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Improving the Quality of Regional Economic Indicators in the UK: A Framework for the Production of Supply and Use and Input Output Tables for the Four Nations

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DISCUSSION PAPER

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Abstract

With increased devolution of powers, the UK's departure from the EU and Covid-19 having different impacts on different areas of the UK, timely regional economic statistics are needed to support regional and national policymaking. This paper develops a strategic framework for the production of supply and use tables (SUTs) and input output tables (IOTs) for the four nations of the UK. Our proposed framework is supported by three pieces of analysis. First, we undertake a comprehensive review of different methods for constructing regional SUTs and IOTs and current international practise. Second, we discuss how the Scottish, Northern Irish and UK SUTs and IOTs are produced and the challenges faced in their construction. Third, we compare the existing Scottish IOT, produced using hybrid methods, with the Scottish IOT we obtain through top-down regionalisation of the UK IOT using location quotients. We conclude our paper by outlining nine key recommendations.

Keywords: input-output, regionalisation, location quotient, non-survey method, hybrid method

JEL classification: C67, C83, O18, R15

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Improving the Quality of Regional Economic Indicators in the UK: A Framework for the Production of Supply and Use and Input Output Tables for the Four Nations

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Executive Summary

With increased devolution of powers, Brexit and Covid-19 changing the economic structure and linkages between different regions, timely regional economic statistics are needed to support regional and national policymaking in the UK. Regional Supply Use Tables (SUTs) provide devolved administrations with a disaggregated insight into the structure of a given region. Regional Input-Output Tables (IOTs) derived from the SUT facilitate estimation of regional impact assessments and economic models which can be used to analyse the effects of regional and national policies on different regions.

Of the four UK nations, only Scotland and Northern Ireland currently produce their own SUTs and IOTs on a regular basis. In this report, we develop a strategic framework for the production of SUTs across the four UK nations. For those unfamiliar with SUTs and IOTs and the difference between them, we begin by introducing these tables and discuss how they are used by economists and statisticians in policy and academia.

We then describe methods for producing regional SUTs and IOTs. We first discuss the bottom-up approach which involves detailed data collection at the regional level. While giving a higher level of accuracy, this approach is also more resource intensive and faces several practical, statistical and conceptual challenges. Many of these challenges arise from the fact that it is more difficult to measure regional activity than national activity. Top-down approaches involve regionalising the national UK SUT or IOT using an indicator variable.

We then focus on the UK data landscape, discussing the UK's sampling frame, the interdepartmental business register. We also consider the UK's Regional Accounts which record estimates of regional Gross Value Added (GVA), Gross Fixed Capital Formation and Gross Disposable Household Income produced using top-down methods. We then go on to discuss how SUTs and IOTs are compiled in the UK, Scotland and Northern Ireland. Importantly, Scotland and Northern Ireland both adopt a hybrid approach, using a combination of regionalised UK data and nation-specific data sources. They also constrain their totals to the Regional Accounts, although, for some sectors, Scotland has moved away from full consistency with the Regional Accounts.

We demonstrate how regional IOTs for the four nations can be produced by regionalising the UK IOT using location quotients (LQs). While producing regional IOTs from the published UK IOT is possible, there are some significant differences between our IOT and those produced using the bottom-up approach. The first key issue is the assumption that the GVA to output intensity for each region is the same as the national average leading to an unrealistic amount of imports and exports to the rest of the UK. The second issue is that using the LQ method produces much smaller intermediate sales and purchases than the bottom-up approach.

In our recommendations for compiling regional SUTs for the UK nations we consider two scenarios. The first scenario sets out how four SUTs for Scotland, Northern Ireland, Wales and England could be constructed using a predominately bottom-up approach. While this scenario is ambitious, it is also pragmatic and sets out how a bottom-up approach could be developed using the existing sampling frame, the interdepartmental business register, and existing business surveys administered by the Office for National Statistics (ONS) and devolved administrations. A bottom-up approach would lead to the four nations adopting similar data collection strategies facilitating comparability and compatibility. This would allow users to understand: (i) the production structure of a given UK nation, (ii) differences in production structure across UK nations and (iii) the production structure of the UK as a whole.

The second scenario is more modest and sets out how four SUTs could be constructed using a hybrid approach. This would involve using the Scottish and Northern Irish approaches as a starting point to develop a framework to produce SUTs for the four nations. Ultimately, this approach would allow users to understand the production structure of a given nation but accuracy declines perhaps rendering comparisons across the SUTs of different nations more problematic. Unlike a bottom-up approach, a hybrid approach may not facilitate similar data collection strategies across nations with an imposition of consistency potentially preventing regions from incorporating useful nation-specific data sources. Regional SUTs are also typically constrained to the UK Regional Accounts produced using top-down methods.

To address these two scenarios we have a number of recommendations. First, when collecting data on Scottish, Welsh and English activity the feasibility of asking Great Britain Reporting Units (RUs) to report on the activity of their Scottish, Welsh and English Local Units (LUs) should be investigated further given that this approach has proven successful in Scotland and Wales, for example, when collecting interregional trade data. Taking this one step further, it may be possible to “create” regional RUs whose industrial classification reflects the dominant activity across regional LUs.

Second, surveys issued by the ONS such as the Annual Business Survey (ABS) and Annual Purchases Survey should have sample sizes which facilitate the estimation of statistics for the four UK nations as well as the UK as a whole.

Third, building on the Whole of Scotland Economic Accounts Project, a fifth SUT could be used to capture foreign production as well as offshore oil and gas extraction preventing the distortion of regional activity.

Fourth, we recommend that the Canadian approach to allocating central government and head office output be investigated in relation to the UK again to prevent distortions of regional activity.

Fifth, recognising that for some industries a top-down approach to regionalisation will be required, we recommend strengthening existing data sources by: exploring the possibility of developing regional GVA to output intensities using ABS microdata; mapping household consumption to industries; and collecting data on internal trade and regional exports, building on existing data collection by the Scottish Government and Northern Ireland Statistics and Research Agency (NISRA).

Sixth, given the issues associated with LQ based top down regionalisation, in particular, the underestimation of interregional exports and imports, we recommend a review of top-down regionalisation methods with respect to the UK IOT. In our unique policy context, it would be beneficial to assess how different top-down methods perform when other regional data (for example, data on interregional trade available from some the devolved administrations) is used to inform the regionalisation process.

Seventh, we would recommend that the four nations publish SUTs annually following a common timeline. The UK SUT, however, could be published earlier each year since the regional SUTs may need to utilise proportions derived from the UK SUT. We also recommend that the four nations agree on the minimum number of industries and products to include in their respective published SUTs. The 64 industries and products used by NISRA may act as a useful starting point. Importantly, each nation could still choose to compile a more detailed regional SUT for their own use.

Eighth, bottom-up data should, where possible, gradually replace the Regional Accounts produced using top-down methods. Where this is not possible, a reconciliation process should take place between the regional SUTs, UK Regional Accounts and UK SUTs with the devolved administrations identifying where Regional Accounts estimates are inappropriate.

Last, we recommend that all four nations also produce industry by industry IOTs annually since these tables are a crucial input for regional economic modelling. In the short-run, this process could be automated through regionalisation of the UK SUT using LQs and strengthened using additional data sources as detailed above.

Contents

List of Abbreviations

ABI	Annual Business Inquiry
ABS	Annual Business Survey
AC	Autonomous Community
APS	Annual Purchases Survey
BEIS	Department for Business, Energy and Industrial Strategy
BERD	Business Enterprise Research and Development
BESES	Broad Economy Sales Exports Survey
BR	Canadian Business Register
BRES	Business Register and Employment Survey
CGE	Computable General Equilibrium
CHARM	Cross-Hauling Adjusted Regionalization Method
CILQ	Cross-Industry Location Quotient
COE	Compensation of Employees
COFOG	Classification of the Functions of Government
COICOP	Classification of individual consumption by purpose
CPA	Classification of Products by Activity
CRA	Canada Revenue Agency
CSO	Central Statistics Office
DAERA	Department of Agriculture, Environment and Rural Affairs
DEFRA	Department for Environment, Food and Rural Affairs
DOE	Department of the Environment

DTM	Distributors’ Trading Margins
DUKES	Digest of UK Energy Statistics
EOTNI	External Overnight Trips to Northern Ireland
EU	European Union
HERD	Higher Education Research and Development
FCE	Final Consumption Expenditure
FISIM	Financial intermediation services indirectly measured
FLQ	Flegg’s Location Quotient
GB	Great Britain
GCS	Global Connections Survey
GDHI	Gross Disposable Household Income
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development survey
GERS	Government’s Government Expenditure and Revenue Scotland
GFCF	Gross Fixed Capital Formation
GOS	Gross Operating Surplus
GVA	Gross Value Added
HHFCE	Household Final Consumption Expenditure
HMRC	Her Majesty's Revenue and Customs
HMT	Her Majesty's Treasury
IDBR	Inter-Departmental Business Register
IMF	Intentional Monetary Fund
IBSP	Integrated Business Statistics Program

