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***A multi-regional  
computable  
general  
equilibrium  
model of the UK  
economy***

A report by PwC  
for HM Revenue  
and Customs

March 2014

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# *Report Commission*

PricewaterhouseCoopers LLP (PwC) were commissioned by HM Revenue and Customs (HMRC) – to construct a Multi-Regional Computable General Equilibrium (MR-CGE) model of the UK economy. PwC's commission involved building a four-region model for England, Northern Ireland, Scotland and Wales. The process involved data collection and model building. Core elements of the model construction were subcontracted to Professor Adam Blake and Bournemouth University.

While HMRC commented on our draft reports, the final reports represent the independent analysis of PwC. Throughout this project we were supported by the regional accounts team at the Office for National Statistics (ONS) and consulted with them on available regional data sources. The ONS and HMRC provided several bespoke regional datasets for use in this project.

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# 1. Overview of Multi-Regional Computable General Equilibrium Modelling

## 1.2. Section overview

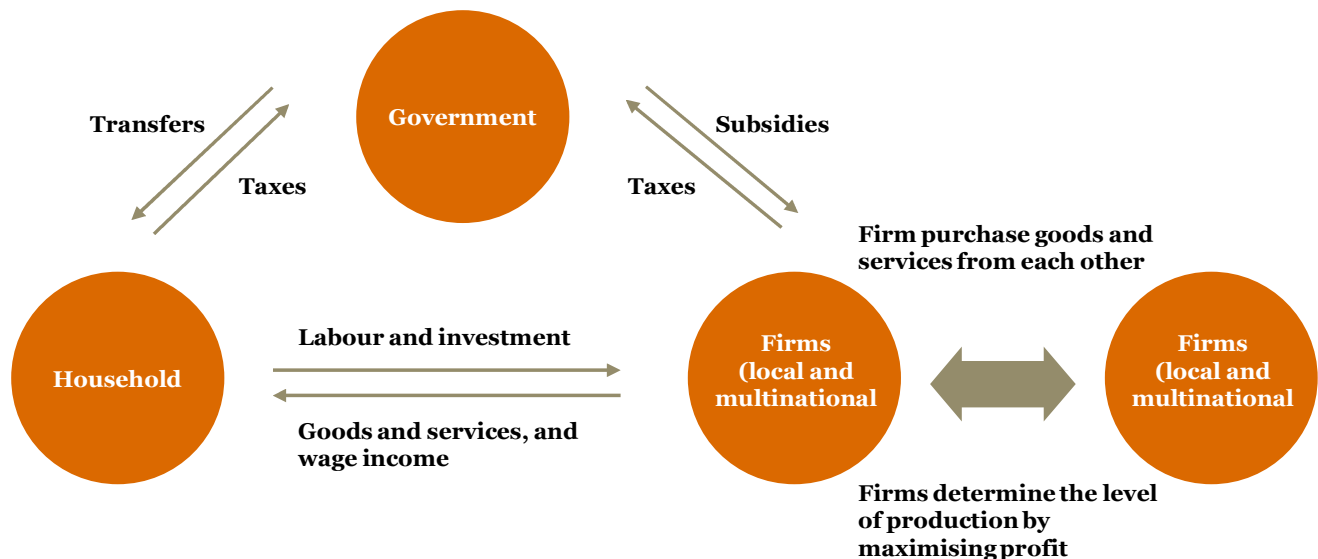
This section provides a basic introduction to Computable General Equilibrium (CGE) modelling concepts and a high level overview of the MR-CGE model.

## 1.3. What are CGE models?

CGE models have become a standard tool for empirical economic analysis. They are used widely by international institutions such as the World Bank, IMF, OECD and European Commission. Their primary use is to assess ‘impacts’ of different government or institutional policies (e.g. changes in tax policy, government spending and the economic effects of CO2 emissions) or to investigate the effects of different economic scenarios (e.g. a change in real exchange rates, or the level of consumer demand).

A CGE model combines economic data and a complex system of equations in order to capture the interactions of the three main institutions in an economy – households, business and the government. Each institution is defined and interlinked either through the labour market or capital market flows, household consumption, intermediate product demand, taxes or Government transfers. Figure 1 illustrates a basic representation of these interactions.

Figure 1: Relationships captured in a CGE model



The economic systems that CGE models attempt to proxy are complex. The multiple households and businesses that are defined in each model will engage in repeated local micro interactions that in turn give rise to macro relationships such as employment, investment and GDP growth. These macro relationships will also feed back

into the determination of local micro interactions. Because of this relationship, CGE models are often referred to as micro-macro models (Sue-Wing and Balistreri, 2012)<sup>1</sup>.

CGE models are scenario models. The equations in the MR-CGE model are calibrated to UK economic data and a baseline view of the economy is created. An economic scenario is then imposed on this baseline - the CGE model measures the difference between the scenario and the baseline and produces key economic metrics such as GDP, employment, household consumption, exports, imports, investment, tax receipts etc. More detailed results at the industry and household level can also be generated.

#### 1.4. How does a “regional” model differ from a “UK” model?

The MR-CGE model extends the current UK level HMRC CGE model from a single region to a multi-region model. The MR-CGE model covers four geographical regions of the UK economy: England, Northern Ireland, Scotland and Wales. Each of the regions in the model interacts with each other. For instance, if wages rise in Scotland, migration flows in the model would dictate that workers from any of the other 3 UK regions might be tempted to move to Scotland in order to achieve greater earnings. A full set of trade linkages also exists, so if a business in the construction sector in Northern Ireland expands, it may then in turn demand more production inputs (cement, plant and machinery etc.). These production inputs could be sourced from within Northern Ireland, imported from another region of the UK, or imported from overseas.

The MR-CGE model specification captures the net effect of movements in economic activity. Since the model is dynamic, it tracks the evolution of the economy over time as it reacts to changes. For instance, if the Northern Ireland economy expands and attracts workers from other UK regions then this could have a negative effect on the regions they leave, as it reduces the pool of labour in that region available to work in other sectors.

#### 1.5. Key issues relevant to regional CGE model specification

In this section, we summarise some of the key issues and ideal characteristics relevant to specifying a regional CGE model. This section is informed by Partridge and Rickman (2010)<sup>2</sup> who identified 5 key issues in constructing regional CGE models:

1. **A regional CGE model should be specified on the basis of regional economic theory instead of borrowing specifications from other national or international CGE models.** The interactions between regions are different from the interactions between nations. For example, the role of government stimulus in increasing the regional quality of life and inter-regional migration are not captured in national models, but can be explicitly portrayed in a regional model. This point is taken specifically into the design of the MR-CGE model, it can assume a central UK government providing services to the whole country, or a devolved government system providing services to a defined region with a region specific public finances.
2. **MR-CGE models should account for a region’s influence on national trade patterns.** National and international models assume that international trade terms and patterns are not influenced by activity in a sub-region (the “small country” assumption)<sup>3</sup>. However, at the country level, large regions can influence trade terms and patterns between regions and this must be captured when specifying a MR-CGE model. Again, this point is included specifically in our modelling, each of the four regions has its own set of inter-regional trade flows and businesses in each region can buy goods and services from each other.

<sup>1</sup> Sue Wing, I. and Balistreri, E.J. (2012) “Computable General Equilibrium Models for Economic Policy Evaluation and Impact Analysis”. Working Paper, Department of Earth and Environment, University of Boston.

<sup>2</sup> Partridge, M & Rickman, D. (2010) "Computable General Equilibrium (CGE) Modelling for Regional Economic Development Analysis," *Regional Studies, Taylor & Francis Journals*, vol. 44(10), pages 1311-1328.

<sup>3</sup> Harris, R. (1983) "Applied General Equilibrium Analysis of Small Open Economies with Scale Economies and Imperfect Competition," Working Papers 524, Queen's University, Department of Economics.

3. **MR-CGE models should contain a time element.** By including a time element, the dynamic impact of economic scenarios can be assessed. Partridge and Rickman note that, until recently, regional models largely ignored the time element, or mimicked the dynamic behaviour of national models. They recommend that the parameterisation of an MR-CGE model must be consistent with the dynamic behaviour of the regional economy. Dynamic-regional models using national parameters may produce adjustment periods inconsistent with empirical evidence on regional dynamic adjustment.

