment are disaggregated, it is seen that the majority of jobs are lost in the alcohol wholesale and alcohol retail sector. This accounts for over 98% of all losses. While the other sectors shown in Figure 4.5 also experience an increase in household spending within the IO model, they are also involved in the value chain of alcohol off-trade. The effect of the reduced demand for alcohol dominates the direct increase in household consumption in these sectors.

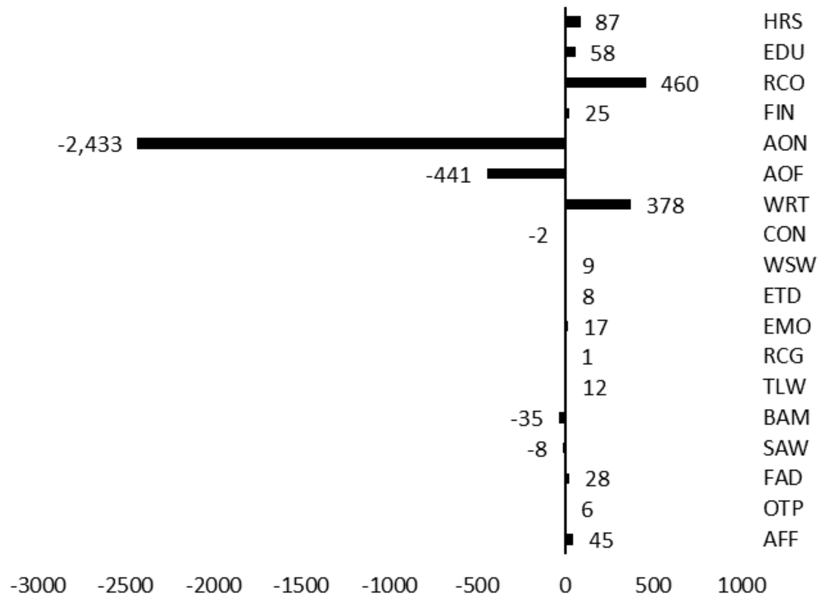


Figure 4.5: Scenario 1: Net Impacts: Sectoral Change in type 2 employment from base period (FTE)
Source: Author's Illustration

A majority of sectors within the economy are shown to experience an increase in employment. In all, 1135 FTE jobs are created through consumption switching from alcohol to other sectors. These are illustrated in Figure 4.5. Notably, wholesale, retail and trade (WRT) and other services (RCO) sectors experience the highest growth of FTE employment. These increases are, however, dominated by the reduction in FTE from the alcohol sectors.

In all, the IO model shows that should there be a reduction in alcohol consumption, the economy could expect to see some negative macroeconomic impacts. The employment impact is estimated to be 1785 FTE losses (-0.08% of total employment). Alcohol off-trade and on-trade jobs are expected to reduce the most.

4.6.2 Scenario 2: An increase in alcohol duty

In the above scenario, the policy used to reduce the level of alcohol consumption was an information campaign. This meant that alcohol consumption reduced without the use of any fiscal policy. In this scenario, we look at the impact of fiscal policy to reduce alcohol consumption on the economy of Scotland. In specific, a 10% increase in the level of alcohol duty is applied in this scenario. This scenario follows Connolly et al. (2019) who have tested the impact of a 10% increase in alcohol duty in the United Kingdom.

To replicate the shock used by Connolly et al. (2019), we use the same method they use to estimate the shock. The impact on final consumption is calculated using the equation below.

$$\Delta f_i = \sum_j^n \left(P_{ij}\Delta C_{ij}\right) \quad \text{... (7)}$$

where C_{ij} is the level of consumption of alcohol and P_{iJ} is the change in the price of alcohol.

The reduction in alcohol consumption is found as a product of the price elasticity of demand for a category of alcohol and the proportionate change in price, represented as the equation below:

$$\dot{C}_{\iota J} = \in_{ij} \ \dot{P}_{\iota J} \quad \text{... (8)}$$

where $\in_{ij}$ is the price elasticity of demand for alcohol.

Further, they find that the change in the level of consumption is given by the following equation.

$$\Delta C_{ij} = \in_{\iota J} (1 - \dot{\alpha} - \beta)\dot{T}_{\iota J} C_{\iota J} \quad \text{... (9)}$$

where $(1 - \alpha - \beta)$ is the share of taxes in the price, and T_{ij} is the rate of alcohol consumption tax.

In their simulations, they find the impact of a 10% increase in alcohol duty. This means that the change in tax rate is calibrated as 0.1.

To find the elasticities, Meng et al. (2014) along with MESAS (2017) is used. The price elasticity of demand for the off-trade alcohol sector is calibrated as -0.50, while for the alcohol on-trade sector is calibrated as -0.81.

To calculate the share of taxes in the price, data from HMRC (2019b) and MESAS (2017) is used. HMRC (2019c) indicates the total alcohol duty collections for the UK. From MESAS (2017), we can find the level of total alcohol consumption in the UK in units. Thus, we can find the alcohol duty per unit of alcohol. From this data, we find that the share of taxes in the price of alcohol in Scotland is, on average, 21.59%. In the equation above, this is calibrated at 0.2159.

Thus, based on equation 6, the following gross shock is introduced in the IO model:

A reduction in the off-trade alcohol household consumption:

$$(-0.50) \cdot (0.2159) \cdot (0.10) \cdot (£569.93 \text{ million}) = £6.15\text{m}.$$

A reduction in the on-trade alcohol household consumption:

$$(-0.81) \cdot (0.2159) \cdot (0.10) \cdot (£1042.81 \text{ million}) = £18.24\text{m}.$$

The gross results of reduction in consumption by households due to an increase in the level of alcohol duty show a fall in all the macroeconomic indicators, as computed through the IO model. Table 4.8 displays the results for the gross impacts of this scenario. The direct impact of increased alcohol duty is noted to be a £24.39m fall in the level of output in the economy. The level of employment is found to fall by 473 FTE in direct impacts on the off-trade and on-trade alcohol sectors. This is indicative of the labour intensity of the alcohol consumption sectors. The level of income is found to fall by £5.81m, while the GDP is found to reduce by 8.39m, which equates to a reduction of 0.006% of the base year GDP. Type 1 results show that the output is expected to shrink as well. It is shown that the output could fall by £39.98m, while employment could fall by 608 FTE. The impact of the GDP is expected to be a fall of 0.013%.

In type 2 impacts, the level of output is expected to fall by £66.89m. Similarly, the level of employment is also seen to fall by 738 FTE. The fall in the level of GDP in percentage terms is at 0.019%. This indicates an overall shrinkage in the size of the economy should the level of alcohol duty increase.

Effects	**Output (£m)**	**Employment (FTE)**	**Income (£m)**	**GDP (£m)**
Direct	-24.39	-473	-5.81	-8.39
Indirect	-15.59	-136	-4.17	-8.15
Type 1	**-39.98**	**-608**	**-9.98**	**-16.54**
Induced	-26.91	-130	-3.72	-7.26
Type 2	**-66.89**	**-738**	**-13.70**	**-23.80**

Table 4.8: Scenario 2: Gross Impacts: Direct, Indirect and Induced effects on output, employment, income and GDP

Variable	**Type 1 Effects**	**Type 2 Effects**
GDP	-0.01%	-0.02%
Employment	-0.03%	-0.03%
Output	-0.02%	-0.03%
Household Consumption	-0.05%	-0.05%
Investment	0.00%	0.00%
Government Spending	0.00%	0.00%
Exports	0.00%	0.00%
Imports	0.00%	0.00%
Gross Wages	-0.01%	-0.02%
Consumer Price Index	0.00%	0.00%

Table 4.9: Scenario 2: Gross Impacts: Type 1 and Type 2 macroeconomic impacts (%)

In sectoral terms, it is seen that the alcohol on-trade sector sees the highest level of job losses in the economy (see Figure 4.6). Since the alcohol on-trade sector purchases from the wholesale, retail and trade (WRT) sector, this has also seen a reduction in the level of employment.

On an aggregate basis, the entire economy sees a shrinkage. The supply chain sectors of the on-trade and off-trade sector feel the highest level of impact, as is expected. Overall, the results are consistent with the ex-ante expectations of this scenario. An important result from this scenario is that the on-trade sector is expected to have a larger economic contraction than the off-trade sector.

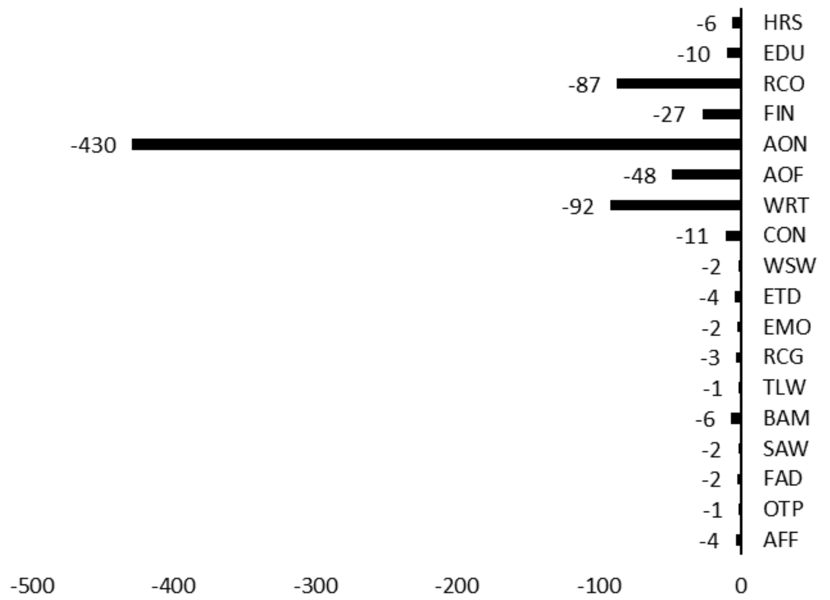


Figure 4.6: Scenario 2: Gross Impacts: Sectoral Change in type 2 employment from base period (FTE)
Source: Author’s Illustration

For the calculation of net effects, we find the increase in government revenue due to an increase in alcohol duty. We find that the total increase in government revenue is £88.84m due to an increase in alcohol duty by 10%, after adjusting for a reduction in the level of alcohol consumption of 1.75% in the on-trade sector, and 1.08% in the off-trade sector. This £88.84m is reallocated to other sectors based on their share of the total government spending from IO tables.

Recycling the increased government spending from alcohol duty to the rest of the economy proportionally within the IO framework shows that the level of output increases by £179.320m, in contrast to a reduction of £66.89m in gross impacts. These results are promising since there is an expansion in the economy in GDP terms and the economy grows by 0.07%. There is an increase in the overall level of employment in the economy by 1489 FTE, as seen in Table 4.10. This is in contrast to a reduction in gross employment by 738 FTE. In terms of income levels, the overall income rises by £55.51m in contrast to a reduction in income by £13.70m in gross impacts.

Effects	Output (£m)	Employment (FTE)	Income (£m)	GDP (£m)
Direct	64.45	891	38.00	48.44
Indirect	5.73	73	2.45	3.51
Type 1	**70.18**	**964**	**40.44**	**51.95**
Induced	109.02	525	15.06	29.41
Type 2	**179.20**	**1489**	**55.51**	**81.35**

Table 4.10: Scenario 2: Net Impacts: Direct, Indirect and Induced effects on output, employment, income and GDP

Variable	Type 1 Effects	Type 2 Effects
GDP	0.04%	0.07%
Employment	0.04%	0.07%
Output	0.03%	0.08%
Household Consumption	-0.05%	-0.05%
Investment	0.00%	0.00%
Government Spending	0.27%	0.27%
Exports	0.00%	0.00%
Imports	0.00%	0.00%
Gross Wages	0.06%	0.08%
Consumer Price Index	0.00%	0.00%

Table 4.11: Scenario 2: Net Impacts: Type 1 and Type 2 macroeconomic impacts (%)

The level of employment, when disaggregated shows that 451 FTE are lost in the alcohol consumption sectors (See Figure 4.7). Other sectors with losses in FTE are primarily the alcohol manufacturing sectors of beer and malt, and spirits and wine. These sectors are the primary input into the alcohol consumption industry and thus contract.

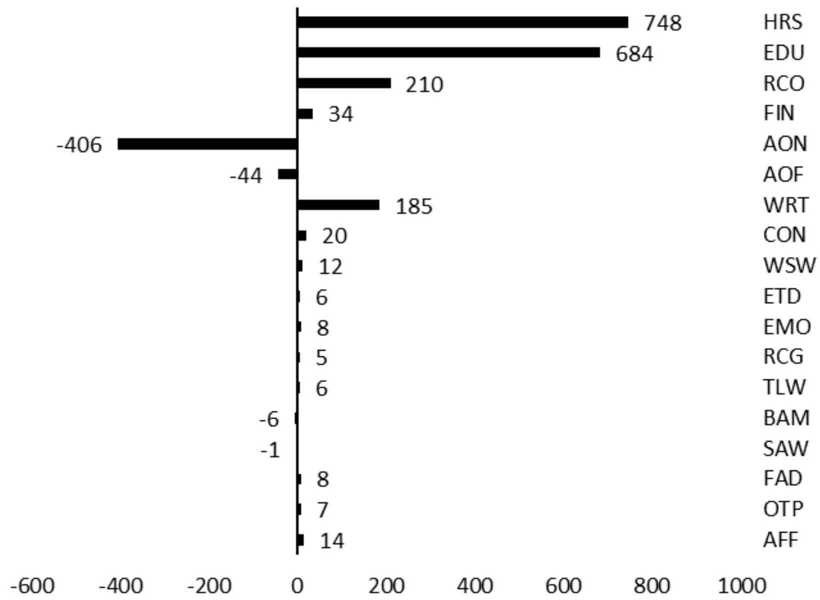


Figure 4.7: Scenario 2: Net Impacts: Sectoral Change in type 2 employment from base period (FTE)
Source: Author’s Illustration

Apart from the above-mentioned sectors, all other sectors within the economy show an overall level of expansion and lead to increased levels of employment. In all, 1947 FTE jobs are increased within the economy. Sectors that show the highest increase include the retail sector, health and education sectors. Overall, the IO model shows positive impacts on the economy, when increased government expenditure is accounted for.

Thus, the utilisation of the IO model in analysing the macroeconomic impacts of reduced alcohol consumption has shown consistently negative results in gross terms. However, recycling government revenue is found to overturn these negative estimated impacts. It is also important to note that the assumptions of the IO model restrict these results since there are no endogenous changes in supply-side considerations of prices and wages.

The overarching theme of the results from the above analysis is that to comprehensively analyse alcohol policy, the analysis should take into consideration the reallocation of household consumption and government revenue. Not doing so indicates that a reduction in the level of alcohol consumption would have negative impacts on the economy. The gross impacts of scenarios 1 and 2 show that every macroeconomic indicator estimated by the IO model in use here shows negative impacts. However, when factors such as switching of household spending and government spending are taken into consideration, the net results show a more optimistic economic outlook. Further considerations such as the preference between capital markets and labour markets, as well as the prices of the products in the sectors can be made through alternative models.

In the next section, we compare the results of this analysis to that of Connolly et al. (2019), since we aim to replicate their results.

4.6.3 Comparing Scenarios 1 and 2 to Connolly et al. (2019)

The results of Scenarios 1 and 2 show the impact of reduced alcohol consumption on the Scottish economy. These results show that this reduction would have negative impacts on the economy if only gross impacts are considered. The net impacts are more optimistic, as the demand in alternative non-alcohol sectors increases. However, another aim of this chapter was to test the resilience of the model used, as it will be used for modelling in further chapters. This is done through replicating the UK wide impacts by Connolly et al. (2019) for Scotland.

The results estimated in this chapter are broadly in line with Connolly et al. (2019). In 2014, the Scottish population, as a proportion of the population of the UK, was 8.28% (ONS, 2020). The net results for scenarios 1 and 2, in comparison to those by Connolly et al., (2019) for the UK are reported below in Table 4.12.

Effects	Output (£m)		Employment (FTE)		GDP (£m)	
	Scotland	UK (Connolly et al., 2019)	Scotland	UK (Connolly et al., 2019)	Scotland	UK (Connolly et al., 2019)
Scenario 1						
Gross Impacts	-437.39	-7289	-4600	-63345	-157.74	-2579
Net Impacts	-64.84	-770	-1785	-21681	2.95	23
Scenario 2						
Gross Impacts	-66.89	-837	-738	-7324	-23.80	-294
Net Impacts	179.20	2154	1489	17041	81.35	847

Table 4.12: Headline Results: Gross vs Net Type 2 impacts of Scenarios 1 and 2 as compared to Connolly et al. (2019)

The results that have been estimated in this chapter are consistent with those for the UK. This shows that the disaggregations within the IO tables are consistent with the existing literature. Thus, the disaggregated IO table is employed in further modelling in chapters 5 and 6.

While it is found that the results of the Scottish specific analysis conducted in this chapter are broadly in line with the UK-wide study conducted by Connolly et al. (2019), the analysis further finds sector-specific results for the Scottish economy. The composition of the alcohol sector in Scotland is different to the rest of the UK, given its high production and exports.

As was seen in chapter 3, the alcohol production sector is a key sector in the Scottish economy, given its production of Scotch Whisky. This commodity is produced by the Spirits and Wine (SAW) sector of the IO model in the results above. The results show that a reduction in household consumption of alcohol does have an impact on the Spirits and Wine sector, but this is limited to domestic sales. It is seen that the level of exports do not fall in Scenarios 1 and 2 when household consumption is reduced through fiscal or other means. While this is primarily due to the lack of pricing mechanisms in the IO model, these sectoral impacts are important and will be studied in more detail in future chapters where a CGE model is used, and prices are estimated endogenously in the model.

4.7 Advantages and disadvantages of using Input-Output Tables for modelling

The previous sections have shown the many uses of IO analyses and models. The results have brought forward some key benefits and drawbacks for the use of IO models in analysing the economy-wide impacts of reducing the consumption of sin goods, namely alcohol. The advantages and disadvantages of using IO models for economic analyses are discussed in this section.

4.7.1 Advantages

The advantages of using IO models in analysing demand changes and consumption switching are many (Fatemi, 2002).

A primary advantage of using IO models is that the set of accounts are easily available for several countries and regions. The accounts have proven to be detailed since several different data sources are employed in the formation of IO tables. It is a comprehensive and consistent set of accounts that may be used for modelling. The data, which is usually from government sources, allows for a wide range of modelling possibilities due to its vast nature (Miller & Blair, 2009). As seen in Chapter 3, the Scottish tables contain a wide range of information about the alcohol sector. The IO accounts contain detailed information about every sector in the economy, albeit, some of them may be aggregated and require some work to disaggregate. The use of these tables as a set of national accounts by EU countries is evidence that the tables can cover a broad range of formal economic activity. Thus, an advantage of using the IO tables is the readily available data and ease of accessing this data.

Since its conception, IO modelling aims to showcase the linkages between various sectors in the economy. With the sectors, directly and indirectly, affecting each other, the ability of these models to use Type 1 and Type 2 multipliers to find forward and backward linkages of sectors makes this a highly sophisticated model. Considering that the model has the ability to interlink sectors, it is possible to produce results from the models that are as specific or as broad as required. In this chapter, it is seen that we have been able to disaggregate the employment results by sector and show how other sectors have reacted to a demand shock in the alcohol sector. Real data on the linkages of the sectors have been used consistent with widely used techniques, and this has extended the existing tables.

The use of type 1 and type 2 multipliers allows for change to be noted not just in directional terms, but also in magnitudinal terms. This allows for a vast range of shocks to be propagated through the economy making it a very efficient model to measure impacts and shocks. It is key here that economy-wide impacts can be measured. Having detailed data on the interlinkages within the wider economy provides scope for a broad range of analyses to be carried out.

Overall, this chapter has shown that IO models may be used with ease when it comes to finding macroeconomic impacts of a shock. It is also seen that the results from IO models showcase sector-specific and economy-wide impacts. Specifically for alcohol consumption, the use of IO tables makes it easy to disaggregate alcohol consumption from within other sectors in the tables. IO models have proven to be a key starting point for the macroeconomic analysis of a reduction in alcohol consumption.

4.7.2 Limitations

While the use of IO models is wide and far-reaching, some limitations of these models have been uncovered in the analysis conducted in this chapter. Some of these disadvantages originate from the assumptions of the production function, and some others are operational disadvantages (Miller & Blair, 2009).

Each industry in the IO models is assumed to produce only one type of product. This means that the level of disaggregation of the IO tables becomes a limiting factor to different types of products that can be analysed. Within the context of alcohol consumption, it is not possible to disaggregate the consumption of different categories of alcohol. Given that different categories of alcohol have different consumption trends (MESAS, 2017) and different tax rates (HMRC, 2020), the use of IO models in alcohol policy could be far-reaching in the presence of such data.

Arising from the same issue, within the model used in this chapter, the technical coefficients are fixed. This is to say that as that an increase in the level of output requires a fixed increase in the level of inputs. The IO model in this chapter has a constant return to scale. This becomes a greater issue when tables are highly disaggregated. Thus, there is a trade-off between the level of disaggregation and substitutability of inputs.

The IO model also does not take into consideration the relative prices of products. This means that the model is unable to gauge the changes in demand when spending on the alcohol consumption sectors reduces. A key issue here is that in the absence of coefficients to model the behaviour of consumers and markets, it is impossible to accurately forecast the macroeconomic impact of reduced alcohol consumption.

There is no constraint in terms of natural resources for the level of production. This makes the effects of some positive demand shocks inaccurate since the economy cannot produce at the levels suggested by the IO model. The level of expansion in a sector in the results of this chapter is not limited by the availability of labour or capital. It is assumed that an unlimited amount of inputs are available.

The process of collation of IO tables is tedious and time-consuming, which means that there is a lag between the availability of data and its collection. For this analysis, the IO tables for Scotland from 2014 are used. The latest available IO model for Scotland is for the year 2016 at present.

Since IO models are a snapshot of the economy at a point in time and are usually created on an annual basis, it becomes hard to look for specific policy effects from the time of implementation. This doesn't allow for specific events to be effectively gauged due to data becoming contaminated from other events that may have taken place throughout the year. Linkages also change through the year depending on specific events which would be of interest to economists but cannot be gauged.

In the analysis conducted in this chapter, the reduction in demand for alcohol is substituted with increased demand in alternative sectors. We must make assumptions on how this consumption switching is carried out since we do not have data on the relative prices and cross-price elasticities of the alcohol sectors with all other sectors in the economy. Additionally, the model is not taking into consideration the availability of resources in alternative sectors when estimating the impact on GDP and output. These pose some of the limitations of IO modelling for alcohol demand modelling. Another limitation of the analysis is that only one household sector is included in the model. This is to say that the household sector is not disaggregated based on, say, level of consumption. Having such a disaggregation would allow for more targeted analysis. However, this would also mean that the household sectors of other industries in the model would also need to be disaggregated in a similar manner, and such specific data is unavailable.

The range of limitations posed by IO models calls for the analysis of policy changes in a model that accounts for some of the limitations mentioned in this section. In the next chapter, an attempt is made to use Computable General Equilibrium models to examine policy changes.

4.8 Conclusions

The main aim of this chapter was to establish the usefulness of IO models in examining the macroeconomic impacts of reducing the consumption of a sin good. The IO model was used in analysing two main demand shocks in the analysis of alcohol consumption. It was seen that the IO model was able to analyse this impact to a limited proficiency.

In Scenario 1, the gross results showed that the level of GDP in the economy would reduce due to lower alcohol consumption. However, upon accounting for consumption switching, the net results showed that this negative impact could be overcome owing to increased consumption from alternative sectors. For the level of output, employment, and, income, both, gross and net impacts were found to be negative. The net impacts were considerably less negative due to increased household demand in non-alcohol sectors.

In Scenario 2, the gross results showed across the board negative impacts on the Scottish economy. When the increased alcohol duty is recycled as government expenditure, the net results overturn the negative economic impacts seen in the gross results. In all, the GDP of the economy could be expected to improve with a reduction in alcohol consumption, as assessed through IO models. These headline results are shown below in Table 4.13.

Effects	Output (£m)	Employment (FTE)	Income (£m)	GDP (£m)
Scenario 1				
Gross Impacts	-437.39	-4600	-90.39	-157.74
Net Impacts	-64.84	-1785	-8.39	2.95
Scenario 2				
Gross Impacts	-66.89	-738	-13.70	-23.80
Net Impacts	179.20	1489	55.51	81.35

Table 4.13: Headline Results: Gross vs Net Type 2 impacts of Scenarios 1 and 2

The aggregated headline results reported above were found to be widely in line with the UK results as seen in Connolly et al. (2019). However, the sectoral results showed some differences that should be considered while framing subnational alcohol policy specific to Scotland. It was seen that the Spirits and Wine (SAW) sector that produces Scotch whisky has a key role in the Scottish economy. In a devolved context, the impact of lower consumption does have a negative impact on the production sectors. However, keeping in mind the impacts of consumption switching, it was seen that these impacts are small. The reliance of this sector on exports for sales is important and should be considered while framing policy for Scotland, alongside the positive impacts in alternative sectors of the economy.

The use of the IO model in the field of examining sin goods was found to be lacking due to some drawbacks. The primary drawback of the model was found to be a passive supply-side constraint. This meant that prices and wages were not endogenously adjusted within the model. Also seen was that the model was insufficient in incorporating the health impacts of increased alcohol consumption, endogenously or exogenously.

In terms of the capability and usefulness of IO modelling to measure demand-side changes in alcohol consumption, the results have shown that IO tables can analyse and report some macroeconomic indicators such as GDP, employment, output and income levels. However, it is also seen that the use of consumption switching can help greatly improve the depth of research. This means that while negative demand shocks will only show the negative effects of a fall in demand of a particular sector, using consumption switching can help pinpoint the positive impacts of a fall in demand for alcohol. Additionally, the model used in the analysis of this chapter was found to be resilient and consistent with the existing literature and can be used for further modelling, while also showcasing the sectoral impacts in the Scottish economy.

In the face of many drawbacks of the IO model, most notably the absence of an active supply-side, the use of a more advanced macroeconomic model is warranted to find the impacts of reducing alcohol consumption. Such a model should have the advantages of the IO model such as sectoral disaggregation and economy-wide modelling, but must also have a dynamic structure that can capture the supply-side impacts alongside the demand-side impacts. The next chapter aims to use one such model which is a CGE model.

Chapter 5: Evaluating economic impacts of demand-side disturbances in the alcohol sector in a CGE framework

5.1 Introduction

The use of IO tables as a set of accounts in chapter 3 gave us an insight into the linkages that exist between the alcohol production and consumption sectors and the rest of the economy. We then used the IO tables as a model in chapter 4, and it was clear that the IO models were not sufficiently useful in the process of showing macroeconomic impacts of reduced alcohol consumption. This was primarily due to the passive supply-side within the model with fixed prices (Allan et al., 2007). The use of a different model with an active supply-side is thus necessary. This chapter aims to investigate the economic impacts of a change in demand for alcohol through various channels of consumption for Scotland using an alternative model. The assumption in IO models of a passive supply side is relaxed in a CGE model.

The use of the IO model in the previous chapter uncovered several issues that posed in the analysis of the alcohol sector. The sectors were unable to choose between factors of production and were bound by the base period processes. Prices were not determined in the IO framework, and this is essential while analysing alcohol policy. Additionally, there was no way to incorporate features of labour productivity into the model. The use of the CGE model solves several of these issues.

Like the IO model, the main structure of a CGE model is that the economy is composed of various sectors which have interlinkages between them. This implies that changes in one sector would have implications for the other sectors as well due to these interlinkages. To establish these interlinkages and matrix structure of the economy, the key data used in CGE models are an extension of IO tables which is a Social Accounting Matrix (SAM). The primary addition of the SAM is the transfers that are made between different institutions of the economy that deal with the distribution of income, such as income-expenditure accounts, which allows for an active supply side.

The WHO (2009) explains that while examining the distributional impacts of health-related policy interventions, the use of CGE models can assess sectoral changes that are important to consider for policymakers. Since CGE models are based on the theory of general equilibrium, they can find results that are driven by changes in relative prices and wages (Smith et al., 2005). This is the benefit of using CGE models over IO models in this study.

A key paper identified in the literature of analysing the economic impacts of reduced alcohol consumption is Wada et al. (2017). This paper finds the employment impacts of reduced alcohol consumption in various American states through the REMI model. They find that an increase in alcohol duties would result in lower employment in the economy when the raised taxes are not recycled. However, when the raised taxes are recycled by the local government, the impact on net employment in the economy is positive. The analysis of this paper is replicated in the current chapter through the AMOS model to find the macroeconomic impacts of reducing alcohol consumption in Scotland through increased alcohol duties.

The results of chapter 4 where the IO model was used were limited by the fixed technical coefficients within the model. Sectors were not able to choose between alternative production inputs and substitute between capital and labour. This is an issue that is resolved through the use of CGE models since it can use alternatives to the Leontief production function assumed in IO models. This is particularly helpful since a CGE model has endogenously determined prices, another drawback of the IO model. The CGE model can compare the relative prices and allow for substitution between the factors of production – Capital and Labour (Lecca et al., 2013).

The modelling framework we use in this chapter is an AMOS model (A Micro-Macro Model for Scotland) (Lecca et al.,2013). This is a CGE framework that has been used in academic research and for policy analysis for Scotland. This is because the model can capture the economy of Scotland in a flexible framework that allows a range of different market and individual behaviours to be modelled. Certain changes have been made to AMOS to allow the model to examine alcohol policy. These will be elucidated in this chapter.

Section 5.2 sets out the reasons for picking a CGE model. Section 5.3 provides a generalised understanding of CGE models through elucidating on the historical development of CGE models and their features. Section 5.4 describes the components and structure of the AMOS model and displays how the AMOS model has been adapted to this research. Section 5.5 elaborates on the strategy for implementation of alcohol duty shocks on alcohol, and the results of a range of such shocks will be displayed and discussed in detail in section 5.6. A further discussion of the results in comparison to the results from chapter 4 is conducted in section 5.7. Section 5.8 shows a sensitivity analysis on a range of other model specifications. Section 5.9 provides a conclusion for this chapter by highlighting the key findings.

5.2 Choice of models

To analyse the macroeconomic impacts of reduced household consumption of a sin good, a comprehensive macroeconomic model could be used to find the market losses of consumption. WHO (2009) recommends that for the estimation of macroeconomic impacts of health issues, models may include market losses, welfare losses, or both. The focus of this thesis is on the market losses of alcohol consumption. We have previously attempted to use the IO model. The use of the IO model demonstrated some weaknesses of the model in analysing the changes in consumption patterns. This leads us to look for alternative models to analyse a reduction in alcohol consumption.

The features we look for in a model to analyse alcohol consumption, as uncovered from the limitations of IO modelling are many. One key feature is that the model must be multi-sectoral and must have the capability to show results in a disaggregated manner. The model must be able to show the economy-wide implications of the reduced consumption. The key macroeconomic variables that could be used to analyse the impacts include changes in the level of output, changes in price levels in the economy, changes to the level of employment, and changes to the overall GDP. These variables can help explain the various effects that would take place in the economy should the consumption of a sin good such as alcohol reduce.

Another feature that is sought from the model is their ability to incorporate the health impacts of reduced consumption. This could be done through various mechanisms such as changes to life expectancy, showing impacts on overall health spending or looking for changes in the level of labour productivity owing to better health. The impacts of the health consequences of alcohol consumption are further discussed in chapter 6.

To find a model that accurately fits the description above, we analyse the literature to find what models have been previously used to find the impacts we are looking for. We then analyse the rationale for picking the model chosen.

5.2.1 Previous methods used in analyzing the changes in household consumption of sin goods

A range of studies has previously analysed the economic impacts of reducing the consumption of various sin goods. The category of sin goods includes goods such as sugar, alcohol, and tobacco amongst others.

One such model used in analysing sin taxes is the Regional Economic Models, Inc. (REMI) model. This model is a multi-sectoral model that is built for forecasting and analysing policy by governments. Being a dynamic model that can analyse the behavioural responses of actors in the economy to changes in prices and other economic factors, this model has been used to analyse alcohol taxes, sugar taxes as well as tobacco taxes.

Wada et al. (2017) the REMI model to look for the employment impacts of increasing excise duty on alcohol in five states in the USA. The study assumes that alcohol is produced in three manufacturing sectors (breweries, wineries and distilleries), and sold through three sales sectors (wholesalers, retailers, and food and drink service establishments). This set-up is similar to the setup adopted in this thesis. Wada et al. (2017) attempt to find the employment impact when the tax on alcoholic beverages is increased. This increase in alcohol taxes includes an increase in specific taxes (alcohol duty) and ad valorem taxes (excise duty). To find the volumetric impact of these taxes, price elasticities are used.

Three main simulations are presented – the gross impact of a reduction in alcohol consumption, a net impact of exogenous redistribution of household income and government taxes, and a net impact of exogenous reallocation of all the newly raised revenue to the healthcare sectors within the model (Wada et al., 2017).