IO	Input-Output
IOT	Input-Output Table
IxI	Industry by Industry
KAU	Kind of Activity Unit
LCFS	Living Costs and Food Survey
LQ	Location Quotient
LU	Local Unit
NCB	National Central Bank
NHS	National Health Services
NI	Northern Ireland
NICVA	Northern Ireland Council for Voluntary Action
NIPS	NI Passenger Survey
NISRA	Northern Ireland Statistics and Research
NSI	National Statistical Institutions
NPISH	Non-Profit Institutes Serving Households
NUTS	Nomenclature of Territorial Units for Statistics
OBR	Office for Budget Responsibility
OECD	Organisation for Economic Co-operation and Development
ONS	Office for National Statistics
OSCAR	Online System for Central Accounting and Reporting
PIPES	Project to Improve Provincial Economic Statistics
PxP	Product by Product
PRODCOM	UK Manufacturers' Sales by Product

QCE	Quarterly Construction Enquiry
RU	Reporting Unit
RUK	Rest of UK
ROI	Republic of Ireland
ROW	Rest of World
SAM	Social Accounting Matrix
SIC	Standard Industrial Classification
SLQ	Simple Location Quotient
SNA	System of National Accounts
SOT	Survey of Overseas Travellers
SUT	Supply Use Table
TSW	Trade Survey for Wales
UES	Unified Enterprise Survey
UK	United Kingdom
UN	United Nations
VAT	Value Added Tax

1. Introduction

The Supply Use Tables (SUTs) for Northern Ireland and Scotland have been a key source of data for our ESCoE projects on interregional trade. More broadly, unlike the national UK SUTs and Input-Output Tables (IOTs), these regional SUTs and IOTs give devolved administrations a more detailed and disaggregated insight into linkages between different parts of the domestic economy. They also allow the estimation of regional impact assessments and economic models.

Our experience of working in and with the Scottish Government and, to a lesser extent, the Northern Ireland Statistics and Research Agency (NISRA), tells us that different decisions about how to compile regional SUTs may affect the level of output of an industry and any associated trade. The intention of this report is to collate our experiences in Scotland and Northern Ireland. We will also survey the work undertaken by academics and national statistical institutions (NSIs) and central banks (NCBs), discussing how regional SUTs and IOTs can be produced using different approaches depending on the availability of regional data. In doing so, we seek to provide a framework to produce regional SUTs and IOTs for the four nations of the UK.

The focus of this report is on SUTs and IOTs which consider a single region, however, our interregional trade estimates (see Grieg et al., 2020 and Davidson and Spowage, 2021) together with regional SUTs could form the basis for *interregional* SUTs and IOTs. For consistency, throughout this report we will refer to SUTs and IOTs relating to provinces, regions, sub-regions and local areas as regional SUTs and regional IOTs. We will refer to Regional Accounts, produced in the UK by the Office for National Statistics (ONS), until recently in accordance with EU regulation, as Regional Accounts.

This report is set out in three distinct parts. For those unfamiliar with SUTs and IOTs and the difference between them, in part A we will introduce these tables. In Sections 2 and 3 we will also discuss how SUTs and IOTs are used by economists and statisticians in policy and academia. In Section 4 we will discuss methods for producing regional SUTs and IOTs, distinguishing between bottom-up approaches and top-down approaches. We will also introduce location quotients (LQs), a popular top-down approach used to regionalise national IOTs. In the last part of this section, we will also explore current international practise.

In part B, we will begin to focus on the UK data landscape. In Section 5, we will contrast how regional SUTs and IOTs are compiled in the UK, Scotland and Northern Ireland. In Section 6, we will demonstrate how regional IOTs for the four nations can be produced by regionalising the UK IOT using LQs. This thought experiment will allow us to contrast bottom-up and top-down approaches and explore the issues which arise when it is not possible to derive the regional IOTs from the regional SUT.

In part C, we will provide our recommendation for a framework to produce regional SUTs and IOTs for the four nations. Section 7 will discuss these in detail while Section 8 will conclude.

PART A: A PRIMER ON NATIONAL AND REGIONAL SUTS AND IOTS

2. SUTs and their Applications

This section is intended to serve as an introduction to SUTs. This includes a high-level overview of what they are, their practical applications and how they are constructed.

However, SUTs and their construction is a large and complex subject. We have aimed to provide an overview by highlighting important concepts, rather than providing a detailed reference. For anyone interested in learning more about SUTs, we highly recommend looking at the Eurostat Manual of Supply, Use and Input-Output Tables.

2.1. An Introduction to SUTs

SUTs form part of the System of National Accounts. They have a number of uses, such as being an ideal way to compile Gross Domestic Product (GDP) and can be transformed into analytical IOTs.

In general, SUTs provide insight into the value of each industry's inputs and outputs in a given year. They also present the relationship between the industries and products (goods and services) in the area.

Supply tables describe the supply (output) of both products and industries within an economy. This includes domestic production of products by industries, as well as imports of products.

Use tables describe the use (consumption) of products, primary inputs (e.g. employee costs) and industries within an economy. Including those used by industries for intermediate consumption, and those used by sources of final use (e.g. households, government etc).

A major step in the production of SUTs is balancing these two tables with each other. The large amount of data used to create these tables, along with this balancing process, provides an understanding of the economy that is consistent with all data sources.

It is therefore recommended that a supply and use framework is used as the basis for all national accounts data.

SUTs are used to provide a wide arrange of key statistics on the area's economy and form the basis for analytical IOTs.

In presentational terms, regional SUTs differ little from national tables. With the major exception being in the export columns and import rows – now split into international exports and rest of UK trade. The latter may also be further separated into trade with individual parts of the UK.

2.2. Important Definitions

In this section we lay out some of the most important definitions used in SUTs which will aid in the understanding of how these tables are constructed.

2.2.1. Products and Industries

Firstly, goods and services are classified into product groups. They are classified according to the Classification of Products by Activity (CPA 2008)[2].

For example, product group 01 is 'Products of agriculture, hunting and related services'. This includes many product subcategories such as wheat (01.11.1) and apples (01.24.1), as well as chickens (01.47.11) and support services to animal production (01.62). All products are covered in 3,142 subcategories in CPA 2008.

Those familiar with the groupings of organisations into industries by standard industrial classifications (SIC 2007) will immediately be able to spot the similarities.

In the SUTs, every industry has a 'primary product' associated with it. For instance, the primary product of industry 'Crop and animal production, hunting and related service activities' is 'Products of agriculture, hunting and related services'.

Organisations are then classified to industries according to the product they produce that makes up the largest share of their output.

An important consideration here that is organisations can be classified to one industry, while also producing (some) products that are not the principal product of that industry (by-products). These other products are called 'secondary output'.

[2] https://ec.europa.eu/eurostat/web/cpa/cpa-2008

2.2.2. Prices

Some key concepts surround SUTs that arise from how the data is collected.

For instance, data on the output of businesses typically asks about their sales. While data on the inputs of businesses typically asks about their costs. These two measures are not equal. Among other differences, the latter is likely to include transportation costs for any goods while the former will not.

This difference is important for SUTs as the tables require outputs and inputs to be balanced. This gives rise to different types of prices.

The basic price is the amount received by the producer for a good or service. This is excluding taxes on products and including subsidies on products.

The producer price is also the amount received by the producer for a good or service. But this is including taxes on products (e.g. alcohol duty), excluding deductible VAT and excluding subsidies.

The purchaser's price is the amount paid by the purchaser for a good or service. This includes non-deductible VAT, trade margins by wholesalers and retailers and transport margins.

The different between basic prices and purchasers' prices are presented in the SUTs as columns for taxes less subsidies on products and distributors' trading margins.

2.2.3. Imports and Exports

In the SUTs for the UK, imports and exports simply refer to the importing and exporting of any goods and services from or to the UK.

However, in a sub-UK setting imports and exports refer to importing and exporting from or to both international countries, *and* other parts of the UK.

For instance, the Scottish Government chooses to segment the exports of Scotland into exports to the rest of the UK and exports to the rest of the world.

NISRA segments the exports of Northern Ireland into exports to the Republic of Ireland, exports to Great Britain, exports to the rest of the EU and exports to the rest of the world. The final two are aggregated in the publicly available data.

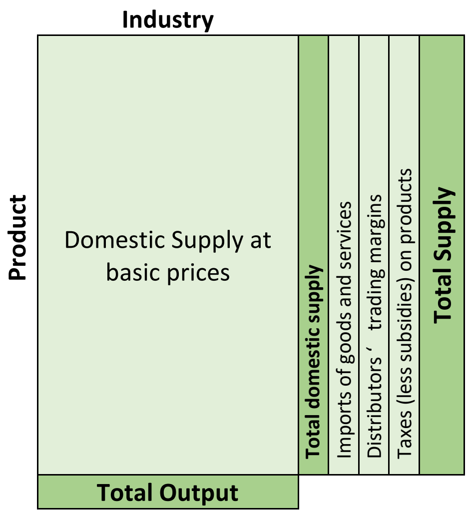
The choice of how to segment exports comes down to both the availability of data and the usefulness to that area.