However, external data is not usually available to calibrate the model based on a benchmark time period, or the external data is usually out-of-date. More complex approaches such as Bayesian estimation approaches (Adkins *et al.*, 2003)<sup>4</sup> or using calibration based on several years of data (Kehoe *et al.*, 1995)<sup>5</sup> have been implemented as an exception rather than a rule. However, the limitations of the UK data prevent this approach. In the MR-CGE model we use sensitivity analyses around the dynamic parameters of interest, which is, as Partridge and Rickman note, a common approach.

4. **MR-CGE models should differ from national and international models by accounting for migration.** Partridge and Rickman note from their survey that national and international models will often make simplifying assumptions of perfectly mobile labour markets and full employment, thereby underestimating the regional income (wage) benefits, or they assume immobile labour markets, overestimating regional income (wages). The human capital approach to migration assumes that individuals are influenced in their migration choice by the income they expect to receive at alternative locations (Sjaastad 1962)<sup>6</sup>. Since Sjaastad's formative paper there has been a greater focus on the spatial characteristics that determine migration flows. On this basis, in the MR-CGE model we capture migration flows between the England, Northern Ireland, Wales and Scotland – this is discussed in more detail in Section 3.7.

## 1.6. The MR-CGE model: overview of key features

The model built for this project is a single-country dynamic model for the UK, based on 2010 data. The UK is split into four country level regions: England, Northern Ireland, Scotland and Wales. Each region interacts with each other through the movement of goods and services, capital and labour. Each region is further broken down into 15 industries, 15 product markets and 15 household types, and differentiates capital provisions between debt and equity. The model also allows for the introduction of frictions which affect the freedom with which capital, labour and traded goods and services move between different regions or overseas.

The MR-CGE model uses a mixture of regional accounts data published by the Office for National Statistics (ONS), the Scottish Government, business survey data from the FAME database<sup>7</sup>, and HMRC's sector tax and international trade data to capture the complex transactions in the economy. These data provide a snapshot of the four regional economies in a single year, which is used as a starting point for comparing policy simulations against a baseline. The number of industries, product markets and household types are constrained by the availability and consistency of data across the four country regions. The model is programmed using GAMS software (General Algebraic Model Software)<sup>8</sup> with the MPSGE (Mathematical Programming Software for General Equilibrium) interface<sup>9</sup>. The number of equations and amount of data used is also constrained by the ability of this software to solve such a model. GAMS/MPSGE is a standard programming tool for CGE models.

<sup>4</sup> Adkins, Lee C., Rickman, D. S., and Hameed, A (2003) "Bayesian Estimation of Regional Production for CGE Modeling," *Journal of Regional Science* 43, pp. 641-661.

<sup>5</sup> Kehoe, T. J., Polo, C., and SanchoF. (1995) "An evaluation of the performance of an applied general equilibrium model of the Spanish economy", *Economic Theory* 6.1, pp. 15-141.

<sup>6</sup> Sjaastad, L. A. (1962) "The Costs and Returns of Human Migration", *The Journal of Political Economy*, 70,(5, Part 2: Investment in Human Beings), pp. 80-93.

<sup>7</sup> The FAME database is a commercially available database containing information on UK company accounts.

<sup>8</sup> More information on the GAMS software package can be found at: <http://www.gams.com>

<sup>9</sup> More information on the MPSGE software interface can be found at <http://www.MPSGE.org>



## 2. Model Design: Data

### 2.1. Section overview

This section describes the data used in the construction of the MR-CGE model. The precise dataset that is needed to build an MR-CGE model for the UK economy did not exist prior to the project. Data was gathered from various sources and then compiled into the format needed for a CGE model.

A key feature of any MR-CGE model is its ability to model trade between regions (i.e. Northern Ireland's exports to Wales, England's imports from Scotland etc.). There is no official inter-regional trade data for the UK, so this data had to be estimated. This section also describes our approach to this problem.

### 2.2. Data used in the MR-CGE model

#### 2.2.1. National accounts and survey data used in the model

CGE models are often based on a form of National Accounts (NA) data known as Supply Use Tables (SUT's). SUT's provide data on sector level output, consumption, business costs and taxation. They are "balanced" in that income equals expenditure – which is an essential property for CGE models. Other forms of data that can be used to build CGE models are input output (IO) tables or Social Accounting Matrices (SAM's). IO tables and SAM's are built on the same structural principles as SUT's and can contain much of the same data. The key differences are that IO tables tend to be at basic rather than market prices (providing a better picture of the economic linkages that exist between consumers and businesses), but they contain less information about industry structure and supply. SAM's contain the core data from either an SUT or IO table, but have less of a fixed structure. Some SAM's add more detailed labour market or household consumption data and often include more detail on financial balances between the households and governments and the rest of the world.

The UK government publishes both SUT's and IO tables for the UK. SUT's are updated annually (with an 18 month lag, the most recent being for 2012), IO tables are updated approximately every 5 years (2010 being the most recent year). The Scottish government publishes on an annual basis a partial SUT (it does not provide as detailed sector information on industry supply) for the year 2010. An IO table exists for Wales for the year 2007 and is published by the Welsh Economy Research Unit (WERU) at Cardiff University. There is no separate IO or SUT data for England and Northern Ireland.<sup>10</sup>

Given the availability of SUT and IO data for the UK regions and following discussions with HMRC and the ONS about data availability we agreed to construct a full SUT dataset for England, Wales, Northern Ireland and Scotland for the year 2010.<sup>11</sup> SUT's for England, Northern Ireland and Wales were then compiled from existing NA data for those regions. Not all of the NA data needed to build these SUT's existed for the year 2010 – some data had to be assumed or drawn from previous years.

The MR-CGE model uses National Accounts (NA) data published by the Office for National Statistics (ONS), HMRC, the Scottish Government and business survey data from the FAME database<sup>12</sup>. Data is taken from a single year (2010) and provides a snapshot of the economy in that year. Details of the key data sources used in this project are provided in Table 1.

<sup>10</sup> Reference IO table from NI.

<sup>11</sup> 2010 was chosen as the base year because the Scottish SUT is published for that year.

<sup>12</sup> FAME contains comprehensive information on companies in the UK and Ireland. It is used for the purposes of deriving debt equity ratios according to ONS SIC codes for the purposes of the MR-CGE model.



Table 1: Key data sources used in the MR-CGE model

Data	Time	Source
UK SUT's	2010	Office for National Statistics <sup>13</sup>
Scotland SUT's	2007	The Scottish Government <sup>14</sup>
Wales Input Output table	2007	Cardiff Business School <sup>15</sup>
Scotland export data	2010	Global Connections Survey 2010, The Scottish Government <sup>16</sup>
Scotland GDP breakdown	2010	Scottish National Accounts Project (SNAP), The Scottish Government <sup>17</sup>
Scotland household expenditure data		Scottish National Accounts Project (SNAP), The Scottish Government <sup>8</sup>
Earnings data by UK Region	2010	Annual Survey of Hours and Earnings, Office for National Statistics <sup>18</sup>
Gross operating surplus by sector and UK Region	2010	Office for National Statistics <sup>19</sup>
Compensation of employees by sector and UK Region	2010	Office for National Statistics <sup>10</sup>
UK Self-employment income by sector and UK Region	2010	Office for National Statistics <sup>10</sup>
UK Production tax by sector and UK Region	2010	Office for National Statistics <sup>10</sup>
Inter-regional trade data by sector and UK Region	2010	PwC calculations
Regional household income and consumption by UK region	2010	Office for National Statistics <sup>20</sup>
Household tax data by UK region	2010	Office for National Statistics <sup>21</sup>
International trade data EU and non-EU	2010	HMRC
Levels of debt and equity finance by sector	2010	FAME database <sup>22</sup>

Source: PwC analysis

Following the collection of the data from the different sources listed above, the data were organised to fit into the SUT framework. Further details on the structure of the SUT data used in the model are included in Appendix A. As described above, SUT's need to balance by satisfying the key national accounting identity: income equals expenditure. However, survey material drawn from a range of sources (the ONS's Annual Business Survey, Expenditure and Food survey etc.) will inevitably demonstrate some inconsistency in terms of the SUT's balancing. The standard approach taken in such circumstances is to balance the matrices using a computer algorithm that preserves the core structure of the data but makes iterative adjustments to preserve the income-expenditure relationship.