The study finds that there is a gross negative employment impact of a reduction in alcohol consumption. When household spending and government spending are exogenously redistributed, there is an increase in the total level of employment in the economy. Reallocating all of the raised government revenues to the healthcare sectors has a further positive impact on the level of employment. These results are true for all five states assessed and for both types of alcohol taxes (Wada et al., 2017).

In this chapter, the AMOS model is used to analyse the impacts analysed by Wada et al. (2017). Within the AMOS model, we attempt to find the impacts based on endogenously determined relative prices and wages, as shown in section 5.6. A key difference between the analysis conducted in this chapter and Wada et al. (2017) is that long-run and short-run macroeconomic impacts are analysed in this study, while Wada et al. (2017) only find short-run impacts on employment. Another difference is that this study does not take into consideration the improvements in labour productivity (Wada et al., 2017). We incorporate these impacts in chapter 6 of this thesis. Thus, we can expand the literature by extending this study by incorporating an externality of reduced consumption.

As with the study by Wada et al. (2017), in their analysis of taxes on SSBs, Powell et al. (2014) use the REMI model to assess the impact of higher taxes on net employment in Illinois and California. The model consists of demand-side considerations such as output, consumption, capital and labour. It also consists of supply-side considerations such as labour supply, price mechanisms, and market shares. The study finds that the economies would experience a net reduction in employment when no substitution effects are applied. However, they find that upon selective substitution to alternative beverage sectors, the net employment reduces, but by a much smaller effect than without consumption. The study finally finds that in the presence of non-explicit substitution, the net employment increases, albeit by a small percentage of between 0.03% and 0.06%.

In the economic analysis of sugar consumption, the focus of current literature lies on sugar-sweetened beverages (SSB). Various economies including the UK have implemented taxes on SSBs to curb consumption and prevent related diseases. However, the implementation of such taxes has been found to have many barriers including the impact on the economy of the region (Thow et al., 2018). There is thus a need to develop models to study these economic impacts to lower the barrier to implementing sin taxes and surrounding policy.

Similarly, Warner et al. (1996) have also used the REMI model to analyse the employment impact of higher tobacco taxes in the United States. Their results also find that an increase in taxes on tobacco would increase the level of employment in non-tobacco states of the country, and the reduction in employment in tobacco states would be much lower than previously estimated using other models.

The use of the REMI models has been used to model the labour market impacts of sin goods. The studies mentioned above do not expand to the assessment of other impacts such as GDP, output and incomes. The studies mentioned above also do not extend their analysis to modelling the productive capacity impacts of reducing the consumption of a sin good. The results are limited to measuring the employment impacts of reduced consumption resultant of a tax change but do not extend to the positive health impacts of lower levels of consumption of alcohol and SSBs (Wada et al., 2017, Powell et al., 2014).

While REMI models use the principle of computable general equilibrium, they are not purely CGE models since they employ econometric estimations, economic geography methods and Input-Output methods within themselves. In contrast, CGE models purely use the principles of general equilibrium in their framework. Thus, CGE models are multi-sectoral models that apply economic theory to model data through a system of equations. CGE models contain demand-side considerations similar to an IO model. They also contain supply-side considerations through the use of an income-expenditure account and data from other sources within a Social Accounting Matrix (SAM). Agents within a CGE model include firms, households and government, and their behaviour can be modelled in a CGE framework (Scottish Government, 2016a).

While pure CGE models have not been used in modelling the macroeconomic impacts of alcohol consumption extensively, they have been used in modelling the impacts of other sectors. Notably, Ye et al. (2006) have used a CGE model for Taiwan to find the economic gains from cigarette taxes. They find that an increase in the cigarette tax in the country would have negative first degree impacts on the economy as the GDP, investment and level of employment are all expected to fall. However, they find that the overall level of household consumption increases due to consumption switching. While the health impacts are not modelled into their CGE model, the authors find that the number of lives saved by this tax when monetized through GDP per capita is greater than the fall in GDP. While this paper uses a CGE model in the field of tobacco much the same as is intended in this chapter, incorporating the health impacts into a CGE model might yield results that are in line with economic theory.

In all, we find that not many macroeconomic models have been used in the field of macroeconomic analysis of alcohol consumption. The use of a CGE model seems the most appropriate since the intent of this thesis is to eventually model the health impacts of reduced alcohol consumption into the macroeconomic model.

5.2.2 Rationale for choosing a CGE model

Assessing the macroeconomic impacts of reduced alcohol consumption requires a multi-sectoral macroeconomic model with detailed inter-industry linkages. As seen in the section above, a very limited number of studies have used CGE models to study the alcohol sector. This is not particularly surprising given that established econometric methods have been used widely in accessing the health impact specific alcohol policies such as by Meng et al. (2014), Meier et al. (2016), Brennan et al. (2015, 2014), Holmes et al. (2014) and Ally et al. (2014). However, these studies do not analyse the economic impact of reducing alcohol consumption but focus on the health aspects of reduced consumption.

Very few studies have been found that use CGE modelling to check the macroeconomic implications of reduced alcohol consumption. While IO models have been used to measure these impacts as seen in chapter 4, a gap exists in the current literature. This is particularly highlighted by the World Health Organisation (2010) in their guide to analysing alcohol titled "Best practice in estimating the costs of alcohol – Recommendations for future studies" where they iterate that CGE models have the potential to capture the economic impacts of alcohol, but WHO (2009) also place caution that since CGE models are dependent on the assumption, sensitivity analyses should be reported alongside results.

"… studies should take into consideration the several aspects of uncertainty surrounding current models, which relate to theory, measurement and specification. Any assumptions … should be tested and validated through extensive sensitivity analysis. The results of sensitivity analysis should be documented and reported alongside the main results." (WHO, 2009 p. 57)

The use of CGE models in examining the changes in alcohol consumption, while has not been extensively performed before, proves to be a promising model. The model allows for changes in demand to be shocked, and supply-side implications can be observed economy-wide.

Thus, taking into consideration the recommendations by WHO (2009; 2010), this research addresses the gap in the current literature to use a CGE model, namely AMOS, to estimate the macroeconomic impacts of changes in alcohol consumption, and pays heed to their advice on reporting sensitivity analysis, as reported in section 5.8.

5.3 An introduction to CGE modelling

The use of CGE modelling in the field of modelling changes in demand is well established (Loveridge, 2004). However, its specific use in modelling sin goods is not extensively done before. Before delving into using a CGE model, the basic concept of a CGE model is explained in this section.

A brief historical background on how CGE models have developed from the basic concepts of IO models is discussed. Also discussed are the components of a CGE model, the process of simulating with a CGE framework, and the advantages and disadvantages of CGE models. This section discusses the general concepts in the area of CGE models. More specific detail on a CGE model used for modelling in this thesis is available in section 5.4.

5.3.1 A historical background of CGE models

In this section, the historical background on how CGE models evolved to be in their current form is briefly discussed. This allows for the understanding of the strengths and weaknesses of the model can be when using them for this analysis. CGE models have emerged from the backdrop of IO models discussed previously in chapter 3 and 4.

CGE models emerged as a result of attempts to solve multisectoral matrices for Norway within a linearized equilibrium system by Johansen (1960). The previous versions of multisectoral models such as IO models did not identify or model the behaviour of individual agents (Dixon & Rimmer, 2010). This is what Johansen set out to contribute to the growing range of multisectoral modelling literature. The model identified the production by industries to minimize costs given production constraints and demand-side factors. The households attempted to maximise their utility function given their budget constraints and capital was allocated between industries to maximise their returns. This allowed for supply-side functions such as prices and wages to adjust and estimate a new balance of demand and supply of industries and factors (Johansen, 1960). This research was the starting point for models with general equilibrium and set the stage for new developments and advancements to this form of modelling.

Applied General Equilibrium (AGE) was then conceptualised by Scarf (1967a) with the application of the Arrow-Debreu equilibrium, which hypothesised that under the assumptions of perfect competition in the economy and convex preferences, there exists a set of prices such that aggregate demand is equal to aggregate supply. This made the theoretical groundwork laid by Johansen and made it into a model that could be used to examine the policy. The theoretical framework of the Arrow-Debreu equilibrium could also be used to prove the existence of the equilibrium described by Walras (1874) and this allowed the Walrasian equilibrium to be applied in a computable general equilibrium model by Shoven & Whalley (1984).

These models by Johansen (1960) and Scarf (1967b) form the basis of CGE models used in policy analysis today. Some elements of the Johansen model are still of relevance in the current CGE model structures including the rectangular system of linear equations and the linear representation of the behaviour of the various factors of production in the economy (Dixon & Rimmer, 2010).

Apart from Johansen and Scarf, there were other researchers in the 1970s who also independently used forms of CGE models in their research. This included Hudson & Jorgensen (1974) who tried to find a Walrasian equilibrium price vector while studying the energy sector. Adelman & Robinson (1978) also claimed to use a primitive version of a CGE model in their work in which they were able to closely recreate the base-period values for exogenous variables that were input into the model (Dixon & Rimmer, 2010).

The use of CGE models in the analysis of policy increased drastically following this period with the publication of papers by Shoven & Whalley (1972), and Miller and Spencer (1977), but their application to regional economics came much after. This lag in the application of CGE models to regional economics might have been due to the way that data was published since regional data required for CGE models was not as easily available as national data.

While some similarities exist between regional and national CGE models, assumptions have to be made to simplify equations of consumption, production and market behaviour for the regional economy to work in a similar way to the national economy. However, some structural differences are prominent here since regional economies are more open than national economies. Nonetheless, these CGE models are now used regularly to analyse regional economic analyses (Partridge & Rickman, 1998).

The key components of current CGE models are a set of accounts that detail the actual income and expenditure of an economy at a specific point in time, along with a set of equations detailing the technical relationships and capturing behavioural tendencies of the various actors, which help in capturing any interdependencies between various sectors of the economy (Shoven & Whalley, 1992)

While CGE models may be diverse in their structure, most CGE models tend to have similar characteristics that have been listed by Gilmartin (2010, p. 17) as to "be static, have two factors of production: labour (which may be disaggregated by skill level), and capital; have a limited number of commodities; model inter-industry linkages using IO fixed coefficients from an accompanying SAM database, and may assume constant returns to scale for production technologies to facilitate an equilibrium concept upon which to base the analysis". In this context, the general features of a CGE model are discussed in the following section.

5.3.2 Components of a CGE Model

IO models have been widely used and continue to be used to quantify system-wide changes in the economy through multiplier analysis. As IO models have a passive supply-side constraint, this model was developed to include microeconomic behaviours of economic agents in a flexible framework for analysing economic shocks. Partridge & Rickman (1998) and Partridge & Rickman (2010) have further reviewed and discussed CGE models.

The primary framework of a CGE model consists of a set of equations that model the behaviour of the economic agents in the economy. These economic agents include firms, households and governments. The equations use economic theory to model the behaviour of these economic agents. Also included in the model are the macroeconomic variables that are affected by the behaviour of the economic agents. Through these equations, the model can create a framework for economic activities such as production, consumption and trade. The underlying assumption of a CGE model is that the conditions for a general equilibrium must be met. This means that the forces of demand and supply must be balanced by factors such as price levels and resources. Thus, the main components of a CGE model are consumption, production and markets.

Within a CGE model, households receive income from the factors of production. This income is spent by households in various sectors and is also used for making payments to the government in taxes. The behaviour of consumption may be modelled through various consumption functions including an inter-temporal consumption function and linear consumption. Households within the economy may consume from either domestic goods or imports. Within this choice, the Armington assumption (Armington, 1969) is adopted. This assumption suggests that domestic goods and imports are imperfect substitutes (Pauw, 2003).

In terms of production, a CGE model may or may not have any intermediate input. A CGE model without intermediate inputs is a relatively simple form of the model, where a linear production function can be used. However, with the introduction of intermediate inputs, the model requires a nested production structure. The production process then requires value-added and intermediate inputs to produce in the economy. A choice between Constant Elasticity of Substitution (CES) and a Leontief production function can be used to determine this production. Within value-added, various factors of production combine in proportions defined by the CES or the Cobb-Douglas production functions. Within intermediate inputs, various inputs from intermediate sectors combine through a Leontief production function. Also made is the Armington assumption between exports and domestic markets by producers (Pauw, 2003).

Within a CGE framework, the various factors of production can compete with one another. These factors compete in the factor markets. A CGE model may have two or more factors of production, such as labour, capital and land. Each factor of production may be described in as much detail as required by the modeller. In labour markets, participants may be classified as mobile or immobile. Mobile labour may move between sectors in the economy. Other aspects that may be detailed include the skill level and migration. The labour market has an endogenous wage rate, which may differ by sector and skill level. Labour is substitutable to other factors of production. Prices within the capital market are determined by the cost of capital, which is endogenously modelled. The flow of capital is fixed in the short-run and may only change in the long run (Banse et al., 2013).

In all, CGE models may be structured in a varying amount of detail. The level of detail in a CGE model increases data requirements and may be able to produce more complex results. However, the trade-off for a more complex model is the increased number of assumptions.

5.3.3 An overview of running CGE Models

From previous sections, we have understood the basic structure of a CGE model. We now look at how a CGE model can be used in the case of modelling alcohol consumption to find economic impacts.

Before running any disturbance within a CGE framework, the model needs to be prepared to find economic impacts as seen in figure 5.1. The preparation of a CGE model begins with the process of calibrating the model. This implies that we must be able to run the model for it to replicate the baseline dataset that is the input for the model. The baseline dataset is in the form of a SAM which is built using data from various sources. The process of updating a SAM is elaborated in section 5.4.3. The process of calibration also allows the model to estimate the parameters required to check the changes made when a shock is applied. Once the model is calibrated, the user should be able to reproduce the baseline dataset, thus showing no change from period 0 (baseline period).

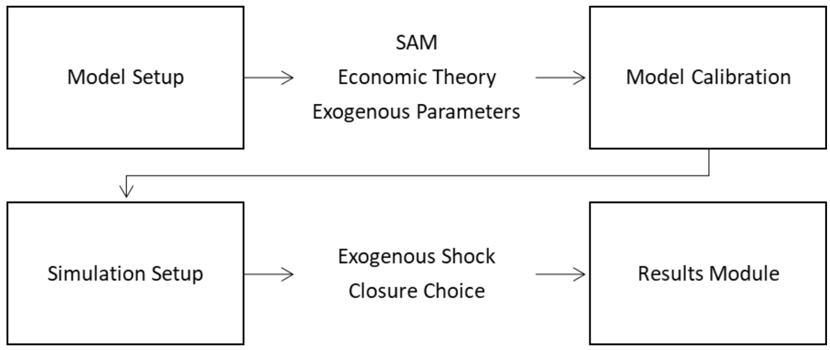


Figure 5.1: Modelling setup of a CGE model
Source: Authors' illustration, adapted from Harrigan et al. (1991)

The process of implementing an exogenous shock is applied through a simulation module. A shock may be formulated exogenously based on economic theory and entered into the model through the simulation module. Once the shock is applied, the model estimates the impact of the shock and computes all endogenous variables, and thus shows changes in demand as described in the sections above. The choices of model specification are also applied at the time of entering the shock. These determine the path followed in making the necessary adjustments to household consumption, capital stock, and thus investment.

The results module is then generated by the model. These include a range of variables such as GDP, employment, changes in household demand for sectoral output and so on. Using the results module, the user can analyse the economic impacts and check the variables desired. The user can find the changes between the equilibrium in the base period and compare it to equilibria in successive periods, thus having the ability to analyse long-run results as well.

It is important to note that the results produced are largely dependent on the accuracy and design of data entered for the base period. A user can aggregate or disaggregate sectors to find implications for particular policy shocks. As an example, the data entered in a CGE model in this thesis includes 18 sectors, including disaggregated on-trade and off-trade alcohol consumption. However, one might be able to disaggregate data differently to find implications of a shock on an alternative sector, say sugary drinks. The sectoral set-up for this research is explained in section 5.4.3.

5.3.4 Strengths of CGE models

Having discussed the various features of CGE models and the process of setting up the modelling, it is important also to recognise the strengths and limitations of this form of modelling. These are discussed in this section.

One of the widely discussed strengths of CGE modelling in the previous sections has been the presence of an active supply-side that can adjust the factors of production. A CGE model can endogenously switch between various factors of production and optimise the costs as firms would in the spirit of cost-minimizing (Lecca et al., 2013).

This brings us to another strength of CGE modelling. The model captures the behaviours of various economic agents such as households, governments and firms. These behaviours are modelled through equations that are consistent with economic theory (McIntyre, 2012).

Another advantage is that the data used in CGE modelling is real data and the model employs economic theory. This, while is prevalent in several other types of models, is an important strength of CGE modelling. The flexibility that is offered by CGE modelling through the use of closures discussed in previous sections also means that CGE models are flexible and can be used to analyse a range of sectors and policies. Given that the data is available, CGE models can be used to address a wide range of economic studies.

However, it is this flexibility in CGE models that also brings about some of its weaknesses. Since analyses are highly sensitive to various optimization settings, such as choice of wage bargaining functions, migration, government spending decisions etc., they might often give widely ranging results. This means that sensitivity analysis becomes of high importance while conducting CGE analysis. Additionally, CGE models are subject to a range of assumptions in their parameterisation, such as assuming elasticities (Partridge & Rickman, 1998). This means that one must be very careful in picking elasticity data since the results could be highly sensitive to these. The use of economic theory to back the choice of elasticity used can help overcome this limitation.

Another weakness of CGE models is that CGE models use data from one year as their base period data. This means that all results that are produced are subject to any problems in the base year data. It does not take into account any larger macroeconomic disturbances that may have occurred in the base year (Holley, 2016).

As with any model, a CGE model makes several assumptions that are based on economic theory such as maximisation of utility by households and minimisation of costs by firms. While these theories make for convenient computation of equations, these are not consistent with empirical evidence (Scottish Government, 2008).

Therefore, while we recognise the strengths of CGE models in general, we also need to take into account that these models have certain limitations and keep in mind that these may have an impact on our results.

5.4 An introduction to AMOS

The AMOS model which is "A micro-macro model of Scotland" was originally developed in the 1980s as a modelling environment to analyse "any single vision of the operation of markets in a small open regional economy such as Scotland" (Harrigan et al., 1991, p.424). It has been developed over the years, and the variant of the model that is used in this thesis was developed by Lecca et al. (2013). Apart from Scotland, the framework of AMOS has been applied to other economies such as Greece (Pappas, 2013) and Illinois (Turner et al., 2012).

With AMOS, a range of different functions can be performed based on the specification of the modelling framework that can be employed by the user. This means that differential assumptions could be employed to analyse a range of scenarios. This is a key benefit of using the AMOS model since the flexibility provided by it allows for the user to check the robustness of the results and analyse their sensitivity to varying assumptions of different factors. An example of this flexibility is the choice that the model offers between the myopic and forward-looking behaviours of economic agents. A switch between these two behaviours would be key for the sensitivity of the results while analysing any economic simulation. This means that the user will be able to check the applicability of the alternative specifications depending on the design of the simulation (Harrigan et al., 1991).

Another advantage of using a CGE model is that it endogenously estimates various variables that would not otherwise be possible to estimate using an empirical model. The AMOS framework can additionally be used to explore the economies of other regions apart from Scotland, so long as the dataset and additional values of parameters can be found (Allan, 2016). These features make the AMOS model highly versatile making it a good choice of model in this thesis.

The structure of the baseline AMOS model is well described by Lecca et al (2013). These are further discussed in the following section.

5.4.1 Components in AMOS

The overview of the structure of the version of the AMOS model used in this chapter is well documented by Lecca et al. (2013) and was developed in the Fraser of Allander Institute. The model contains several “Transactors” and “Markets” that interact with each other. The main “transactors” are Firms, Households, Government, and other regions. Notably, being a single region model, the model structure of AMOS allows for the Scottish economy to interact with alternative regions including “Rest of the UK” (RUK) and “Rest of the World” (ROW). In terms of “Markets”, the model covers the Labour market, Goods market, and capital markets. All these components of the AMOS model are bound by certain constraints. Each of the markets is monetised in prices.

Consumption

In AMOS, the final demand is comprised of five main components – Household consumption, non-household personal consumption, government consumption, exports and investment. For this thesis, a key component is household consumption. Households are modelled to maximise their discounted intertemporal utility and are subject to a lifetime wealth constraint (Hermannsson et al., 2013).

Both, domestic and foreign goods are consumed by households. Armington elasticities are used to model the choice between the consumption of RUK and Scottish goods, and for the choice between domestic and ROW household consumption. The prices of these goods are dependent on the transport and distribution costs, and tax mark-ups on the endogenously calculated basic prices.

After these mark-ups are added, cost-minimising processes are applied to generate the final composite prices of goods consumed by households. This plays a pivotal role in determining the changes in household demand for other goods, given a change in household demand for one good (Lecca et al., 2013). Non-household consumption is based on the base year share of demand by sectors, and prices are calculated similarly.

The household consumption function within AMOS is thus given by the following equation.

$$C_{h,t} = YNG_{h,t} - SAV_{h,t} - HTAX_{h,t} - CTAX_{h,t}$$

… (Equation 5.1)

where total consumption by households for each time period is represented by $C_{h,t}$, and is a function on the income ($YNG_{h,t}$) less savings ($SAV_{h,t}$), income taxes ($HTAX_{h,t}$) and consumption taxes ($CTAX_{h,t}$)

Production

A very important component of the AMOS model is the choices of production functions. These choices include Constant elasticity of substitution (CES), Cobb Douglas, or Leontief fixed proportion. Additionally, the model allows for substitution between domestic production and imports from ROW, based on the Armington elasticity (Armington, 1969). This elasticity is also applicable between RUK imports and Scottish production when the domestic production is chosen at the previous tier. This nested production function is used in AMOS (see figure 5.1).

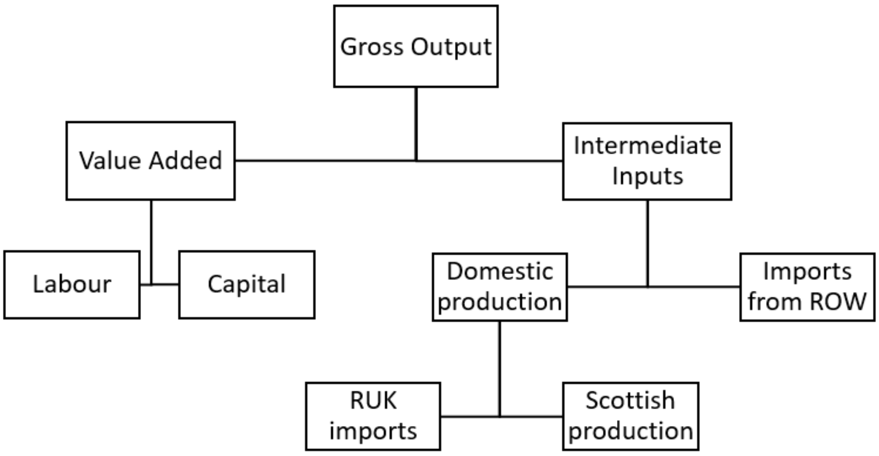


Figure 5.2: Nested Production function
Source: Allan (2016)

It is evident from the figure above that capital and labour combine in some proportion given by the CES to produce value-added. Similarly, domestic intermediate inputs and foreign intermediate inputs combine in some proportion to produce intermediate goods. These intermediate goods and value-added combine to produce the output for a sector (as seen in figure 5.2).

As an example, the bottling of spirits may be more capital intensive due to highly automated machines employed in the process. The bottler may be able to substitute capital for labour by reducing the machines employed and substituting for labour. However, the bottles and the bottle caps which are intermediate goods required for the process may be produced in another industry, perhaps in another country or locally. These are imperfect substitutes. The intermediate goods demand in AMOS is given by the profit maximising considerations.

The model endogenously calculates the prices of intermediate goods. The model uses endogenous commodity prices to determine endogenous composite intermediate prices for each sector. This is done through a cost function where a composite price of value-added is formulated using the rental values of labour and capital. Similarly, the model endogenously calculates the composite price of intermediate goods. The gross activity output price is calculated as a function of the composite intermediate and value-added prices (Lecca et al., 2013).

Trade

As is seen in figure 5.2 above, the intermediate production of sectors can be either domestic or from imports. Within the model, domestic goods and imports are considered imperfect substitutes. These combine in a proportion determined by the Armington elasticity. In the case of domestic production, Scottish produce and produce from the rest of the UK are chosen based on cost minimisation. These functions describe the level of imports into the economy within AMOS.

For exports, each sector can supply domestic and foreign regions. The exports are determined through export price elasticity and terms of trade in an export function as described by equation 5.2. This export function is used for both RUK exports and ROW exports.

$$E_{(i,t)} = \overline{E}_i \cdot \left(\frac{PE_{i,t}}{PR_{i,t}}\right)^{\sigma_i^x} \qquad \text{… (Equation 5.2)}$$

where $E_{(i,t)}$ are exports, $\overline{E_i}$ are the exports in the base year, $PE_{i,t}$ are the export prices, $PR_{i,t}$ are the commodity prices, and σ_i^x is the export elasticity.

Value Added Taxes

A key feature in the AMOS model that is utilised in this thesis is the decomposition of the fiscal structure of various taxes in the Scottish economy. Within the model, consumption taxes are determined by subtracting household VAT revenues from household transfers as taxes. These household transfers as taxes and VAT revenues by sector are found in the SAM. These VAT revenues are aggregated for all sectors to give the total household VAT revenue. The VAT rate is calculated through the VAT revenue as a proportion of household consumption in each time period. Further, the VAT collections are determined in each sector, which allows shocks to be applied to any given sector. This feature of the model is used extensively in this chapter, as alcohol duties are increased.

Government Income and Spending

As has been extensively discussed in chapter 2, the case of Scotland in the context of fiscal devolution is evolving. To reflect this, the AMOS model presents various model choices on government income and spending. This means that simulations can be carried out in various fiscal regimes since they have varied economic implications. The model specifies equations for the income and spending of both the UK and Scottish Governments since both of these are responsible for making spending decisions in Scotland.

One such model choice is that of fixed government spending. Under this choice, the income and spending of both the UK and Scottish Governments are held constant in real terms in line with the base year. This means that there should be no change in the real Scottish Government spending. The Scottish or the UK governments do not spend any taxes raised in the economy. Instead, when taxes are raised through one taxable avenue, these are passed on as tax reductions in other taxable avenues. Similarly, a reduction in tax collections from one taxable avenue means that these would be recovered through an increase in tax collection from other taxable avenues. In all, the total government revenue and expenditure remains the same as the base year in the model.

Another choice of model is where all the government spending in the economy is allocated to the Scottish Government, instead of being allocated to both the UK and the Scottish Government. The income of the UK government from Scottish tax revenues is allocated to the Scottish Government through a block grant. To this block grant, all other taxes raised in Scotland are added, including the total VAT revenue, income taxes, pensions, council tax, and stamp duty. Additionally, newly raised household taxes, firm taxes, corporation taxes, national insurance contributions, indirect business taxes and household consumption taxes are allocated to the Scottish Government. This income is then spent by the Scottish Government in various sectors, as specified in the base year of the model.

Labour market

The wage determination in the labour market is given by two alternative closures – regional bargaining and national bargaining. In regional bargaining, the wages are computed using the bargained real wage function (Layard et al., 1991) which is econometrically parameterised. There is an inverse relationship between real wages and regional unemployment. This implies that real wages would be directly related to the workers' regional bargaining power. This relationship is described by the equation below.

$$\ln\left(\frac{w}{cpi}\right) = \omega - \varepsilon \ln(u) \qquad \text{… (Equation 5.3)}$$

where w is the nominal wage for Scotland; cpi is the Scottish consumer price index, ω is the calibrated parameter to ensure that there is an equilibrium in the base year, ε is the elasticity of wages related to the level of the unemployment rate and u is the base year unemployment rate in Scotland. This optimisation choice is assumed in our model.

Migration of workers

Scotland being an open regional economy as a part of the UK, it is important to look at the migration of labour within AMOS. The labour force in the model is endogenously determined. Under this assumption, it may be assumed that the labour force can migrate to and from the rest of the UK. For this study, we assume that there is migration to and from the Scottish economy, in line with its current policies. In any case, this assumption will be subject to a sensitivity analysis. This net migration is given by the following equation.

$$\ln\left(\frac{m^S}{L^S}\right) = \mu - 0.08(\ln u^S - \ln u^R) + 0.06\left(\ln\left(\frac{w^s}{cpi^S}\right) - \ln\left(\frac{w^R}{cpi^R}\right)\right)$$

… (Equation 5.4)

where m is the net migration and L is the labour force; μ is the calibrated parameter which assumes that there is zero net migration is the base period, u is the unemployment rate, w is the nominal wage rate and cpi is the consumer price index. The subscripts represent the regions – S is Scotland and R is the Rest of the UK (RUK).

Dynamics of adjustment

As described by Lecca et al. (2013) and Allan (2016), the basic structure of AMOS runs as “static periods” that allows for analysing the differences between each time-period including the base period equilibrium and the final equilibrium. This means that the various equilibria in the transitionary period can also be analysed.

Another advantage of such a model is that shocks may not necessarily have to be applied in the initial period. In certain cases, it is possible to apply a shock in a future time-period. The analyst can analyse the economy in short-run, long-run, or any transitionary period in between depending on the case.

Since the model is calibrated to external data from a SAM which has annual data, each time-period would also produce annual data implying that each time-period is representative of one year. However, should an analyst wish to use more disaggregated data, they would be able to alter this assumption.

Households and Firms

The choice of insight to a policy that is offered in AMOS is between myopic and forward-looking closures. In both cases, the assumption is that the economy is initially in a state of long-run equilibrium. This implies that when no disturbances or “shocks” are applied, the model would replicate the economy in every time-period, thus resulting in no changes. This is further discussed in section 5.3.3.

In the myopic case, consumption by households is a linear function of the real income or disposable income. This household consumption can be distributed amongst the sectors of the economy and depends on the relative prices of domestic goods and foreign goods as described in section 5.3.1. This household demand is therefore dependent on the disposable household income and falls when the disposable household income falls and vice versa.

An assumption is made that there is no relationship between investment and regional savings in AMOS, as is the assumption in most regional CGE models (Lecca et al., 2013). Given the above assumption, the investment in the myopic AMOS model is endogenously calculated. The actual capital stock is also assumed to be equal to the desired capital stock in the base period. The investment demand then adjusts the level of capital stock in each transitionary time-period, and this updates to show the trajectory of the capital stock in each sector over the long run. This change in investment between time-periods is given by the depreciated capital stock in the previous time-period plus a proportion of the desired and actual capital stock for the given time-period. This is the mechanism for the capital stock to adjust.

Recall that firms run on the principle of cost minimisation as discussed in section 5.3.1, and thus the computation of the desired capital stock of a sector takes this into account, alongside nominal wages, commodity outputs and user cost of the capital (Lecca et al., 2013).

There are some differences in the operation of the forward-looking scenario in AMOS. Consumption decisions made by households are made to maximise the lifetime utility of households, subject to wealth constraints. Intertemporal optimisation is first used by the forward-looking households to solve for the consumption path to optimise their lifetime utility. The CES function is then used to find the sectoral composition of household consumption. To ensure that household consumption doesn't exceed household wealth, a dynamic budget constraint is also assumed. As mentioned in the myopic case, a relationship between savings and investment is not assumed.

The adjustment of capital stock in the forward-looking setting is quite different from the myopic case. In this setting, rather than achieving a proportion of the desired capital stock, sectors can achieve their currently desired capital stock through investment. This is done through a quadratic function of the investment since the investment made by sectors is made with the foresight of future demands as well as prices. This allows for investment to be determined through intertemporal optimisation. Another difference is that sectors can foresee changes in demand and able to make supply-side adjustments before the change in demand. This allows for fewer disturbances in the supply side post introduction of the demand shock. Since there is perfect foresight, sectors are not prone to make "overinvestments". This is different from the myopic case where there is no prior knowledge of prices or demand.

In all, AMOS offers several different modelling choices which drastically affect the results of simulations. It is important to ensure that relevant assumptions are made while modelling policy to ensure the quality of results. Lecca et al. (2013) provide an extended description of the AMOS model.

5.4.2 The SAM for AMOS

Some of the data that is necessary to AMOS is input using a SAM as discussed before. However, since the Scottish Government releases the IO tables with a 3-year lag, the data for AMOS needs to be updated, for example, the 2014 IO tables were published in 2017. At the start of the analysis, the latest available IO tables were of the year 2014. Thus, this is used in the base year for this thesis. It is also noted that the composition of the alcohol sector has not seen any significant changes between 2014 and 2017. Thus, the SAM used in this chapter is built from the 2014 IO tables used in chapter 4. This allows the results to be comparable.