2.3. Overview of the Supply Table

A supply table describes the goods and services (products) produced by industries within the area, as well as imported goods and services imported.

The diagram below shows a simplified supply table.

Supply Table



This table is a product by industry table. That is, the rows represent products and the columns represent industries (and imports / distributors' trading margins). The final column shows the total supply of each product within the area, no matter if this is sourced from domestic or non-domestic industries (i.e. imports).

The domestic supply section therefore shows the products (both primary and secondary) produced by domestic industries.

In a square matrix, where the number of products is the same as the number of industries, the primary products would lie across the diagonal with the secondary products making up the remainder of the rows in a given industry column.

However, SUTs can include more products than industries, making these rectangular. Whatever decision is made over the number of industries and products to include, it should be the same selection and number for both the supply and the use table.

The columns for Distributors' trading margins and taxes (less subsidies) on products will be explained in more detail later but it is included so that the tables can be balanced.

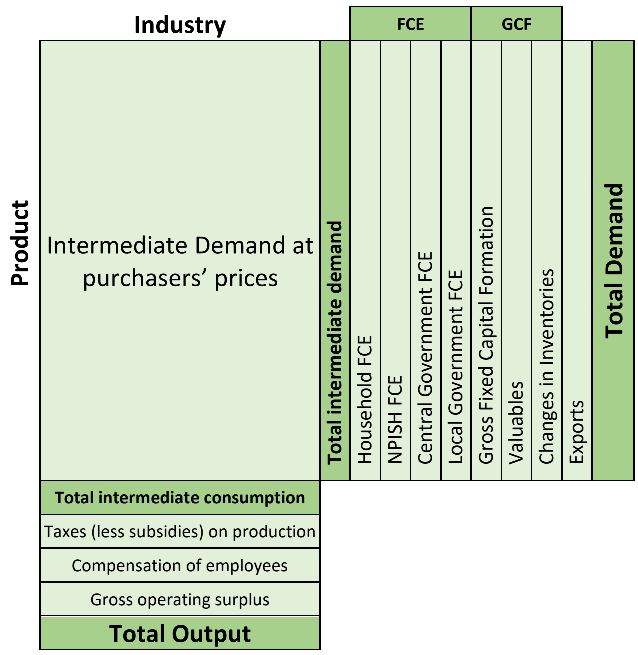
2.4. Overview of the Use Table

While the supply table shows how goods and services in the economy are supplied by industries and imports, the use table shows how goods and services are used by industries and final uses (e.g. final consumption, exports etc.).

The use table also shows how industries generate value added.

The table below shows a simplified use table.

Use Table



This table is also a product by industry table. The final column represents the total domestic output of each product.

The final row represents the total inputs of each industry. The section on balancing below explains why total inputs are equal to total outputs.

The use table includes three tables:

- A table of intermediate use which describes how industries use products to produce their output.
- A table of final use which describes how sources of final demand purchase products. Part of this is Final Consumption Expenditure (FCE), part is Gross Capital Formation (GCF) and the remaining part is exports.
- A table of value added.

The table of value added includes taxes (less subsidies) on production, compensation of employees (part of which is wages) and gross operating surplus.

Together, these form gross value added (GVA) – a measure of the contribution of an industry to GDP. GVA represents the difference between industry output and industry intermediate consumption.

The table of intermediate use in measured at purchasers' prices as, in practical terms, businesses will be asked about their input costs.

The table of final use includes a final consumption expenditure section, typically with columns for households, non-profit institutes serving households (NPISH), central government and local government. Gross Fixed Capital Formation (GFCF, essentially investment), valuables and change in inventories follows this. The final section includes exports, which is sometimes split into different export destinations (e.g. EU or non-EU).

2.5. Understanding Balancing

The initial SUTs must go through what is called 'balancing'. The basic premise of this is that:

- The total supply of a product is equal to the total use of a product
- The total output of an industry must equal the total input of an industry

An example of this is that if the agriculture industry sells £100m, then it must be that case that other industries or final uses (e.g. households) are buying £100m from the agriculture industry. And the same is true for the products of agriculture.

Using the valuation matrices, which include distributors' trading margins and taxes less subsidies on products, we can transform the supply table at basic prices into purchasers' prices.

Once the supply and use tables are both at purchasers' prices, a balancing process can occur.

Typically, a manual balancing is first undertaken. This is informed by past tables, external information and the robustness of data sources.

When in an almost balanced state the final balancing is achieved automatically by using a method known as the RAS procedure.

In the balancing of the ONS UK SUTs, the intermediate consumption has more adjustments made than output as the data for the latter is thought to be more reliable. For the columns of the use table, HMRC compensation of employees data is also seen as a more accurate data source and much of the balancing occurs in private non-financial corporations' gross operating surplus instead (for some industries, mixed income[3] is instead adjusted). For the rows of the use table, expenditures are typically seen as weaker data sources. Inventories and valuables are not adjusted while the main balancing occurs in household expenditure. Trade in services is also adjusted more than goods.

In the Scotland and Northern Ireland tables, the weakest data is interregional trade – particularly purchases from the rest of the UK. This is the primary focus of balancing in these tables.

2.6. Applications of SUTs and Measuring GDP

Official statistics provide a useful way to understand important trends and characteristics of an economy. However, many data sources lack consistency with each other.

For example, output data often does not match use data due to different prices, methodologies, surveys, respondents, classifications and so on. This can lead to difficulties in understanding the characteristics of economic activity occurring within an area.

SUTs bring together all available output, input, GVA, income and expenditure data sources in a consistent framework, presenting accounts of an area's economic activity and playing an important role in the quality of national accounts.

SUTs are an excellent source of information on major aggregates. Examples of these aggregates include:

[3] Businesses are able to separate their remuneration of capital (gross operating surplus) from their remuneration of labour (compensation of employees). For unincorporated businesses, (e.g. sole proprietors) it is often impossible to separate these and this remuneration is described as "mixed income".

- Gross Domestic Product
- Gross Value Added
- Household Final Consumption Expenditure
- Government Final Consumption Expenditure
- Trade (exports and imports)
- Gross Fixed Capital Investment

A major benefit of the consistency between data sources is the ability to present (and balance) Gross Domestic Product in the three approaches – the output approach, the income approach and the expenditure approach. The next section explains this in more detail.

SUTs are the building block of analytical IOTs (described in Section 3). These are useful in a wide array of applications, and provide the basis of much macroeconomic modelling.

Due to the nature of SUTs, they can also be used to 'fill in the gaps' of any missing data.

For instance, there are legal requirements in Scotland of forecasting for the Scottish Budget. The Scottish Government uses a quarterly SUTs to produce a quarterly National Accounts, which is used for this forecasting. However, not all data is produced on a quarterly basis. The SUTs framework can be used to create sensible estimates for this missing data which fits with the data that is available quarterly.

The Supply and Use framework enables GDP to be estimated using three measurement approaches in a consistent set of tables.

The three approaches include:

- The production approach
- The income approach
- The expenditure approach

GDP measured using the production approach includes the output less intermediate inputs, and the taxes on products less subsidies on products.

GDP measured using the income approach is calculated as GVA plus taxes less subsidies on products.

In the SUTs, GVA is shown as the sum of compensation of employees (e.g. wages, pension contributions, and national insurance), taxes less subsidies on production[4] (e.g. business rates) and Gross Operating Surplus. These three rows can be seen at the bottom of the use table.

GDP measured using the expenditure approach includes the sum of total final demand less total imports.

This is readily seen in the final demand columns of the use table, showing the final demand of households, non-profit institutions serving households, government, gross capital formation, and exports. Imports can be found in the supply table.

[4] Taxes less Subsidies on Production are compulsory taxes and/or subsidies levelled on production even if no profit is made (e.g. taxes on land and buildings, subsidies to farms). Taxes less Subsidies on Products are taxes and/or subsidies applicable when the products are sold (e.g. VAT, stamp duty)

3. IOTs and their Applications

Analytical IOTs describe the monetary flows of goods and services in the economy, and the relationships between industries, types of final demand (e.g. household consumption, exports etc) and inputs (e.g. labour).

They have a wide range of applications, but are most commonly used to analyse the impact of the economy from a change in final demand. For instance, it can show the impact on jobs, GVA and output of an additional £100m of final demand for the manufacturing sector.

There are two types of IOTs – industry by industry (IxI) and product by product (PxP). These describe the choice of the intermediate rows and columns. Each lends itself well to different types of analyses, depending on whether you wish to examine impacts on a product or industry basis.

IO modelling models can be extended to look at many additional applications such as pollution, water use, incomes and much more.