<sup>13</sup> <http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcn%3A77-256175>

<sup>14</sup> <http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/IOAllFiles2007>

<sup>15</sup> [http://business.cardiff.ac.uk/sites/default/files/IO\\_2007\\_Final\\_30\\_6.pdf](http://business.cardiff.ac.uk/sites/default/files/IO_2007_Final_30_6.pdf)

<sup>16</sup> <http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Exports/GCSDData>

<sup>17</sup> <http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/SNAP/expstats/aggregates/SNAP2012Q2>

<sup>18</sup> <http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcn%3A77-238620>

<sup>19</sup> Provided directly by ONS

<sup>20</sup> <http://www.ons.gov.uk/ons/rel/household-income/the-effects-of-taxes-and-benefits-on-household-income/50-years-of-the-effects-of-taxes-and-benefits-analysis/sty-taxes-and-benefits-on-household-income.html>

<sup>21</sup> <http://www.ons.gov.uk/ons/rel/household-income/the-effects-of-taxes-and-benefits-on-household-income/50-years-of-the-effects-of-taxes-and-benefits-analysis/sty-taxes-and-benefits-on-household-income.html>

<sup>22</sup> [http://www.bvdinfo.com/en-gb/products/company-information/national/fame?gclid=CMCSyoPvsLoCFTTItAodjxwA\\_g](http://www.bvdinfo.com/en-gb/products/company-information/national/fame?gclid=CMCSyoPvsLoCFTTItAodjxwA_g)

There are a range of algorithm's that can be used to undertake these adjustments (they are used as standard practice by the European Commission and international governments).<sup>23</sup> The ONS have previously used the RAS (Row and column Sums) approach to balance the UK SUT's and this is the approach used in our modelling.<sup>24</sup> The RAS approach is based on the principle that XXXXXXXX

The RAS approach is applied to all four regions in the UK

## 2.3. Calculating inter-regional trade data

### 2.3.1. The availability of regional trade data

A key part of the balancing process centres around the calculation of inter-regional trade data as this determines the flow of goods and services between regions. Usually when CGE models are built, regional trade data are available: examples include Spain (Gillham, 2004)<sup>25</sup>, Australia (Regional version of the ORANI model, which is a MR-CGE model of the Australian economy).<sup>26</sup> Not all countries produce this data and in some cases it has been assumed; for instance, the, USAGE-51 model<sup>27</sup>, is built on commodity flow data for 51 States of the US, but this data is only partially represents inter-regional trade as it does not include transactions.

There are several sources of data that describe the trade between the UK and other countries. However, with the exception of Scotland, there are no official government data sources on trade between regions of the UK. The Scottish Government publishes this data as part of the Scottish SUT data described in Table 1. However, it refers only to trade between Scotland and the rest of the UK – it does not distinguish its trade between England, Northern Ireland and Wales. Given this lack of data, we were required to estimate regional export and import data for the UK.

The remainder of this Section describes the methodology we used to estimate the inter-regional trade data.

### 2.3.2. Building a inter-regional trade dataset: our approach

To calculate inter-regional trade flows, we first estimate exports from England, Wales, Scotland and Northern Ireland to each of the other regions. We then compute import estimates by adding up the exports coming into each of the regions i.e. Scotland's exports to Wales are directly equivalent to Wales' imports from Scotland – the net regional trade balance by definition is zero.

Given the lack of data in this area we follow the location quotient approach outlined by Robinson and Liu (1997)<sup>28</sup>. The location quotient approach compares the relative employment level across industrial sectors and regions and is interpreted as follows:

- A location quotient greater than one indicates that the regional economy is employing relatively more people in a particular sector than the national economy employs in that sector. The implication is that the sector is

<sup>23</sup> Eurostat Manual of Supply, Use and Input-Output Tables (2007), Eurostat Methodologies and Working Papers Series ISSN 1977-0375. Available at: [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-RA-07-013/EN/KS-RA-07-013-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-07-013/EN/KS-RA-07-013-EN.PDF)

<sup>24</sup> "Blue Book 2008 - Balanced Estimates of Gross Domestic Product using a Supply and Use Approach", (2008), Roger Akers & Alex Clifton-Fearnside, Office for National Statistics. Available at: [file:///C:/Users/901792/Downloads/BlueBook2008SUT\\_tcm77-144039.pdf](file:///C:/Users/901792/Downloads/BlueBook2008SUT_tcm77-144039.pdf)

<sup>25</sup> Gillham, J. (2004) "The economic inter-relationships of tourism: A Computable General Equilibrium Analysis" PhD Thesis, University of Nottingham. [http://etheses.nottingham.ac.uk/1330/1/436728\\_VOL1.pdf](http://etheses.nottingham.ac.uk/1330/1/436728_VOL1.pdf)

<sup>26</sup> More details on the ORANI model can be found at: <http://www.copsmodels.com/oranig.htm>

<sup>27</sup> More detail on the USAGE\_51 model can be found in the following article: Dixon, P.B., Rimmer, M.T. and Wittwer, G. (2012) "USAGE-R51, a state-level multi-regional CGE model of the US economy" GTAP working paper, <https://www.gtap.agecon.purdue.edu/resources/download/5933.pdf>

<sup>28</sup> Robinson, Dennis P. and Zuomin Liu (2006): "The Effects of Interregional Trade Flow Estimating Procedures on Multiregional Social Accounting Matrix Multipliers". *The Journal of Regional Analysis & Policy*, 36(1). pp 94-114

producing more than the local economy needs, and therefore, it is exporting some proportion of the goods and services produced by the sector.

- Alternatively, a location quotient of less than one indicates that the regional economy is employing relatively less people in a particular sector than the benchmark economy employs in that sector. The implication is that the sector is producing less than the local economy needs, and therefore, it needs to import some of the goods and services consumed by the sector.

Our approach follows the following steps:

1. Calculating exports
  - a. Calculating location-quotient based export estimates
  - b. Comparison of estimates with Scottish data
  - c. Adjustments made for specific sectors
2. Adjustments and rebalancing

These steps are described in more detail below.

### 2.3.3. Calculating exports

#### 2.3.3.1. Calculating location-quotient based export estimates

We calculate location quotients based on Labour Force Survey data by industry sector and region from the ONS for the year 2010 using the following formula presented in Robinson and Liu (2009):

$$LQ_i^R = \frac{\frac{E_i^R}{E_T^R}}{\frac{E_i^B}{E_T^B}}$$

Where:

- $E_i^R$  is employment in sector  $i$  in region  $R$
- $E_T^R$  is the total employment in all sectors in region  $R$
- $E_i^B$  is employment in sector  $i$  in the benchmark economy (all UK in this context)
- $E_T^B$  is the total employment in all sectors in the benchmark economy

Once the location quotient is calculated, the export share of any sector  $i$  in region  $R$  ( $ES_i^R$ ) is:

$$ES_i^R = 1 - \frac{1}{LQ_i^R}$$

The export share, indicates the portion of a sector's employment that is devoted to producing exports. The next step is to multiply the export share with the total production in the region to estimate the value of exports by UK region. It is not mathematically possible for all regions to have a location quotient greater than 1, some regions will be net exporters and other regions will be net importers.

#### 2.3.4. Comparison of estimates with Scottish data

We compared the export shares calculated using the methodology described above and compared the results with the direction of trade for Scotland in 2009. The comparison is shown on the table below.

1. The first three columns in the table show the actual direction of trade in 2009 based on ONS data,
2. the direction of trade estimated using the location quotients approach, and
3. whether the direction estimated matches the actual.

To assess the relative importance of the sector in terms of GVA and trade volumes, the table also shows GVA in the sector (as a percentage of total GVA) and the absolute trade volume (exports plus imports) in the sector (as a percentage of total trade volume).

For example, in the agriculture sector, the actual direction of trade was negative while the estimated direction of trade based on the location quotient approach is positive. Therefore, our estimates do not match the actual direction of trade. However, the agriculture sector GVA constitutes only 0.8% of the total GVA in the economy while agricultural trade volume constitutes only 1.77% of total trade volume in the economy.