To create a SAM that is readable by AMOS, data needs to be collected from various sources, the IO tables being the main source. The main addition that converts the IO tables to a SAM is the transfers that are made between the institutions such as governments, firms, and households. Thus, a SAM contains information about the monetary flows within the economy. These linkages can be created using additional data that is collected from various government sources (Ross et al., 2014).

The process of creation of a SAM involves two main components – an IO table, and income-expenditure accounts. A combination of these two is used to create a SAM. To create the SAM for this study, the alcohol disaggregated IO model created in Chapter 4 is used to build the SAM. The 2014 Scottish Income-Expenditure tables are created using a range of data sources detailed by Ross et al. (2014).

The additional data sources used to create the income-expenditure accounts includes GERS, IO tables, the ONS Blue Handbook. For the Income-expenditure account used for the SAM in this study, see Appendix C. The sectoral aggregations used for this study are given in Table 5.1 below and remain the same as in chapter 4.

No.	Sector Code	Sector Names	SIC Classification (2007)
1	**AFF**	Agriculture, forestry and fishing	1-3
2	**OTP**	Other primaries	5-9, 19-21
3	**FAD**	Food and drink	10, 11.07,12
4	**SAW**	Spirits and Wine	11.01-04
5	**BAM**	Beer and malt	11.05-06
6	**TLW**	Textiles, leather and wood	13-18
7	**RCG**	Rubber, Cement and glass	22-25
8	**EMO**	Electrical, mechanical and other manufacturing	26-33
9	**ETD**	Energy transmission and distribution	35
10	**WSW**	Water, sewerage and Waste	36-39
11	**CON**	Construction	41-43
12	**WRT**	Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	45-56
13	**AOF**	Alcohol Off-trade	46,47 – Alcohol
14	**AON**	Alcohol On-trade	56 – Alcohol
15	**FIN**	Financial services, insurance and services	64-66, 69.2-70, 73, 74, 82
16	**RCO**	Real Estate, Communication and other services	58-63, 68-69.1, 71, 72, 75-81, 90-97
17	**EDU**	Education and Admin	84-85
18	**HRS**	Health, residential care and Social Work	86-88

Table 5.1: Sectoral aggregation of the SAM for CGE modelling

5.5 Modelling strategy

The AMOS model described in section 5.4 is the model used in this thesis. The application of the model in analysing the economic impacts of alcohol taxes means that an appropriate model specification should be applied. A key paper in this literature, which is Wada et al. (2017), motivates the scenarios modelled in this analysis, where increased alcohol duty is used to stimulate a fall in the level of household consumption. The increased duty collections are initially not recycled in gross results but are spent by the Scottish Government in net results.

As described in the previous section, the AMOS model has an active supply-side. This means that the model will be able to compute endogenously changes in prices, wages, capital, labour and other important macroeconomic variables not computed by the IO model. This means we can expect results with a higher level of detail, and thus would be beneficial for policymakers. Additionally, both long-term and short-term impacts can be captured through this model.

Due to the difference in the structure and assumptions of the IO model and CGE model, the results are expected to vary from the results of chapter 4. The primary feature of an active supply-side means that the results produced in this chapter would be comparable to the results of section 4.7. This comparison is also laid out to understand the difference between the approaches of IO and CGE.

In terms of model specification, we assume that there would be a permanent increase in the level of alcohol duties in the economy. This shock would be carried out in a forward-looking specification. The model assumes that there is migration, and this causes the labour supply in the economy to be dynamic. In terms of dynamics, each time period is considered to be one year, since the SAM for AMOS is created for annual data for 2014.

Using the modelling setup described above, we aim to understand the macroeconomic impacts of reduced alcohol consumption. To do so, we replicate the analysis conducted by Wada et al. (2017) for Scotland through the AMOS model. A key scenario presented by Wada et al. (2017) scenarios in their analysis on the employment impacts of alcohol consumption is a 5-cent increase in excise tax on alcohol. This scenario is replicated in this chapter. For Scotland, this scenario is reframed as a 5-pence increase in alcohol duty.

In their analysis, Wada et al. (2017) find the employment impacts of changes to the taxes on alcohol products. They find the level of reduction in alcohol consumption in each of the scenarios through the use of price elasticities of demand on various categories of alcohol. The calculated reductions in the level of alcohol consumption are used to calibrate shocks within the REMI model.

In the AMOS model, the relative price elasticities are endogenously calculated. Thus, the shock applied does not need to take into consideration the changes to the level of consumption before it is introduced into the model. The shock is calibrated by simply increasing the level of duty per unit of alcohol, and scaling this up by the total number of units sold.

Following Wada et al. (2017), the structure of the price of alcohol is assumed to be given by the equation below:

$$Price_i = [(Net - of - Tax\ Price_i) + Alcohol\ Duty_i] \times (1 + VAT\ Rate_i)$$

where i stands for either on-trade or off-trade consumption.

From MESAS (2017), we have the price of alcohol in the on-trade and off-trade sector per unit of alcohol sold. We can calculate the alcohol duty per unit based on HMRC data on alcohol duty collections in combination with MESAS (2017) data on the total number of units of alcohol sold. We know from HMRC (2020) that the VAT rate on alcohol products is 20%. From this information, we are also able to calculate the Net of Tax price of alcohol. It is also noted that as per MESAS (2017), the total number of units of alcohol sold in Scotland in 2014 was 4,730m. This data is presented in Table 5.2 below.

Category	Net of Tax Price	Alcohol Duty	VAT	Price
Beer	0.56	0.19	0.15	0.90
Cider	0.46	0.08	0.11	0.65
Wine	0.38	0.26	0.13	0.76
Spirits	0.46	0.30	0.15	0.90
Total	**0.47**	**0.23**	**0.14**	**0.84**

Table 5.2: Decomposition of the price of alcohol in Scotland
Source: MESAS (2017), HMRC (2020), Author's Calculations

An important assumption in this analysis is that in the scenarios presented below, the increase in duty is passed on to the consumer. To emulate this, there is an increase in the newly calculated price. This price increase also means that the total VAT collected would increase. The increase in alcohol duty is calculated to be £236.50m. The resultant increase in VAT is found to be £39.42m. Thus, the total increase in alcohol taxes is found to be £275.92m. The total alcohol duty and VAT collections for Scotland in 2014 was £1,727.40m. Based on this, it is found that a 5p increase in alcohol duties per unit is an increase of 15.97% from the base alcohol taxes.

Within the AMOS model, alcohol duties are not disaggregated. These are a part of the consumption taxes that are aggregated in the model. However, VAT is disaggregated in the model. To simulate the change in alcohol taxes, we increase the VAT allocated to the alcohol off-trade and on-trade sectors by the alcohol duties collected through those sectors. As previously mentioned, consumption taxes are calculated in AMOS by subtracting VAT revenues from the total taxes collected from households. This means that increasing the VAT on alcohol sectors to include alcohol duties reduces the calculated consumption taxes, keeping the model balanced.

As in Wada et al. (2017), the scenarios are simulated in gross and net terms. Gross impacts are obtained by increasing the level of alcohol duties. In this scenario, it is assumed that the increased government revenue is not recycled through higher government spending. To calculate the net impacts, the newly raised tax revenues are returned to the economy. The Scottish Government spends these endogenously within the model.

The scenarios that we model in the AMOS model are as follows.

Scenario 3: Gross impacts of an increase in alcohol duty

In this scenario, the alcohol duty is raised by 5p per unit. This increase in taxes increases the consumption price of alcohol, and this, in turn, reduces the level of alcohol consumption. However, the increased tax collections are not recycled by the government through higher spending.

Scenario 4: Net impacts of an increase in alcohol duty recycled through government spending

In this scenario, the alcohol duty is raised by 5p per unit as in scenario 3. This tax increase reduces the level of alcohol consumption. The tax collections are spent by the Scottish government. The net impact is thus that of a reduction in alcohol consumption, alongside an increase in government spending.

The assumption that the Scottish government spends all the newly raised tax collections, instead of the UK government is in line with Wada et al. (2017), where all the taxes are allocated to local governments. However, it is acknowledged that we are also able to look at different allocations of the newly raised taxes as per the Smith Commission recommendations or Barnett formula, as is relevant for Scotland through the AMOS model.

Through the AMOS model, we generate and report results for 50 time periods. Short-run and long-run results have been reported in the results section below. The results for every variable show changes in each time period as a change against the base year values.

The above-described scenarios will be introduced into AMOS as VAT shocks. As with any demand shock, the expectations of a VAT shock are quite similar. An increase in the VAT implies an increase in consumption prices. In theory, such a shock would reduce demand for the alcohol sector, and backward-linkages. Based on Allan et al. (2014) and Lecca et al. (2012), the shock in scenarios 3 is expected to yield a negative impact on the economy. However, in scenario 4, we expect that higher government spending, at least in part, would overcome the negative impacts of higher alcohol duties. The net impact on the economy could be positive or negative depending on the comparative labour intensity of the sectors where government spending occurs, as compared to the alcohol consumption sectors.

5.6 Results of simulations

In this section, we will report and discuss the results for the different scenarios of simulations explained in section 5.5.

5.6.1 Scenario 3: Gross impacts of an increase in alcohol duty

In this scenario, a shock is applied to the alcohol duties on alcohol consumption sectors (Sectors 13 and 14 in Table 5.1). The results for this case are discussed in detail below.

As discussed in previous sections, when a forward-looking outlook is used, economic agents have the foresight of the shock and their behaviour is made in reaction to the shock, unlike in the myopic case. The active supply-side allows for the model to endogenously determine the comparative prices and wages, unlike IO models where a passive supply-side limits such analysis.

As seen in figure 5.3, there is a small reduction in GDP in the short-run. As the increase in alcohol duty is introduced in the short-run, the level of alcohol production from the base period exceeds the level of consumption, which prompts a short-run increase in exports. There is also a fall in the level of imports. However, the level of household consumption and investment is seen to fall in this period as well. These effects overcome the fall in exports, thus causing the GDP to rise. The household consumption in AMOS is a function of the comparative prices of each sector which are endogenously estimated. This implies that the households find sectors where they can maximise their utility outside of buying from the alcohol off-trade and on-trade sectors.

While the household demand increases in these alternative sectors, there is also a need to produce more output in these sectors as the level of output generated in the base period is not sufficient to fulfil this excess demand in period 1. This calls for an increase in the capacity of some other sectors. The increase in capacity is subject to the factors of production. AMOS can minimise the cost of production by choosing between capital and labour subject to their relative prices and elasticities. The overall impact on output is short-run reduction.

However, the backward linkage sectors of alcohol consumption sectors experience a fall in the level of output. In all, the net impact on the output in the short-run is negative. Also noted is a fall in the level of employment (figure 5.4) and investment (figure 5.9) where sectors pick a certain level of labour and capital respectively to change capacity. As seen in figure 5.5, the level of output in the alcohol consumption sectors falls by £62.78m. This is the main contributor to the net fall in the total output. Increases in output are seen in sectors such as wholesale, retail and trade and other services.

The fall in demand for labour in the short-run is also reflected through the fall in labour supply (figure 5.4). Fall in total demand leads to reduced employment and thus, falling wages since the labour supply reduces (figure 5.7). As seen in figure 5.7, there is a fall in real wages, although nominal wages increase. Thus, this rise in CPI can be attributed to increased real wages and higher indirect taxes in the alcohol sector. Since there is a forward-looking sight in this simulation, sectors will be able to produce the adequate quantity in order to meet the fall in demand, causing the CPI to fall as is reflected in figure 5.10.

Beyond period 1, the sectors reduce their production in period 2. This reduction in production is quite rapid, as is reflected by the fall in GDP compared to the base year. The impact of shrinking production is accompanied by a fall in employment in period 2 (figure 5.4) and a reduction in investment (figure 5.9). Apart from employment, as the level of investment falls, the nominal wages are also seen to reduce. This has an impact on the overall level of household consumption within the economy. While the consumption from the alcohol sector is already low, a reduction in the level of consumption from alternative sectors is responsible for this reduction in household consumption. The long-run level of household consumption is lower than the base year level of household consumption by 0.032% (Table 5.4). However, the level of real wages is seen to recover over the long-run and reach base year levels.

In the short-run, the impact of a small increase in exports, investments and household consumption causes a reduction of GDP to the tune of £14.18m as seen in Table 5.2. This is due to the increase in the productive capacity of the economy. The fall in the level of employment in the short-run is 241 FTE jobs. This fall in employment is predominantly in the supply chain of alcohol, such as in the alcohol-producing sectors, alcohol off-trade sector and wholesale, retail and trade sectors.

The net output of the economy in the long-run falls by £118.21m, as opposed to a fall of only £17.29m in the short-run. Figure 5.6 shows the sectoral disaggregation of these losses in output. The level of employment falls in the long-run by 1189 FTE, while the GDP falls by £71.72m.

Variable	Short-run	Long-run
Output (£m)	-17.29	-118.21
Employment (FTE)	-241	-1189
GDP (£m)	-14.18	-71.72

Table 5.3: Scenario 3: Short-run v/s Long-run change in Output, Employment and GDP

Variable	Short Run	Long Run
GDP	-0.011%	-0.058%
Employment	-0.011%	-0.052%
Output	-0.007%	-0.051%
Household Consumption	-0.014%	-0.032%
Investment	-0.044%	-0.045%
Government Spending	0.000%	0.000%
Exports	0.012%	-0.043%
Imports	-0.026%	-0.018%
Real Wages	-0.019%	0.000%
Consumer Price Index	0.026%	0.048%

Table 5.4: Scenario 3: Short-run and Long-run macroeconomic impacts (%)

As seen in Table 5.4, the short-run fall in GDP is due to a fall in the level of imports, investments and household consumption. The level of employment falls, as does the level of output. Wages and prices are also seen to fall. In the long-run, it is seen that the level of GDP falls. Falls in the level of household consumption and investment are also noted, leading to a further fall in the GDP. The overall negative economic impacts are as expected, and similar impacts have been seen in studies looking at higher taxes (Allan et al. 2014; Lecca et al., 2012). A key point noted here is that the increased alcohol tax is not recycled in this case. In the absence of government spending any alcohol taxes, the level of government spending remains unchanged. In the next scenario, we see the economic impacts of recycling these alcohol taxes by the Scottish government through higher government spending.

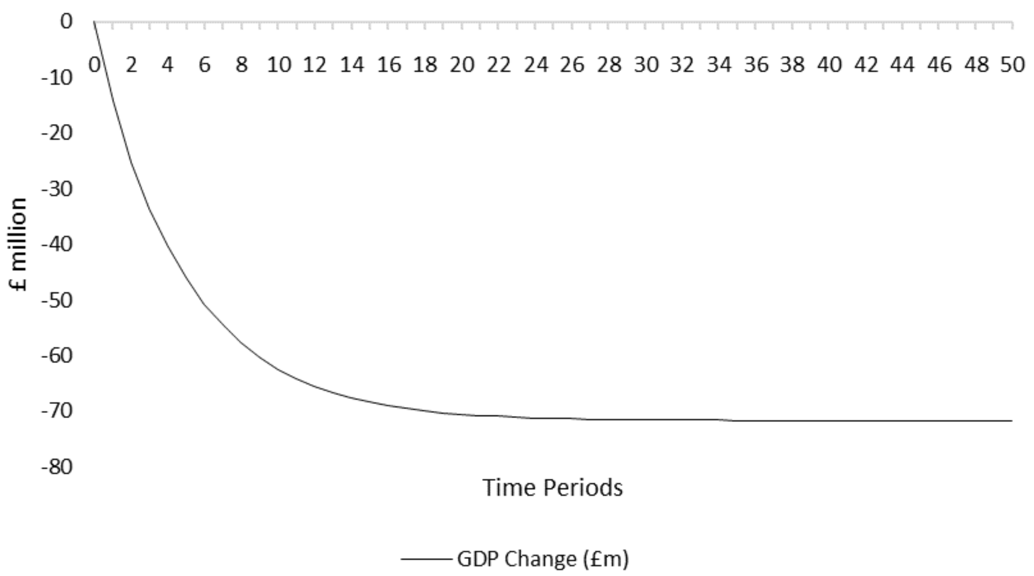
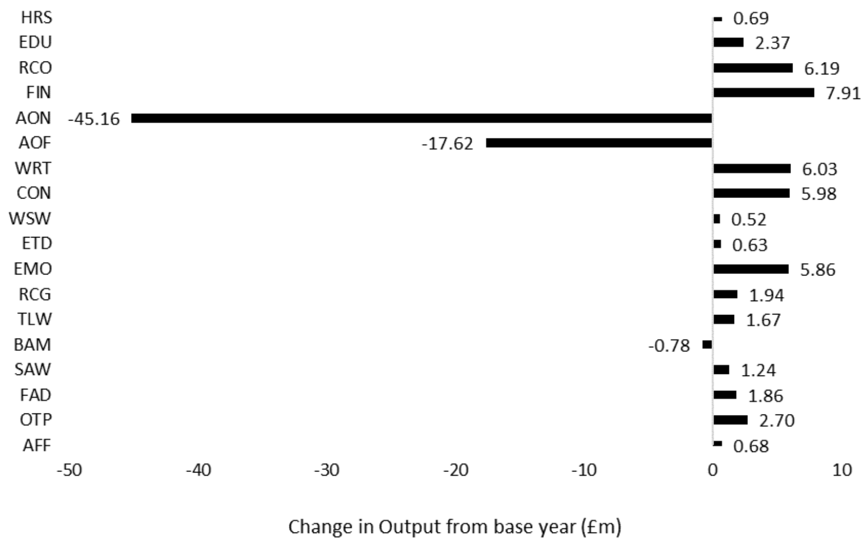


Figure 5.3: Scenario 3: Change in GDP (£m)
Source: Author's Illustration

Figure 5.4: Scenario 3: Change in employment (FTE)
Source: Author's Illustration



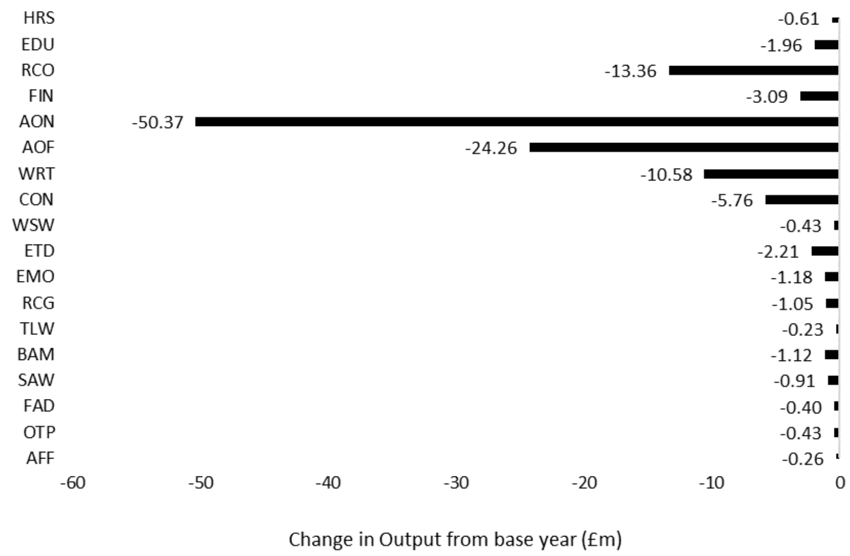


Figure 5.5: Scenario 3: Sectoral Change in output from base period in SR (£m)
Source: Author’s Illustration

Figure 5.6: Scenario 3: Sectoral Change in output from base period in LR (£m)
Source: Author’s Illustration

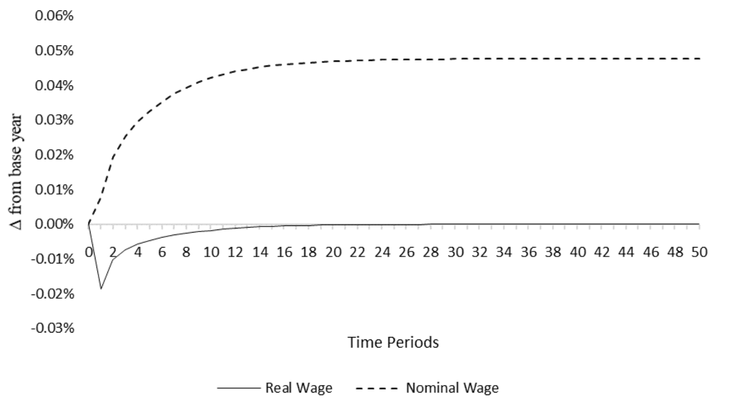


Figure 5.7: Scenario 3: Change in real and nominal wages (% change)
Source: Author's Illustration

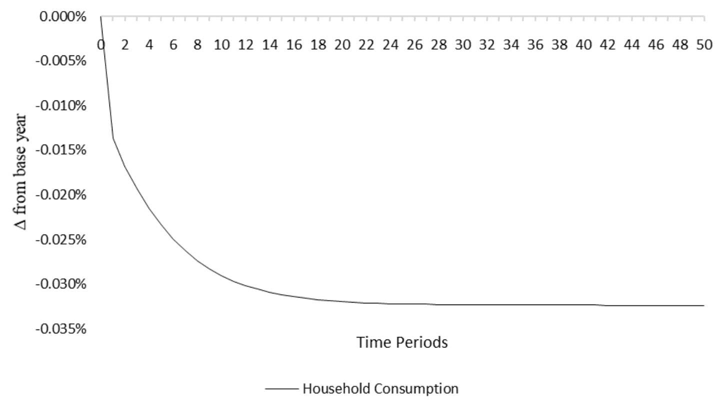


Figure 5.8: Scenario 3: Change in household consumption (% change)
Source: Author's Illustration

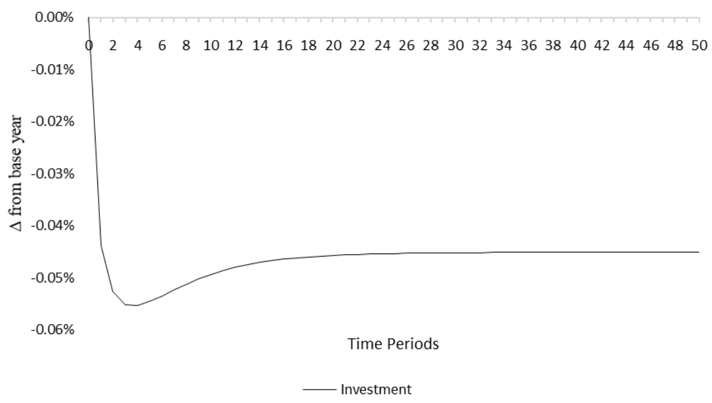


Figure 5.9: Scenario 3: Change in investment (% change)
Source: Author's Illustration

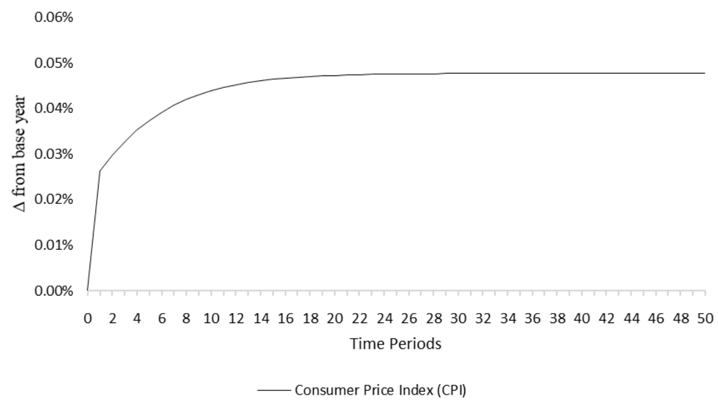


Figure 5.10: Scenario 3: Change in CPI (% change)
Source: Author's Illustration

5.6.2 Scenario 4: Net impacts of an increase in alcohol duties recycled through government spending

Similarly to scenario 3, this scenario is carried out through the introduction of a shock on the alcohol duties targeting the alcohol on-trade and off-trade consumption sector. The on-trade sector is where alcohol is sold for consumption in an establishment such as a bar, pub or restaurant, while the off-trade sector sells alcohol through stores.

As seen in figure 5.11, there is a sharp reduction in the GDP in period 1 when the shock is introduced. As seen in Table 5.6, reductions are noted in household consumption and investment. However, there is an increase in the level of government spending. This leads to a smaller fall in GDP in the short-run, as compared to scenario 3, where there is no increase in government consumption. As consumption reduces in the alcohol sectors, there is an increase in government spending in the economy. This primarily takes place in sectors such as healthcare and education. As seen in figure 5.13, the increased spending by the government causes the level of output in the economy to fall. This reduction in output is found to be 0.003% in the short-run.

In terms of scale, at its peak, the fall in GDP is £41.61m in the long-run. As the output in the economy falls, the level of capital and labour falls in the economy. In terms of capital, there is a fall in investment spending (figure 5.17). This is primarily since the level of production has fallen in the economy through lower government consumption. Reduced production is seen in non-alcohol and government sectors in the short-run, while output falls in the alcohol production sectors as well as the beer and malt sector. As was seen in chapter 3, the beer has a high proportion of consumption through the on-trade channel, this sector finds itself producing at a lower level. In the short-run, it is also found that exports have increased by as much as 0.003%.

Alcohol consumption sectors, particularly the on-trade sector is labour intensive. However, it is also noted that government consumption sectors have a high level of labour intensity. Apart from the government sector, there is also an increase in the level of output from other non-alcohol sectors. However, the fall in employment from the alcohol sectors dominate over the government spending effects, causing a fall in the level of employment in the short-run.

In the short run, most non-alcohol sectors have increased employment. The only sectors that see a reduction in employment are the alcohol consumption sectors and some of their backward linkage sectors. These include alcohol on-trade, off-trade and beer and malt production. Thus, the fall in employment is primarily in the alcohol producing and serving sectors. The increase in demand for labour in other sectors, while there is a fall in demand for labour in alcohol producing sectors, is reflected through falling real wages but rising nominal wages (figure 5.15). Since there is an increase in demand for goods, and firms increase their supply, further increasing the CPI (figure 5.18). The rise in the CPI is due to this.

However, as non-alcohol sectors reduce their output, the level of total employment falls in the economy in the long run. This is since in the long run, apart from the government sectors, other non-alcohol sectors do not continue to produce at a higher level. The reason for this levelling out of demand from non-alcohol sectors is that wages are seen to approach base year levels in the long-run.

In the long-run, it is seen that the level of GDP drops gradually to a reduction of £41.61m in the long-run (figure 5.11). This is mainly attributable to the fall in household consumption, investment and imports. Despite this, the level of government spending is above base year levels. There is a reduction in household demand from other sectors in the long-run, which is due to lower income levels as real wages are low. Thus, this demand reduction is attributed to low real wages. To reduce the level of supply in the economy, firms move to produce at a lower level, as seen in figure 5.14, than in period 1. This production is lower than the base year output. There is a further decline in the level of production and sales of alcohol. This causes the level of employment to further reduce (figure 5.12).

The impact of reduced production is also felt on the investments since there is a decrease in demand for capital as well (figure 5.17). The CPI increases and stays high, as there is an increase in the level of indirect taxes, specifically VAT (figure 5.18).

Variable	Short-run	Long-run
Output (£m)	-7.02	-68.58
Employment (FTE)	-80	-686
GDP (£m)	-6.80	-41.61

Table 5.5: Scenario 4: Short-run v/s Long-run change in Output, Employment and GDP

Variable	Short Run	Long Run
GDP	-0.005%	-0.033%
Employment	-0.003%	-0.030%
Output	-0.003%	-0.030%
Household Consumption	-0.010%	-0.019%
Investment	-0.024%	-0.026%
Government Spending	0.023%	0.002%
Exports	0.003%	-0.025%
Imports	-0.012%	-0.010%
Real Wages	-0.006%	0.000%
Consumer Price Index	0.018%	0.028%

Table 5.6: Scenario 4: Short-run and Long-run macroeconomic impacts (%)

In terms of the aggregated impact of increased alcohol duty under local recycling of government taxes (Table 5.5), we see that there is a fall in the level of GDP of £6.80m compared to the base year in the short-run. When compared to scenario 3, this impact is slightly lower. The long-run impact on GDP is found to be a reduction of £41.61m, while employment is found to fall by 686 FTE. The level of output falls in the short-run by £7.02m, while it falls in the long-run by £68.58m. In all, negative economic impacts are noted in the long-run.

Other studies have also notably found similar impacts when increased government spending is included in their analysis of raised taxes. Allan et al. (2014) found that in a case where carbon taxes were increased in the Scottish economy, there was a reduction in economic indicators. However, when the raised taxes were returned to the economy through various mechanisms, the results ranged from being less negative to even positive. The results found in this scenario are, thus, in line with the expected results from the literature in the field of CGE modelling.