This section provides an understanding of IOTs and how they are derived. It then covers their many applications, including analysing linkages between industries and use in demand-driven IO models which measure the impact of changes to the economy.

3.1. An Introduction to IOTs

The analytical IOT is constructed from the SUT and, as a result, has many similarities.

Table 1 below shows an industry by industry IOT for Scotland in 2017. This has been aggregated into two industries for simplicity.

Table 1: Simplified industry by industry IOT for Scotland, 2017, £m, basic prices

	Non-Services	Services	**Total intermediate use**	Household FCE	NPISH FCE	Gov FCE	GFC	Exports	**Total Use**
Non-Services	12,802	5,787	**18,589**	8,018	25	923	1,673	32,931	**62,160**
Services	7,181	34,674	**41,854**	46,182	3,366	37,914	13,523	45,956	**188,795**
Total domestic use	**19,983**	**40,461**	**60,445**	**54,200**	**3,391**	**38,838**	**15,196**	**78,887**	**250,955**
Imports	16,663	29,893	**46,556**	31,861	-	875	10,846	4,300	**94,438**
Total intermediate use	**36,646**	**70,354**	**107,000**	**86,062**	**3,391**	**39,712**	**26,041**	**83,187**	**345,393**
Taxes less subsidies on products	1,627	4,302	**5,929**	10,779		7.4	814	841	**18,370**
GVA	23,887	114,139	**138,026**						
Total Output	**62,160**	**188,795**	**250,955**						

The first thing to note is the similarity between the IOT and the use table. The columns include industries and sources of final demand, while the rows include the primary inputs. It should be noted that the IxI IOT is at basic prices.

The IxI IOT can be understood by reading across the rows or down the columns.

The rows describe sales. Looking across the services industry row, firms in the services industry sell £7.2bn and £34.7bn to firms in the non-services and services industry respectively. Firms in the services industry also sell £46.2bn to households in the form of final consumption expenditure, £37.9bn to government, £46.0bn as exports and so on.

The columns describe the purchases made in order to produce the outputs. Looking down the services industry column, services firms purchase £5.8bn and £34.7bn from non-services and services firms respectively. They also purchase £29.9bn of imports and an amount on compensation of employees (GVA is typically separated into its components).

These tables therefore provide a huge amount of useful information. For instance, you can see that firms in the services industry buy a considerable amount from other services firms. The manufacturing industry makes a proportionately large contribution to Scottish exports and imports, and so on.

3.2. Creating IOTs and deriving the Leontief

IOTs can be produced through a transformation of the SUTs. In basic terms this represents the shift from a product by industry combined SUT to a product by product or industry by industry table.

The first step in this process is to transform the SUTs from purchasers' prices to basic prices.

This is easy for the supply table as the transformation components are represented in the columns of the table (imports, margins and taxes less subsidies on products).

For the use table this is more difficult as these values are buried within many elements of the table. Each of the transformation components therefore needs a use table constructed – these sum together to make the 'transition matrix'. Subtracting this transition matrix from the use table at purchasers' prices results in the use table at basic prices.

With the SUTs now at basic prices, these can be transformed into industry by industry or product by product analytical IOTs.

This transformation requires a choice of assumption around secondary production.

For the IxI tables, an assumption is required for the sales structure and for the PxP tables the assumption is for the input structure.

3.2.1. The Industry by Industry IOT

An example of the issue of secondary production is the production of whisky which creates a number of by-products which are suitable for livestock feed and bio-energy production.

The required assumption revolves around whether the sales structure of the livestock feed sold by a whisky producer reflects the sales structure of the whisky industry, or reflects the sales structure of the livestock feed product.

For the fixed industry sales structure assumption, the assumption is that each industry has its own specific sales structure, irrespective of its product mix.

The fixed product sales structure assumption is that each product has its own specific sales structure, irrespective of the industry where it is produced.

The Eurostat manual states that the fixed product sales structure assumption is the more plausible of the two.

3.2.2. The Product by Product IOT

The industry technology assumption is that each industry has its own specific way of production, irrespective of its product mix. For example, the whisky industry has a specific input structure and even if the output mix changes, the proportion in which the inputs are used are not affected.

The product technology assumption is that each product is produced in its own specific way, irrespective of the industry where it is produced. For example, the same input structure is used to produce a unit of the livestock feed product, no matter which industry produces it.

The Eurostat manual states that the product technology assumption is the preferable choice of the two. However, the product technology assumption can be more suitable in cases when the secondary and primary products are technologically unrelated while the industry technology can be better suited to cases such as by-products.

A hybrid technology assumption can be used which combines both of these methods. This is typically done by dividing the supply table into two product by industry matrices. The first matrix contains the cells of the supply table to be processed under the product technology assumption and includes primary and subsidiary products – this is when the secondary products are technologically unrelated to the primary products. The second matrix contains the cells of the supply table to be processed under the industry technology assumption and includes the by-products (e.g. whisky and animal feed) or joint-products (beef and hide). Each of these matrices can then be used to generate transformation matrices, and the two transformation matrices can be combined into a single hybrid transformation matrix[5]. Both the Scottish Government and NISRA follow the hybrid assumption.

3.3. Applications of Analytical IOTs

Analytical IOTs have a wide range of uses. They are used extensively in government, academia and the private sector. Some of these uses include: the foundation of IO modelling,

[5] More discussion on the process of creating input output tables with a hybrid technology assumption can be found in the Eurostat Manual of Supply, Use and Input-Output Tables (2008).

hypothetical extractions and Computable General Equilibrium (CGE) modelling. In this section, we focus on how IOTs can be deployed in the public sector while briefly making reference to techniques pioneered in the academic literature.

3.3.1. Impact Analysis

IO modelling uses the relationships in the tables to determine the economy-wide impacts of a change. The IOT can be transformed into the Leontief Inverse Matrix. This matrix include the economic multipliers of each sector. The results from IO modelling include three effects.

Direct effects are the simplest – if there is an increase in demand for a sector then the output of that sector will increase by at least that amount.

Each sector in the economy is linked to the others, so an increase in output in one sector (which buys inputs from others sectors) will also require an increase in the output of the linked input sectors and these, in turn, have their own suppliers. This is known as the indirect effects.

The additional demand seen in the direct and indirect effects also requires increased labour inputs. The increase in employment generates further activity in the economy as the additional wages are spent on goods and services. This is known as the induced effect.

Direct and indirect effects are collectively known as 'Type I' effects while all three effects are collectively known as 'Type II' effects.

Multipliers are typically presented for output, GVA and employment[6]. They can be interpreted for a single industry as follows:

- **Output multiplier**: the increase in output in the economy resulting from an additional £1m (one-unit) of final demand for an industry.
- **GVA multiplier**: the increase in GVA in the economy from an additional £1m final demand for an industry.
- **Employment multiplier**: the increase in employment in the economy from a £1m increase in final demand for an industry.

[6] There can be inconsistencies around the naming of multipliers. For example, some reports categorise multipliers into "effects" and "multipliers". In these cases, "effects" are described as the increase in the variable of interest (e.g. employment, GVA) resulting from an additional £1m of final demand in an industry, i.e. what has been described in this paper. "Multipliers" are instead a ratio of direct and indirect impacts (or direct, indirect and induced impacts in the case of Type II models) to direct impacts.

These multipliers are typically presented in Type I or Type II terms.

Using the IOT in the setup detailed above is known as demand-side modelling which is the most common approach. The analytical tables can also be used to undertake supply-side modelling. This is also known as the price model. The demand driven IO model is developed using the Leontief calibration with the assumption of constant input coefficients whereas the supply-side (or price) IO model uses the Ghosh assumption, with fixed output coefficients. In the price model supply drives the model with demand reacting. This is the opposite of the demand-model where supply reacts to changes in demand.

Examples of some of the questions that IO can answer include:

- What is the impact of a construction project?
- What is the impact of changes (reallocation) in Government spending?
- What is the impact of increasing exports for specific sectors?
- What are the impacts of changes in tax for a specific item?
- What are the economy-wide impacts of job losses?
- What are the impacts of changes in household consumption (e.g. less private transport more public transport)
- What is the impact of changes in supply for a specific item?

3.3.2. Hypothetical extractions

As discussed, IOTs can be used to estimate the potential impacts arising from policies and projects. In addition, another use of IOTs, especially if time-series are available, is in descriptive and decomposition analysis.

IOTs can be used to determine sectoral backwards and forward linkages using a variety of methods. One core methodology is key sectoral analysis, measuring sectoral strengths of links to the ‘supply-chain’ and output. A variety of measurements can be made in key sectoral analysis with Leontief backward linkages and Ghosh forward linkages being most common. To rank sectors weighted Leontief and Ghosh measurements are frequently calculated.

The Hypothetical Extraction Method (HEM) is another method which uses the interconnectedness between sectors to quantify the economic importance of an individual sector or groups of sectors by hypothetically shutting down its production. A sector with “lower connectedness” (i.e. linkages with other sectors) would generate smaller knock on effects from being shut down.