On the other hand, in the manufacturing sector, the actual direction of trade and the estimated direction of trade are both positive. The manufacturing GVA constitutes 11.5% of the total economy GVA, and manufacturing trade volume accounts for close to 38.5% of the total trade volume in the economy.

The direction of trade calculations matches actual data for Scotland for 11 out of 19 sectors. This covers approx. 61% of GVA and approx. 80% of total trade volumes (export and imports). We make certain adjustments to the location quotients approach for sectors where there is a mismatch which are described in the next section.

### *2.3.5. Adjustments made for specific sectors*

To account for the lack of consistency in the direction of trade, we use different sector-specific adjustments to our methodology, either in the calculation of export shares, or at the final stage, i.e. when estimating the exports and imports for each region. The adjustments made to each sector are as follows:

- For the financial sector, we think the inconsistency arises because of the influence of large export volumes to the rest of the world. Scottish exports to the rest of the world are c. 24% of the total domestic demand (compared to an average of 8% for all sectors). We correct for this by adjusting the location quotient calculations to remove employment devoted to exports to the rest of the world.
- For the accommodation and food services sector, we continue to use location quotients because they are consistent with tourism data.
- For the household activity sector, we use compensation of employees instead of employment to calculate location quotients
- For the agriculture sector, we continue to use employment based location quotients due to instability in the sector.
- The impact of the public administration, health and education sectors on the economy is small and not material, and so we used the location-quotients based approach to estimate exports.
- For the arts and entertainment sector, and for the real estate sector, we use the export to GVA ratios along with the total GVA of the sector in the region to obtain the export estimates of the region.

Table 2: Direction of trade: Comparison between location-quotient based estimates and Scotland data

Sector	Direction of trade			GVA	Total trade volume
	Data (2009)	Calculations	Match (✓/✗)	% of total (2009)	% of total (2009)
Agriculture, forestry and fishing	-ve	+ve	✗	0.80%	1.77%
Mining and quarrying	+ve	+ve	✓	3.06%	7.68%
Manufacturing	-ve	-ve	✓	11.50%	38.48%
Electricity, gas, steam and air-conditioning supply	+ve	+ve	✓	2.52%	2.61%
Water supply; sewerage and waste management	+ve	+ve	✓	1.60%	0.48%
Construction	+ve	+ve	✓	7.59%	2.94%
Wholesale and retail trade; repair of motor vehicles	-ve	-ve	✓	10.06%	2.02%
Transportation and storage	-ve	-ve	✓	4.80%	4.95%
Accommodation and food service activities	-ve	+ve	✗	3.24%	1.89%
Information and communication	-ve	-ve	✓	3.55%	6.78%
Financial and insurance activities	+ve	-ve	✗	9.30%	14.25%
Real estate activities	+ve	-ve	✗	6.26%	0.68%
Professional, scientific and technical activities	-ve	-ve	✓	5.92%	7.17%
Administrative and support service activities	-ve	-ve	✓	3.99%	6.59%
Public administration and defence; compulsory social security	+ve	+ve	✓	5.94%	0.00%
Education	+ve	-ve	✗	6.76%	0.75%
Human health and social work activities	-ve	+ve	✗	10.09%	0.07%
Arts, entertainment and recreation	-ve	+ve	✗	1.56%	0.63%
Other service activities	-ve	-ve	✓	1.19%	0.21%
Activities of households	+ve	n.a.	✗	0.26%	0.05%

Source: Scotland IO tables (Direction of trade and trade volumes, 2009) and ONS (GVA, 2009)

### 2.3.6. Other adjustments and rebalancing

Where exports and imports are significantly higher than the GVA share of the sector, and where this high ratio could not be justified, we have adjusted the share of exports (and the converse imports) down based on the export to GVA shares of the region and using other studies. We have also reconciled the estimates with the Scotland Input Output tables, the estimated Welsh Input Output tables and other sector studies. Following these adjustments, further minor adjustments were made to the overall export and import estimates so that the system remains balanced.

## 3. Model Design: Core Properties

### 3.2. Section overview

This section lists the core properties of the MR-CGE model. It also provides a description of the key underlying economic theory that the model is based on.

### 3.3. The circular flow of income

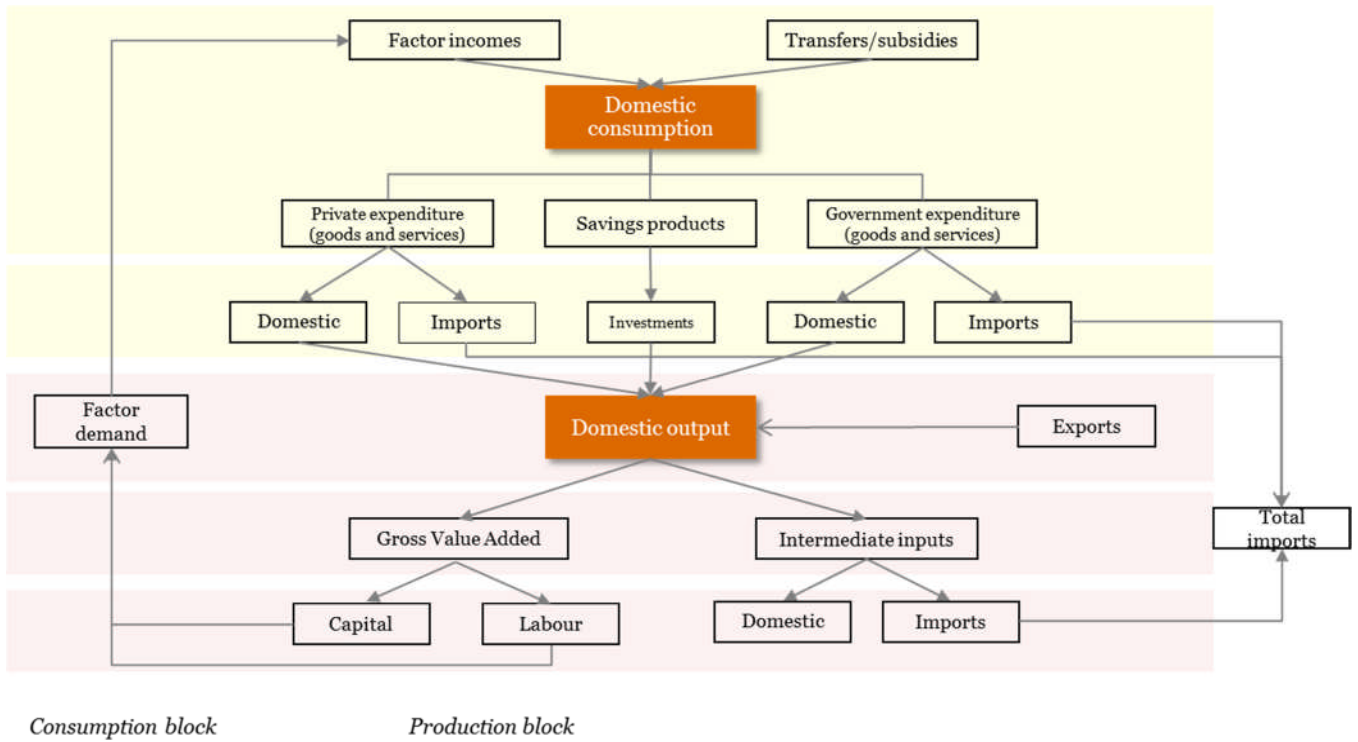
CGE models are based on the circular flow of income which illustrates how economic agents receive and spend income in the economy. Figure 2 provides a summary of the circular flow in the context of the MR-CGE model. The model is split into two components – or “blocks” as they are often referred to when describing CGE models.

1. the production block; and
2. the consumption block.

Each block contains both data and equations that correspond to a key feature of the model e.g. exports or household consumption. The way that we have presented these blocks does not capture all economic linkages in the MR-CGE model, they are designed to summarise the key economic interactions in a reasonably intuitive way.

In Figure 3 the square shapes represents blocks of model equations and data. The shaded arrows represent two-way direct, indirect and induced linkages in economic activity. The dotted arrows used in later figures, represent key elasticity parameters and their associated functional forms that govern the interactions of these relationships. These pictorial definitions are used throughout this report.