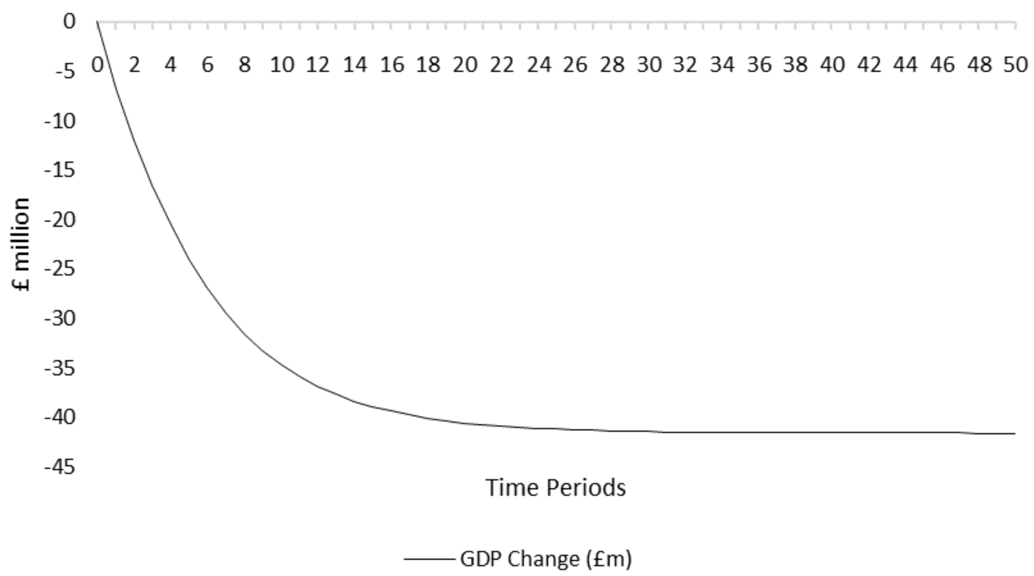


Figure 5.11: Scenario 4: Change in GDP (£m)
Source: Author's Illustration

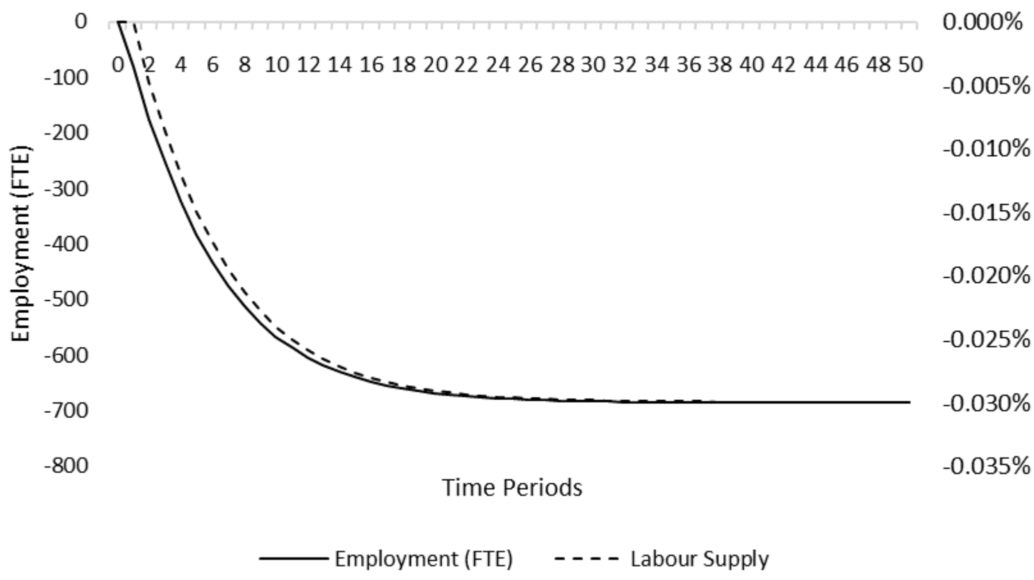
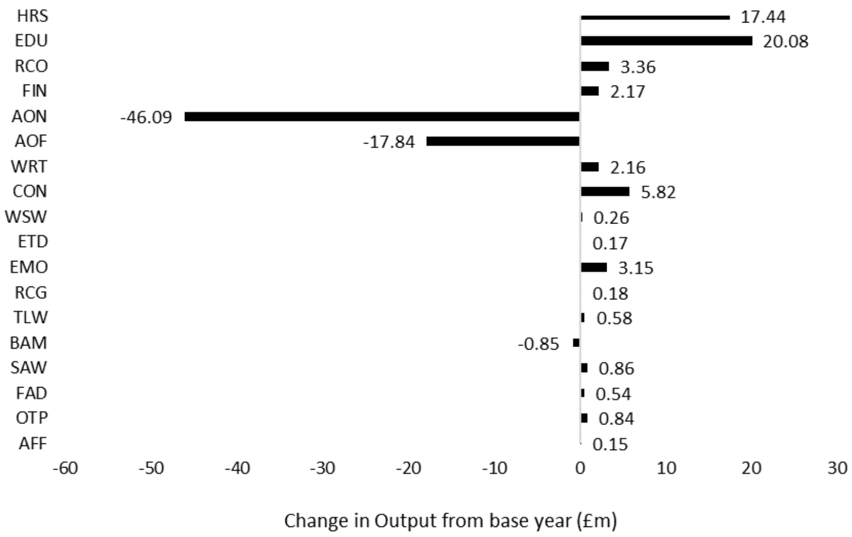


Figure 5.12: Scenario 4: Change in employment (FTE)
Source: Author's Illustration



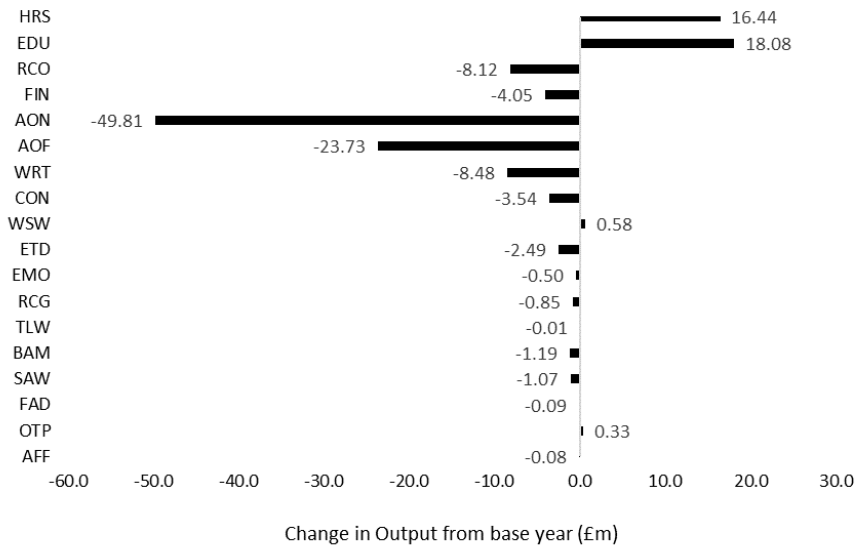


Figure 5.13: Scenario 4: Sectoral Change in output from base period in SR (£m)
Source: Author's Illustration

Figure 5.14: Scenario 4: Sectoral Change in output from base period in LR (£m)
Source: Author's Illustration

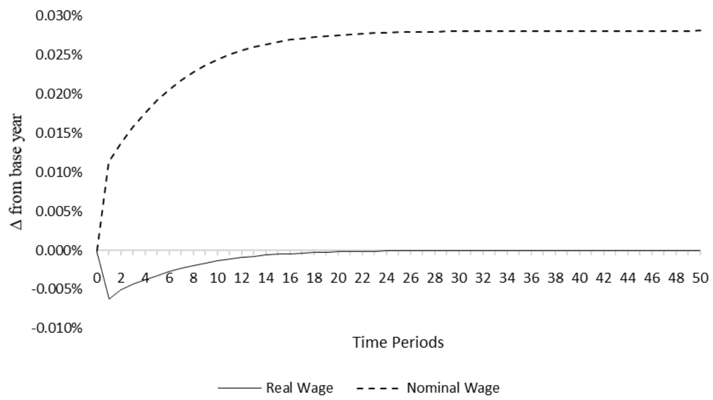


Figure 5.15: Scenario 4: Change in real and nominal wages (% change)
Source: Author’s Illustration

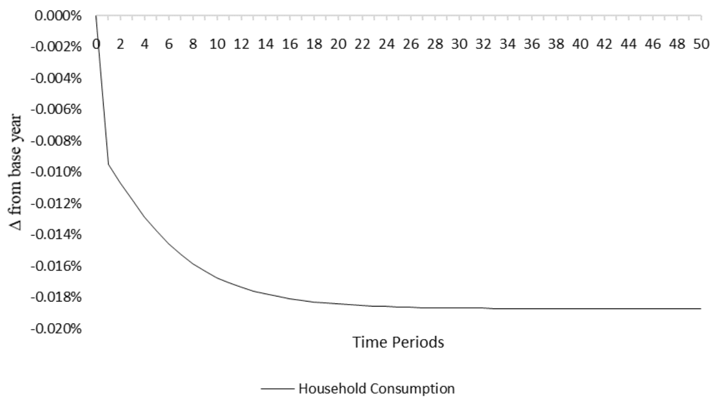


Figure 5.16: Scenario 4: Change in household consumption (% change)
Source: Author’s Illustration

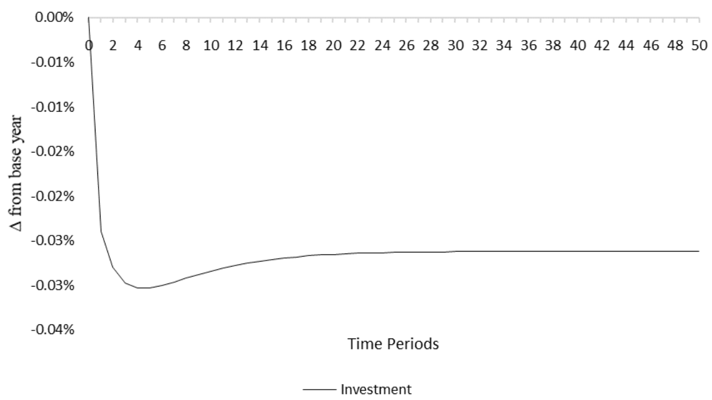


Figure 5.17: Scenario 4: Change in investment (% change)
Source: Author’s Illustration

Figure 5.18: Scenario 4: Change in CPI (% change)
Source: Author’s Illustration

5.7 Discussion of results

The results discussed in section 5.6 show the economic impacts of increasing alcohol duties through a CGE model. In this study, two main scenarios were analysed. Scenario 3 looked at an increase in alcohol duties without being recycling in the form of increased government spending. In a similar way to a price control measure, this scenario increased the duty on alcohol, making it more expensive to purchase by consumers. The duty was assumed to be collected by the government but was not spent. In Scenario 4, the raised revenue through increased alcohol duty was recycled by the local government, specifically, the Scottish Government. This increased government spending was seen to have further positive impacts on the economy.

Model	Output (£m)	Employment (FTE)	GDP (£m)
Scenario 3: Gross Impacts			
Short-run	-17.29	-241	-14.18
Long-run	-118.21	-1189	-71.72
Scenario 4: Net Impacts			
Short-run	-7.02	-80	-6.80
Long-run	-68.58	-686	-41.61

Table 5.7: Headline Results: Gross vs Net impacts of Scenarios 3 and 4

The results of scenario 3 showed that the policy would have all-round negative impacts on the economy in the long run. The level of employment was found to fall by 1189 FTE in the long-run, but only by 241 FTE in the short-run. Broadly, these results are consistent with the study conducted by Wada et al. (2017). The fall in the level of employment was primarily seen in the alcohol manufacturing and distribution sectors, while increases in employment were seen in other non-alcohol sectors.

The results of scenario 4 showed that in the short-run, the level of employment would fall by 80 FTE, while the GDP would fall by £6.80m. However, over the long-run, the level of employment was found to reduce by 686 FTE. While these results are a departure from Wada et al. (2017) showing a negative impact, the overall direction of change from the gross case to the net case is in line with the expected results. A majority of the negative impacts were found in the backward linkages of alcohol consumption and production sectors. Despite this, sectors, where a majority of government spending takes place such as health and education, saw an increase in the level of employment.

Overall, the initial small reduction in the level of employment is seen due to the increase in labour demand from alternative non-alcohol sectors to produce a higher level of output, and from the government sectors, where there has been an increase in spending funded by the increased duty collections. In a general equilibrium setup, the mechanism described would induce a fall in nominal wages, which would reduce the labour demand, and cause the level of employment to fall. In all, the long-run employment impact is found to be negative.

5.8 Sensitivity analysis

As has been stressed before, CGE models can examine the impacts of alcohol consumption but must include a sensitivity analysis since the changes in assumptions made by the model can produce widely varying results. In keeping with this recommendation, the results of the modelling conducted in scenario 4 are checked for sensitivity to two main assumptions in this section. These assumptions include using a forward-looking model and allowing migration within the model.

5.8.1 Myopic v/s Forward-Looking

As discussed before, myopic specification implies that the households and firms in the economy do not have the foresight of the shock that is implemented. This means that they are not aware that there would be a shock in the future, the magnitude of the shock or the duration it will last. In contrast, a forward-looking specification implies that actors will have complete foresight of the shock and will be aware of it before it is implemented. This allows households and firms to make the relevant consumption and investment decisions in response to the shock and adjust their demand and supply accordingly. In the myopic case, the actors respond to the shock after it has happened and is not prepared for it.

Figure 5.19 shows that both cases are similar in period one and the actors behave in the same way. Households reduce their alcohol consumption and switch to output from other sectors. The difference between both cases is that the firms do not oversupply the economy with the forward-looking assumption. With no preannouncement, period 1 response by households and firms is the same as in the case with a pre-announcement. Firms increase their level of production in the same way by increasing the factors of production employed. There is an increase in employment by other sectors and a reduction in employment by the alcohol distribution sectors. Since the reduction in employment in alcohol sectors is lesser than the increase by other sectors, we notice a net reduction in employment (figure 5.20). This increase in employment is smaller in the forward-looking case, and the production increase is smaller in non-alcohol sectors.

Beyond the short-run, it is noted the level of GDP begins to drop sharply in both cases. However, the long-run results of the myopic and forward-looking model are both converge. These results converge as expected (Lecca et al., 2013).

Variable	Myopic		Forward-Looking	
	Short-run	Long-run	Short-run	Long-run
Output (£m)	-5.11	-68.58	-7.02	-68.58
Employment (FTE)	-62	-686	-80	-686
GDP (£m)	-6.29	-41.61	-6.80	-41.61

Table 5.8: Sensitivity Analysis: Short-run v/s Long-run change in output, employment and GDP – Myopic v/s Forward-Looking

As is understood from this section, the use of the alternative forward-looking specification would produce more slightly muted results in the short-run, but long-run results are the same, as is expected (Lecca et al., 2013). While we assume that the rationale to use this myopic specification may not be applicable while studying the economic impacts of increasing alcohol duty, the results for the alternative assumption are not found to be vastly different.

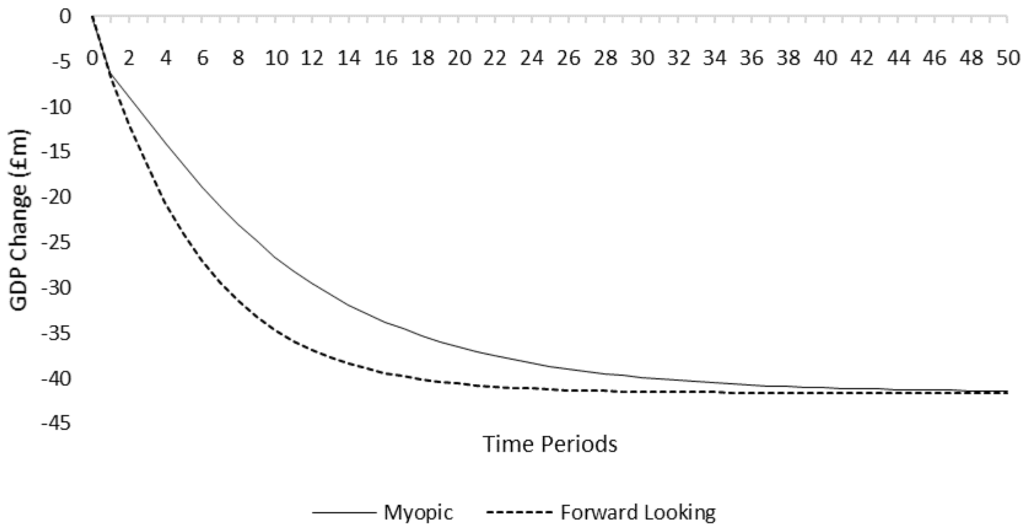


Figure 5.19: Sensitivity analysis: GDP – Myopic v/s Forward-Looking (£m)
Source: Author's Illustration

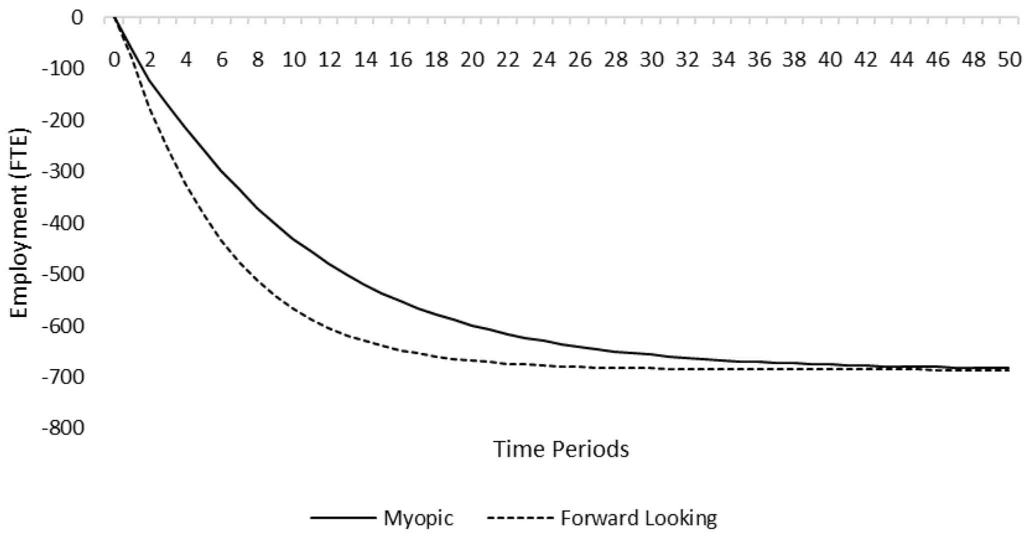


Figure 5.20: Sensitivity analysis: Employment – Myopic v/s Forward-Looking (FTE)
Source: Author's Illustration

5.8.2 Migration v/s No Migration

The level of labour supply in the economy can influence the results of the simulations conducted in section 5.6. Within our modelling setup, we allowed for migration since this is the existing labour market specification in Scotland. However, not allowing for migration would fix the labour supply in the economy. We test our results for sensitivity to our assumption of a flexible labour supply.

As seen in figure 5.21, in period 1, there is no change between allowing for migration and not allowing for it. There is a fall in the level of GDP in the economy, along with a falling level of total output, due to reductions in alcohol consumption sectors. This increases the real wages in the economy, making it attractive to external migrants, and here is an increase in labour supply in period 2 (figure 5.23).

As there is higher competition for labour, and there is an over-supply in the labour market with falling levels of employment, the level of real wage reduces steeply as compared to the case of no migration. This reduction in the real wage is accompanied by a fall in the labour supply in the economy. In the presence of migration, the labour supply starts to recover, as there is an exodus of labour due to low real wages. In all, when migration specification is used, it is seen that the wages correct back to base-period levels, by changing the level of labour supply.

Variable	Migration		No Migration	
	Short-run	**Long-run**	**Short-run**	**Long-run**
Output (£m)	-7.02	-68.58	-7.02	-26.60
Employment (FTE)	-80	-686	-80	-194
GDP (£m)	-6.80	-41.61	-6.80	-17.56

Table 5.9: Sensitivity Analysis: Short-run v/s Long-run change in output, employment and GDP – No Migration v/s Migration

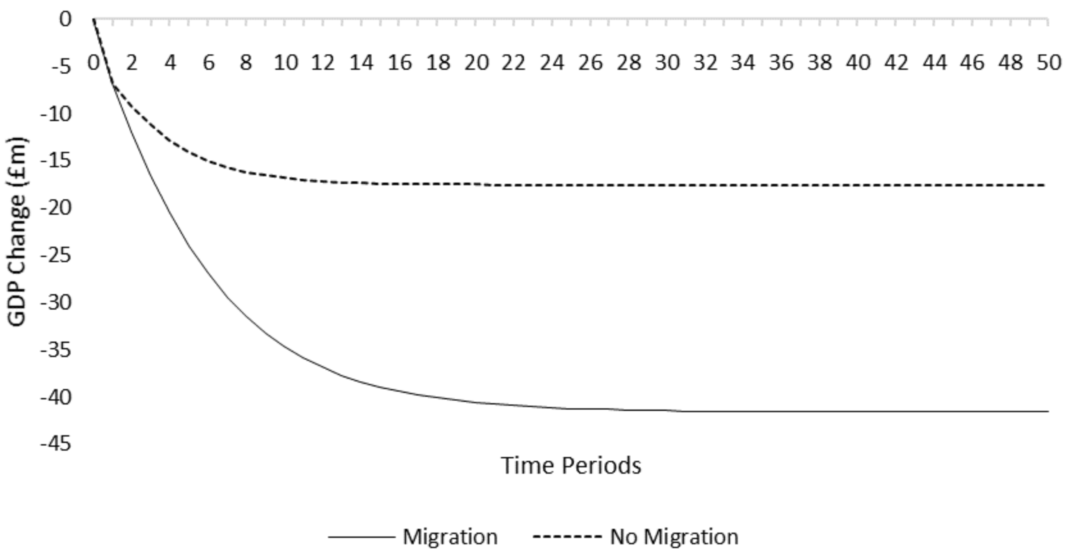


Figure 5.21: Sensitivity analysis: GDP – Migration v/s No Migration (£m)
Source: Author’s Illustration

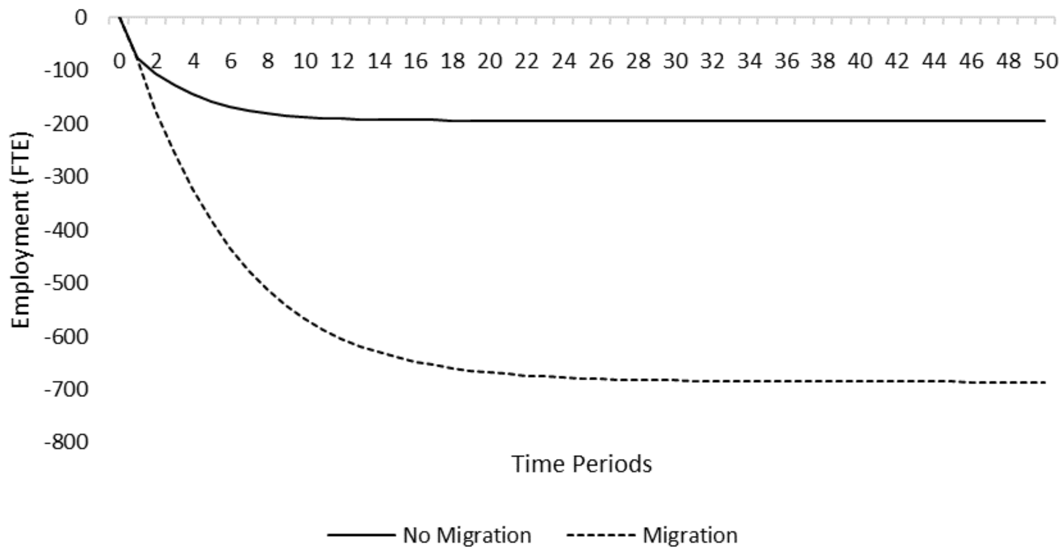


Figure 5.22: Sensitivity analysis: Employment – Migration v/s No Migration (FTE)
Source: Author's Illustration

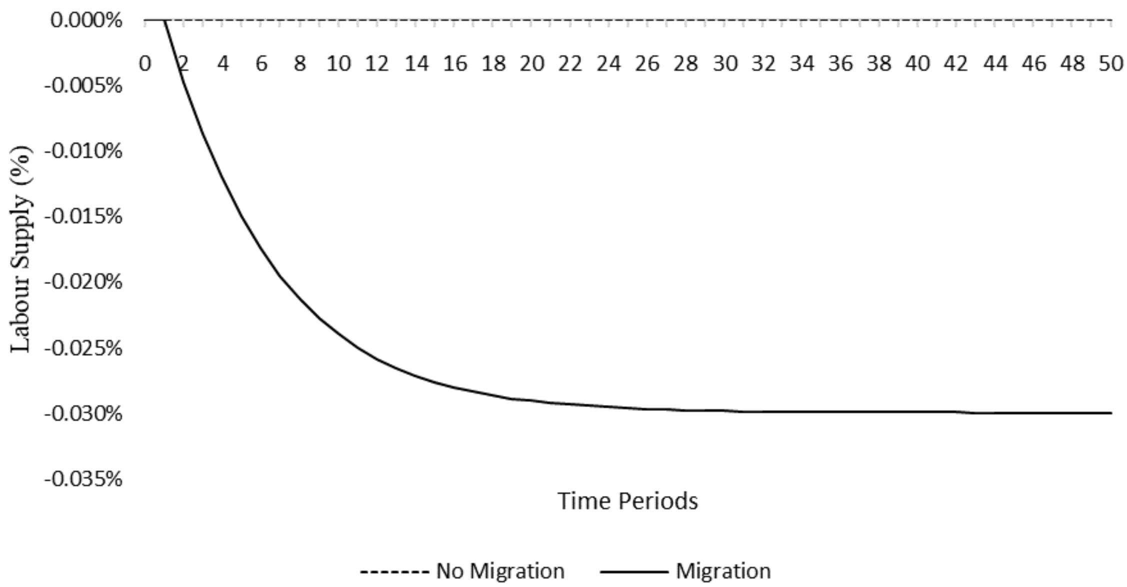


Figure 5.23: Sensitivity analysis: Labour Supply – Migration v/s No Migration (%)
Source: Author's Illustration

In aggregate terms, we see that there are differences in the long-run values equivalents between the different cases discussed in this section. When the forward-looking specification is adopted, the results are found to be slightly more pessimistic than the myopic specification. Allowing for migration shows more negative impacts on the economy. These results are seen in Tables 5.8 and 5.9. However, the choice of specifications in our main results have the intent to analyse the macroeconomic implications for the regional economy of Scotland.

5.9 Conclusions

In this chapter, an attempt has been made to extend from the multi-sectoral IO modelling performed in chapter 4 in the economic analysis of reduced alcohol consumption through the use of a CGE model. While CGE models have been used to examine various sectors, their use in the field of modelling alcohol consumption to find macroeconomic impacts is very limited. Wada et al. (2017) is a key paper in this literature as they use the REMI model to find the employment impacts of increased alcohol duties. The use of the REMI model extends to examining other sin goods such as SSBs and tobacco. We extend the use of CGE models to examine the macroeconomic impacts of alcohol consumption in Scotland.

The use of a CGE model progresses from chapter 4 where an IO model was employed to perform an economic analysis. The main advantage of the CGE model over the IO model in making this analysis was the flexible supply side. This rigid assumption of the IO model was relaxed through the use of the CGE model which included endogenous estimation of prices and flexibility in factors of production.

The CGE model was able to provide a dynamic view of the demand shock. The model could show results for successive time-periods and show how the various macroeconomic variables changed from one period to another. This allowed us to analyse the impact through the duration of the shock, unlike in the IO case where the results were a snapshot of the economy without any time dynamic.

In this chapter, the AMOS model was used to find the macroeconomic impacts of reduced alcohol consumption. The macroeconomic variables examined were GDP, employment, labour supply, real and nominal wages, investment, household consumption and the CPI. These variables were measured in a time dynamic to produce a systematic set of results which allowed us to examine the complete story of the economic impacts of increased alcohol duties. The impacts that were found could be particularly important in the framing of fiscal policy concerning alcohol consumption since the impacts on the wider economy can be noted alongside sector-specific impacts. Further from IO models, the CGE model was able to show this impact in a general equilibrium framework where the results were driven by endogenously calculated prices and wages, as is recommended by the WHO (2009).

The scenarios used in this study attempted to dissect the economic impacts of an increase in alcohol duty, and the subsequent impact of increased government spending. This simulation strategy allowed us to examine the gross and net impacts of a potential fiscal policy, as prescribed by Wada et al. (2017).

The use of a CGE model to analyse the potential economic impact of increased alcohol duty is a key contribution of this chapter. The inclusion of the sensitivity analysis checks the robustness of our results and this is in fulfilment of the recommendations made by the WHO (2009, 2010). In doing so, this chapter can fill a gap in the economic impact literature on sin goods. The applicability of these simulations in alternative sectors, possibly with a different sectoral aggregation could open the door for the use of CGE analysis in other sectors. This may have wide-reaching implications to study the response of the economy while designing a policy to regulate goods with similar properties to alcohol.

The results of the scenario presented in this chapter have all shown negative long-run impacts of an increase in alcohol duty. Specifically, the level of employment was found to fall by 686 FTE, taking into consideration the net impacts of increased government spending. However, the analysis was not able to capture an essential element of reduced alcohol consumption: the health benefits. The case of alcohol consumption is highly complicated.

CGE models are not built to capture the benefits of reducing the demand for a sector that does not have a direct economic impact. As an example, the reduction in consumption of a sin good may have positive externalities that benefit the economy and society. However, these externalities may not be captured within the framework of a multi-sectoral model. One such positive externality of reducing alcohol consumption is the improvement in health in the labour market. As is widely found in health literature, the consumption of alcohol causes serious illnesses. A reduction in alcohol consumption can help avoid these health problems.

This chapter has shown us that CGE models have an important place in examining the macroeconomic impacts of sin goods. Results from this chapter showed that the CGE model is capturing the macroeconomic impacts of increased alcohol duties. However, an extended analysis of this sin good requires that the economic impacts of better health also be incorporated into the model. To carry this out, we extend the use of the AMOS model employed in this chapter to incorporate one of the positive externalities of reducing alcohol consumption, which is an increase in labour productivity. This is discussed in chapter 6 that follows.

Chapter 6: Modelling the Economic Impacts of Health Improvements from Reduced Alcohol Consumption

6.1 Introduction

Throughout the previous chapter, the effectiveness of using modelling techniques to analyse the possible macroeconomic impacts of increased alcohol duty was discussed. In chapter 4 and 5, it was shown how changes in consumption of alcoholic products could impact the Scottish economy through a demand-side analysis. The results of the IO and CGE model were compared. Through the use of the AMOS model, it was found that the reduction in alcohol consumption through higher alcohol duties would have small negative macroeconomic consequences in the long run, while the short-run impacts were found to be positive.

A key assumption in the analysis was that only the direct economic impacts of changes in demand were taken into consideration, which is, an increase in the duty on alcohol was introduced. However, alcohol consumption also has negative externalities associated with it. One such externality is that there are negative health consequences of alcohol consumption (WHO, 2009). In this chapter, we expand the analysis from chapter 5 to include selected economic impacts of improved health owing to a reduction in alcohol consumption. As is seen in the literature from chapter 2, alcohol taxes have a double dividend associated with them. These include a reduction in alcohol consumption and offsetting the negative externalities of alcohol misuse. Specifically, we incorporate increased labour productivity, which can be associated with reduced alcohol consumption.

Within health economics literature, health is often associated with labour productivity (Mattke et al., 2007; Mathias et al., 1995; Knies et al., 2013; Muysken et al., 1999). In this chapter, better health outcomes of reduced alcohol consumption are quantified in terms of labour productivity and exogenously introduced into the CGE model used in Chapter 5. This allows for the macroeconomic impacts of increased labour productivity resulting from lower demand for alcohol to be assessed, thus producing results that explore an additional mechanism that is previously unexplored within a CGE framework. While it is acknowledged that the health benefits being explored in this analysis are selected, this analysis is able to showcase a method to incorporate such costs, and this can be extended to other benefits in future work.

Since we have seen negative employment impacts of reduced alcohol consumption in chapter 5, we further use results from simulations in chapter 6 to find the increases required in labour productivity to offset the negative impacts of reducing alcohol consumption.

To estimate the changes in labour productivity, we use two main economic losses associated with alcohol consumption. These losses are presenteeism and absenteeism. The Scottish Government (2010) defines these as below.

"**Presenteeism –** the reduced activity and productivity of those who misuse alcohol but who are at work;
Absenteeism – taking paid time off work due to health-related and other problems, some of which may be directly or indirectly due to alcohol misuse."

In all, this chapter aims to understand the links between improved health consequences of reducing the level of consumption of sin goods in an economy, as modelled in a CGE framework. To do this, the literature on health and labour productivity is reviewed; where it is found that the poorer health outcomes have a direct relationship with reduced labour productivity in the workplace. Also reviewed in the literature on the use of CGE models in modelling health impacts. In all, the review of the literature shows that CGE models can analyse the health-side impacts of reduced alcohol consumption and that increased labour productivity may be used as a tool to model this health consequence.

Thus, we argue that including health impacts in a macroeconomic assessment allows for a comprehensive analysis of the economic indicators and may suggest the economic impacts that can be expected when policies are designed to contract consumption through a sector that has negative externalities. In addition to contributing to the debate on alcohol policy in Scotland, the findings of this chapter also contribute to the modelling literature in the field of analysing the economic impacts of sin goods.

Further details on the economic consequences of poorer health outcomes are elaborated in section 6.2, alongside the quantification of absenteeism and presenteeism as a method to estimate labour productivity losses. The linkage between labour productivity and health is derived through a literature review in this section. This is particularly important as it allows us to use changes in labour productivity changes as a reflection of improved health deriving from reduced alcohol consumption. Also discussed in this section is the use of CGE models in the existing literature to study the economic impacts of health. Once this linkage has been established, the modelling of labour productivity in AMOS is discussed in section 6.3, alongside the modelling strategy. This allows us to understand the relationship between labour productivity and the results produced in future sections. Section 6.4 provides the results for this analysis and a discussion is reported in section 6.5.

6.2 Economic Consequences of Poorer Health

As seen in earlier chapters, the level of alcohol consumption in Scotland exceeds the maximum recommended level of 14 units per week per individual by over 30% (MESAS, 2017). The consequences of demand-side reductions in the level of consumption through increased alcohol duties have revealed impacts on the economy of Scotland through the IO and CGE analyses in chapters 4 and 5. Estimates from the previous chapter produced through the AMOS model indicated expansion in the GDP of the economy in the short-run, while the long-run impacts were found to be negative. However, the inclusion of health impacts may offer an extended outlook of the macroeconomic impacts.

In this section, we look in the literature for linkages between health and labour productivity. We also find how economic impacts of poorer health associated with reduced alcohol consumption have been previously estimated.

6.2.1 Health and Labour Productivity

As has been seen previously in chapter 2, the use of alcohol has severe consequences for health.

One of the most common ailments caused by alcohol consumption is chronic liver disease. Becker et al. (1996) found that alcohol intake has a strong impact on the prediction of alcohol-induced liver disease. It was further found that self-reported levels of alcohol consumption could be used as a “good predictor” of the future development of liver diseases. The alcohol-related liver disease research survey of Scotland (2015) found a sharp increase in the liver diseases diagnosed in Scotland amongst both men and women.

Not just liver disease, but also cancer has a link to high levels of consumption of alcohol. Ingold et al. (2019) found that the use of alcohol beyond the recommended 14 units per week could have significant impacts on the development of cancers in the head and neck. They concluded that the threshold of 14 units per weeks is required to manage the risk of future development of cancers. Further research from Germany shows that the risk of developing cancer increases with even modest use of alcohol (Scherubl, 2019).

Strong evidence has been found on the linkages of alcohol consumption and the price level of alcohol, as well as of alcohol consumption and the development of health conditions. It is also found that time restrictions on alcohol sales had a mixed response to reducing the social costs of alcohol misuse.

The link between health-related problems that arise from alcohol and loss in productivity has its roots in the health economics literature. Studies have been conducted for various diseases that show a loss in productivity arising from health-related problems. Healthcare problems have two main implications on the productivity of an active workforce – absenteeism, and presenteeism.

Mathias et al. (1995) show that a self-reported sample of women with chronic pelvic pain in the US reported 15% time lost from paid work (absenteeism) and 45% of respondents experienced reduced work productivity (presenteeism). Similar results were found for Irritable Bowel syndrome by Dean et al. (2005) with 15% time lost from paid work and 21% reduced work productivity through a two-phase survey in the USA. These type of studies have been analysed by

Mattke et al. (2007) who say that health-related problems cause losses in productivity in the USA, but add that there is very little research in showing the linkages between presenteeism and labour productivity. Another drawback, they mention, is the lack of valid methods to monetize this loss in labour productivity arising from health-related problems.