A HEM can be used to extract a whole sector (e.g. construction), a sub-sector (e.g. construction of residential buildings), a set of activities across sectors (e.g. renewable energy activities) or a specific company (e.g. closure of a company).

Key sector analysis and HEM can be used to answer many questions, such as:

- What is the impact of “shutting down” a specific sector?
- What is the impact of “shutting down” a sub-sector?
- What would the impact be if a particular project had not taken place?
- What is the impact of a particular firm shutting, and this domestic production permanently being replaced by imports?
- Which sectors have the strongest linkages with other sectors? Which have the strongest domestic supply chains? Which are highly supportive of domestic employment?
- How has the structure of the economy changed over time?

3.3.3. Computable General Equilibrium and Macroeconometric Models

Macroeconometric models and CGE models use IOTs as an input to measure the impacts of changes to a baseline economy. However, CGE models are an extension , using a combination of IOTs and economic theory to relax several of the assumption of IO models.

The uses of CGE models vary greatly and there is no ‘one size fits all’ for the modelling structure, with the structure being driven by the questions to be answered. However, the fundamental principle of all CGE models is the same in that there is a set of equations with a range of variables characterizing the economy along with a real database on the inter-industrial flows of the economy. In the modelling setup, CGE models are generally (but not necessarily) based on neoclassical economic theory whereby consumers maximize their utility subject to a budget constraints while producers maximize profit/minimise cost.

Macroeconometric models are another type of simulation model which use analytical IOT as a primary input. These models are often compared to CGE and are generally applied to answer similar questions, with many of the same output indicators used.

Fundamentally the theory underpinning macroeconometric models differs from CGE models. CGE models are based on neoclassical economic theory with a high level of optimisation assumed. Macroeconometric models are based on post-Keynesian economic theory with agents’ behaviour determined from previous relationships.

For CGE and macroeconometric models the base database is the Social Accounting Matrix (SAM) which is an extension of an IOT. This incorporates transactions and transfers between institutions related to the distribution of income of the economy.

In IO models the fundamental assumption is that prices are fixed with impacts solely determined by the demand side. For CGE and macroeconometric models relative prices are flexible. Therefore these models can examine supply side impacts.

CGE and macroeconometric models therefore have advantages in looking at supply side changes (e.g. labour productivity), or very large demand shocks which are likely to impact prices. Their drawbacks mainly revolve around the complexity of the modelling, the (typical) granularity of industries and the requirement to specify certain parameters.

Examples of when to use CGE or macroeconometric models include:

- Large scale construction projects
- Increase in labour and/or capital productivity due to a change in policy
- Changes in labour supply
- Increase in Government spending funded by increase in tax
- Changes in capital supply
- Changes in taxation (corporation tax, income tax)
- Changes in tariffs on international trade

3.3.4. Understanding the Impact of Small Shocks on the Macroeconomy

Input output tables can also be useful for studying how small shocks are amplified and propagated through an economy and result in macroeconomic impacts.

For example, research has been undertaken to understand the impact of import competition from China on employment in manufacturing industries in the US (Acemoglu et al., 2016). And global impacts of local natural disasters can be examined, such as the impact of the 2011 Tohoku Earthquake in Japan (Boehm et al., 2019).

3.4. Core assumptions

IOTs are a useful tool in economic modelling and, in particular, understanding the relationships between industries in the economy. However, as with all modelling, it requires assumptions. It is important to be mindful of these assumptions when interpreting any results. Standard IO modelling assumptions include constant cost shares, a passive supply side, a static "snapshot" of the economy, and inability to determine legacy effects resulting from long-term changes to prices, wages and labour supply. These assumptions can be addressed through other models, such as macroeconometric and CGE models.

4. Methods for Producing Regional SUTs and IOTs

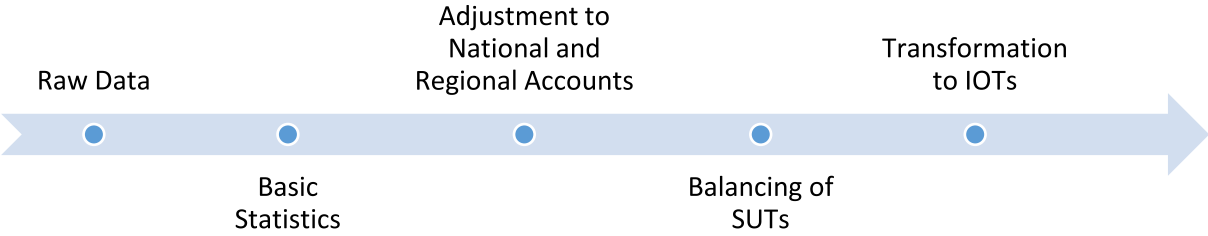
In this section we will contrast different methods for producing regional SUTs and IOTs, distinguishing between "bottom-up" and "top-down" approaches. We will also make clear which practical and statistical challenges arise when producing regional tables that are not faced when producing national tables. We will conclude the section by discussing approaches adopted by foreign statistical agencies when constructing regional tables.

4.1. Bottom-Up Approaches

Data availability is an important determinant of which methods are suitable for producing regional SUTs and IOTs. The bottom-up approach is the preferred and most accurate method for producing regional SUTs. However, producing regional tables using a bottom-up approach involves detailed data collection at the regional level and presents several practical and statistical challenges. Details of this approach are provided in the first column of **Table 2** and the data flow is shown in **Figure 1**.

Many of the practical challenges involved in constructing regional tables using a bottom-up approach also arise when producing national tables. However, these issues tend to become heightened as the number of regions under consideration and consequent complexity of the exercise increases. These issues are discussed in UN (2018) when summarising the Canadian approach to producing regional tables. First, regional tables are associated with a higher cost and greater operational complexity. In Canada, 50 members of staff are involved in the input-output programme within the Canadian System of Macroeconomic Accounts, reflecting the importance attributed to this work. Producing regional SUTs and IOTs on an annual basis also involves considerable co-ordination and means that revisions and historical continuity need to be managed. Second, where regional SUTs and IOTs are used to inform important policy decisions at the regional level considerable data scrutiny is likely to take place. This limits the use of top-down approaches further in favour of detailed data compilation which carries more credibility. Third, when detailed data is collected measures need to be put in place to safeguard confidentiality. This can involve supressing cells and only releasing highly aggregated data. That said, in the Canadian case, full details have been made accessible to all users since 2016. A final important point to note is that due to the lengthy compilation process SUTs are only available with a time lag. For instance, in 2020, the 2017 or perhaps 2018 SUT may be publicly available.

Figure 1: Data Flow



Reproduced from: Louhela and Koutaniemi (2006)

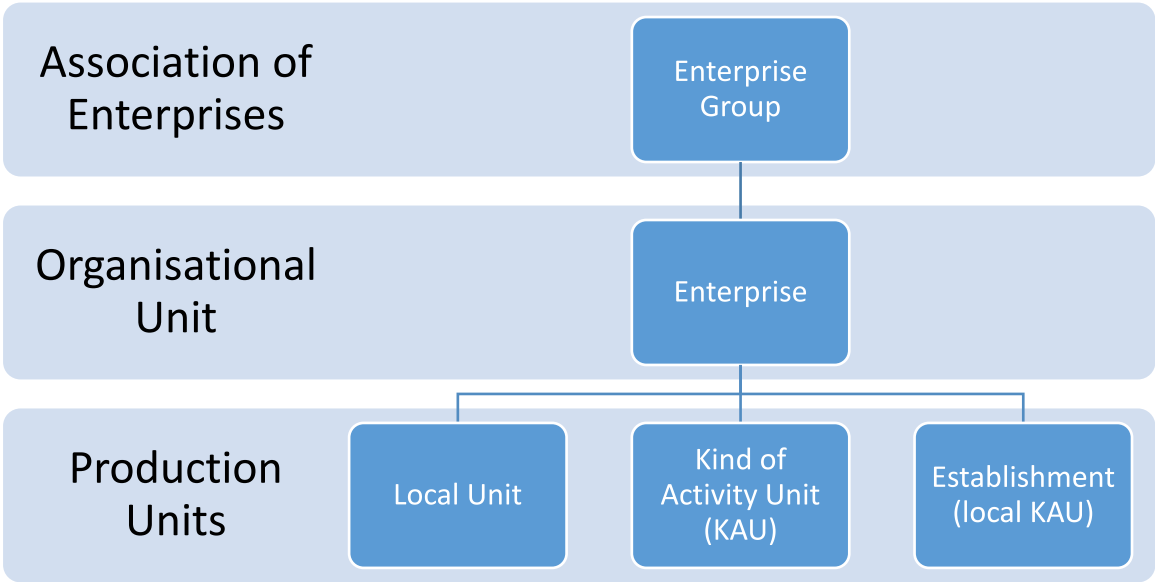
Statistical challenges which are not faced when compiling national tables also arise. Data collection in most countries will be based on a business register which contains information (e.g. activity, size, location) on existing businesses in the economy and their links with foreign businesses. The business register will also act as the sampling frame for business surveys. However, in most cases the data collection process will have been designed to capture a country's overall activity as oppose to regional activity (see UN, 2018, Ch. 16 for a useful summary). This means that the unit responsible for reporting may not be the most appropriate for regional data collection.