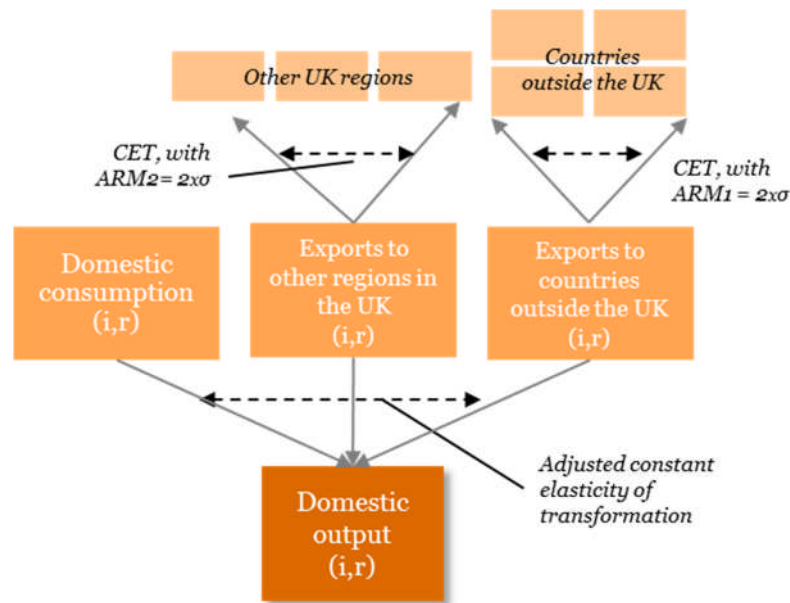
Figure 2: The circular flow of income



### 3.4. The production block

In the MR-CGE model, demand from domestic consumption and abroad leads to domestic output being sold to the domestic and export markets. Firms choose the amounts to supply to each market as they cannot switch costlessly from supplying to one market to another (e.g. exported goods need to cater to foreign tastes). These relationships are illustrated in Figure 3 below.

Figure 3: The domestic output nest



In the MR-CGE model, output produced in sector  $i$  and region  $r$  can be exported overseas, exported to another region of the UK or consumed by households in any UK region. When an economic scenario is imposed on the model, the proportions that are exported and consumed then adjust according to changes in relative export and domestic prices that are determined endogenously by the model. A Constant Elasticity of Transformation (CET)<sup>29</sup> function governs the rates at which these proportions change. For example, if the CET equals 3, a rise in the relative price of exports outside the UK by 1% causes firms to increase the relative quantity of exports to countries outside the UK by 3%.

Domestic output comprises of intermediate inputs used in the production process – both domestically produced and imported – and Gross Value Added (GVA). In the MR-CGE model, the Leontief function<sup>30</sup> is used to represent the technological relationship between the amount of inputs (GVA and intermediate inputs) used and the amount of output that can be produced. Using a Leontief function ensures that the proportion of inputs (GVA and intermediate inputs) is fixed. These relationships are illustrated in the domestic production nest in Figure 4 below.

The domestic production nest determines that when an economic scenario is imposed on the CGE model then:

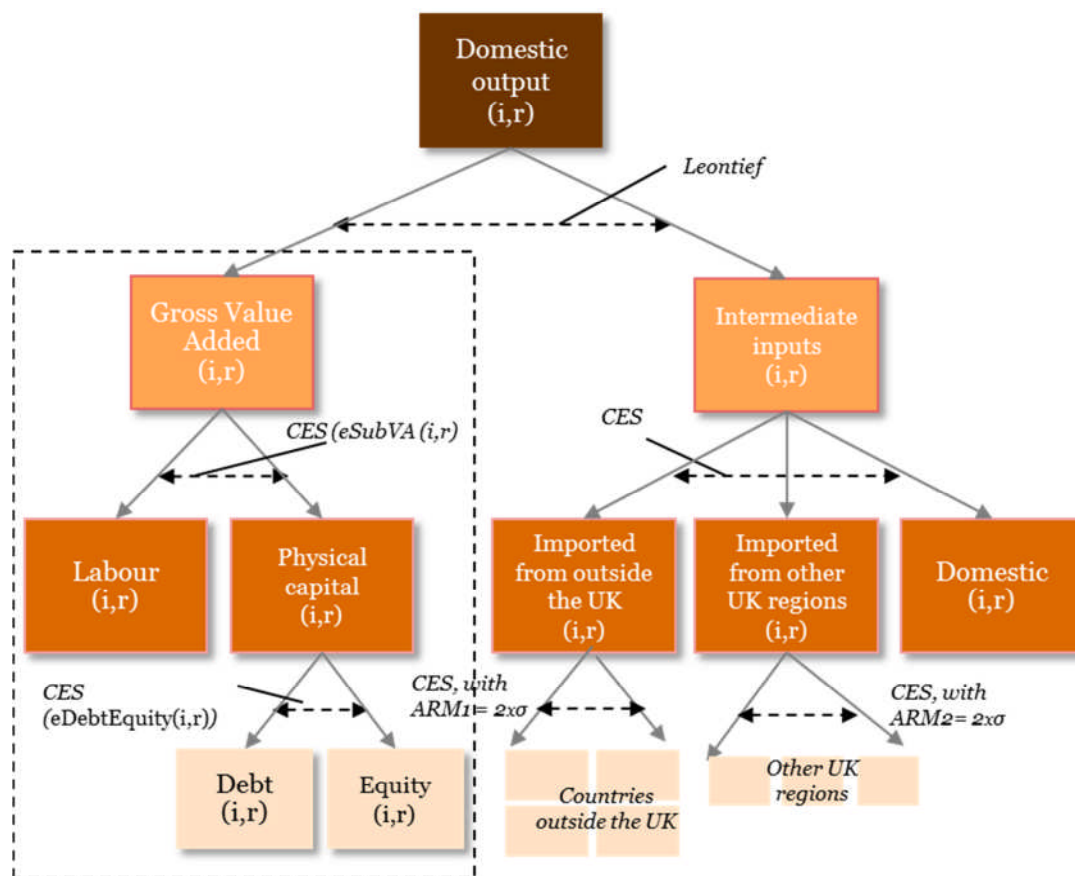
- GVA will vary by industry  $i$  and region  $r$ .
- Intermediate inputs will vary by industry  $i$ , region  $r$  and product  $j$ . Intermediate inputs are sourced from the use matrix and are subject to taxes on production.

Figure 4: the domestic production nest

<sup>29</sup> The CET models producers' decisions about how they allocate production to the domestic and export markets. It is the corollary of the CES function. For a more detailed description see: Powell, Alan A.; Gruen, F.H.G. (October 1968). "The Constant Elasticity of Transformation Production Frontier and Linear Supply System". *International Economic Review* (Wiley) 9 (3): pp. 315–328

<sup>30</sup> The Leontief production function or fixed proportions production function is a production function that implies the factors of production will be used in fixed (technologically pre-determined) proportions, as there is no substitutability between factors. For a more detailed discussion see: Allen, R. G. D. (1968). *Macro-economic Theory: A Mathematical Treatment*. London: Macmillan. p. 35





Gross Value Added (GVA) comprises compensation for the use of production factors (physical capital and labour) which is measured by gross operating surplus (GOS, which consists of operating profits and other capital income), wages, and taxes on the production process. Net taxes on production include business rates and some subsidies.

Producers have a choice over using physical capital and labour, and the choice depends on the marginal productivity of these inputs and their relative prices. The Constant Elasticity of Substitution (CES)<sup>31</sup> governs the rate at which the proportions of labour and physical capital change. For example, if  $CES = 3$ , then a rise in the relative price of labour of 1% leads to a 3% increase in the relative quantity of physical capital used in production.

When financing capital growth, businesses can choose between debt and equity. This choice is also governed by a CES function. This data is sourced from the FAME database described above.