"The challenges involved in measuring presenteeism and its costs are far greater than those involved in measuring absenteeism because reduced performance on the job is less tangible than absence." (Mattke et al., 2007, p. 213)

In a systematic review of literature, Schultz & Edington (2007) use seven studies to find the linkage between health conditions and losses in labour productivity. They find that all the studies in their review show that respondents in surveys with health conditions show negative impacts on presenteeism. Furthermore, they find that the results of the studies are consistent in their view that an increased number of chronic health condition leads to reduced workplace productivity. They conclude that to improve workplace productivity, employers could provide low-cost educational programs on managing health. Employers may also improve productivity by spending money on relevant treatments of the problem. Cancelliere et al. (2011) further find that the use of health promotion programs at the workplace is an effective tool to reduce the level of presenteeism.

Not only physical health problems but also mental health problems are associated with losses in workplace productivity. Beck et al. (2011) and Lerner et al. (2004) find that there is a relationship between the severity of symptoms of depression and the losses in productivity at the workplace. Beck et al. (2011) show that for every 1-point increase in the 9-point scale of depression symptoms, the level of productivity reduced by 1.65%.

The implication of mental health is very relevant to our analysis since high levels of alcohol consumption are a cause of clinical depression (NHS, 2020).

The implications of health-related studies on the measurement of absenteeism and presenteeism are limited to surveys. The estimation is done in terms of the number of paid days lost due to the disease for absenteeism and presenteeism. The valuation of these days lost do not directly translate into loss in productivity since this process involves making several assumptions.

A critical issue in assessing presenteeism is that while data for absenteeism may be gathered from the leave registers of firms, collecting data for presenteeism is more challenging. The collection of presenteeism data relies on surveys and may be under-reported (Mattke et al., 2007).

Zhang et. al. (2011) have shown that the measurement of loss of labour productivity can be measured in numerous ways. These include the Human Capital (HC) approach and the Friction Cost (FC) approach. The issue pointed out with both these approaches is that they treat human beings as production inputs. The study goes on to analyse these methods of quantification. Since there exists a gap between observed wage rates and actual productivity due to factors such as team participation, time-sensitive production, etc., the actual productivity loss of a worker can vary from the loss in wage.

In workplaces with the issues listed above, it is common to observe compensation mechanisms, whereby the absence of a worker would not cause as much loss in productivity. These compensation mechanisms include cross-training of workers as well as substitute workers (Jackob-Tacken et. al., 2005). This implies that although we can calculate the loss in the number of paid work days for workers, employers may still not face a loss in output. The caveat here is that while a loss in output may not be experienced, the costs of implementing compensation mechanisms causes productivity to fall invariably with inputs increasing (in the form of capital as well as labour) (Severens et. al., 1998).

A key issue in the measurement of labour productivity is that the value of compensation mechanisms may vary widely. Since no established method exists to estimate the degree of compensation mechanisms, objective measures in this regard are unavailable. However, measuring labour productivity without incorporating compensation mechanisms would lead to overestimating the impacts of absenteeism and presenteeism (Meerding et al., 2005)

Thus, while Severens et al. (1998) have found that 70-75% of labour productivity losses are reduced after adjusting for compensation mechanisms, the true valuation of losses in labour productivity must include the increased costs of their implementation.

In our study, we incorporate compensation mechanisms by using a study of compensation mechanisms for the United Kingdom (Knies et al, 2013). Through the use of a CGE model, we aim at finding a valid method to calculate and quantify losses in labour productivity arising from alcohol consumption. The use of CGE models in modelling health consequences is presented in the section below.

6.2.2 The use of a CGE framework to analyse health impacts

Several studies have been conducted that analyse the health impacts of policies within a CGE framework. These studies incorporate the impact of a health concern or disease through various economic variables into a CGE model, and this shows the economy-wide implications of said diseases.

In their study, Smith et al. (2005) use a single-region British CGE model to evaluate the impact of antimicrobial resistance on the economy. The shock is exogenously introduced into the model as a combination of "labour supply, input productivity and healthcare delivery costs" and is applied directly onto the health sector (Smith et al., 2005). This is representative of the increased resistance of the MRSA bacteria to the relevant antibiotics. Different scenarios are introduced for this, each with an increase in healthcare delivery cost, reduced productivity and labour supply.

The paper finds that the use of a CGE model extends the impact to the rest of the economy, rather than focusing solely on the healthcare sector. This is important since the reduction in labour supply resulting from increased resistance to antibiotics would extend to the wider economy. This is true for a reduction in alcohol consumption as well, where a reduction in alcohol consumption would have impacts on the labour supply in the wider economy.

Bosello et al. (2006) find the economy-wide health impacts of global warming using a multi-country CGE model. This is done through a variant of the GTAP (Global Trade Analysis Project) model. A key feature of the model used here was that future equilibria for selected long-run time-periods were exogenously forecasted and entered into the model for calibration. The model used in our study does not require this exogenous calculation since the equilibrium is determined endogenously through solving multiple equations.

The estimation of the impact of global warming on health is done by finding the changes in mortality over the estimation period and expressing this in GDP terms. This change in GDP is set exogenously in the future equilibria benchmark to find the path followed by the economy. In all, the method followed to estimate the health impacts by Bosello et al. (2006) involves several exogenous calculations of future equilibria based on data from WHO and other sources and then allowing the CGE model to find the path to the pre-determined equilibrium. Thus, Bosello et al. (2006) can find a unique application for the GTAP model, which had previously not been used in the field of healthcare.

While the two studies described above use various representations of health in their analysis, a very limited number of studies have used labour productivity as a proxy for health while modelling in a CGE setup (Verikios et al., 2015).

The first use of labour productivity as a proxy for health noted is by Rutten & Reed (2009). In their policy analysis of reducing rationing within the NHS in the United Kingdom, a CGE model was used with the intent to examine endogenous impacts on the production of the economy and income of labour force participants driven by changes in healthcare provision. To do this, the paper uses a CGE model with a health extension where the health of the workers is a function of the healthcare provision through the NHS. This creates an indirect link between increased labour productivity and betterment in output. In contrast to this study, we use a direct linkage between labour productivity and reduced alcohol consumption since we exogenously shock labour productivity. This paper is used as a basis by Verikios et al. (2015) that finds improvements in labour productivity owing to improved healthcare disaggregated by age.

In their study to observe the economic impact of improvements in health in different age groups in Australia, Verikios et al. (2015) used a CGE model with a labour market disaggregated by age group. The model uses data on the sale of health products to the various age groups in the labour market to assess changes in the health of a specific cohort. The results of this study found that health improvements affected the output from older cohorts more since they were more susceptible to health problems. Younger cohorts showed a lower improvement in productivity since they relied less on healthcare systems. The study used the probability of changes in health status among different age groups to form their exogenous shock. This shock was performed on labour productivity, similar to the shock that is formulated in this chapter.

Keogh-Brown et al. (2010) and Smith et al. (2013) have also made use of absenteeism data to estimate the macroeconomic impact of health in their analysis of the influenza pandemic of 2003 in the UK and other countries respectively. Workplace absenteeism and school closure data was used to formulate exogenous shocks to the labour supply. This means that reduced absenteeism was treated as an increase in labour supply. However, we treat absenteeism as a reduction in labour productivity. Since absenteeism was caused due to a combination of reduced demand and supply of labour, the use of labour productivity is more apt in our study.

Thus, CGE models have been used previously in the field of modelling macroeconomic consequences of health. The literature reviewed shows that in this small set of papers, health impacts are modelled within a CGE framework as a function of either labour supply or labour productivity depending on the case. With a reduction in alcohol consumption, and since labour productivity is shown to have a direct impact as seen in section 6.2.1, this is the selected route to introduce a supply-side shock into the economy.

6.2.3 Previous estimates of economic Impacts of alcohol consumption on labour productivity in Scotland

Previously, only one study has examined the economic costs of alcohol consumption in Scotland. The Scottish Government (2010) conducted this study for the year 2007. The study attributed these economic costs to poorer health outcomes in the Scottish population. The economic implications of poorer health outcomes were assessed by quantifying the impact of the productive capacity of the workforce (Scottish Government, 2010). To compare the results produced in future sections of this chapter, we replicate the above-mentioned study for the year 2014.

The key elements of this productive capacity that were elucidated in this report match the widely recognised criteria set for such a type of analysis and these have been conducted for other European regions through the same methodology (Alcohol Action Ireland, 2017). The economic costs include presenteeism and absenteeism. The quantification of these economic costs involved the use of several government data sources that are also employed in future sections.

The method of quantification of the economic costs of alcohol consumption is described below and the results from the report (Scottish Government, 2010) have been replicated for the year 2014, which is the base year in our analysis. This analysis allows us to understand the scale of the economic costs of alcohol consumption and can be further used in our analysis to compare the economic gains we estimate through the use of a CGE model.

Estimating the economic cost of presenteeism

As previously defined, presenteeism is the reduced productivity of workers misusing alcohol leading to economic losses for their employers and thus, the economy. These losses can be estimated using methods used by the Scottish Government (2010).

Data is used from a survey which was carried out by reed.co.uk in 2004. The results of this survey showed “workers turn up at work with a hangover on an average of two and a half days per year” (Scottish Government, 2010). The efficiency of their work was lower by 27% compared to if they were not hungover. This calculation means 0.68 days (27% X 2.5 days) were lost per employee annually due to presenteeism. Accounting for part-time and full-time employees, an assumption is made that part-time employees would lose 0.34 days annually. The number of days lost is multiplied with the estimated costs to the employer per day to calculate the adjusted costs of presenteeism.

To calculate the costs to employers, an uplift of 15% on the earnings per working day is calculated to cover for employer’s contribution for national insurance and pensions, along with facilities provided at the workplace such as heating, lighting, office spaces, food, etc. It can be shown that the economic cost of presenteeism caused by alcohol consumption is estimated to be £171.6m in 2014.

Days lost due to presenteeism	**Cost due to Alcohol Misuse**
1,258,103	£171.6m

Table 6.1: Costs of Alcohol-related presenteeism to the Scottish economy in 2014
Source: Adapted from the Scottish Government (2010)

Estimating the economic cost of absenteeism

Economic costs of absenteeism are calculated in a very similar method to presenteeism. This involves the calculation of days lost and multiplying with the costs to the employer.

To calculate the days lost, the LFS, 2016 was used which shows that an average of 4.4 days was lost per worker in 2014 in the UK to sick days/ injuries. Multiplying the total number of part-time and full-time employees with this 4.4 days gives the total days of absence.

A study by Leontaridi, 2003 shows that 6% - 15% of all sick days can be attributable to alcohol-related sickness in the UK. The midpoint of this range (10.5%) is used by the Scottish Government to estimate the economic cost of absenteeism. Thus, we assume that 10.5% of all sick days can be attributed to alcohol-related sickness and is used to calculate the days of absence attributable to alcohol misuse from the previously calculated total days of absence. Given the days of absence due to alcohol misuse and the cost to employer per day employment, the cost of absenteeism due to alcohol misuse was thus calculated. It can be shown that the economic cost of absenteeism caused by alcohol consumption is estimated to be £141.3m in 2014.

Type of employee	Total Days of Absence	Days due to Alcohol Misuse	Cost due to Alcohol Misuse
Full-time employees	8,139,120	854,608	£118.7m
Part-time employees	1,545,500	162,278	£22.6m
All employees	9,684,620	1,016,886	£141.3m

Table 6.2: Costs of Alcohol-related Absenteeism in Scotland, 2014
Source: Adapted from the Scottish Government (2010)

Total economic costs of alcohol consumption in Scotland

Sourcing all of the calculations from the sections above, the results are presented in Table 6.3. The total loss in labour productivity is estimated to be 2.27m working days in Scotland. This translated to an economic loss of £312.9m to the overall economy. In terms of scale, these losses are estimated to be 0.93% of the total Scottish budget for 2014. In comparison, the costs to the Scottish economy of absenteeism and presenteeism estimated by the Scottish Government (2010) for 2007 was at £378.2m. However, it is important to note that the estimate for the rate of absenteeism across the economy was 6.7 days for the year 2007 (CBI, 2008), as opposed to 4.4 days in 2014 (LFS, 2016).

Resource Category	Days Lost	Cost for 2014
Presenteeism	1,258,103	£171.6m
Absenteeism	1,016,886	£141.3m
Total	2,274,988	£312.9

Table 6.3: Estimated Costs (£ million) to Productive Capacity of Scottish Economy Due to Alcohol Misuse in 2014
Source: Adapted from the Scottish Government (2010)

However, throughout these calculations, we find that several assumptions have been made. While they can broadly estimate the economic cost of alcohol consumption, they do not find the impacts of this consumption on macroeconomic indicators such as GDP, output and employment. The use of a CGE model to estimate the economic costs of health consequences of alcohol consumption should be able to find these impacts. To do this, we must find the level of lost labour productivity in Scotland, which is shown in section 6.3, alongside the strategy for modelling.

6.3 Estimation of productivity shocks and modelling strategy

As described in the previous chapter, the AMOS framework that is employed in this thesis employs a large range of variables that may be modelled, making the model highly flexible. One such variable is labour productivity. Labour productivity within AMOS is defined as the efficiency of labour and is a function of the technical change in labour as a factor of production.

Within the AMOS framework, under the nested production function seen in chapter 5, the production function of value-added includes the combination of capital and labour as shown in equation 6.1.

$$VA_{i,t} = \left[a_i\left(\gamma L_{i,t}\right)^{\frac{\varepsilon_i-1}{\varepsilon_i}} + (1-\alpha_i)\left(K_{i,t}\right)^{\frac{\varepsilon_i-1}{\varepsilon_i}}\right]^{\frac{\varepsilon_i-1}{\varepsilon_i}}$$

… (Equation 6.1)

Where L and K are labour and capital, and γ is the labour productivity parameter, and ε is the elasticity of substitution between labour and capital. Within the standard AMOS, the labour productivity parameter is endogenous. However, in our simulations, we exogenously shock this parameter for each time period and each sector.

A change in labour productivity has two main implications for the economy: changes in the level of output which can be produced with a given amount of labour input (given the change in technical efficiency of labour and change in the level of labour demand). The consequences of these then have knock-on implications for the economy in terms of macroeconomic variables such as GDP, employment, inflation, as well as variables at the sectoral level.

The estimation of the level of labour productivity shock introduced is done by adding the level of lost labour productivity owing to presenteeism and that owing to absenteeism. Differential losses in labour productivity for each sector are calculated to represent sectoral differences. These losses are calculated to find the magnitude of a positive labour productivity shock that can be introduced to offset the negative employment effects shown in chapter 5.

To calibrate the loss in labour productivity associated with alcohol-dependent absenteeism, we use data from ONS (2014) which disaggregates the reasons for sickness absence in the UK by sectors and reasons.

The data from ONS (2014), as shown in Table 6.4, gives the rate of absence by industry and the corresponding number of absent days. From this, the total number of working days in each industry is computed by dividing the number of absent days with the rate of absence. Also found from this data is the absence due to alcohol. As an example, in the 'Agriculture, forestry and finishing' sector, of the 279.78 days worked on an average by a worker, they take 4.26 days of absence. However, we know from ONS (2014) that only 6% of these 4.26 days are taken due to alcohol consumption. Thus, we derive the formula for loss in labour productivity from absenteeism due to alcohol.

Alcohol associated loss in labour productivity from absenteeism =

$$\frac{\text{Absence due to alcohol X Number of absent days}}{\text{Number of Working days}}$$

Industry	Rate of Absence (ONS, 2014)	Number of Working days (ONS, 2014)	Number of absent days (Calculated)	Absence due to alcohol (ONS, 2014)
Agriculture, forestry and fishing	1.52%	279.78	4.26	6%
Energy and water	1.96%	259.13	5.08	11%
Manufacturing	2.07%	259.51	5.37	10%
Construction	1.74%	227.04	3.95	15%
Distribution, hotels and restaurants	1.74%	210.61	3.67	15%
Transport and communication	1.96%	230.7	4.52	11%
Banking and finance	1.63%	209.99	3.43	6%
Public admin, education and health	2.72%	208.35	5.67	11%
Other services	1.74%	210.12	3.66	8%

Table 6.4: Sectoral data collected to calculate the alcohol-associated loss in labour productivity from absenteeism.
Source: ONS (2014), Author's Calculations

As seen in the table above, various industries have different disaggregations of absent days due to alcohol consumption. Industries such as construction, manufacturing and Distribution have very high absences due to alcohol consumption, while other industries such as agriculture and services have a lower record of taking absences from work due to alcohol consumption. The economy, here, is disaggregated into 9 sectors, while the CGE model uses 18 sectors. Based on the SIC classification, the industries from the table above are classified as in Table 6.5. The formula that is established above is also applied, and the results are displayed in the table below.

Sector	Number of absent days	Number of Working days	Absence due to alcohol	Absenteeism productivity (unadjusted)	Absenteeism productivity (adjusted)
AFF	4.26	279.78	6%	0.09%	0.06%
OTP	4.26	279.78	6%	0.09%	0.06%
FAD	5.37	259.51	10%	0.21%	0.14%
SAW	5.37	259.51	10%	0.21%	0.14%
BAM	5.37	259.51	10%	0.21%	0.14%
TLW	4.26	279.78	6%	0.09%	0.06%
RCG	5.37	259.51	10%	0.21%	0.14%
EMO	5.37	259.51	10%	0.21%	0.14%
ETD	5.08	259.13	11%	0.22%	0.14%
WSW	5.08	259.13	11%	0.22%	0.14%
CON	3.95	227.04	15%	0.26%	0.17%
WRT	3.67	210.61	15%	0.26%	0.17%
AOF	3.67	210.61	15%	0.26%	0.17%
AON	3.67	210.61	15%	0.26%	0.17%
FIN	3.43	209.99	6%	0.10%	0.06%
RCO	4.52	230.70	11%	0.22%	0.14%
EDU	5.67	208.35	11%	0.30%	0.20%
HRS	5.67	208.35	11%	0.30%	0.20%

Table 6.5: Calculated alcohol-associated loss in labour productivity from absenteeism
Source: Author’s calculations

However, a key issue that arises in this calculation is that with absenteeism of one worker, the total level of output may not fall since other workers in a firm may be expected to pick up the loss in output, thus reducing the level of fall in output (Knies et al, 2013). Firms may employ compensation mechanisms to prevent falling levels of output associated with absenteeism. In all, Knies et al. (2013) find that in the United Kingdom, when a worker takes a leave of absence, 50.1%-82.2% of the output that is attributable to that worker is lost. This implies that there is a loss in the level of productivity of the labour force. Since this is the only estimate of recovery of output using compensation mechanisms in the UK that we find, we use an average of this range to scale the loss of productivity associated with absenteeism. Thus, this scaling factor is calculated at 66.15%.

The calculations for presenteeism is more complicated since very little data is available for presenteeism.

The most recent study in this regard is by (Bhattacharya, 2019), where the level of presenteeism is calculated for the UK. This study finds that on average, each worker turns up to work with a hangover on 0.7 days per year. Further, this study finds that workers are 39% less productive these days. This calculation shows that 0.273 days a year are lost to presenteeism per worker. However, in this study, 9% of workers surveyed said that they turned up to work with a hangover or were intoxicated in the past 6 months, while 33% of the workers said that they had not done so in the past 6 months. To find the annual rate of presenteeism, the 6-month numbers were doubled. This means that the 33% who may not have been hungover or intoxicated at work in the past 6 months were assumed to not have done so for the whole year. Thus, the estimate of this study could be underestimated.

Furthermore, the Institute of Alcohol Studies (2017) reveals other estimates by PruHealth (2006), Norwich Union (2008), Drinkaware (2010), and Willis PMI (2016). These studies estimate the number of days of hangover or intoxication to be higher than Bhattacharya (2019). However, it is important to note that all of these studies were conducted for the UK, and not specifically for Scotland. In terms of the loss in productivity due to hangovers and intoxication, the range in the literature for the UK is between 25-30% (Bhattacharya, 2019). Thus, we choose a study that has been used by the Scottish Government (2010) in their estimation and is in line with the estimates from the existing literature.

As mentioned before, a study by Reed.co.uk has found that in Scotland, workers turned up at their jobs in a less than productive state due to alcohol consumption on an average of 2.5 days per year. They claimed to be 27% less productive these days in their tasks. This means that on average, a worker lost 27% of 2.5 days of a paid working day due to alcohol consumption, which is 0.675 days a year. This number is used as a means of calculating the loss in labour productivity due to presenteeism. Additionally, each worker has also lost some days to absenteeism and this needs to be discounted from the total number of working days.

The loss in alcohol-related labour productivity from presenteeism is thus 0.675 days of the total number of days worked for each industry. This is represented in Table 6.6 as shown below.

Sector	Number of absent days	Number of working days	Actual number of working days	Presenteeism productivity
AFF	4.26	279.78	275.52	0.24%
OTP	4.26	279.78	275.52	0.24%
FAD	5.37	259.51	254.14	0.27%
SAW	5.37	259.51	254.14	0.27%
BAM	5.37	259.51	254.14	0.27%
TLW	4.26	279.78	275.52	0.24%
RCG	5.37	259.51	254.14	0.27%
EMO	5.37	259.51	254.14	0.27%
ETD	5.08	259.13	254.05	0.27%
WSW	5.08	259.13	254.05	0.27%
CON	3.95	227.04	223.09	0.30%
WRT	3.67	210.61	206.94	0.33%
AOF	3.67	210.61	206.94	0.33%
AON	3.67	210.61	206.94	0.33%
FIN	3.43	209.99	206.56	0.33%
RCO	4.52	230.70	226.18	0.30%
EDU	5.67	208.35	202.68	0.33%
HRS	5.67	208.35	202.68	0.33%

Table 6.6: Calculated alcohol-associated loss in labour productivity from presenteeism.
Source: Author’s calculations

From Table 6.7 and 6.8, we can calculate the total alcohol-associated losses in labour productivity. These are shown in Table 6.7. In terms of the CGE model, the sectoral shocks in the labour productivity parameter seen in equation 6.1 are represented in this table. Alcohol-associated labour productivity is found to be 0.423% of total labour productivity.

Sector	Absenteeism productivity (adjusted)	Presenteeism productivity	Total alcohol-associated productivity
AFF	0.06%	0.24%	0.30%
OTP	0.06%	0.24%	0.30%
FAD	0.14%	0.27%	0.41%
SAW	0.14%	0.27%	0.41%
BAM	0.14%	0.27%	0.41%
TLW	0.06%	0.24%	0.30%
RCG	0.14%	0.27%	0.41%
EMO	0.14%	0.27%	0.41%
ETD	0.14%	0.27%	0.41%
WSW	0.14%	0.27%	0.41%
CON	0.17%	0.30%	0.47%
WRT	0.17%	0.33%	0.50%
AOF	0.17%	0.33%	0.50%
AON	0.17%	0.33%	0.50%
FIN	0.06%	0.33%	0.39%
RCO	0.14%	0.30%	0.44%
EDU	0.20%	0.33%	0.53%
HRS	0.20%	0.33%	0.53%

Table 6.7: Total alcohol-associated loss in labour productivity from absenteeism and presenteeism.
Source: Author's calculations

While the estimates made in Table 6.7 show the losses in labour productivity associated with alcohol consumption, it is important to note that within the AMOS model, these are introduced as positive shocks to labour productivity. This is done to denote that a reduction in alcohol consumption would reduce sickness caused by alcohol and thus improve workplace productivity, as we found in section 6.2.1 from a review of the literature.

In this chapter, the CGE model that is employed to include the impacts of the health externalities of alcohol consumption is the AMOS model that was also used in the previous chapter. The changes in labour productivity are introduced into the AMOS model exogenously. As shown above, our computation of changes to labour productivity is sector-disaggregated. Thus, we can model different changes in labour productivity for each sector in the AMOS model.

The simulations seen in chapter 5 introduced a high tax on alcohol consumption. We calculate short-run and long-run estimates of macroeconomic indicators including Output, Employment and GDP. In this chapter, the same setup of AMOS will be used, and changes to labour productivity would be introduced exogenously. As with chapter 5, the active supply-side allows for endogenous price determination of sectors within the model. Since we exogenously shock the level of consumption and supply, to maintain a general equilibrium, the model finds sectors where consumption would take place based on the endogenously calculated relative prices.

Since changes in labour productivity are not planned by households, we use the myopic specification to carry out the simulations. This allows us to measure the impact of a policy, where the actors in the economy have limited foresight over the future. In such a case, as explained before, we see that the households and firms adjust to the policy over the simulation. As an example, if a fiscal policy is introduced by a government to reduce alcohol consumption, firms are now aware that alcohol would reduce in the current time-period but would act under the assumption that the policy will continue indefinitely. However, if the policy changes in a subsequent time-period, since they are not prepared for this outcome in advance, they are unable to make decisions in advance to prevent adverse effects, for example by changing the level of production. Thus, the myopic specification is adapted to simulate uncertainty in the policy. Similarly, we also specify the model to allow for migration. We assume that there is migration to and from the economy.

In all, AMOS is used with the same specifications used in chapter 5. This allows for results to be comparable. The addition in the simulations of this chapter is the addition of a positive labour productivity shock of the magnitude estimated above. Till now, labour productivity changes were discussed as a loss to society and were denoted as negative figures. However, since we are measuring the impacts of a reduction in alcohol consumption, these shocks are introduced into AMOS as positive shocks. Thus, a reduction in alcohol consumption is expected to have an increase in labour productivity as is seen from the literature in section 6.2.1. This assumption is made based on the literature review on the relationship between labour productivity and health ailments in section 6.2.

Two scenarios are simulated and analysed in this chapter. These represent increases in labour productivity associated with alcohol consumption.

Scenario 5: An overall increase in alcohol-associated labour productivity

In this scenario, labour productivity in the economy is increased to incorporate the calculated alcohol-associated labour productivity. This implies that all of the labour productivity lost due to alcohol consumption is added back, as has been performed previously by Verikios et al. (2015) in their analysis (see section 6.2.2). Alcohol-associated labour productivity is found to be 0.423% of total labour productivity.

The labour productivity impacts on the economy are analysed under two mutually exclusive assumptions of government spending decisions – fixed government spending, and all spending happens through the Scottish Government.

We expect that the results of these simulations would find increased levels of GDP in the short-run and long run. The level of employment can be expected to fall in the short run since less labour is required to produce the same level of output. In the long run, the level of employment should increase. The mechanisms for these changes are further explained in section 6.6.

Scenario 6: A calibrated increase in alcohol-associated labour productivity alongside a fall in household demand for alcohol

Here, an increase in alcohol-associated labour productivity is complemented with a fall in alcohol consumption through an increase in alcohol duties. Two alternative assumptions of fixed government spending and recycling of raised taxes through the Scottish Government are tested. Scenarios 3 and 4 from chapter 5 are replicated in this simulation, where the household demand for alcohol was reduced through the use of alcohol duties. To our knowledge, no literature exists with regards to the parity between reduction in alcohol demand and increase in alcohol-associated labour productivity. Thus, we find the level of increase in alcohol-associated labour productivity required to offset the long-run losses in employment reported in Scenarios 3 and 4 of chapter 5.

The results from modelling an increase in duties on alcohol yielded results with falling levels of output, employment, and GDP in the long run (Scenario 3, Chapter 5). Scenario 5 is expected to yield an increase in the level of output, employment, and GDP as labour productivity increases. Thus, we use a combination of these two scenarios to find the level of increased alcohol-associated labour productivity required to offset the negative economic impacts of a reduction in household consumption of alcohol. Specifically, we attempt to find the alcohol-associated labour productivity required to offset the fall in employment, as noted in Scenario 3 of chapter 5.

Similarly, Scenario 4 from chapter 5 is replicated in this simulation, where the household demand for alcohol was reduced through the use of alcohol duties. Government spending is done through the Scottish Government in this scenario. In this scenario, we find the level of increase in alcohol-associated labour productivity required to offset the long-run losses in output reported in Scenario 4 of chapter 5.

The shocks that are described above are thus introduced as labour productivity shocks and demand shocks into the CGE model. The model specification, as mentioned, is the same as in chapter 5. This allows us to compare the results and draw conclusions. Thus, we aim to incorporate the health impacts of reduced alcohol consumption and find whether these could lead to positive impacts of a reduction in household demand for alcohol.

6.4 Results and discussion of simulations

In this section, the results of the various scenarios discussed in section 6.5 are reported and discussed. The inclusion of labour productivity in our analysis would help us in analysing comprehensively the impact of reduced alcohol consumption. In all, alcohol-associated labour productivity is found to be 0.423% of the total labour productivity.

6.4.1 Scenario 5: An overall increase in alcohol-associated labour productivity

In this scenario, the level of labour productivity in the economy is increased by the total alcohol-associated labour productivity. This means that all of the labour productivity that is lost due to the consumption of alcohol is added back to the economy. This is conducted under two mutually exclusive government spending regimes – fixed government spending, and complete autonomy to the Scottish Government in making spending decisions. The results of both of these simulations show the same mechanism, and this is explained below. However, the results for both these simulations are presented in Table 6.8 and 6.9.

As seen in figure 6.1, there is a sharp increase in GDP in period 1. The results further find that the overall level of net exports increases in the economy in period 1. Government spending is also found to increase. Figure 6.7 also shows a sharp rise in the level of investment. Thus, the increase in GDP is attributed to increased investment, government spending and net exports. However, it is also noted that there would be a reduction in the level of household consumption.

As there is an increase in the level of labour productivity, less labour is required to produce the same level of output. This causes the level of employment in period 1 to fall. The reduction in employment is shown in figure 6.2.

As the demand for labour has reduced in period 1, so have the wages. Figure 6.5 indicates a fall in both real and nominal wages in period 1. Due to a reduction in the CPI in period 1, the reduction in real wages in comparison to nominal wages is lower (Figure 6.8). However, the fall in CPI increases household consumption. Alongside this, a larger crowding in of investment boosts the GDP, and thus the GDP has a net positive impact in the short run.

As we move beyond period 1, the economy adjusts to the new increased level of labour productivity. The impact of this is there is an increase in the level of employment and the level of output remains high. However, since labour is more productive than before, firms substitute for labour in the production of value-added, and this causes the level of investment to drop slightly in the economy. This causes the level of employment to increase beyond the base year level. The increase in demand for labour has an impact on wages. Both real and nominal wages rise. However, the increase in real wages is greater than that of nominal wages. While real wages rise beyond base period values, the nominal wages remain lower because of the sustained reduction in the CPI.

The level of investment in the economy, though above base year level, is seen to fall slightly, as the favourability towards labour over capital wears away. However, increased government spending, household consumption and net exports continue to fuel an increase in the level of GDP. The fall in the level of investment is attributed to the substitution for labour in the production of value-added. Thus, the impact of the labour-productivity increase has net positives long-run impacts on the economy in terms of aggregate results.

Variable	Fixed Government Spending		Recycled Government Spending	
	Short-run	**Long-run**	**Short-run**	**Long-run**
Output (£m)	457.02	933.70	498.74	1251.39
Employment (FTE)	-2501	39	-1828	4189
GDP (£m)	256.88	531.32	276.23	720.78

Table 6.8: Scenario 5: Short-run v/s Long-run change in Output, Employment and GDP

In the case of fixed government spending, the short-run impacts are an increase in the level of GDP by £256.88m, as the output increases by £457.02m in the economy. However, employment is seen to fall by 2501 FTE. The long-run impacts are found to be more optimistic, with employment increasing by 39 FTE. The GDP and output are also seen to extend their positive outlook (see Table 6.8).

In the case of recycled government spending through the Scottish Government, the impact of the increased labour productivity associated with alcohol consumption causes an increase in GDP of £276.23m in the short-run as seen in Table 6.8. This is due to the increased level of investment in period 1, combined increases in net exports and government expenditure. GDP increases are sustained in the long run by an increased level of household consumption from period 2 onwards. In the long run, the GDP increases by £720.78m.

As seen in figure 6.2, there is a short-run reduction in the level of employment. This is noted to be 1828 FTE jobs in period 1. However, employment increases in the long run, as 4189 FTE jobs are added. This increase in employment is attributed to the substitution of capital by labour since labour is now more productive making it favourable. This is because wage bargaining was assumed to be regional. In terms of output, an increase of £498.74m is seen in the short run. The level of increase in output remains higher than the base period by £1251.39m over the long run.

As previously explained, the shock that is implemented in this scenario is a labour productivity shock. Previously, a similar shock has been run in a CGE model similar to the model used in this thesis by Hermannsson et al (2014) while examining the regional economic impacts of the increased number of graduates in the Scottish labour market. The simulation in their paper assumes fixed government spending along with no migration in the labour market. However, broadly, the long-run results reported in scenario 5 are in line with their results – a large increase in GDP, output and exports, and smaller increases in employment and consumption. The sectoral impacts are different as expected, but the macroeconomic impacts are in line with the expectations of such a shock.