As discussed in the 2008 SNA (United Nations, European Commission, IMF, OECD and World Bank, 2009), we can partition an enterprise, an organisational unit producing goods and services, into different types of production units (**Figure 2**). The 2008 SNA (United Nations, European Commission, IMF, OECD and World Bank, 2009, pp.88 – 89, bold formatting our own) defines:

- a local unit as "an enterprise, or a part of an enterprise, that engages in productive activity **at or from one location**".
- a kind of activity unit (KAU) as "an enterprise, or a part of an enterprise, that engages in **only one kind of productive activity** or in which the principal productive activity accounts for most of the value added".

- an establishment or local KAU as "an enterprise, or part of an enterprise, that is situated in a **single location** and in which only a **single productive activity** is carried out or in which the principal productive activity accounts for most of the value added".

Figure 2: Types of Statistical Units



Source: Adapted from Eurostat (2003)

In a questionnaire launched by Eurostat in February 2019, 31 countries answered questions on the compilation of national SUTs and IOTs[7]. It was found that enterprise/institutional units and KAUs were the statistical units used most frequently while establishments were the second least frequently used statistical unit.

Importantly, establishments, the statistical units relevant for capturing regional activity may not be sampled since they do not possess sufficient information to answer. Instead, statistical units which have activities in multiple regions may be sampled. Regional activity must then be allocated using the "residence" approach or "territorial" approach. In the case of the residence approach, GVA is simply assigned to the region where the statistical unit resides and GFCF is assigned to the region where the producer unit owning the goods uses

[7] Results from the questionnaire are available here: https://ec.europa.eu/eurostat/statistics-explained/index.php/Review_of_national_supply,_use_and_input-output_tables_compilation

them. In the case of the territorial approach, GVA is assigned to the region where economic activities are carried out (UN, 2018).

It may also be the case that businesses which are active in more than one industry may be sampled. Typically, regional tables are produced using the industry of the reporting statistical unit in question, rather than reflecting the industry of the local area. This is done in order for the activity in industries in local areas to add up to the regional and national total, but does lead to the information on local economies not always being completely reflective of the actual activity. So consistency and coherence is preferred over the GVA estimates for an area being the most reflective of that area.

The construction of regional tables also face another statistical challenge relating to power allocation, an issue summarised in Beaumont et als. (2014) discussion of Statistic's Canada's contributions to survey methodology. If regional data collection is required this means that a business survey's sample of businesses needs to be stratified by geography. However, if each region's sample allocation is proportional to its size, this may result in good precision at the national level but poor precision at the regional level, particularly for smaller regions. Conversely, if each region's sample allocation achieves nearly equal precision across regions this may cause the quality of national precision to fall. To overcome this trade-off, a compromise can be achieved through power allocation (Bankier, 1988) where regional estimators of nearly equal precision are obtained while minimising the reduction in precision of the national estimator. While the focus of our report is regional SUTs and IOTs, the reader interested in production of local SUTs and IOTs may also wish to consider small area estimation which involves combining survey-based estimates with model-based estimates. Small area estimation is discussed in more detail in Beaumont et al. (2014, Section 2.4.4.). This is particularly relevant if we wish to considering the construction of SUTs or IOTs at the NUTS 2 or NUTS 3 level.

A third constraint faced in compiling regional tables is that there must be coherence and consistency between the regional tables and national tables. This means that regional tables are typically constrained to national tables. Paradoxically, this can sometimes mean that regional information collected at the national level takes precedent over regional information collected at the regional level.

Turning to regional IOTs, these can also be produced using a bottom-up approach. If a regional survey-based SUT is compiled, the corresponding regional IOTs can be derived from the SUT as described in Section 3. Generally, when planning the SUT framework, it is therefore important to keep in mind the needs of IOTs users. Practical and statistical challenges associated with compiling the regional SUT are therefore directly applicable to the regional IOTs. However, since IOTs require the SUT to be finalised before their production can begin, IOTs are sometimes subject to an even longer time lag before being made publicly available. Since IOTs are used by academics and policymakers to undertake different types of regional analysis as described in Section 3, the fact that tables are only available with a lag can make it difficult to deliver timely analysis which reflects the current state of the economy.

4.2. Top-Down Approaches

When detailed regional data is unavailable or only partially available, top-down approaches can be used to derive regional tables from national tables. The academic literature describing how national IOTs can be regionalised is far more extensive than the literature focussing on the regionalisation of national SUTs. This is perhaps driven by the fact that IOTs are needed to undertake regional modelling and analysis.

Consequently, to consider how national SUTs can be regionalised we draw on examples which are government funded or led by NSIs. Country-specific innovations and approaches, however, will be discussed in the subsequent sub-section. Here, we will simply focus on providing a broad overview of the methodology.

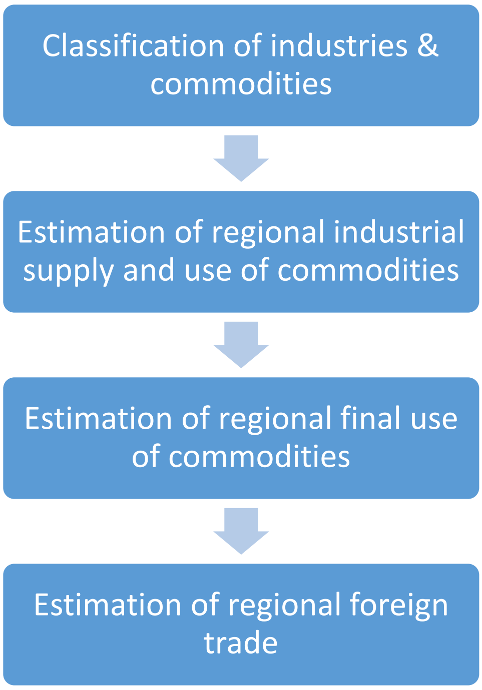
In discussing a Dutch project to construct bi-regional SUTs, Eding et al. (1999) breaks down and discusses the top-down regionalisation process into 4 steps. We show this in **Figure 3**[8] and summarise Eding et als. (1999) discussion.

The first step involves classification of industries and commodities. The number of industries and commodities considered in regional SUTs should be driven by users' needs, however, due to time and resource constraints they are typically likely to be in smaller in number than the national SUT. This means that regional classifications will be aggregations of national classifications. Aggregations of commodities should recognise that commodities should be

[8] If producing an interregional SUT then estimation of interregional trade is the 5th step.

kept separate when: there are taxes or subsidies on products; there are relatively high trade or transport; there are differences between commodities' foreign import/export ratios or share of final expenditure or production technology. In the Dutch case, aggregation of industries involves combining industry groups which produce the same commodities or have little production.

Figure 3: Regionalising the National SUT



Based on information in: Eding et al. (1999)

Estimation of regional industrial supply and use is then undertaken along the commodity or industry dimension. Since production data tends to be concerned with industries rather than commodities, Eding et al. (1999) argue in favour of regionalisation along the industry dimension. This involves developing regionalisation indicators and coefficients, for instance based on regional and national employment data, which are used to rescale cells of the national matrix to estimate cells of the regional matrices. Examples of such indicators are provided in Smith et al. (2015, Table 2) who, in a government funded project, regionalised the national SUT of New Zealand using a hybrid approach before producing national and regional Social Accounting Matrices (SAMs). As noted in Piispala (2000), however, this may result in a misleading representation of industry structures. For instance, the structure of an industry may be different in regions where headquarters rather than production units are located.

Estimation of regional final use of commodities uses similar methods while regionalisation of foreign trade is more idiosyncratic due to a lack of available data.

The top-down methods used to derive regional IOTs from the national IOT are similar to the methods used to derive regional SUTs from the national SUT. Details of the approaches we will consider are provided in the second, third and fourth column of **Table 2**. Top-down methods are low-cost, can be undertaken quickly and, as noted by Louhela and Koutaniemi (2006), ensure that the Regional Accounts cohere with the national accounts. However, they are predicated on a number of assumptions and are likely to be less accurate.

Another important point to note is that we focus on regionalisation methods which are suitable for regionalising national IOTs which have directly allocated imports and are classed as variant "B" (see the United Nations 1973 handbook on IO analysis which discusses four IOT variants). These are also known as non-competitive import-type tables and are the variant most frequently used by regional economists. This means we will not discuss the cross-hauling adjusted regionalization method (CHARM) developed in Kronenberg (2009) which builds on traditional commodity balancing methods (see Bonfiglio, 2005). However, it is worth pointing out that the refined CHARM developed by Tobben and Kronenberg (2015) allows for cross-hauling in both interregional and international trade. This means that a region can simultaneously export and import products belonging to the same industry. No regionalisation method available to variant "B" tables has this flexibility.