International trade is governed. This is based on the “rule of two”<sup>32</sup> method which is now commonly adopted in CGE modelling and can be described as follows: suppose a business has made its decision about the amount of

<sup>31</sup> The two factor (Capital, Labor) CES production function introduced by Solow, R.M (1956). "A contribution to the theory of economic growth". The Quarterly Journal of Economics 70: 65–94

<sup>32</sup> This assumption dates back to the work of Jomini *et al.* (1991) in the context of global CGE modelling. Jomini *et al.* find that most studies focused on estimating the elasticity between domestic and imported goods as a whole, but did not distinguish between imports from different regions. For this reason, they sought a "rule of thumb" linking these two parameters. Using earlier estimates of the elasticity of substitution of domestic and imported goods by Corado and de Melo (1983) as a justification, they adopted the "rule of two". References are as follows: Jomini, P., J. F. Zeitsch, R. McDougall, A. Welsh, S. Brown, J. Hambley, and J. Kelly (1991). *SALTER: A General Equilibrium Model of the World Economy 1. Model Structure, Database and Parameters*. Canberra, Australia: Industry Commission.

capital it will use in its production process. It must then make a choice about how to finance this capital outlay – it could use debt or equity finance. The principle behind the “rule of two” is the decision about the source of finance is more elastic than the decision to use capital or not. The “rule of two” is used in several instances in the MR-CGE model where specific elasticity estimates are not available.

A wide range of intermediate inputs are used in the production of domestic output. These inputs are purchased from the 15 sectors in the model. For example, a manufacturing company may purchase local IT services, which will be recorded as expenditure by the manufacturing company on domestic intermediate inputs. Consumption of the manufacturers by the IT supplier could also be purchased in turn from the manufacturer.

There is a regional element of cross-border intermediate purchases which is captured in the inter-regional trade flows, although the data is not able to explicitly distinguish between final demand and imported intermediates. The inputs are either be sourced from domestic producers, or they are imported from other regions in the UK, or from outside the UK. The choice between domestic inputs and imported inputs is determined by a CES function.

VDA (Value of domestic sales at agent prices) measures the output that is sold in the regional market. VDA comprises of domestic output sold in the regional market and imports from outside the region. VDA comprises of total supply, stocks and imports (both foreign and regional) less exports (both foreign and regional).

The value of domestic output that is sold in the UK market comprises of total supply and stocks less exports. In this model, a Cobb-Douglas relationship is used to represent the relationship between domestic output and imports. A Cobb-Douglas function with unit elasticity of substitution means that a rise in 1% of the relative domestic price of a product will cause a 1% reduction in the relative quantity of imports of the same product.

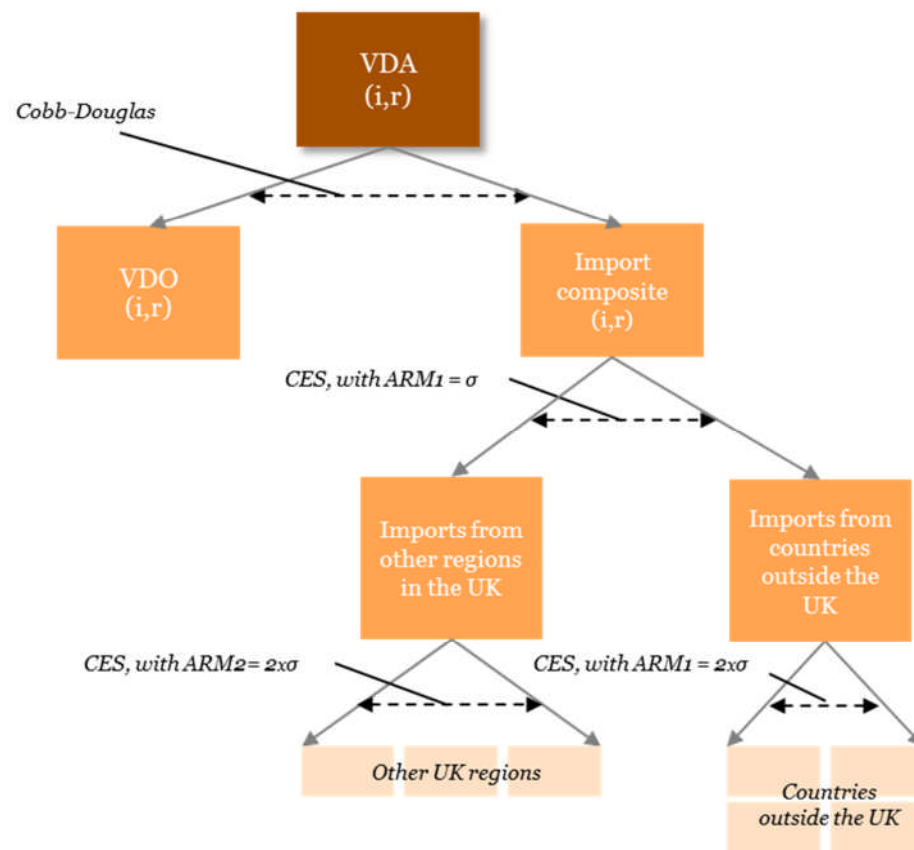
The choice between importing from other regions in the UK and from outside the UK is based on Armington preferences<sup>33</sup>. Armington preferences account for consumers’ preference for variety, in terms of the source of their purchases. The choice between different regions for imports from other regions, and the choice between different countries for imports from the rest of the world is also based on Armington preferences, with the elasticity of substitution being twice that of the higher nest. This is again based on the ‘Rule of two’.

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Corado, C. and J. de Melo (1983). An ex-ante model for estimating the impact on trade flows of a country's accession to a customs union. Discussion Paper No. DRD67, World Bank, Washington, DC.

<sup>33</sup> An Armington elasticity represents the elasticity of substitution between products of different countries, and is based on the assumption that products traded internationally are differentiated by country of origin. For a more detailed discussion see: Armington, Paul, 1969, "A Theory of Demand for Products Distinguished by Place of Production", International Monetary Fund Staff Papers, XVI (1969), 159-7

Figure 5: Structure of inter-regional output



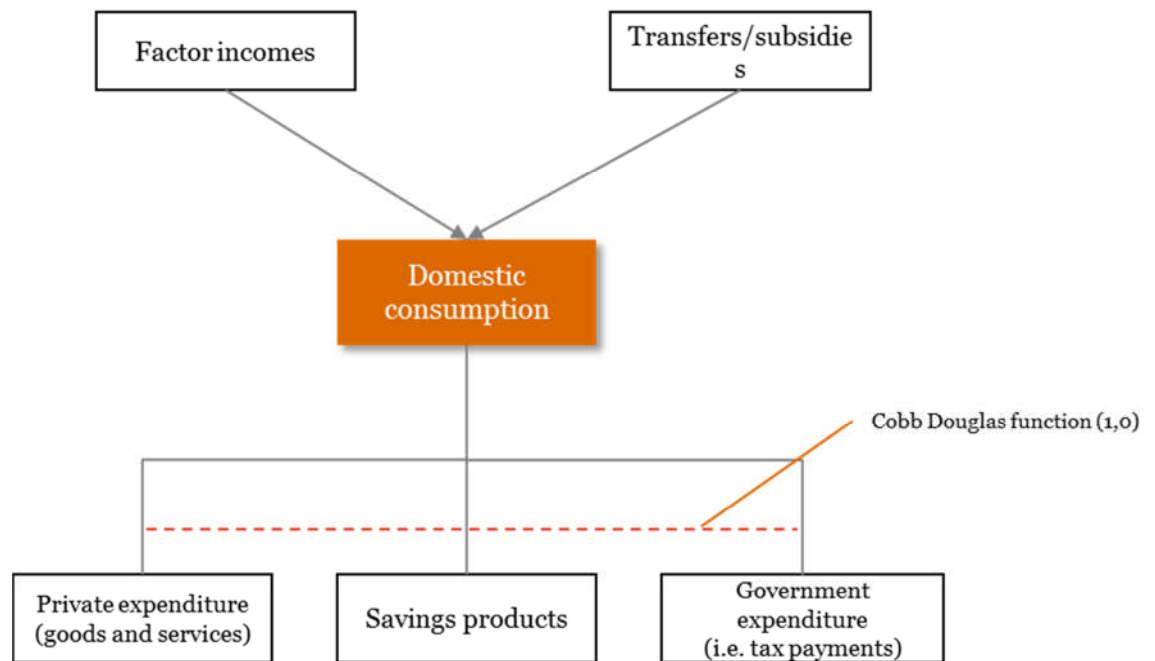
### 3.5. The consumption block

In the MR-CGE model, income is spent in three ways in the economy: private expenditure, government expenditure and savings products.