Variable	Fixed Government Spending		Recycled Government Spending	
	Short Run	**Long Run**	**Short Run**	**Long Run**
GDP	0.206%	0.427%	0.222%	0.579%
Employment	-0.109%	0.002%	-0.080%	0.183%
Output	0.197%	0.403%	0.215%	0.540%
Household Consumption	-0.049%	0.045%	0.014%	0.142%
Investment	0.690%	0.354%	0.812%	0.470%
Government Spending	0.000%	0.000%	0.200%	0.568%
Exports	0.247%	0.590%	0.173%	0.590%
Imports	0.008%	-0.049%	0.098%	0.058%
Real Wages	-0.191%	0.000%	-0.140%	0.000%
Consumer Price Index	-0.117%	-0.226%	-0.079%	-0.226%

Table 6.9: Scenario 5: Short-run and Long-run macroeconomic impacts (%)

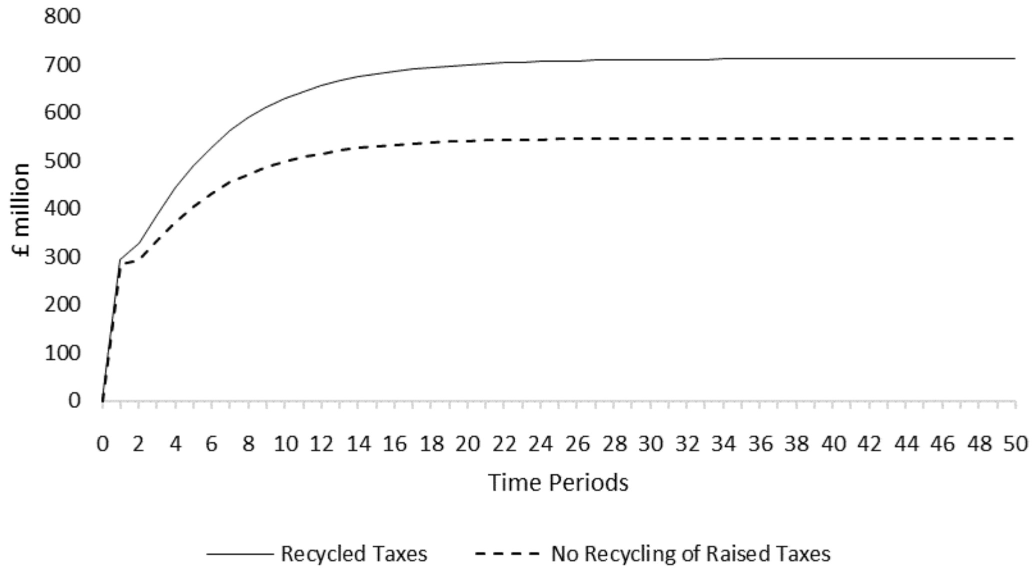


Figure 6.1: Scenario 5: Change in GDP (£m)
Source: Author's Illustration

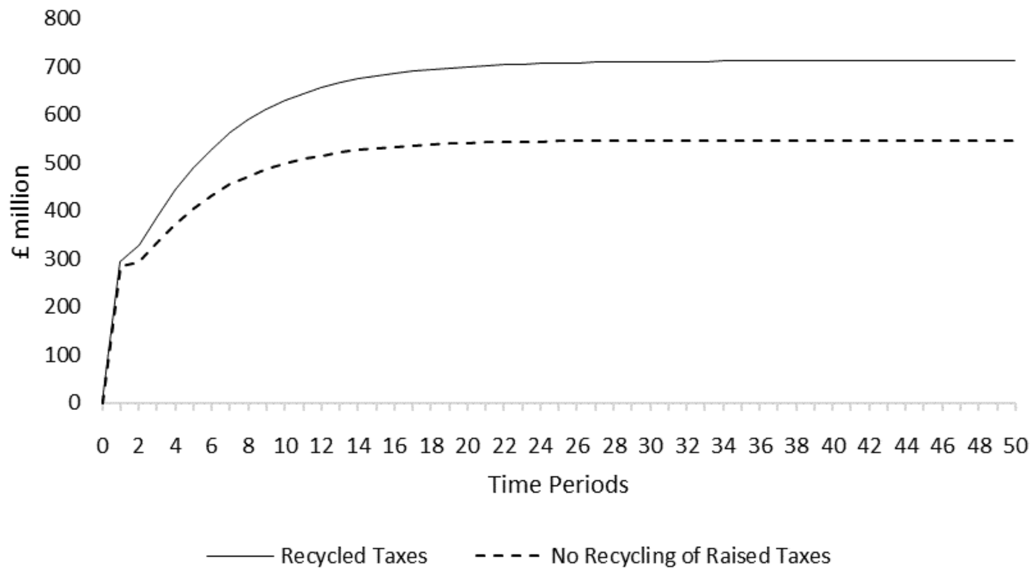
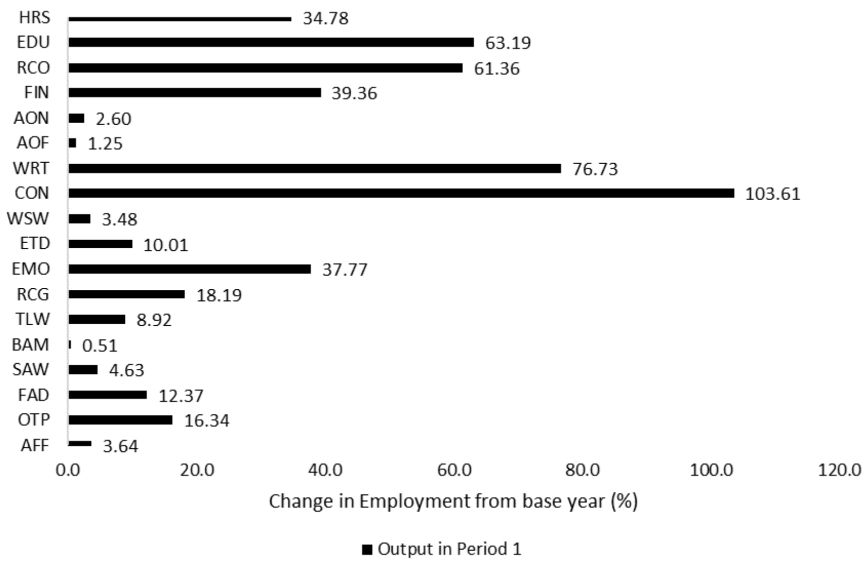


Figure 6.2: Scenario 5: Change in employment (FTE)
Source: Author's Illustration



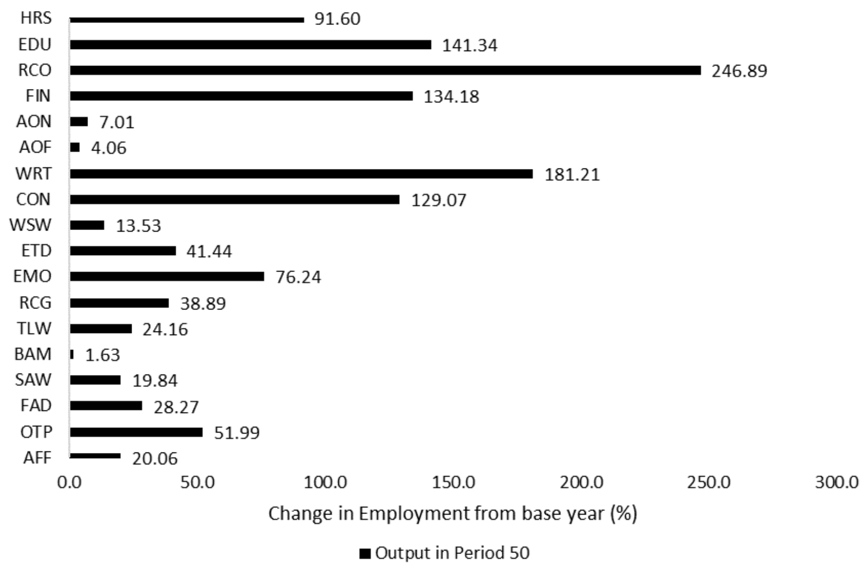


Figure 6.3: Scenario 5: Sectoral Change in output from base period in period 1 (£m)
Source: Author's Illustration

Figure 6.4: Scenario 5: Sectoral Change in output from base period in period 50 (£m)
Source: Author's Illustration

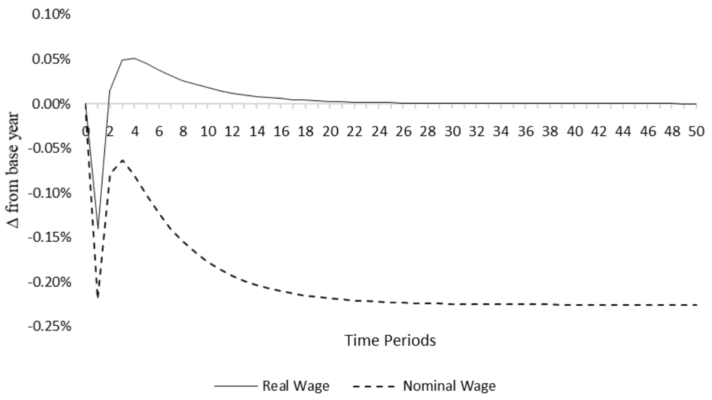


Figure 6.5: Scenario 5: Change in real and nominal wages (% change)
Source: Author's Illustration

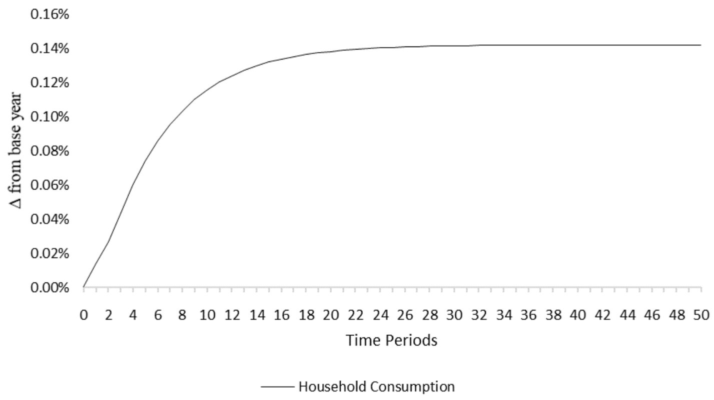


Figure 6.6: Scenario 5: Change in household consumption (% change)
Source: Author's Illustration

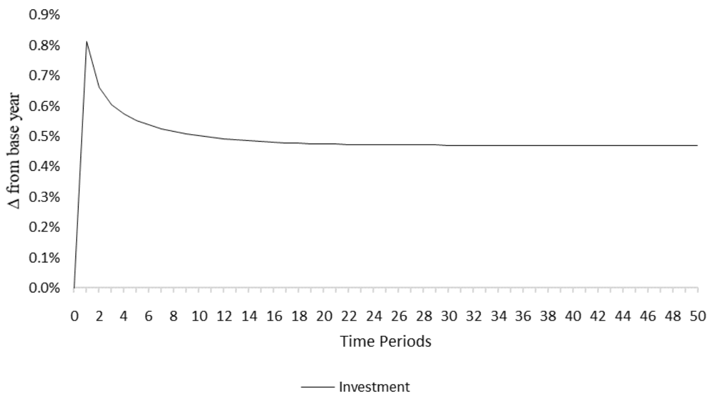


Figure 6.7: Scenario 5: Change in investment (% change)
Source: Author's Illustration

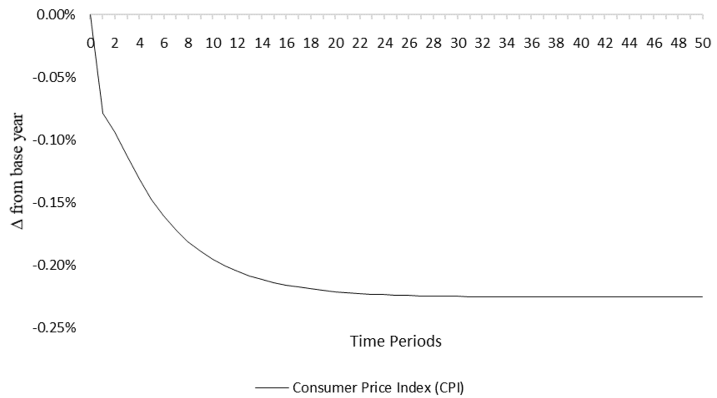


Figure 6.8: Scenario 5: Change in CPI (% change)
Source: Author's Illustration

6.4.2 Scenario 6: A calibrated increase in alcohol-associated labour productivity alongside an increase in alcohol duties

As seen in Scenarios 3 and 4, an increase in the duty on alcohol in the off-trade and on-trade sectors could have negative impacts on output, employment and GDP in the economy in the long run. The short-run economic impacts were found to be negative as well. This was found to be true under two alternative assumptions of government spending – Fixed real government spending and recycling of raised taxes by the Scottish Government. Thus, these scenarios find that a reduction in alcohol consumption has negative impacts on the economy, which is expected.

Despite this, the results of scenario 5 indicated that increased levels of labour productivity could increase the level of output, employment and GDP in the long run. However, the short-run employment impacts were found to be negative. In the results of Scenario 5, we saw that the level of employment in the long run increases by 4189 FTE, when all of the alcohol-attributable labour productivity is added back to the economy and the raised taxes are spent by the government. When taxes are not spent by the government, this increase in employment, in the long run, is found to be 39 FTE.

In this scenario, we estimate the level of increase in alcohol-associated labour productivity required to offset the negative economic impacts seen in Scenario 4. Further, this calibrated increase in alcohol-associated labour productivity is applied in scenario 3 as well.

In Scenario 4, we find that the level of long-run reduction in employment is expected to be 686 FTE. In Scenario 5, we saw that the level of employment in the long run increases by 4189 FTE, when all of the alcohol-attributable labour productivity is added back to the economy.

We are now able to estimate what level of labour productivity is required to increase the lost output, employment and GDP from reduced alcohol consumption. To find this, we divide the level of fall in the economic indicator in Scenario 4 with the increase in the same indicator in Scenario 5. This number is then multiplied by the total alcohol-associated labour productivity.

Thus, we find that 16.36% of the alcohol-associated labour productivity would be required to offset the fall in long-run employment caused by higher alcohol taxes. This increase amounts to an increase of 0.0692% of total labour productivity. We should expect positive impacts on output and GDP, and no net impact on employment in the long run.

Table 6.11 shows that an increase in alcohol-associated labour productivity by 16.36% would increase employment by 686 FTE, and have positive long-run impacts on the economy. When this is applied simultaneously with scenario 4, the results show no change in overall employment in the long run, while GDP and output increase (Table 6.12). However, it should be noted here that although the level of employment remains the same in the long run, there are sectoral impacts. The alcohol consumption sectors do see reductions, while alternative sectors see increases in employment, and indeed, output (figures 6.13, 6.14).

Variable	Fixed Government Spending		Recycled Government Spending	
	Short-run	Long-run	Short-run	Long-run
Output (£m)	-17.29	-118.21	-7.02	-68.58
Employment (FTE)	-241	-1189	-80	-686
GDP (£m)	-14.18	-71.72	-6.80	-41.61

Table 6.10: Scenarios 3 and 4: Short-run v/s Long-run change in Output, Employment and GDP

Variable	Fixed Government Spending		Recycled Government Spending	
	Short-run	Long-run	Short-run	Long-run
Output (£m)	75.12	152.80	81.91	204.70
Employment (FTE)	-408	5	-298	686
GDP (£m)	42.25	86.99	45.38	117.94

Table 6.11: 16.36% increase in alcohol-associated labour productivity: Short-run v/s Long-run change in Output, Employment and GDP

Variable	Fixed Government Spending		Recycled Government Spending	
	Short-run	Long-run	Short-run	Long-run
Output (£m)	57.82	34.48	74.90	136.06
Employment (FTE)	-649	-1184	-378	0
GDP (£m)	28.07	-15.23	38.59	76.31

Table 6.12: Scenario 6: Simultaneous increase in alcohol taxes and labour productivity: Short-run v/s Long-run change in Output, Employment and GDP

A similar analysis is conducted for scenario 3 as well. When the same alcohol-associated labour productivity uplift of 16.36% is applied under the assumption that the government spending stays fixed, we find that the level of long-run reduction in GDP is expected to be £86.99m. The level of employment is also seen to rise by 5 FTE.

Thus, when the uplift in labour productivity is considered simultaneously to an increase in alcohol duty, the results show a fall in employment and GDP in the long run. It is clear from the results in table 6.12 that an increase in alcohol-associated labour productivity of 16.36% is not sufficient to overcome the negative impacts on the economy. Increased government spending of raised taxes alongside an increase in labour productivity is key to overcoming the negative impacts of higher alcohol taxes.

In terms of dynamics, in period 1, a sharp increase in GDP is noted (figure 6.9). This increase in GDP is attributed to increases in consumption, investment, government consumption and increased net exports. An increase in the level of household consumption (figure 6.14) and an increase in the level of investment (figure 6.15) are noted. Since there is a reduction in the household demand for alcohol, we see that alcohol household demand falls in the alcohol off-trade and on-trade sectors. However, there is an increase in the level of consumption of alternative goods from the wholesale, retail and trade sector, as well as other service sectors.

An increase in employment is noted in the level of employment in period 1 as the labour demand increases. The labour supply is also seen to increase through higher inward migration. This increase in employment means that the nominal wages rise since there is a higher demand for labour in the market. However, a steep reduction is also seen in the CPI. This reduction in CPI could be attributed to increased levels of household demand. Therefore, firms in some sectors can produce a higher level of output, thus reducing prices in the economy. The implication here is that as real wages are seen to rise, they allow for household consumption to increase in period 1 as compared to the base year.

Post period 1, we see a gradual but slight decline in GDP from period 2, before stabilizing. This reduction in GDP is attributed to a reduction in household consumption and investment. A reduction in the level of employment is sustained, and this reaches base-year levels in the long run. The reduction in the level of employment is due to a fall in real wages. The CPI also increases slightly but remains below base-year levels.

Variable	Fixed Government Spending		Recycled Government Spending	
	Short Run	Long Run	Short Run	Long Run
GDP	0.023%	0.012%	0.031%	0.061%
Employment	-0.028%	-0.052%	-0.017%	0.000%
Output	0.025%	0.015%	0.032%	0.059%
Household Consumption	-0.022%	-0.025%	-0.007%	0.005%
Investment	0.069%	0.013%	0.109%	0.051%
Government Spending	0.000%	0.000%	0.056%	0.095%
Exports	0.052%	0.054%	0.032%	0.071%
Imports	-0.025%	-0.026%	0.003%	-0.001%
Real Wages	-0.050%	0.000%	-0.029%	0.000%
Consumer Price Index	0.007%	0.011%	0.005%	-0.009%

Table 6.13: Scenario 6: Short-run and Long-run macroeconomic impacts (%)

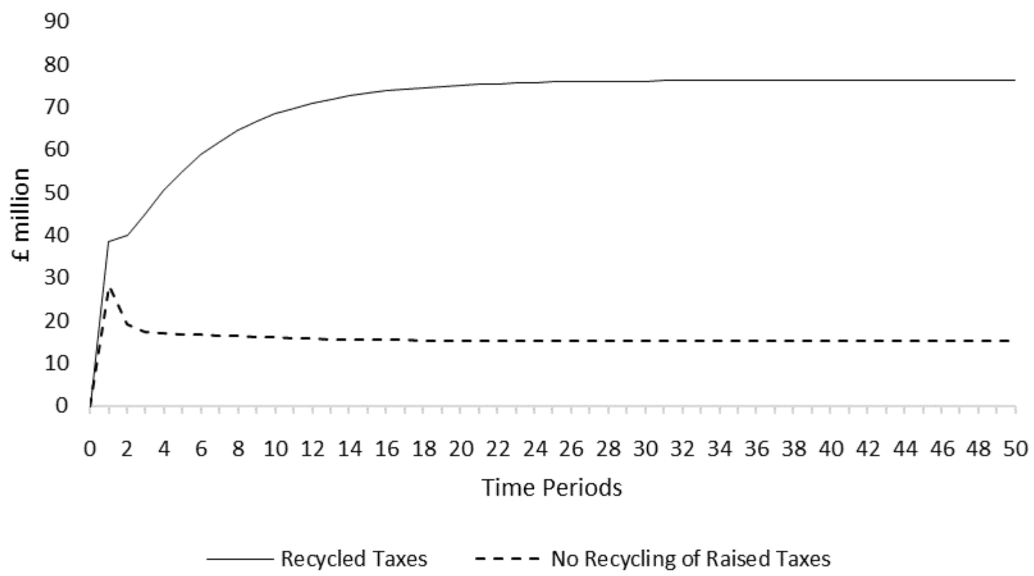


Figure 6.9: Scenario 6: Change in GDP (£m)
Source: Author’s Illustration

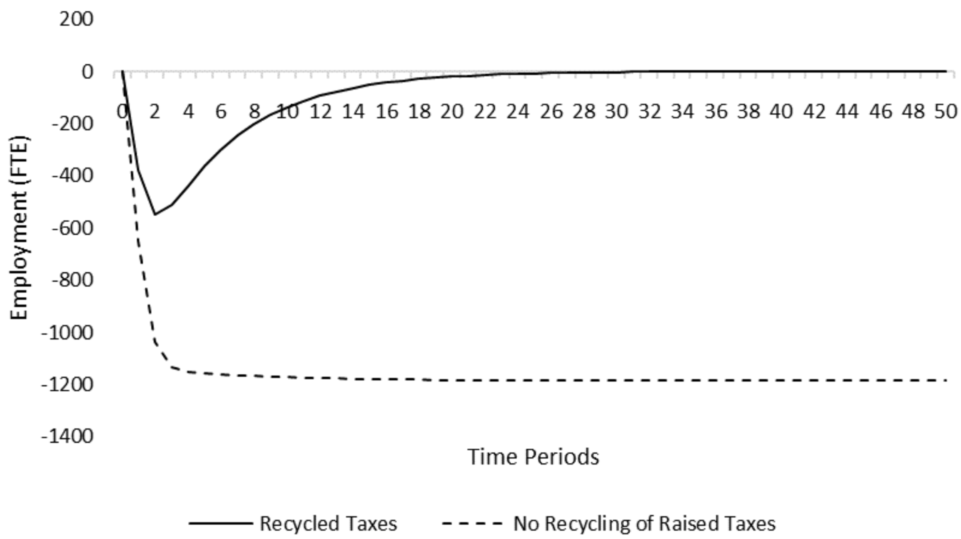


Figure 6.10: Scenario 6: Change in employment (FTE)
Source: Author’s Illustration

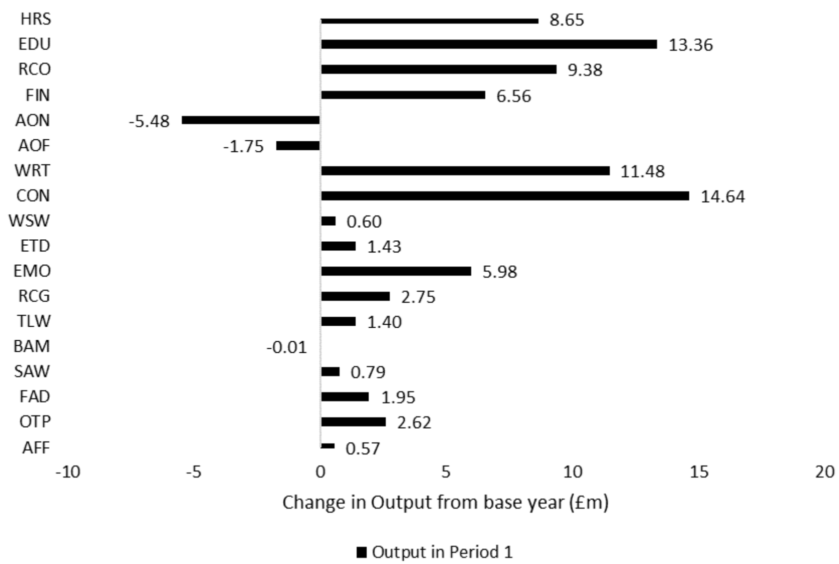


Figure 6.11: Scenario 6: Sectoral Change in output from base period in period 1 (£m)
Source: Author's Illustration

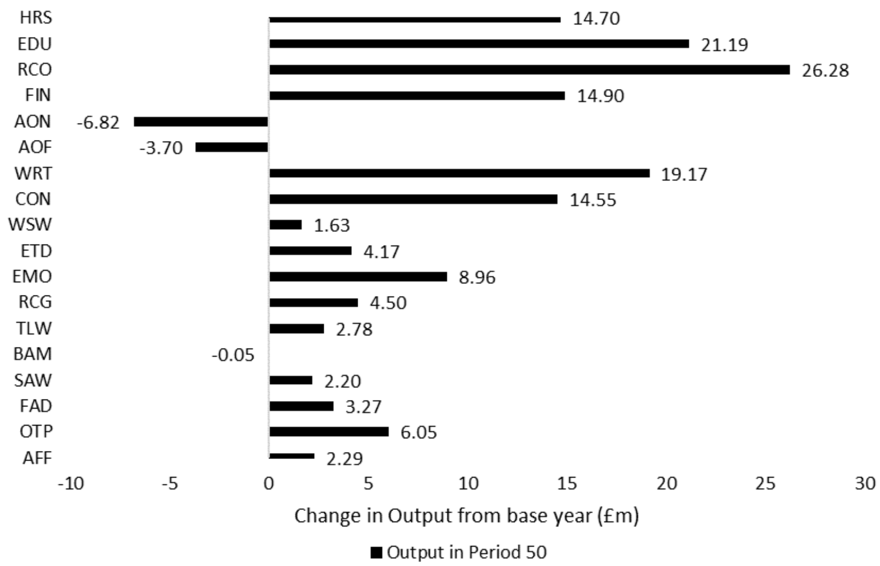


Figure 6.12: Scenario 6: Sectoral Change in output from base period in period 50 (£m)
Source: Author's Illustration

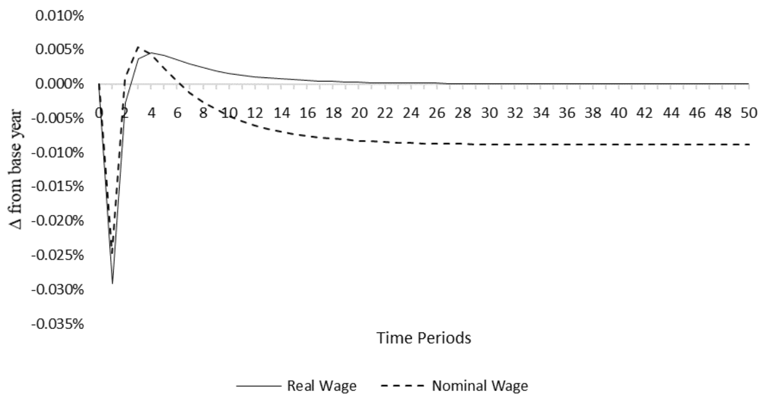


Figure 6.13: Scenario 6: Change in real and nominal wages (% change)
Source: Author's Illustration

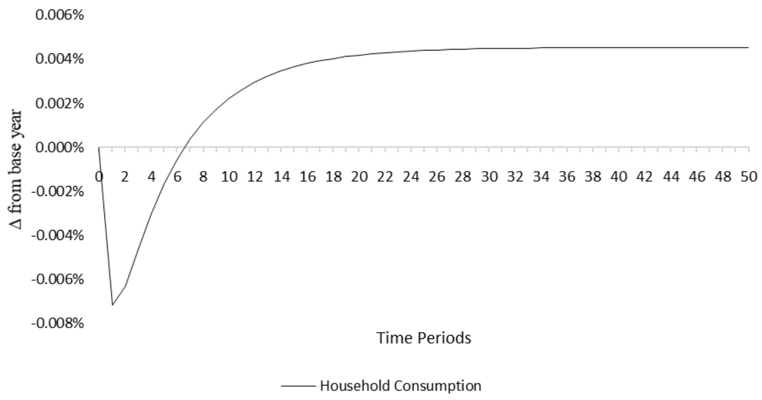


Figure 6.14: Scenario 6: Change in household consumption (% change)
Source: Author's Illustration

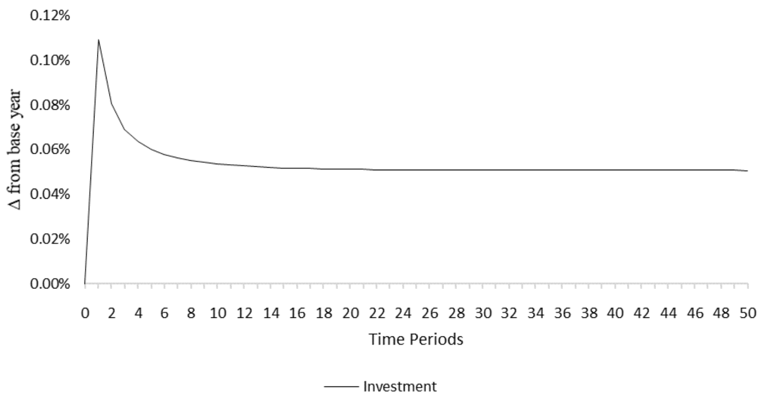


Figure 6.15: Scenario 6: Change in investment (% change)
Source: Author's Illustration

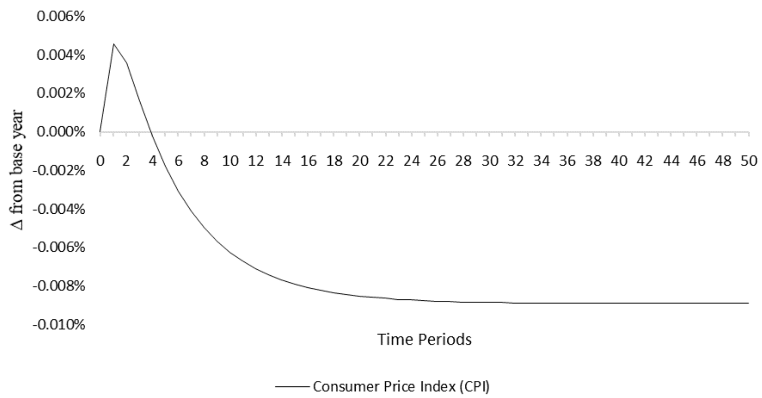


Figure 6.16: Scenario 6: Change in CPI (% change)
Source: Author's Illustration

6.5 Further analysis and discussion of results

The results reported in sections 5.6 and 6.4 show the economic impacts of reduced levels of alcohol consumption through higher taxes and increased level of labour productivity respectively.

It was clear from scenarios 3 and 5 that it is not possible to offset the negative long-run gross impacts of an increase in alcohol duty through alcohol-associated labour productivity. However, since the gross impacts assume fixed government spending, these results are not realistic. This assumption is relaxed by allowing the Scottish Government to make all spending decisions in scenarios 4 and 6.

Comparative results across Scenarios 3, 4 and 6 are presented in Table 6.14 below. These results denote an increase in the level of alcohol duties.

The results find that accounting for alcohol-associated labour productivity within the AMOS framework, the GDP of the economy increases by £38.59m in the short-run. The long-run impact on GDP is found to be £76.31m. The level of employment is found to decrease in the economy by 378 FTE in the short-run. The level of output is also expected to rise by £74.90m in the short-run, and £136.06m in the long-run. Thus, the increased labour productivity has positive impacts on the overall long-run output, employment and GDP of the economy.

Model	Output (£m)	Employment (FTE)	GDP (£m)
Scenario 5: Increased alcohol-associated labour productivity (Gross)			
Short-run	457.02	-2501	256.88
Long-run	933.70	39	531.32
Scenario 5: Increased alcohol-associated labour productivity (Net)			
Short-run	498.74	-1828	276.23
Long-run	1251.39	4189	720.78
Scenario 6: Gross Impacts with a labour productivity boost			
Short-run	57.82	-649	28.07
Long-run	34.48	-1184	-15.23
Scenario 6: Net Impacts with a labour productivity boost			
Short-run	74.90	-378	38.59
Long-run	136.06	0	76.31

Table 6.14: Headline Results: Economic impacts of Scenarios 5 and 6

6.6 Sensitivity Analysis

As was previously mentioned, the WHO (2009) recommends the use of CGE models in the macroeconomic analysis of health issues, but further states that the assumptions made by such models should be tested for sensitivity. The key assumptions that were made in the analysis of this chapter were the use of a forward-looking variant of the model and allowing for migration of labour within the economy. In line with the recommendations of WHO (2009), we test these assumptions for sensitivity in this section.

6.6.1 Myopic v/s Forward-Looking

The short-run responses of using an alternative choice of a myopic model show that while the economy reacts in a very similar way to the results seen in the forward-looking model, there are minor differences in the GDP, employment and output. The results of the myopic model are slightly more pessimistic, and this is in line with the expectation (Lecca et al., 2013). As the actors have policy foresight in the forward-looking model, they are able to adjust and circumvent some negative impacts. The change in employment is seen to be a fall of 398 FTE in the myopic model, compared to 378 FTE in the forward-looking model.