Where little or no detailed regional data exists, LQs are a popular means to regionalise the national IOT. We will present the simplest version first before discussing more recent extensions which we will use in Section 6 to illustrate how the UK IOT can be regionalised.

The simple location quotient (SLQ) for industry i in region R compares regional specialisation in an industry (numerator) with national specialisation in an industry (denominator):

$$SLQ_i^R = \frac{output\ of\ industry\ i\ in\ region\ R\ /total\ output\ in\ region\ R}{output\ of\ industry\ i\ in\ national\ economy\ N/\ total\ output\ in\ economy\ N}$$

If regional data on output is unavailable on a consistent basis, we then need to find an appropriate proxy for economic activity at the regional and national level. Other possibilities include labour market data, personal income earned and value added (Miller and Blair, 2009).

If using the most popular indicator, employment data, we require: E_i^R, regional employment in industry i; E^R, total regional employment; E_i^N , national employment in industry i; and E^N, total national employment. The SLQ therefore becomes:

$$SLQ_i^R = \frac{E_i^R/E^R}{E_i^N/E^N}$$

To give a numerical example as in Miller and Blair (2009, chs 7-8), if $SLQ_i^R = \frac{0.022}{0.016} = 1.375 > 1$ this means that industry i's regional output accounts for 2.2% of total regional output. However, industry i's national output accounts for only 1.6 % of total regional output. This results in a LQ greater than 1, implying that the region is more specialised in industry i than the country as a whole and can meet local demand. Consequently, the national coefficients for industry i are applicable to the region and $a_{ij}^N = a_{ij}^{RR}$.

Conversely, if $SLQ_i^R = \frac{0.016}{0.022} = 0.727 < 1$ this means that industry i's regional output accounts for 1.6 % of total regional output. However, industry i's national output accounts for only 2.2 % of total regional output. This results in a LQ less than 1, implying that the country as a whole is more specialised in industry i than the region. This means the region cannot meet local demand and will need to import. Consequently, to obtain the regional direct input coefficient we scale the national coefficients with the location quotient and $a_{ij}^{RR} = a_{ij}^N \times SLQ_i^R$.

To summarise:

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

Several refinements on the SLQ have been suggested (see Miller and Blair, 2009, chs7-8 and Szabo, 2015 for a summary). The cross-industry location quotient (CILQ) builds on the SLQ, also taking into account the relative size of the purchaser and producer industries and the effect this has on an industry's ability to meet regional demand. If we assume industry i supplies inputs to sector j, we can write the CILQ as follows:

$$CILQ_{ij}^R = \frac{SILQ_i^R}{SILQ_{ij}^R}$$

Flegg's location quotient (FLQ) (Flegg et al., 1995, Flegg and Tohmo, 2013) builds on the CILQ, taking into accounting the relative size of a region, λ, and the effect this has on an industry's ability to meet regional demand:

$$FLQ_{ij}^{R} = \lambda^{R} \times CILQ_{ij}^{R}$$

$$\lambda^{R} = [\log_2[1 + \frac{output\ in\ region\ R}{output\ in\ national\ economy\ N}]]^{\delta}$$

where $0 \leq \delta < 1$. Again, proxying economic activity using employment data the second expression becomes:

$$\lambda^{R} = [\log_2[1 + \frac{E^{R}}{E^{N}}]]^{\delta}$$

This means that the CILQ is scaled by the logarithm of relative size and the strength of the scaling depends on the sensitivity parameter δ whose number is chosen by the practitioner. The larger the value of δ the stronger the adjustment with larger values being chosen for smaller regions which are likely to be more import intensive. Importantly, the choice of δ is crucial to the FLQ results but the literature has not reached a consensus on how this should be selected. Typically, studies use a value of $0.1 \leq \delta \leq 0.35$. Recently, the literature has moved towards using a regression equation to estimate δ for each region (Flegg and Tomho, 2013). For each region, this is undertaken using data on regional size, relative interregional import propensity and the ratio of average use of intermediate inputs to national proportion of intermediate inputs. Kowalewski (2015) extend this approach, allowing for variation in δ by industry.

When used to regionalise national IOTs, there are three strong assumptions identified by Norcliffe (1983) underlying LQ methods. First, they assume that productivity per employee in each region in each industry is the same. This arises from the assumption that regional shares of employment reflect regional shares of production. Second, they assume that there is identical consumption per employee in each region. Third, they assume there is no cross-hauling between regions. This means that a region cannot simultaneously export and import products belonging to the same sector which results in interregional trade being underestimated. Harris and Liu (1998) note that this likely to be unrealistic in industries with product differentiation and strong brand preferences as well as in cases where distance costs between small regions is low.

RAS-based methods or mathematical optimisation can be implemented when no survey data exists and have a lower data requirement than FLQs (Szabo, 2015). These only require a national IOT (or the IOT of another region with a similar economic structure) and the framework of a regional IOT (i.e. the row and column totals). The first step involves assuming that the regional IOT is identical to the national IOT. The regional IOT is then iteratively adjusted until the row and column restrictions are met. However, rather than being applied as a single method, RAS is more often applied to tables constructed using other approaches (either bottom-up or top-down) as part of the balancing process.

LQ methods can also be augmented using available survey data leading to what is known in the literature as a partial-survey or hybrid approach. Rather than multiplying national coefficients by LQs to obtain regional coefficients, they can multiply national coefficients with LQs developed using survey data or some other measure developed using LQs. Such an approach would tend to continue to reflect the shortcomings on the LQ method which forms the basis for the rescaling of the national coefficient.

Table 2: A Review of Existing Methods for Producing Regional SUTs and IOTs

	Bottom-Up Approach: Survey Based	Top-Down Approach		
		Non-survey		Hybrid
Description	Detailed data collection at regional level to obtain regional values	Indicators or LQs regionalise national SUT or IOT using a proxy for sectoral regional specialisation e.g. wages, employment, GVA	RAS-based or mathematical optimisation methods regionalise the national IOT table, retaining the structure of the national table while meeting regional constraints	Similar to LQ methods but increases precision by incorporating survey data
Assumptions	• Statistical reporting unit industry reflects local activity • Statistical reporting unit location reflects local activity	Across regions: • Identical productivity • Identical consumption • No cross-hauling	• The regional table has a similar economic structure to the national table	Across regions: • Identical productivity • Identical consumption • No cross-hauling
Advantages and Disadvantages	• More accurate • Can be used for a wider range of analysis • Requires detailed regional data • Costly and operationally complex • Higher data scrutiny • Poses more confidentiality challenges • Revisions and historical continuity need to be managed • Tables for a given reference year only available with a lag	• Low cost but less accurate • Does not require detailed regional data • Can be produced quickly • Consistent with National Accounts	• Low cost but less accurate • Does not require detailed regional data • Can be produced quickly • Consistent with National Accounts	• Low cost but less accurate • Takes advantage of available regional data • Can be produced quickly

Summarised from: Norcliffe (1983), Round (1983), Lahr (1993), Harris and Liu (1998), Bonfiglio and Chelli (2007), Riddington et al. (2006), Szabo (2015), Boero et al. (2018), Miller and Blair (2009, Chs.7-8), UN(2018), Louhela and Koutaniemi (2006)

4.3. Current International Practise

Before considering how SUTs and IOTs are compiled for the UK, Scotland and Northern Ireland, we now examine how regional SUTs and IOTs are compiled in other countries. We focus on countries where NSIs and national central banks (NCBs) have undertaken these exercises rather than academic studies which typically have different objectives in seeking to assess the efficacy of different top-down approaches.

We summarise approaches adopted by different countries in **Table 3**. Importantly, none of these examples constitute a fully bottom-up approach since, in practise, a top-down approach will always be required for some sectors. Notably, with the important exception of Canada, as far as we are aware, no other country's NSI or NCB in Europe or North America currently compiles regional SUTs or IOTs on a regular basis. Instead, Finland, the Netherlands and Belgium have undertaken irregular exercises in the 1990s and 2000s with Finland and the Netherlands providing documentation of the compilation process in English (Piispala, 1999, 2000, Louhela and Koutaniemi, 2006 and Eding et al., 1999) . EU legislation now also requires the compilation of Regional Accounts (as oppose to tables) by its members. In Asia, however, China, South Korea and Japan regularly produce regional tables with Japan providing documentation in English of the process used to produce interregional IOTs for 2005 (see METI, 2010). For the most part, we will focus on the Canadian case while also briefly summarising recent approaches adopted in Finland and Japan.

Turning to the Canadian case, a leader in the production of regional statistics, a detailed case study is provided in the 2018 UN Handbook on Supply and Use Tables and Input Output-Tables with Extensions and Applications. We summarise key points here and provide an updated account of the Canadian approach to statistical sampling.