There are two sources of income in the MR-CGE model: factor incomes i.e. wages and gross operating surplus and government transfers/subsidies from redistributions of taxes collected by the government. This income is used in three ways: private expenditure, savings products (also called national savings) and government expenditure. In the MR-CGE model, a Cobb Douglas function<sup>34</sup> with unit elasticity is used to represent that a rise in 1% of the relative price of private expenditure, due to a tax hike for example, will initially lead a 1% reduction in the relative quantity of private expenditure. Subsequent behavioural effects and relative price changes are likely to dampen this effect.

<sup>34</sup> The Cobb–Douglas production function is a particular functional form of production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs.

Figure 6: The domestic consumption block



Private and government spending lead to demand for domestic and imported goods, and savings products drive investments in the economy.

In the MR-CGE model, Armington preferences are used to allocate demand for domestic and imported goods within the same product category. Such preferences mirror real world trading patterns where countries simultaneously import and export goods in the same product category.

Spending by households is governed by the Linear Expenditure System (LES). The functional form of the LES requires households to have a minimum level of consumption for subsistence (e.g. housing and food). The scale of these minimum requirements is linked to the income elasticity of demand for these goods. Typically subsistence goods have income elasticity  $<1$ , so as income falls, demand falls less than proportionately. The minimum requirements for each good are calibrated so as to achieve certain income elasticities of demand for goods as specified by sourced estimates for the UK from the GTAP (Hertel, 1997) database.

Household types are determined by the groupings in the Family Resources Survey (FRS) and range from Retired households, single adult households and various specifications of households with children.

National savings or purchases of savings products drive investments in the economy. Spending by the government is governed by a Cobb Douglas function with unit elasticity to represent spending in each sector as being a constant proportion of total government spending.

Households maximise inter-temporal utility subject to:

- Expected prices of goods and services; and
- Factor earnings

Demand for domestically produced goods and return on investments drive domestic production, which then drives the demand for factors of production.

Factor incomes received by households and firms in turn support domestic consumption in a circular loop.

### 3.6. The Government sector

Governments perform two functions in the MR-CGE model: they collect taxes and spend money. Government expenditure is split into the two main functions used in government accounting: Departmental Expenditure Limits (DEL) and Annually Managed Expenditure (AME).

There is a specific DEL sector in the MR-CGE which is a catch-all for the non-capital elements of government department spending (R-DEL). The model also captures capital DEL or (C-DEL) which is government expenditure on capital investment projects, i.e. infrastructure spending. The model estimates the government's capital stock and combines it with the assumption that it depreciates at a rate of 5% per annum, so some form of government investment is necessary, to preserve the level of capital.

AME data is available at the household and regional level, and is split into tax credits/benefits linked explicitly to hours worked, state pensions, disability benefits and other benefits.

The MR-CGE model has a detailed treatment of the UK tax system. HMRC has a range of data at the sectoral and regional level, and at the sectoral and household level. PwC were not given access to the majority of this data because of risks to taxpayer confidentiality in building the model. HMRC have updated this part of the model separately. PwC constructed the model using assumptions about the burden of taxation across households and regions in line with published HMRC statistics<sup>35</sup> about regional tax payments. The MR-CGE model accounts for around 95% of all tax payments to the UK exchequer – only taxes paid on a realisation basis (e.g. stamp duty, capital gains tax, dividend taxes and inheritance tax) are not modelled. All other UK taxes are captured in the model.

The Government budget balance is dictated by what is known in CGE modelling terms as a closure rule, i.e. the gap between government spending and receipts can be “closed” within the model in different ways. Suppose government DEL spending increases – then there are various options in the model:

- A specific tax head (VAT, corporation tax, income tax etc.) can increase to finance the additional spending (tax closure);
- Spending could be financed through an ad hoc lump sum tax on households (Harberger closure rule)<sup>36</sup>;
- The extra spending can be funded by increasing the fiscal deficit (debt closure); or
- Benefits could be cut (household transfer closure).

Correspondingly, if taxes were cut, then in addition to the debt, or household transfer rules being invoked, government spending could be cut to restore balance to the public sector balance sheet (government closure).

The tax closure rule allows the model to investigate revenue neutral tax reform options. For instance, if the government chose to increase income tax to finance a cut in VAT, then this could be specified as a separate closure rule in the model. This allows the economic efficiency of different tax options to be compared. For instance, if a cut in VAT which is financed by an increase in income tax led to a reduction in GDP, then this would imply that the income tax is a less economically efficient tax than VAT. The outcome of this experiment would be dependent on a range of factors, e.g. which bands of income tax were cut, which elements of VAT were increased (the standard or reduced rate), the initial rates of taxation, the surrounding assumptions about the economic environment (i.e. strong consumption outlook vs. weak labour market outlook). The full plethora of revenue neutral options are not specified in the basic version of the model, but are specified separately depending on the scenario modelled.

<sup>35</sup> <http://www.hmrc.gov.uk/statistics/receipts/disagg-method.pdf>

<sup>36</sup> Harberger, A.C (1962) “The Incidence of the Corporation Income Tax” *The Journal of Political Economy*, Vol. 70, No. 3. (Jun), pp. 215-240

Rather than specify particular taxes to offset each other or to avoid using a specific tax head to close the model when investigating changes in spending or government debt, an alternative closure rule is specified to proxy the effects of an assumed “lump-sum” tax. This tax assumption is taken from Harberger (1962) and is used as a neutral closure assumption. This is the most commonly used closure rule in CGE modelling. The lump sum tax levies an equal tax on each household in response to a change in spending, government debt or other taxes.

The debt closure rule assumes that changes in the budget position are not offset by other policies, but affect the level of national debt. A change in government debt levels leads to a transfer to/from the corporate sector which buys/sells gilt-edged bonds to finance the government debt. The model features an assumption whereby the National Debt affects the risk premium faced by investors in the economy. Increasing levels of national debt raise the risk premium resulting in lower returns to investors. The model allows this relationship to be strengthened or weakened in sensitivity testing.

The MR-CGE model also splits the government into four regional components. For instance, if the Welsh government chose to cut the Welsh corporate tax rate, then this would need to be financed from Welsh government spending, Welsh transfer payments, Welsh debt, or increases in other Welsh taxes. The central UK government would not fund this tax cut in the model. Further, if the Welsh corporate tax cut reduced the level of activity in Scotland, then Scottish tax receipts would fall. The model would automatically invoke the Harberger closure rule to bring the Scottish fiscal position back into balance.

### **3.7. The labour market and migration flows**

The MR-CGE model forms a direct relationship between employment, wages and levels of economic activity. Underlying the model is a dynamic labour market function. Its core properties are as follows:

- 1) Workers can enter and exit the labour market as wages rise or fall.
- 2) Workers can move between sectors and regions as these expand or contract depending on the level of economic activity. If wages rise in the Scottish retail sector, then conceivably a worker from the Welsh government sector may wish to move into a new country and industry to gain from this wage rise.
- 3) If workers move between sectors, it is assumed they need to retrain (e.g. an investment banker cannot turn into a chef overnight). The model assumes a temporary loss in productivity as people retrain and subsequently their wages will fall during this period. This decline in wages approximates a degree of labour market rigidity in the model.
- 4) Current patterns of migration flows which would limit the flow of workers between regions.
- 5) The wage sensitivity of migration flows is governed by a separate elasticity parameter.

Data on employee compensation are sourced from ONS GVA data: gross wages are a subcomponent of employee compensation, the other component being benefits in kind (BIKs). BIKs consist of a range of financial and non-financial employee remuneration such as company mobile phones, vans, accommodation allowances etc. Employee compensation data are broken down by region and by sector in the model.

### **3.8. Model dynamics**

The MR-CGE model is dynamic; this means that it makes a forward looking projection of the economy over time. The model assumes perfect foresight and can be run for approximately 40 time periods. The length of time for which the model can be run is dependent on two key factors:

- **the size of the scenario being run:** larger scenarios use more computing power and make the model harder to solve, thus necessitating the need to reduce the number of time periods); and
- **the overall size of the model:** the additional equations relating to the dynamic labour market and imperfect competition increase the size of the model considerable and therefore the required computing power.