Beyond the short-run, it is noted the level of GDP continues to rise in both cases, and this converges over the long run. Similarly, the level of employment begins to recover and converges over the long-run to stabilise at no change from base-year levels. The results of the sensitivity analysis show that the choice of model will have some minor impacts on the short-run results. However, the long-run results of the myopic and forward-looking model converge (Lecca et al., 2013).

Variable	Myopic		Forward-Looking	
	Short-run	**Long-run**	**Short-run**	**Long-run**
Output (£m)	73.26	136.06	74.90	136.06
Employment (FTE)	-398	0	-378	0
GDP (£m)	37.83	76.31	38.59	76.31

Table 6.15: Sensitivity Analysis: Short-run v/s Long-run change in output, employment and GDP – Myopic v/s Forward-Looking

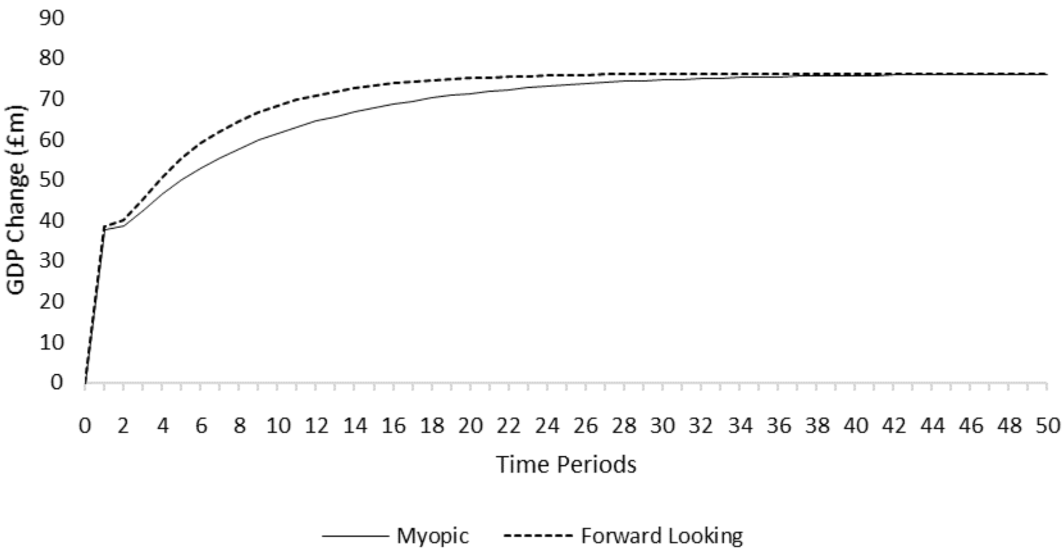


Figure 6.17: Sensitivity analysis: GDP – Myopic v/s Forward-Looking (£m)
Source: Author's Illustration

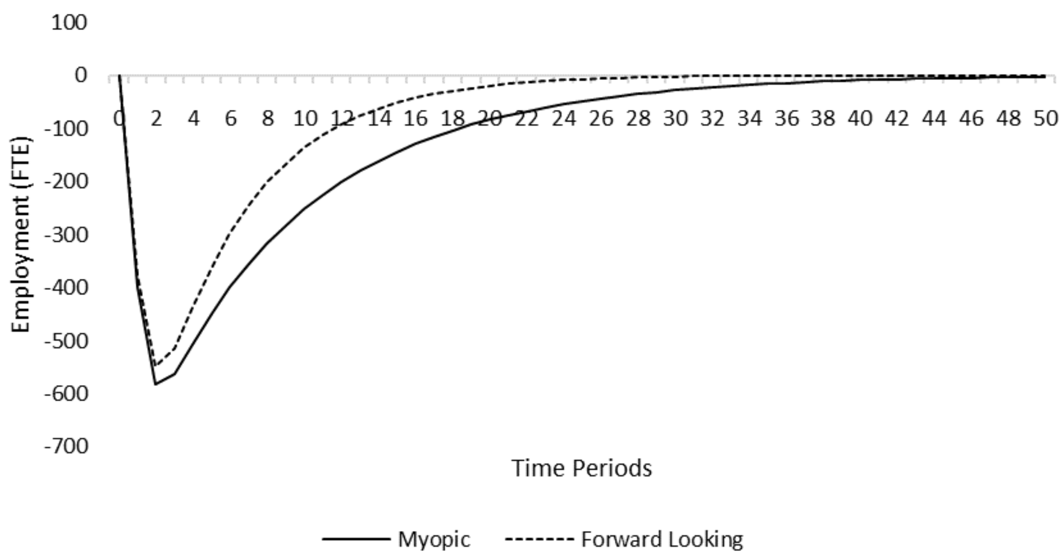


Figure 6.18: Sensitivity analysis: Employment – Myopic v/s Forward-Looking (FTE)
Source: Author's Illustration

6.6.2 Migration v/s No Migration

The migration of labour in the economy can also have an impact on the results, as the composition of the labour market can change due to this. While this migration is allowed within the model used in this chapter, we test this assumption for sensitivity. Keeping the labour market fixed at base year levels allows us to do so.

As is expected, in the short-run, there is no change between allowing for migration and not allowing for it. There is a fall in the level of GDP in the economy, along with a falling level of total output, due to reductions in alcohol consumption sectors. This has a knock-on impact on the real wages in the economy which rise, making it attractive to external migrants, and there is an increase in labour supply.

As there is higher competition for labour, and there is an over-supply in the labour market with falling levels of employment, the level of real wage reduces steeply as compared to the case of no migration. This reduction in the real wage is accompanied by a fall in the labour supply in the economy. In the presence of migration, the labour supply starts to recover, as there is an exodus of labour due to low real wages. In all, when migration specification is used, it is seen that the wages correct back to base-period levels, by changing the level of labour supply.

Variable	Migration		No Migration	
	Short-run	Long-run	Short-run	Long-run
Output (£m)	-7.02	-68.58	-7.02	-26.60
Employment (FTE)	-80	-686	-80	-194
GDP (£m)	-6.80	-41.61	-6.80	-17.56

Table 6.16: Sensitivity Analysis: Short-run v/s Long-run change in output, employment and GDP – No Migration v/s Migration

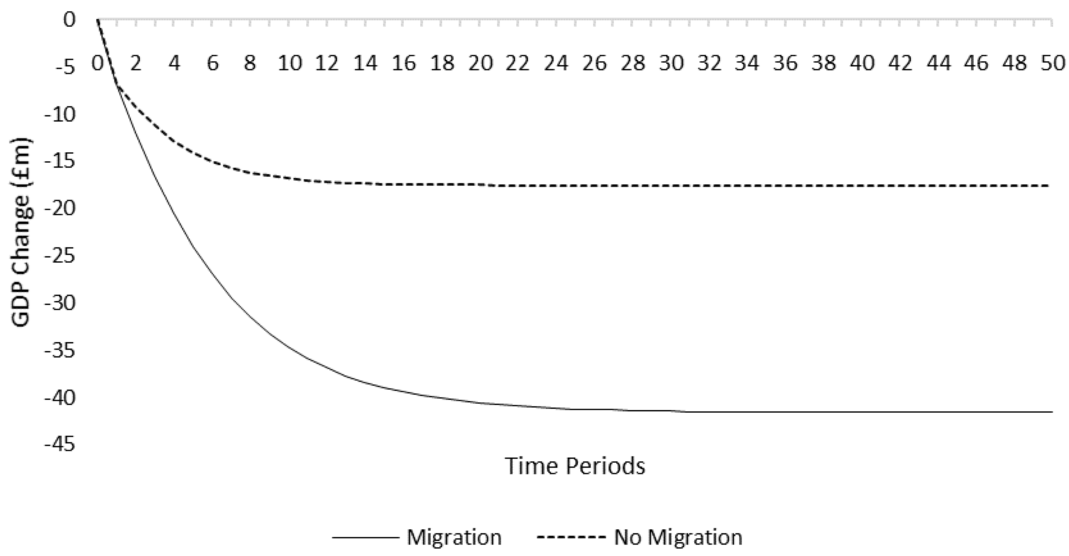


Figure 6.19: Sensitivity analysis: GDP – Migration v/s No Migration (£m)
Source: Author's Illustration

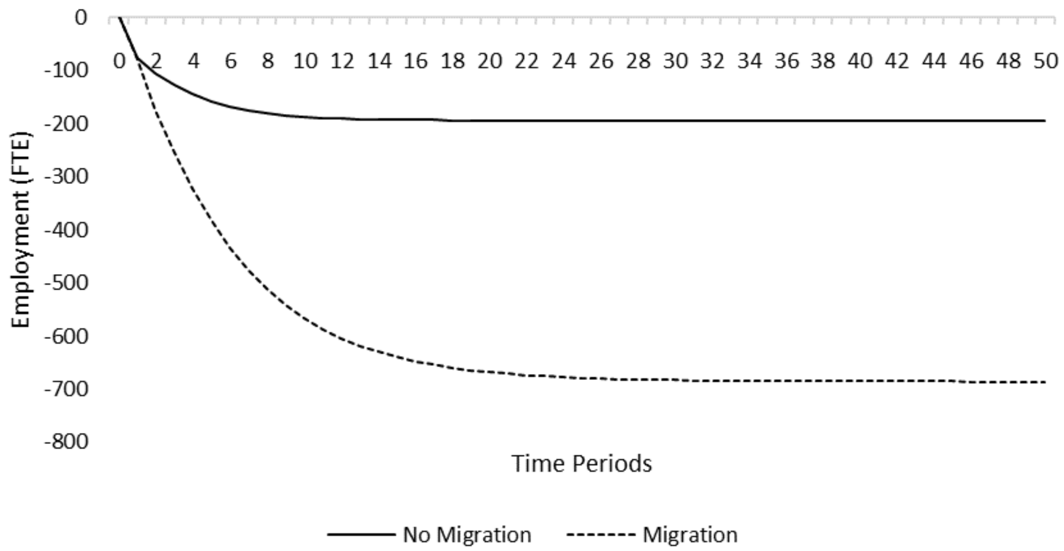


Figure 6.20: Sensitivity analysis: Employment – Migration v/s No Migration (FTE)
Source: Author’s Illustration

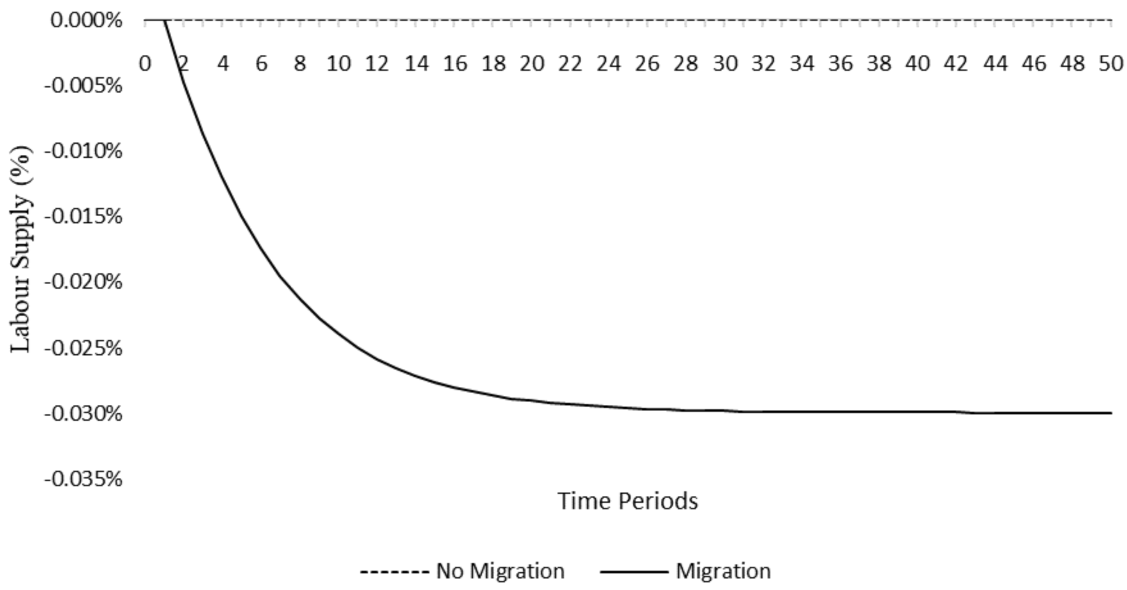


Figure 6.21: Sensitivity analysis: Labour Supply – Migration v/s No Migration (%)
Source: Author’s Illustration

Overall, it is noted that the choice of model between myopic and forward-looking variants does not have large differences in the aggregate results. However, allowing for the migration of labour shows more negative results, as the economy has more supply of labour than it requires. The employment impacts of not allowing for migration are less negative, compared to the alternative assumption.

6.7 Conclusions

In this chapter, a CGE model, more specifically the AMOS model, was used to incorporate the health side implications of alcohol consumption. The literature in chapter 2 pointed towards the double dividend of alcohol taxes – to reduce alcohol consumption along with offsetting the negative externalities of misuse of alcohol. This chapter extended the use of CGE models from chapter 5 and incorporated the second dividend by taking into consideration a negative externality of alcohol consumption, which is a loss in labour productivity. Thus, the relationship between health and labour productivity incorporated the health impacts of alcohol misuse. It was found that alcohol consumption reduces labour productivity, and the economic costs associated with loss in economic productivity were calculated. This labour productivity was then used in the AMOS model to incorporate the health impacts into the economic analysis.

The chapter started with assessing the social costs of alcohol consumption, specifically the costs associated with loss in labour productivity. It was found that there are two main economic costs associated with alcohol consumption – absenteeism and presenteeism.

The use of CGE models to assess the macroeconomic impacts of health problems has been previously done before. While this literature is limited, it is an evolving application of CGE models. This chapter was able to extend the literature reviewed and showed that the use of labour productivity can be used to model improved health consequences. Thus, the application of this method to the case of alcohol consumption is novel, and this method can be further extended to analyse other sin goods as well. This is because it was also found that labour productivity has been previously used to assess various sin goods such as SSBs and tobacco.

Adaptation of the method used by the Scottish Government (2010) found that the estimated total cost to the economy of these losses to the Scottish society was £312.9m. It was thus, gathered that reducing alcohol consumption could offset some of these costs. A literature review on the relationship between health and productivity found a link between the two. It was concluded from here that when employees suffer from ailments, it has an impact on their workplace productivity.

The use of labour productivity in the CGE model was then emphasised. Both absenteeism and presenteeism were converted into labour productivity shocks, and this combined shock was labelled as "alcohol-associated labour productivity". The introduction of this shock into the CGE model was sectorally disaggregated since different sectors have varied levels of labour productivity and alcohol consumptions.

The model setup was therefore set out, and the same specifications of the model used in chapter 5 were used. This allowed for the comparison of results across the simulations. Three scenarios were set out – Scenario 5 isolated the impact of the increased alcohol-associated labour productivity. Scenario 6 analysed the increased labour productivity in combination with a fall in household demand for alcohol under alternative assumptions of fixed and recycled government spending. It was found that an increase in the level of alcohol-associated labour productivity would have positive long-run impacts on the economy, even as the short-run impacts were found to be negative.

The initial results of Scenario 6 assumed fixed government spending. Due to this assumption, it was found that the alcohol-associated labour productivity, which accounts for 0.423% of total labour productivity, would not be sufficient to offset the negative long-run economic impacts of higher alcohol duties. However, since the assumption of fixed government spending was found to be rigid, this was relaxed, in line with Wada et al. (2017) to allow local governments to make the spending decisions.

Thus, it was found that an increase in the level of alcohol-associated labour productivity of 16.36% would be sufficient to overcome the negative employment impacts of reduced alcohol consumption, while smaller shocks would be enough to offset the negative output and GDP impacts.

Since the increase in the level of labour productivity required to offset the negative economic impacts of higher alcohol duties is found to be lesser than the total alcohol-associated labour productivity, it is concluded that there exists a case where the negative economic impacts can be overcome through increased labour productivity.

Furthermore, comparing the initial estimates of absenteeism and presenteeism calculated using the methodology of the Scottish Government (2010), we find that increases in alcohol-associated labour productivity would increase Scottish GDP by as much as £276.23m in the short-run and £720.78m in the long-run, as compared to the previously calculated £312.9m. Apart from this we also find that increasing labour productivity would increase the level of employment in the economy in the long-run by 4189 FTE while reducing the employment in the short-run by 1828 FTE. The use of the CGE model in estimating these impacts provides a more comprehensive set of results and could be used in future estimates of calculating losses in productive capacity.

To completely offset the negative economic impacts of reduced alcohol consumption, it is found that alcohol-associated labour productivity in the economy would have to increase by 16.36% or 0.0692% of total labour productivity. This increase would mean a reduction in employment in the alcohol service sectors, but higher demand and output from other sectors would offset this reduction in employment.

In all, this chapter was able to find the health side economic impacts of increased alcohol consumption. It was found that increased labour productivity has the potential to offset the negative impacts of higher alcohol duties. It is therefore shown that while analysing goods such as alcohol, where negative externalities exist, within a macroeconomic framework such as a CGE model, it is essential to consider the economic impacts of the reduction in these negative externalities as well. The applicability of this finding could help in further analysis of similar good such as tobacco and sugar. In policy terms, increased labour productivity is thus found to overcome the negative macroeconomic impact of higher alcohol duties. Economies attempting to reduce high levels of consumption may use this positive economic impact of increased labour productivity to justify their policies.

Chapter 7: Conclusions and Future Work

A key commitment of the Scottish Government is to promote healthier attitudes towards alcohol consumption and boost the productivity of the Scottish labour market through reduced absenteeism (Scottish Government, 2019a). The level of consumption of alcohol in Scotland is over 30% above the recommended maximum level of consumption by the NHS (2018a). Thus, assessing the macroeconomic impacts of reduced alcohol consumption and increased alcohol-associated labour productivity is the key aim of this thesis.

A reduction in alcohol consumption will have macroeconomic impacts on the Scottish economy. Since the food and drink sector is one of the "Key sectors" of the Scottish economy, these macroeconomic impacts need to be assessed in detail to formulate appropriate policies to reduce alcohol consumption.

The main contribution of this thesis is the setup of a modelling framework to assess the macroeconomic impacts of taxes on sin goods. This contribution is made through the use of an IO and then a CGE model (AMOS) to evaluate the macroeconomic impacts of one such sin good, which is alcohol. The use of the AMOS framework is extended to include the macroeconomic impacts of improved health outcomes resulting from reduced alcohol consumption.

The case of Scotland is used in this study since the levels of alcohol consumption far exceed the recommended maximum level (NHS, 2018). The case of Scotland is further interesting in academia due to its complicated devolved status which means that policy options to curb alcohol consumption are limited. Innovative policies such as MUP have been enacted to circumvent the complications of devolution.

In the current literature, the use of CGE models to study the macroeconomic impacts of sin goods with the incorporation of positive health outcomes has not been implemented before. A selected few studies have used an IO model to analyse the macroeconomic impact of alcohol consumption (Connolly et al., 2019), though none have been conducted for Scotland. The REMI model has been previously used to find economic impacts of increased alcohol duty (Wada et al., 2017), but these are limited to short-run employment impacts.

Effects	Output (£m)	Employment (FTE)	Income (£m)	GDP (£m)
Scenario 1: Fall in household alcohol consumption				
Gross Impacts	-437.39	-4600	-90.39	-157.74
Net Impacts	-64.84	-1785	-8.39	2.95
Scenario 2: Increase in alcohol duty				
Gross Impacts	-66.89	-738	-13.70	-23.80
Net Impacts	179.20	1489	55.51	81.35

Table 7.1: Headline results of Chapter 4: The use of IO models in analysing alcohol policy

Model	Output (£m)	Employment (FTE)	GDP (£m)
Scenario 3: Gross Impacts of an increase in alcohol duty			
CGE – Short-run	-17.29	-241	-14.18
CGE – Long-run	-118.21	-1189	-71.72
Scenario 4: Net Impacts of an increase in alcohol duty			
CGE – Short-run	-7.02	-80	-6.80
CGE – Long-run	-68.58	-686	-41.61
Scenario 6: Gross Impacts with a calibrated labour productivity boost			
CGE-LP – Short-run	57.82	-649	28.07
CGE-LP – Long-run	34.48	-1184	-15.23
Scenario 6: Net Impacts with a calibrated labour productivity boost			
CGE-LP – Short-run	74.90	-378	38.59
CGE-LP – Long-run	136.06	0	76.31

Table 7.2: Headline results of Chapters 5 and 6: The use of CGE models in analysing alcohol policy

In this thesis, seven different scenarios were modelled. In Chapter 4, An IO model was used to find the impacts of a reduction in on-trade and off-trade alcohol consumption (Scenario 1) and an increase in alcohol duty (Scenario 2).

In Chapter 5, a CGE model was used to find the impacts of higher alcohol duty in gross terms (Scenario 3) and net terms (Scenario 4). The net impacts were found through recycling tax collections through the local government.

In Chapter 6, alcohol-associated labour productivity was found to be 0.423% of the total labour productivity in Scotland (Scenario 5). It was found that only 0.0692% of total labour productivity would be required to offset the negative economic impacts in the net case (Scenario 6), while gross impacts cannot be overcome through increase alcohol-associated labour productivity.

Thus, it was seen that when the local government recycled higher alcohol duties, the economic impacts of the consequent reduction in alcohol consumption could be positive, given increases in labour productivity.

7.1 Summaries and contributions of chapters

Chapter 2 is an analysis of the literature on decentralisation and sin taxes. The history and present status of the devolution in Scotland is then discussed. This analysis finds that limited fiscal powers are devolved to Scotland and that the Scottish Government remains committed to devolving alcohol taxes in the future (Scottish Government, 2010).

The literature on sin taxes asserts that sin taxes have a double dividend – They help reduce consumption of the sin good, and they offset the costs of negative impacts risen from their consumption. There is a consensus in the literature that sin taxes that are collected should be earmarked to offset the negative costs and should not be used as a revenue-generating tax.

Alcohol consumption statistics for Scotland and England & Wales are also compared. It is found that there is a wide gap in the level of consumption between the regions. Since alcohol duties are set and collected by the UK government, the Scottish Government has limited fiscal tools to manage the consumption in the region. The main contribution of this chapter is that it sets out the context of reducing alcohol consumption in Scotland as a subnational issue in the United Kingdom.

Chapter 3 elucidates the role of alcohol in the Scottish economy. Within this chapter, a historical analysis is conducted on the consumption levels in Scotland and the policies used to tackle them. This analysis is useful to understand that the high level of alcohol consumption is not a new issue. The present set of policies in Scotland in place to reduce alcohol consumption are also discussed.

A primary contribution of chapter 3 is that it defines the alcohol production and consumption sectors in Scotland and shows that the alcohol sector is very important to the Scottish economy. The level of consumption and production in Scotland is very high, contributing to the off-trade and on-trade alcohol sectors. It is found that the industry is an important employer in the economy. Its contribution to taxes and government budgets is also of importance. Scotch Whisky is also seen as one of the biggest non-oil exports from the Scottish economy. In all, this analysis finds that the alcohol sector is important in the Scottish economy.

Chapter 4 employs the use of the IO tables as an economic model. A historical background shows that IO tables have been extensively developed and used to analyse economic impacts. Their extensive use is discussed in the assessment of economic policy. The structure and process of converting an IO table into an IO model are extensively explained within this chapter.

The use of an IO model is employed in assessing two main scenarios, in line with Connolly et al. (2019). The results of these scenarios show that the economy would sustain negative impacts given a reduction in alcohol consumption. However, these scenarios, when simulated with the inclusion of reallocation of consumer and government spending, show small but positive impacts on the GDP of the economy. The level of employment is found to remain negative upon simulating switching of spending to alternative sectors. However, when government spending is recycled, the results show a positive net impact on employment.

The assumption of a passive supply-side has a bearing on the usefulness of IO models in the analysis of consumption of sin goods. Due to this assumption, IO models cannot assess the changes in prices, and thus the reallocation of spending to other sectors of the economy cannot be done scientifically.

Instead, an assumption is made that all of the household spending reduced from the alcohol sectors is reallocated to other sectors in proportions of their original consumption.

The contribution of this chapter is the incorporation of reallocation of household spending reduced from alcohol consumption sectors to other sectors within an IO framework. While this has been done before by Connolly et al. (2019) for the United Kingdom, an IO model has not been employed to assess the impacts of alcohol consumption in Scotland.

Chapter 5 extends the analysis conducted in chapter 4 through the use of a CGE model. The chapter begins with assessing different models that have previously been used to analyse changes in the consumption of sin goods. The recommendations of the WHO (2009, 2010) are taken into consideration, and the use of a CGE model is found to be optimal for the analysis we intend to conduct. Within this literature, a key paper identified is Wada et al. (2017). This paper analyses the economic impacts of reduced alcohol consumption, driven through an increase in alcohol duty. This analysis is replicated in Chapter 5.

A description of CGE models is explained, where the general structure and components of CGE models are discussed. It is seen that the structure of CGE models may range from simple production structures to more complex production functions. In particular, the AMOS model is used in this analysis and the components of this model are then discussed. Since the AMOS model has an active supply side, the model can endogenously determine wages and prices. It is seen that the AMOS model offers several optimisation choices. The appropriate choices are made and justified, along with the statement of the modelling strategy. The scenarios modelled are in line with Wada et al. (2017), and represent gross and net impacts of an increase in alcohol duty.

The gross results show that an increase in alcohol duty by 5p a unit would reduce the GDP of the Scottish economy by £71.72m in the long-run, while employment losses are noted to be 1189 FTE. When the increased tax revenues are recycled through Scottish Government spending, the net impacts are more optimistic than the gross case but remain negative in the long-run. Short-run impacts show a decline in employment by 80 FTE, while long-run losses in employment are noted to be 686 FTE.

The main contribution of this chapter is that it uses a CGE model in analysing a reduction in alcohol consumption in Scotland through increased alcohol duties. This extends the analysis conducted by Wada et al. (2017) for Scotland. The size of the increase in alcohol duties used is an increase of 5p per unit of alcohol, which amounts to about a 15.97% increase in alcohol taxes in Scotland.

Chapter 6 further extends the analysis conducted in chapter 5 by the incorporation of the positive health outcomes of reducing alcohol consumption. Within the chapter, the economic consequences of poorer health are first analysed. It is found that reduced labour productivity is an economic loss that is associated with poor health. The two main types of losses are found to be presenteeism and absenteeism. A study by the Scottish Government (2010) that assesses the economic losses of alcohol misuse in Scotland is replicated for 2014, and it is found that they also use presenteeism and absenteeism to assess the losses to the economy.

Within the review of the literature surrounding absenteeism and presenteeism, two common problems are noted in the quantification of these costs: one, very limited data is available for presenteeism, and all the available data is self-reported; secondly, the assumption that all of the labour productivity associated with absenteeism is lost. Since the only available data for presenteeism in the UK is a survey commissioned by the British

Government, this study is used. To resolve the assumption of complete loss in output associated with absenteeism, a study of compensation mechanisms at the workplace for the UK is used to scale the absenteeism associated labour productivity shock.

The results for chapter 6 show that alcohol-associated labour productivity accounts for 0.423% of the total labour productivity. Under the assumption of local government spending, this level of increase in labour productivity would reduce employment by 1828 FTE in the short-run, but increase the long-run employment by 4189 FTE. It is also noted that given a reduction in alcohol consumption, only a portion of this alcohol-associated labour productivity would increase. Since the short-run impacts of an increase in alcohol duty are positive, the short-run losses due to increased labour productivity could be offset.

The amount of alcohol-associated labour productivity to offset the negative impacts of an increase in alcohol duty is then found. We show that 16.36% of the alcohol-associated labour productivity would be required to completely offset the negative long-run impacts of higher alcohol duties. This is equivalent to 0.0692% of the total labour productivity in Scotland. In all, alcohol-associated labour productivity is sufficient to offset any economic losses caused by higher alcohol duties, if the local government recycles the additional tax revenues through higher spending.

The key contribution of chapters 5 and 6 is that a CGE model is used to assess the macroeconomic impact of reduced alcohol consumption, and the positive health outcomes of this reduction are also incorporated with the framework. To our knowledge, the use of CGE models has not been previously employed to assess changes in GDP and employment owing to reduced consumption of sin goods alongside positive outcomes of a reduced negative externality. While it is acknowledged that alcohol consumption has several externalities associated with it, these can be incorporated into a similar model in the future.

Thus, two overarching contributions of this thesis are that it has explored the macroeconomic impacts of higher alcohol taxes through a variety of models and that it has incorporated the positive health outcomes of reduced alcohol consumption into a framework for analysing the macroeconomic impacts. Apart from these contributions, the wider impact of this work has shown the usefulness for policymakers and academics to use a CGE model while analysing the macroeconomic impacts of reduced consumption of sin goods, and to incorporate the positive impacts of reduced negative externalities of the sin good being analysed.

7.2 Contributions to Policy and Future Work

While we note the contributions of this thesis, future work that may be conducted in this realm is also noted.

As previously noted, the primary focus of this thesis has been on examining the macroeconomic impacts of reducing alcohol consumption in Scotland. However, the results that have been produced have wider implications in the framing of policy in the realm of sin taxes in Scotland and beyond.

The results showed that an increase in alcohol duty would have negative macroeconomic implications prima facie. These negative impacts would be greatly reduced under the assumption that the collected taxes are spent by the Scottish Government. This points to an important aspect of the role of sin taxes in the economy. Often, such taxes have been viewed as a source of generating revenue by governments across the world. However, it was seen in chapter 2 that the aim of the tax is to reduce the level of consumption of the sin good being taxed. Thus, the focus while framing policy dealing with sin taxes should be squarely on ensuring that the level of consumption is reduced. Government spending of the raised tax is key to ensuring that the economic outcomes of increasing a tax are favourable.

The fiscal policy that has been implemented in Scotland to reduce alcohol consumption, Minimum Unit Pricing, could be analysed through this framework as well. In such a policy, there is an increase in the price of alcohol. However, there is no provision to ensure that the raised revenue can be returned to the economy to ensure higher spending. This could be done by ensuring that the raised revenue is spent in the regional economy as higher investments, or through other channels. However, the results of this thesis show that unless there is a spending boost to the economy, raising sin taxes could have negative macroeconomic implications.

Further from government spending, this thesis showed that the negative macroeconomic impacts of higher sin taxes can be overcome through increased health outcomes. This result shows that the aim of the tax is not limited to reduce the consumption of a good, but to further reduce the negative societal consequences that stem from its consumption. While the focus in this thesis has been on the productivity of labour, this concept can be extended to a number of other negative outcomes of consuming sin goods. As an example, the use of alcohol has been shown to have implications for societal issues such as crime, social care systems, education apart from health and productive capacity. Raising a sin tax would also have implications for these other negative societal effects and, indeed, on the economy. The impacts of these must also be studied to ensure that sin taxes are implemented in an appropriate manner to overcome these societal issues. As the analysis of each of the mentioned negative externalities is lengthy and complicated, further research is required to conduct a comprehensive analysis to overcome this limitation of the conducted analysis.

Not just alcohol, but sin taxes on other products such as tobacco and sugar can also be analysed through the modelling scheme suggested in this thesis. The policy implications can be expected to be similar to alcohol, as increased taxes on sugar would reduce the level of consumption of a good in the economy, but the positive health outcomes could overcome the initial negative economic impacts.

From a modelling perspective, the work conducted in this thesis has also pointed to some important avenues of focus for future work. The disaggregation conducted in chapter 4 to add the detail of the on-trade and off-trade alcohol consumption sectors can be further expanded. As seen in chapters 2 and 3, different classes of alcohol are associated with different consumption behaviours. These classes also have different rates of duties applied to them. Should the consumption of these classes of alcohol be disaggregated, the analysis within the IO framework could be extended to find the implications of changes in tax rates by category of alcohol. This analysis would be of interest to policymakers in the setting of alcohol duty rates by categories and inform policies such as uniform volumetric taxation.

The disaggregation could be further extended to the level of alcohol consumption by households. As has been seen in econometric literature on the issue of alcohol consumption, consumption patterns by households differ widely. Certain policies implemented have focussed on reducing the level of harmful alcohol consumption while avoiding trying to penalise occasional and moderate drinkers. One such policy is Minimum Unit Pricing. Within the framework used in this thesis, there is the scope of such a disaggregation to be carried out in order to find the impacts of such policies and to further device policies that are able to do this.

Additionally, the analysis conducted in chapter 6 relies on limited data for presenteeism from 2004. Should new and updated data be available in this context, the assessment of the impact of presenteeism could be improved in quality. This is increasingly important since a lot of advancements have been made in technological terms at workplaces over the last decade that may boost workplace productivity and, thus, reduce the occurrence of presenteeism. As with presenteeism, new and more reliable data is required for the scaling of absenteeism shocks to adjust for compensation mechanisms in the workplace. This could also be incorporated into the analysis.

The Scottish Government (2010) finds that apart from losses to productive capacity, several other costs are associated with alcohol consumption. These include the cost of crime and policing, drink driving costs and loss of life due to alcohol-related health problems. While it was beyond the scope of this thesis to incorporate all of these costs into a CGE framework, doing so could provide a deeper insight into the macroeconomic implications of reducing alcohol consumption.

Since one of the contributions of this thesis was to create a framework for future macroeconomic impact analyses of sin goods, the framework was used to analyse other sin goods such as SSBs and tobacco. A larger range of literature exists on the impacts of SSBs as sugar taxes are currently being implemented across different countries. Comparing the results from a CGE framework to other models used to study macroeconomic impacts could help in furthering the modelling literature on sin goods.

Apart from the above-mentioned work that is possible within the modelling framework suggested within this thesis, additional analysis of specific policies can greatly help policymakers in better understanding economic consequences. This includes analysing policies such as Minimum Unit Pricing (MUP) which essentially creates a price floor for the sale of alcohol, as well as Uniform Volumetric Taxation (UVT) where the tax rates on specific classes of alcohol are standardised. The analysis of policy is especially possible since MUP has been enacted in 2018, and IO tables for this year alongside MESAS data on the level of alcohol consumption in Scotland should be available in the coming years. This could help understand the impact of the policy in Scotland and would help make adjustments to the policy to enhance effectiveness.

Linking health directly into the CGE model through health measures such as Quality-Adjusted Life Years (QALYs) would have greatly enhanced the results to show how changes in alcohol consumption affected the health of the population. This could be carried out in the future to enhance the CGE modelling in the field of healthcare.

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Appendices

Appendix A – List of 101 sectors within the disaggregated IO model

S.No.	Sector's name	SIC Code
1	Agriculture	01
2	Forestry planting	02.1, 02.4
3	Forestry harvesting	02.2-3
4	Fishing	03.1
5	Aquaculture	03.2
6	Coal & lignite	05
7	Oil & gas extraction, metal ores & other	06-08
8	Mining Support	09
9	Meat processing	10.1
10	Fish & fruit processing	10.2-3
11	Dairy products, oils & fats processing	10.4-5
12	Grain milling & starch	10.6
13	Bakery & farinaceous	10.7
14	Other food	10.8
15	Animal feeds	10.9
16	Spirits & wines	11.01-04
17	Beer & malt	11.05-06
18	Soft Drinks	11.07
19	Tobacco	12
20	Textiles	13
21	Wearing apparel	14
22	Leather goods	15
23	Wood and wood products	16
24	Paper & paper products	17
25	Printing and recording	18
26	Coke, petroleum & petrochemicals	19, 20B
27	Paints, varnishes and inks etc	20.3
28	Cleaning & toilet preparations	20.4
29	Other chemicals	20.5
30	Inorganic chemicals, dyestuffs & agrochemicals	20AC
31	Pharmaceuticals	21
32	Rubber & Plastic	22
33	Cement lime & plaster	23.5-6
34	Glass, clay & stone etc	23OTHER
35	Iron & Steel	24.1-3

36	Other metals & casting	24.4-5
37	Fabricated metal	25
38	Computers, electronics & opticals	26
39	Electrical equipment	27
40	Machinery & equipment	28
41	Motor Vehicles	29
42	Other transport equipment	30
43	Furniture	31
44	Other manufacturing	32
45	Repair & maintenance	33
46	Electricity	35.1
47	Gas etc	35.2-3
48	Water and sewerage	36, 37
49	Waste, remediation & management	38, 39
50	Construction	41-43
51	Wholesale - vehicles	45
52	Wholesale - excl vehicles and alcohol	46
53	Alcohol Wholesale	46 (A)
54	Retail - excl vehicles	47
55	Rail transport	49.1-2
56	Other land transport	49.3-5
57	Water transport	50
58	Air transport	51
59	Support services for transport	52
60	Post & courier	53
61	Accommodation	55
62	Accommodation - Alcohol	55 (A)
63	Food & beverage services	56
64	Alcohol service	56 (A)
65	Publishing services	58
66	Film video & TV etc; broadcasting	59, 60
67	Telecommunications	61
68	Computer services	62
69	Information services	63
70	Financial services	64
71	Insurance & pensions	65
72	Auxiliary financial services	66
73	Real estate - own	68.1-2
74	Imputed rent	68.2IMP
75	Real estate - fee or contract	68.3
76	Legal activities	69.1
77	Accounting & tax services	69.2

78	Head office & consulting services	70
79	Architectural services etc	71
80	Research & development	72
81	Advertising & market research	73
82	Other professional services	74
83	Veterinary services	75
84	Rental and leasing services	77
85	Employment services	78
86	Travel & related services	79
87	Security & investigation	80
88	Building & landscape services	81
89	Business support services	82
90	Public administration & defence	84
91	Education	85
92	Health	86
93	Residential care and social work	87, 88
94	Creative services	90
95	Cultural services	91
96	Gambling	92
97	Sports & recreation	93
98	Membership organisations	94
99	Repairs - personal and household	95
100	Other personal services	96
101	Households as employers	97

Appendix B – The mathematical representation of the AMOS model

List of Equations

Prices

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

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

$$PX_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PE_{i,t} \cdot E_{i,t}}{R_{i,t} + E_{i,t}} \quad \textbf{(A.3)}$$

$$PQ_{i,t} = \frac{PR_{i,t} \cdot R_{i,t} + PM_{i,t} \cdot M_{i,t}}{R_{i,t} + M_{i,t}} \quad \textbf{(A.4)}$$

$$CPQ_{i,h,t} = \left(1 + VAT_{i,h,t}\right) \cdot PQ_{i,t} \quad \textbf{(A.5)}$$

$$PIR_{j,t} = \frac{\sum_i VR_{i,j,t} \cdot PR_{j,t} + \sum_i VI_{i,j,t} \cdot \overline{PI}_j}{\sum_i VIR_{i,j,t}} \quad \textbf{(A.6)}$$

$$PY_{j,t} \cdot Y_{j,t} = \left(PR_{j,t} \cdot X_{j,t} - \sum_i VR_{i,j,t} \cdot PR_{j,t} - \sum_i VI_{i,j,t} \cdot PI_{j,t} - \sum_i VM_{i,j,t} \cdot PM_{j,t} \right) - IBT_{i,t} \quad \textbf{(A.7)}$$

$$UCK_t = Pk_t \cdot (ir + \delta) \quad \textbf{(A.8)}$$

$$PC_{h,t} = \frac{\sum_i \overline{QH}_{i,h} \cdot PQ_{i,t}}{\sum_i \overline{QH}_{i,h}} \quad \textbf{(A.9)}$$

$$PGov_t = \frac{\sum_i \left(\overline{QG}_i + \overline{SQG}_i\right) \cdot PQ_{j,t}}{\sum_i \left(\overline{QG}_{i,j} + \overline{SQG}_{i,j}\right)} \tag{A.10}$$

$$w_t^b = \frac{w_t}{(1 + nie)} \tag{A.11}$$

$$w_t^n = \frac{w_t^b}{(1 + it_t + ni_t)} \tag{A.12}$$

$$w_{s,t}^b = \frac{w_{s,t}}{(1 + nie)} \tag{A.13}$$

$$w_{s,t}^n = \frac{w_{s,t}^b}{(1 + it_t + ni_t)} \tag{A.14}$$

$$w_t = \frac{w_{s=skilled,t} \cdot L_{s=skilled,j,t} + w_{s=unskilled,t} \cdot L_{s=unskilled,j,t}}{\sum_j L_{j,t}} \tag{A.15}$$

$$PK_t = \frac{\sum_j PQ_{j,t} \cdot (1 - tk_t)^{-1} \cdot \sum_i KM_{i,j}}{\sum_j PQ_{j,t=0} \cdot (1 - tk_{t=0})^{-1} \cdot \sum_i KM_{i,j}} \tag{A.16}$$

Production technology

$$Y_{i,t} = a_i^{Y^{\sigma_i^z}} \cdot \left(\frac{PX_{i,t}}{PY_{i,t}}\right)^{\sigma_i^z} \cdot X_{j,t} \tag{A.17}$$

$$V_{i,t} = a_{i,j}^{V^{\sigma_i^z}} \cdot \left(\frac{PX_{i,t}}{PQ_{i,t}}\right)^{\sigma_i^z} \cdot X_{i,t} \tag{A.18}$$

$$Y_{i,t} = A(\xi_{i,t}) \cdot \left[\delta_i^k \cdot K_{i,t}^{\varrho_i} + \delta_i^l \cdot L_{i,t}^{\varrho_i}\right]^{\frac{1}{\varrho_i}} \tag{A.19}$$

$$rk_{j,t} = PY_{j,t} \cdot \delta_j^k \cdot A(\xi_{j,t})^{\varrho_j} \cdot \left(\frac{Y_{j,t}}{K_{j,t}}\right)^{1-\varrho_j} \tag{A.20}$$

$$L_{j,t} = \left(A\left(\xi_{j,t}\right)^{\varrho_i} \cdot \delta_j^l \cdot \frac{PY_{j,t}}{w_t}\right)^{\frac{1}{1-\varrho_j}} \cdot Y_{j,t} \quad \textbf{(A.21)}$$

$$L_{j,t} = \left(\left(\beta^{s=skilled} \cdot L_{s=skilled,j,t}\right)^{\rho^{sk}} + \left(\beta^{s=unskilled} \cdot L_{s=unskilled,j,t}\right)^{\rho^{sk}}\right)^{\frac{1}{\rho^{sk}}} \quad \textbf{(A.22)}$$

$$L_{s,j,t} = \left(\beta^s \cdot \delta_j^l \cdot \frac{w_t}{w_{s,t}}\right)^{\frac{1}{1-\rho^{sk}}} \cdot L_{j,t} \quad \textbf{(A.23)}$$

Intermediate Demand

$$V_{i,j,t} = \gamma_{i,j}^{vv} \cdot \left[\delta_{i,j}^{vm} VM_{i,t}^{\rho_i^A} + \delta_{i,j}^{vir} VIR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.24)}$$

$$\frac{VM_{i,j,t}}{VIR_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vm}}{\delta_{i,j}^{vir}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.25)}$$

$$VIR_{i,j,t} = \gamma_{i,j}^{vir} \cdot \left[\delta_{i,j}^{vi} VI_{i,t}^{\rho_i^A} + \delta_{i,j}^{vr} VR_{i,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.26)}$$

$$\frac{VR_{i,j,t}}{VI_{i,j,t}} = \left[\left(\frac{\delta_{i,j}^{vr}}{\delta_{i,j}^{vi}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.27)}$$

Exports

$$E_{i,t} = \bar{E}_i \cdot \left(\frac{PE_{i,t}}{PR_{i,t}}\right)^{\sigma_i^x} \quad \textbf{(A.28)}$$

Regional Demand

$$R_{i,t} = \sum_j VR_{i,j,t} + \sum_h QHR_{i,h,t} + QVR_{i,t} + SQGR_{i,t} + QGR_{i,t} \quad \textbf{(A.29)}$$

Total Production

$$X_{i,t} = R_{i,t} + E_{i,t} \quad \textbf{(A.30)}$$

Households

Forward-looking behaviour

$$\frac{C_t}{C_{t+1}} = \left[\frac{PC_t \cdot (1+\rho)}{PC_{t+1} \cdot (1+r)}\right]^{-\left(\frac{1}{\sigma}\right)} \quad \textbf{(A.31)}$$

Myopic behaviour

$$C_{h,t} = YNG_{h,t} - SAV_{h,t} - HTAX_{h,t} - \sum_{dngins} TRSF_{dngins,h,t} \quad \textbf{(A.32)}$$

$$SAV_{h,t} = mps_h \cdot YNG_{h,t} \quad \textbf{(A.33)}$$

$$W_t = NFW_t + FW_t \quad \textbf{(A.34)}$$

$$\begin{aligned} NFW_t(1+r_t) = NFW_{t+1} & \\ + \Bigg(\sum_i w_t^b \cdot L_{i,t} + \sum_h TRG_{h,t} + \sum_h STRG_{h,t} \cdot PC_t & \\ + \sum_h \sum_{dnginsp} TRSF_{dngins,h,t} - \sum_h HTAX_{h,t} & \\ - \sum_h CONSTAX_{h,t} \Bigg) & \end{aligned} \quad \textbf{(A.35)}$$

$$FW_t(1+r_t) = FW_{t+1} + d_{dngins}^{K} \cdot rk_{i,t} \cdot \sum_i K_i - \sum_h SAV_{h,t} \quad \textbf{(A.36)}$$

$$YNG_{h,t} = d_h^L \cdot w_t^n \cdot \sum_i L_i + d_h^K \cdot rk_{i,t} \cdot \sum_i K_i + \sum_{dnginsp} TRSF_{dngins,t} + TRG_{h,t} + STRG_{h,t} \cdot PC_t + \varepsilon_t \cdot REM_h \quad \textbf{(A.37)}$$

$$TRSF_{dngins,t} = PC_t \cdot \overline{TRSF}_{dngins} \quad \textbf{(A.38)}$$

$$\left(QH_{i,h,t} + VAT_{h,t}\right) = \delta_i^{f\,\rho_i^c} \cdot \left(\frac{PC_{h,t}}{\left(CPQ_{i,h,t}/CPQ_{i,h,t=0}\right)}\right)^{\rho_i^c} \cdot C_{h,t} \quad \textbf{(A.39)}$$

$$QH_{i,t} = \gamma_{i,h}^f \cdot \left[\delta_{i,h}^{hr} \cdot QHR_{i,h,t}^{\rho_i^A} + \delta_{i,h}^{hm} \cdot QHM_{i,h,t}^{\rho_i^A}\right]^{\frac{1}{\rho_i^A}} \quad \textbf{(A.40)}$$

$$\frac{QHR_{i,h,t}}{QHM_{i,h,t}} = \left[\left(\frac{\delta_i^{hr}}{\delta_i^{hm}}\right) \cdot \left(\frac{PM_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \quad \textbf{(A.41)}$$

Government

Smith closure

$$SGY_t = BLOCKGRANT - BGA1_t + IT_t + \frac{\sum_h VAT_{h,t}}{2} + \sum_h CT_{h,t} + \sum_h SD_{h,t} \quad \textbf{(A.42)}$$

$$BGA1_t = \psi \cdot \frac{LS_t}{LS_{t=0}} \left(IT_{t=0} + \frac{\sum_h VAT_{h,t=0}}{2} + \sum_h SD_{h,t=0}\right) \quad \textbf{(A.43)}$$

Barnett closure

$$SGY_t = BLOCKGRANT \quad \textbf{(A.44)}$$

All Taxes Devolved closure

$$SGY_t = BLOCKGRANT - BGA2_t + \sum_h VAT_{h,t} + \sum_i IBT_{i,t} + \sum_h HTAX_{h,t} + CTAX_t + \sum_h CONSTAX_{h,t} + IMT_{j,t} \sum_h CT_{h,t} + \sum_h SD_{h,t} \quad \textbf{(A.45)}$$

$$BGA2_t = \sum_h VAT_{h,t=0} + \sum_i IBT_{i,t=0} + \sum_h HTAX_{h,t=0} + CTAX_{t=0} + \sum_h CONSTAX_{h,t=0} + IMT_{j,t=0} \quad \textbf{(A.46)}$$

$$SGE_t = SGY_t - \sum_h STRG_{h,t} \cdot PC_t \quad \textbf{(A.47)}$$

$$SQG_{i,t} = \delta_i^{scotg} \cdot SGE_t \quad \textbf{(A.48)}$$

$$QG_{i,t} = \delta_i^{g} \cdot GE_{t=0} \quad \textbf{(A.49)}$$

$$FD_t = \sum_i QG_{i,t} \cdot PGov_{i,t} + \sum_i SQG_{i,t} \cdot PGov_{i,t} + \sum_h TRG_{h,t} + \sum_h STRG_{h,t} \cdot PC_t - \left(d_g^k \cdot \sum_i rk_{i,t} \cdot K_{i,t} + \sum_i IMT_{i,t} + \sum_j nie \cdot L_{j,t} \cdot w_t^b + \sum_h VAT_{h,t} + \sum_i IBT_{i,t} + \sum_h HTAX_{h,t} + CTAX_t + \sum_h CONSTAX_{h,t} + \overline{FE} \cdot \varepsilon_t \right) \quad \textbf{(A.50)}$$

Taxes and subsidies

$$VAT_{h,t} = \sum_i vat_{i,h,t} \cdot QH_{h,t} \quad \textbf{(A.51)}$$

$$IT_t = it_t \cdot \sum_i w_t^b \cdot L_{i,t} + it_t^{Pensions} \cdot TRG_{h,t} \qquad \textbf{(A.52)}$$

$$HTAX_{h,t} = \delta_h^T \left(IT_t + ni_t \cdot \sum_i w_t^b \cdot L_{i,t} \right) + CT_{h,t} + +SD_{h,t} \qquad \textbf{(A.53)}$$

$$IBT_{i,t} = btax_i \cdot X_{i,t} \cdot PX_{i,t} \qquad \textbf{(A.54)}$$

$$CTAX_{i,t} = rk_{i,t} \cdot KS_{i,t} \cdot tk \qquad \textbf{(A.55)}$$

$$IMT_{j,t} = \sum_i mtax_j \cdot VM_{i,j,t} \cdot PM_{i,t} \qquad \textbf{(A.56)}$$

$$SUBSY_{i,t} = sub_i \cdot X_{i,t} \cdot PX_{i,t} \qquad \textbf{(A.57)}$$

$$CONSTAX_{h,t} = CONSTAX_{h,t=0} \cdot \left(\frac{QH_{i,h,t}}{QH_{i,h,t=0}} \right) \qquad \textbf{(A.58)}$$

$$CT_{h,t} = CT_{h,t=0} \cdot \left(\frac{QH_{i,h,t}}{QH_{i,h,t=0}} \right) \qquad \textbf{(A.59)}$$

$$SD_{h,t} = SD_{h,t=0} \cdot \left(\frac{QH_{i,h,t}}{QH_{i,h,t=0}} \right) \qquad \textbf{(A.60)}$$

Time path of investment

$$J_{i,t} = I_{i,t} \left(1 - bb - tk + \frac{\beta}{2} \cdot \frac{I_{i,t}}{K_{i,t}} \right) \qquad \textbf{(A.61)}$$

Forward-looking behaviour

$$\frac{I_{i,t}}{KS_{i,t}} = \frac{1}{\beta} \cdot \left[\frac{\lambda_{i,t}}{PK_{i,t}} - (1 - bb - tk) \right] \qquad \textbf{(A.62)}$$

$$\lambda_{i,t} \cdot (1 + r_t) = rk_{i,t+1} \cdot (1 - tk) + \left(PK_{t+1} \cdot \frac{\beta}{2} \cdot \frac{I_{i,t}}{KS_{i,t}}\right)^2 + \lambda_{i,t} \cdot (1 - \delta) \qquad \textbf{(A.63)}$$

$$VF_{i,t} = \lambda_{i,t} \cdot K_{i,t} \qquad \textbf{(A.64)}$$

Myopic behaviour

$$I_{i,t} = v \cdot \left[KS_{i,t}^{*} - KS_{i,t}\right] + \delta \quad \cdot KS_{i,t} \qquad \textbf{(A.66)} \qquad \textbf{(A.65)}$$

$$KS_{i,j}^{*} = \left(A\left(\xi_{j,t}\right)^{\rho_i} \cdot \delta_j^k \cdot \frac{PY_{j,t}}{uck_t}\right)^{\frac{1}{1-\rho_j}} \cdot Y_{j,t} \qquad \textbf{(A.67)}$$

Investment by sector of origin

$$QV_{i,t} = \sum_j KM_{i,j} \cdot J_{j,t} \qquad \textbf{(A.68)}$$

$$QV_{i,t} = \gamma_i^v \cdot \left[\delta_i^{qvm} \cdot QVM_{i,t}^{\rho_i^A} + \delta_i^{qvir} \cdot QVIR_{i,t}^{\rho_i^A}\ \right]^{\frac{1}{\rho_i^A}} \qquad \textbf{(A.69)}$$

$$\frac{QVM_{i,t}}{QVIR_{i,t}} = \left[\left(\frac{\delta_i^{qvm}}{\delta_i^{qvir}}\right) \cdot \left(\frac{PIR_{i,t}}{PM_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \qquad \textbf{(A.70)}$$

$$QVIR_{i,t} = \gamma_i^{vir} \cdot \left[\delta_i^{qvi} \cdot QVI_{i,t}^{\rho_i^A} + \delta_i^{qvr} \cdot QVR_{i,t}^{\rho_i^A}\ \right]^{\frac{1}{\rho_i^A}} \qquad \textbf{(A.71)}$$

$$\frac{QVR_{i,t}}{QVI_{i,t}} = \left[\left(\frac{\delta_i^{qvr}}{\delta_i^{qvi}}\right) \cdot \left(\frac{PI_{i,t}}{PR_{i,t}}\right)\right]^{\frac{1}{1-\rho_i^A}} \qquad \textbf{(A.72)}$$

Labour Market closures

For the Regional Bargaining closure,

$$ln\left[\frac{w_{s,t}^{n}}{PC_t}\right] = \omega - \varepsilon \ln\left(u_{s,t}\right) \qquad \textbf{(A.73)}$$

For the Fixed Real Wage closure,

$$\frac{w_{s,t}^{n}}{PC_t} = \frac{w_{s,t=0}^{n}}{PC_{t=0}} \qquad \textbf{(A.74)}$$

For the National Bargaining closure,

$$w_{s,t}^{b} = w_{s,t=0}^{b} \qquad \textbf{(A.75)}$$

Factors accumulation

$$KS_{i,t+1} = (1-\delta) \cdot KS_{i,t} + I_{i,t} \qquad \textbf{(A.76)}$$

$$\begin{aligned} LS_{s,i,t+1} = \Bigg(1 + \Bigg(\varsigma - \nu^{u}[ln(u_t) - ln\,(\bar{u}^{N})] \\ + \nu^{w}\left[ln\left(\frac{w_{s,t}^{n}}{PC_t}\right) - ln\left(\frac{w_{s,t=0}^{n}}{PC_{t=0}}\right)\right]\Bigg)\Bigg) \cdot LS_{s,i,t} \end{aligned} \qquad \textbf{(A.77)}$$

$$K_{i,t} = KS_{i,t} \qquad \textbf{(A.78)}$$

$$LS_{s,t} \cdot \left(1 - u_{s,t}\right) = \sum_{j} L_{s,j,t} \qquad \textbf{(A.79)}$$

Total demand for import and current account

$$M_{i,t} = \sum_j VI_{i,j,t} + \sum_j VM_{i,j,t} + \sum_h QHM_{i,h,t} + SQGM_{i,t} + QGM_{i,t} + QVI_{i,t} + QVM_{i,t} \quad \textbf{(A.80)}$$

$$TB_t = \sum_i M_{i,t} \cdot PM_{i,t} - \sum_i E_{i,t} \cdot PE_{i,t} + \varepsilon_t \cdot \left(\sum_{dngins} \overline{REM}_{dngins} + \overline{FE} \right) \quad \textbf{(A.81)}$$

Public and foreign debt

$$D_{t+1} = (1 + r - \tau) \cdot D_t + TB_t \quad \textbf{(A.82)}$$

$$Pgov_{t+1} \cdot GD_{t+1} = \left[1 + r - \tau g + \left(\frac{Pc_{t+1}}{Pc_t} - 1 \right) \right] \cdot GD_t \cdot Pgov_t + FD_t \quad \textbf{(A.83)}$$

Steady State conditions

$$KS_{i,T}\delta = I_{i,T} \quad \textbf{(A.84)}$$

$$R^k_{i,T} = \lambda_{i,T}(r_T + \delta) \quad \textbf{(A.85)}$$

$$FD_T = -\left[r - \tau g + \left(\frac{Pc_{t+1}}{Pc_t} - 1 \right) \right] \cdot Pgov_T \cdot GD_T \quad \textbf{(A.86)}$$

$$TB_T = -(r - \tau) \cdot D_T \quad \textbf{(A.87)}$$

In the short-run

$$KS_{i,t=1} = KS_{i,t=0} \quad \textbf{(A.88)}$$

$$LS_{t=1} = LS_{t=0} \quad \textbf{(A.89)}$$

$$GD_{t=1} = GD_{t=0} \tag{A.90}$$

$$D_{t=1} = D_{t=0} \tag{A.91}$$

List of Variables and Parameters

i,j	the set of goods or industries
dngins	the set of domestic non-government institutions
h $(\subset dngins)$	the set of households
s	the set of skills

Prices

$PX_{i,t}$	output price
$PY_{i,t}$	value added price
$PR_{i,t}$	regional price
$PQ_{i,t}$	price of composite
$CPQ_{i,h,t}$	consumer price index
$PIR_{i,t}$	national commodity price (regional + RUK)
$PI_{i,t}$	RUK price
$PM_{i,t}$	import price
$PE_{i,t}$	export price
$rk_{i,t}$	rate of return on capital
w_t	labour costs
w_t^b	gross wage
w_t^n	wage net of all labour taxes
$w_{s,t}$	labour costs by skill segmentation
$w_{s,t}^b$	gross wage by skill segmentation
$w_{s,t}^n$	wage net of all labour taxes by skill segmentation
PK_t	capital good price
UCK_t	user cost of capital
$\lambda_{i,t}$	shadow price of capital
$PC_{h,t}$	household consumption price index
$PGov_t$	Government consumption price index

Endogenous variables

$X_{i,t}$	output
$Y_{i,t}$	value added
$R_{i,t}$	regional supply
$M_{i,t}$	import
$E_{i,t}$	export (interregional + international)
$L_{i,t}$	labour demand
$L_{s,i,t}$	labour demand by skill segmentation
$LS_{i,t}$	labour supply
$LS_{s,i,t}$	labour supply by skill segmentation
$K_{i,t}$	physical capital demand
$KS_{i,t}$	capital stock
$V_{i,jt}$	intermediate inputs
$VR_{i,jt}$	regional intermediate inputs
$VM_{i,jt}$	ROW intermediate inputs
$VIR_{i,jt}$	national intermediate inputs (REG+RUK)
$VI_{i,jt}$	RUK intermediate inputs
SGY_t	Scottish Government income
$(S)GE_t$	(Scottish) Government expenditure
$QG_{i,t}$	government expenditure
$C_{h,t}$	aggregated household consumption
$QH_{i,h,t}$	total households consumption in sector *i*
$QHR_{i,h,t}$	regional consumption in sector *i*
$QHM_{i,h,t}$	import consumption in sector *i*
$QV_{i,t}$	total investment by sector of origin *i*
$QVR_{i,t}$	regional investment by sector of origin *i*
$QVM_{i,t}$	ROW investment demand
$QVIR_{i,t}$	national investment (REG+RUK)
$QVI_{i,t}$	RUK investment demand
$I_{j,t}$	investment by sector of destination *j*
$J_{j,t}$	investment by destination *j* with adjustment cost
u_t	regional unemployment rate

$R_{i,t}^{k}$	marginal net revenue of capital
$VF_{i,t}$	value of firms
$SAV_{h,t}$	household saving
$YNG_{h,t}$	household income
$TRSF_{dngins,dnginsp,t}$	transfer among *dngins*
$(S)TRG_{h,t}$	(Scottish) Government transfers
BGA_t	block grant adjustment
IT_t	income tax revenues
$HTAX_{h,t}$	household taxes
NI_t	national insurance contributions
$VAT_{i,h,t}$	VAT revenue by sector
$CT_{h,t}$	council tax
$SD_{h,t}$	stamp duty
$CONSTAX_{h,t}$	consumption taxes not otherwise defined
$CTAX_{h,t}$	corporation tax
FD_t	fiscal deficit
TB_t	current account balance
GD_t	government borrowing
D_t	foreign debt
$SUBSY_t$	production subsidies

Exogenous variables	***(some may be made endogenous)***
$\overline{REM}_t$	transfers for *dngins*
$\overline{FE}_t$	transfers for the Government
$vat_{i,t}$	VAT rate by sector
r_t	interest rate
it_t	income tax rate
ni_t	national insurance rate paid by employees
nie_t	rate of national insurance paid by employers
tk	corporation tax rate
$BLOCKGRANT$	block grant
$vat_{i,h,t}$	VAT rate by sector

$btax_i$	business tax
sub_i	rate of production subsidy
$mtax_i$	rate of import tax
ε_t	exchange rate

Elasticities

σ	constant elasticity of marginal utility
σ_i^z	elasticity of substitution between intermediate and value-added
ϱ_j	between labour and capital in sector *j*
ρ_i^A	in Armington function
σ_i^x	of export with respect to terms of trade
ρ^{sk}	elasticity between skilled and unskilled labour
μ	elasticity of real wage with respect to unemployment

Parameters

$a_{i,j}^V$	Input-output coefficients for *i* used in *j*
a_j^Y	share of value added on production
$\delta_j^{k,l}$	shares in value added function in sector *j*
$\delta_{i,j}^{vir,vm,vr,vi}$	shares parameters in CES function for intermediate goods
$\delta_{i,j}^{qvir,qvm,qvr,qvi}$	shares parameters in CES function for investment goods
$\delta_{i,h}^{hr,hm}$	shares parameters in CES function for households consumption
$\delta_i^{(scot)g}$	share value for (Scottish) government consumption
$\gamma_{i,j}^{vv,vir}$	shift parameter in CES functions for intermediate goods
γ_i^f	shift parameter in CES function for households consumption
β^s	shift parameter for *s* skill within production technology
d_{ins}^k	institutional shares of capital
ψ	proportion of labour supply to total population in Scotland
v	interregional migration elasticities
$KM_{i,j}$	physical capital matrix
mps_{dngins}	rate of saving in institutions *dngins*
ρ	pure rate of consumer time preference

bb	rate of distortion or incentive to investment
δ	rate of depreciation
δ_h^T	share of household taxes by household group
β	investment adjustment cost parameter

Appendix C – The income-expenditure Accounts for 2014

HOUSEHOLDS			
1. Income	**135,079**	**10. Expenditure**	**135079**
2. Income from Employment	72482	11. IO Expenditure	93807
3. Profit Income (OVA)	10,852	12. Payments to Corporations	3304
4. Income from Corporations	22272	13. Payments to Government	23,849
5. Income from Government	22771	14. Transfers to RUK	227
6. Transfers from RUK	3,991	15. Transfers to ROW	113
7. Transfers from ROW	2711	16. Payments to Capital (Savings)	13778
8. Mixed and Proportional.			
Income Unallocated.	6485		
9. Total Household Income	**135079**	**17. Total Expenditure**	**135079**
CORPORATIONS			
18. Income	**52229**	**24. Expenditure**	**52229**
19. Profit Income (OVA)	34,482	25. Payments to Households	22272
20. Income from Households	3304	26. Payments to Government	6,797
21. Income from Government	6524	27. Transfers to RUK	3,711
22. Income from RUK	3959	28. Transfers to ROW	6,977
23. Income from ROW	3959	29. Payments to Capital (Savings)	12472
GOVERNMENT			
30. Income	**73071**	**37. Expenditure**	**73071**
31. Profit Income (OVA)	6629	38. IO Expenditure	33440
32. Net Commodity Taxes	18568	39. Payments to Corporations	6,524
33. Income from Households	23,849	40. Payments to Households	22771
34. Income from Corporations	6,797	41. Transfers to RUK	9,440
35. Income from RUK	17227	42. Payments to Capital (Savings)	895
36. Total Gov Inc Balancing Total	**73071**	**43. Total Gov Exp Balancing Total**	**73,071**
CAPITAL			
44. Income	**25534**	**49. Expenditure**	**25534**
45. Households	13778	50. IO Expenditure	25534
46. Corporations	12472		
47. Government	895		
48. RUK/ROW	-1611.822		

EXTERNAL			
51. RUK Income from Scotland	69018	58. RUK Expenditure in Scotland	70124
52. Goods & Services from RUK	55641.00	59. Goods & Services to RUK	44946
53. Transfers to RUK	13377	60. Transfers from RUK	25,177
54. ROW Income from Scotland	36842	61. ROW Expenditure in Scotland	33178
55. Goods & Services from ROW	29751	62. Goods & Services to ROW	26507
56. Transfers to ROW	7091	63. Transfers from ROW	6671
		64. Tourist Expenditure in Scotland	4171
57. Total Income	**105860**	**65. Total Expenditure**	**107472**
		66. Surplus/Deficit	-1612
G&S TRADE BALANCE		**TOTAL BALANCE OF PAYMENTS**	
67. RUK	-10695	69. RUK	3682.952
68. ROW	-3245	70. ROW	-2071.13
		71. Total Balance of Payments	1611.822
EXTERNAL BALANCE			
72. RUK Total Flows Balance	-1105		
73. ROW Total Flows Balance	3664		
74. Tourist Balance	-4171		
75. RUK/ROW Surplus/(Deficit), Lending/(Borrowing) with Scotland	-1612		