Time periods are linked through savings, household utility, and capital accumulation. In each time period capital adjustment is governed by a standard depreciation plus investment function. The model is calibrated so

that each time period is equal to 1 year. Although, this is approximate and where possible the adjustment processes in the model should be compared directly to econometric evidence about adjustment speeds to policy changes to refine the model's accuracy.

Investment in each industry, and by type of capital, is subject to installation costs (Uzawa 1961,<sup>37</sup> Markusen *et al.*, 2000)<sup>38</sup> whereby the cost of investment is related to the amount of installed capital. The equations are set-up so that more rapid capital accumulation therefore becomes increasingly costly.

### 3.9. Imperfect competition

Industries are imperfectly competitive with increasing returns to scale. Imperfect competition is based on the Dixit-Stiglitz large-firm Cournot structure<sup>39</sup>. Perceived or real entry by rival firms forces economic profits to zero. Firms set a mark-up depending on their perception of the elasticity of demand for their product. Firm's perception of their elasticity of demand is a function of an index of firms in each industry (this also varies by region) and a conjectural variation parameter. This is used to calibrate firms' market power in both domestic markets, regional markets and overseas export markets for all commodities that they produce.

### 3.10. International trade

The foreign sector is largely governed by the Armington (1969)<sup>40</sup> assumption, whereby domestically produced and imported goods are treated as being qualitatively different. This assumption is used in most trade models. In CGE models, products are often differentiated on the basis of their geographic point of production as well as by their physical characteristics, with "similar" products being close substitutes in demand.

This assumption of product heterogeneity is used to accommodate the statistical phenomenon of cross-hauling (the simultaneous importing and exporting of the same good) in the data used, and to exclude complete specialisation in production as a behavioural response in the model.

<sup>37</sup> Uzawa, H. (1961) "Neutral Inventions and the Stability of Growth Equilibrium", *Review of Economic Studies*, 28(2), 117-124

<sup>38</sup> Markusen, James, R. , Rutherford, Thomas, F., & David Tarr (2000) "Foreign Direct Investments in Services and the Domestic Market for Expertise," NBER Working Papers 7700, National Bureau of Economic Research, Inc.

<sup>39</sup> Dixit, A. and Stiglitz, J.E. (1977) "Monopolistic Competition and Optimum Product Diversity", *American Economic Review*, June, 297-308

<sup>40</sup> Armington, Paul, 1969, "A Theory of Demand for Products Distinguished by Place of Production", *International Monetary Fund Staff Papers*, XVI (1969), 159-7

# Appendix A: Data sources

## A.1 Data Sources

The precise dataset that is needed to build an MR-CGE model for the UK economy did not exist prior to the start of this project. CGE models are based on a form of National Accounts (NA) data known as SUT's, or input output (IO) tables. SUTs are available for Scotland and the UK as a whole, while an IO table exists for Wales. No equivalent dataset exists for England and Northern Ireland. This meant that these tables needed to be constructed for the purposes of this project. The data sources for this purpose are listed in Section 2.1.

Following the gathering of data, it is then collated into a format so that it can be entered into the SUT framework. There are instances of missing data – particularly for sectoral investment, inter-regional trade, and services imports and exports; and in the case of England and Northern Ireland, the core product use coefficients. Where data was missing at the sectoral level, regional aggregate totals were apportioned using either UK level data, GVA data or information from sector/industry specific reports. The gathering of data was undertaken by PwC with assistance from HMRC and the Office for National Statistics. Much of the survey information listed in Section 2.1 feeds into the existing UK and Scottish SUTs.

Given that some elements of the model's data were estimated, we have undertaken sensitivity tests by varying the range of this data by plus/minus 50% to observe the extent to which it influenced the model's results. The plus/minus 50% range was considered to be the absolute maximum error that would be present in our data, as a range of what the actual data values could be, as inferred from the data that was already in existence and the central balancing principles that form the basis of the UK National Accounts (e.g. income equals expenditure, supply equals demand etc.). Our findings strongly suggest that even with the assumption of a potentially wide variation in missing data, it is insufficient to change the core findings of the model.

## A.2 The Supply Use Framework

Fitting the survey data to this framework led to a number of inconsistencies. For instance, an initial step was to aggregate the Scottish SUT and UK SUT to the same set of SIC codes and then subtract the Scottish SUT from the UK SUT to obtain a starting point for building the Welsh, Northern Ireland and English SUTs. However, there were large inconsistencies with the tables which led to several negative entries, which would be inconsistent with UK level National Accounts data. Other inconsistencies appeared when summing household level data to compare with National Accounts aggregates. Because of these inconsistencies, a rebalancing algorithm known technically as the RAS approach was used to iteratively balance the whole dataset to ensure consistency with data published in the ONS Blue Book. Such problems are common in the construction of SUT tables.

Additional data have been added to the SUT framework and key differences are illustrated by displaying the Use table in Table A12. A 2x2 commodity – industry description of the components in the Use tables are given as follows:

Activity (Production) Accounts: these are represented by the row entries in Table A13.

- **A** represents intermediate goods and raw materials, which are the Leontief coefficients in the supply and use tables. Intermediates are purchased to produce commodities.
- **TX** represents taxes on production paid by different industry groups.
- **SE** represents self-employment income, this data is not normally published as part of the SUT data, but is published at the sector level.
- **YL** represents compensation of employees.



- **NIC**, or national insurance contributions have been added at the sector level to the SUT framework.
- **GOS-D and GOS-E** represents capital returns accruing to debt and equity in the gross operating surplus (GOS). GOS data is published as part of the SUTs, but these additional ratios are supplemented from company survey data.
- **CT** represents corporate tax payments.
- **CA** represents capital allowances.
- **TS**, or total supply, represents the column total.

Commodity Accounts: these are represented by the column entries in Table A13 and can be described as follows:

- **HC** represents household consumption. The SUT data is broken down using coefficients on household consumption patterns obtained from the ONS Living Costs and Food Survey (LCF). The Scottish SUT provides additional information on the level of household consumption in Scotland by non-Scottish households. Unfortunately we were unable to obtain this data for other UK regions.
- **NPISH** represents consumption of business outputs by non-profit organisations.
- **GC** represents Government consumption by UK region.
- **GFCF** represents Gross Fixed Capital Formation – an indicator for business investment. This data is segmented by product type at the regional level using UK level totals.
- **SINV** represents Stocks and inventories, net position at year end.
- **X-SCO, X-WAL, X-NI** represent exports to Scotland, Wales and Northern Ireland – data on each region is modelled separately. This data does not exist, so was proxied using aggregate Scottish data and supporting information on levels of economic activity, relative to employees.
- **X-ROW** represents exports to the rest of the World.
- **TE** represents total expenditure represents the row total.

The Supply tables are only adjusted in a limited manner. Regional imports are added in the same way as exports described above and taxes on products are broken down into VAT paid on final consumption, VAT paid by exempt sectors, other taxes on products.

Table A13: Use table core data structure – sample for England

		Products											Total expenditure
		Intermediate consumption by industrial sector		English household consumption of UK products by household category	Non-profit institutions consumption	Government consumption by English governments local and at the country level	Gross fixed capital formation	Stocks and inventories	Exports to Scotland	Exports to Wales	Exports to Northern Ireland	Exports to rest of the world	
Industries	Intermediate use by industrial sector	A	A	HC	NPISH	GC	GFCF	SINV	X-SCO	X-WAL	X-NI	X-ROW	TE
		A	A	HC	NPISH	GC	GFCF	SINV	X-SCO	X-WAL	X-NI	X-ROW	TE
	Taxes on production	TX	TX										
	Self employment income	SE	SE										
	Compensation of employees	YL	YL										
	Employers National insurance contributions	NIC	NIC										
	Gross operating surplus - capital returns accruing to debt	GOS-D	GOS-D										
	Gross operating surplus - capital returns accruing to equity	GOS-E	GOS-E										
	Corporation tax	CT	CT										
	Capital allowances	CA	CA										
<b>Total supply</b>	<b>TS</b>	<b>TS</b>											

Source: PwC analysis



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