As of 1997 as part of the Project to Improve Provincial Economic Statistics (PIPES), Canada uses a bottom-up approach in all but a few areas to produce regional SUTs and interregional trade flows[9] which can then be combined to produce an interregional SUT. The interregional SUT can then be transformed to obtain an interregional IOT. There are several important features regarding the compilation of regional SUTs in Canada.

[9] For a discussion of the production of Canadian interregional trade statistics the reader is referred to Davidson and Spowage (2021).

Table 3: A Review of Country-Specific Approaches for Estimating Regional SUTs and IOTs

	Canada	Finland	Netherlands	Belgium	Japan	South Korea	China
Developed By	Statistics Canada	Statistics Finland	Statistics Netherlands & University of Groningen	Federal Planning Bureau	Ministry of Economy, Trade & Industry	Bank of Korea	China's National Statistics Bureau
Products	Interregional SUTs and Interregional IOTs based on Regional SUTs and Interregional Trade Flows	Interregional IOT based on Regional SUTs	Bi-regional IOTs based on regional SUTs	Interregional SUTs	Regional IOTs and Interregional IOT	Regional IOTs and Interregional IOT	Regional IOTs
Frequency	Annually since 1997	1995, 2002	One-off exercise undertaken circa. 1999	2003, 2007, 2010	Every 5 years since 1960	Every 5 years since 2003	Every 5 years since 1987
Regions	13 + 1 extra-territorial region	20 at NUTS 3 level + 1 extra-territorial region in 2002	14	3	9	17	30
Disaggregation	For the regional SUT 230 industries, 490 products, 278 final use categories	For the detailed Regional SUT 37 industries, 44 commodities (1995), for the interregional IOT 40 industries (2002)	For the regional SUTs 139 industries and 206 commodities	For the regional SUT 140 industries, 350 products and 8 final demand components	For the interregional IOT 53 sectors	For the interregional IOT 33 sectors	For the regional IOTs 42 sectors

From left of the table to the right of the table summarised from: UN (2018, Ch.16), Piispala (1999, 2000), Louhela and Koutaniemi (2006), METI (2010), Jiang (2011), Eding et al. (1999) and Van den Cruyce (2019)

First, the Canadian regional tables are compiled for 14 regions, consisting of 10 provinces and 3 territories. The 14th region was created to account for foreign production, for instance, by embassies, armed forces overseas and offshore oil and gas extraction. If such activities were allocated across regions, this could distort regional GVA.

Second, head offices with multiple establishments are classified and allocated to different regions as follows. Rather than creating a separate head office industry, the industrial classification of head offices depends on the industry of the primary establishment. To allocate GVA associated with the head office to the region in which it resides, the output of head offices (intermediate expenses, staff compensation and, where data is available, consumption of fixed capital) is shown as an input purchased by establishments which the head office serves.

Third, the output of central government must be allocated across regions. In the Canadian case, they do not allocate government revenue and expenditure on a per capita basis. Instead, they allocate expenditures according to where production takes place. In practise, this depends on where wages are paid, intermediate inputs are used and physical capital is consumed. Consumption taxes collected in all regions are regionalised according to where the taxable products are consumed for intermediate use or purchased as final use.

Fourth, in Canada sectors which are difficult to regionalise are treated in different ways. For construction, GVA is allocated according to where the structure is put in place rather than where the contractor or its employees reside. Air transportation suffers from limited data and is allocated using regional GVA. Different approaches are used to regionalise different aspects of financial services. Financial intermediation services indirectly measured (FISIM) is allocated by sector across regions using a regional distribution of assets and liabilities from the Canadian System of Macroeconomic Accounts. Fee-for-service financial services are allocated to regions using the average level of assets and liabilities or, if this is not possible, wages. In terms of insurance services, the location of production is assumed to be the head office region in line with the idea that insurance offers risk pooling. However, it is also recognised that a part of total insurance output is produced regionally and wages are used to undertake this allocation. Brokerage services consisting of financial advice are produced and consumed in the same region whereas trading execution is produced in the head office region and consumed in the region where the client resides. Since there is insufficient data on transactions, costs of such services are allocated using proxies of investment income. Lastly, the purchase of mutual funds is allocated as follows. Output is allocated regionally using the fund location. Again household expenditure on such services are allocated using proxies of investment income.

If we now consider the Canadian approach to regional allocation of most remaining goods and services, it is useful to begin by discussing the Canadian approach to business surveys. This has evolved considerably over the last 25 years and is documented in Brodeur et al. (2005) and Statistics Canada (2015). The Canadian Business Register (BR), however, has always remained an important part of statistical sampling. The BR is a sampling frame which includes all businesses operating in Canada and foreign businesses which have links with Canadian companies (Statistics Canada, 2010). In Canada, two statistical units are key when undertaking business surveys (please refer also to **Figure 2**). The enterprise is at the top of the operating structure and has access to a complete set of financial statements. An establishment, on the other hand, is a production unit which produces the same goods or services and doesn't cross regional boundaries. An enterprise may have multiple establishments spanning different industries and regions.

Turning to the surveys themselves, as part of PIPES, a single master survey programme, the Unified Enterprise Survey (UES), was introduced in 1997 covering all major industries in Canada and more than two thirds of Gross Business Income. The goal of this project was to integrate all business surveys into one programme and to collect industry and commodity data in more detail at the provincial level (Brodeur et al., 2005). The UES ultimately covered 58 surveys. While the UES wished to collect information from establishments, there was a recognition that collection arrangements needed to be made with the enterprise. Negotiations would then take place between firms and Statistics Canada to determine the appropriate responding unit. This would then result in allocation of economic data only available at the enterprise level to establishments, a necessary requirement for producing regional estimates. However, collecting data directly from each respondent increased the response burden. Customisation also meant that different surveys undertook allocation in different ways.

In 2010, the UES which covers 58 surveys was superseded by the Integrated Business Statistics Program (IBSP) which seeks to achieve further standardisation and efficiency while minimising customisation. Consequently, a new approach was developed to allocate economic data only available at the enterprise level to establishments to produce regional estimates. Allocation variables are stored in the BR and are either based on BR profile variables or administrative Canada Revenue Agency (CRA) data. The CRA data consists of data on salaries and the regional distribution of revenue for complex businesses with multiple establishments. If the business can be identified by a business number, the data is more up to date than the profile variables and the data covers all regions, the CRA data is preferred. This standard approach is used across all IBSP surveys.

The Finnish case also provides several useful insights. Statistics Finland undertook two one-off exercises to create regional SUTs for 1995 and 2002 which when combined with interregional trade flows can be used to produce interregional IOTs(see Piispala, 1999, 2000 and Louhela and Koutaniemi, 2006). Both use Finnish Regional Accounts as their starting point and then use bottom-up and mixed approaches to construct regional SUTs at the NUTS 3 level[10]. Here, we will focus on the compilation of the more recent 2002 tables discussed in Louhela and Koutaniemi (2006). Importantly, in the 2002 exercise, an extra-territorial region of Finland is included. For the 2002 tables, mixed approaches use data from the national and Regional Accounts. While a variable may be regionalised using a bottom-up approach at NUTS 1 level, top-down methods are then need to undertake further regionalisation to NUTS 2 level with small area estimation sometimes being used to regionalise to NUTS 3 level.

First, the regional balance of resources was compiled using data on production from the Regional Accounts in order to obtain the discrepancy between each region's supply total and use total. At this stage narrow aggregates were used. Second, regionalisation of the supply table is then undertaken. In one third of cases the value of products were obtained by apportioning national production using information on industries regional output from the Regional Accounts. Data sources used to regionalise FISIM, industrial production, some services, and imports were local supply and demand, industrial output statistics, statistics on finances and activities of municipalities and joint municipal boards, customs data and structural business statistics. Third, regionalisation of the use table takes also takes place using a mixed approach with local government consumption and final consumption

[10] For a discussion of the production of Finnish interregional trade statistics the reader is referred to Davidson and Spowage (2021).

expenditure being regionalised using statistics on finances and activities of municipalities and joint municipal boards and Finland's household budget survey respectively. Fourth, foreign exports and imports were estimated separately using customs data and enterprise and trade statistics. Finally, to reconcile differences between independently compiled Supply and Use Tables, regionalised figures were compared to national totals. After that, discrepancies between the supply and demand of movable products was accounted for by making adjustments to interregional trade flows. Any remaining discrepancies were removed through adjustment using the RAS method.

Other European countries which publish regional tables include Belgium and Spain. The Belgian case is summarised in Table 3. Unfortunately, it is difficult to source information in English on the Spanish case. However, Cazcarro et al. (2013) note that in Spain the first regional IOTs were built for the year 1995 and that initially there were five regional IOTs. They also state that the first time period for which it is possible to construct a multiregional model for Spain is 2005. When their study was undertaken, regional tables were available from Spain's regional statistical institutes for 10 of the autonomous communities (ACs) for the year 2005. Regional tables were also available for an additional 5 ACs for earlier years[11].

In Japan (see METI, 2010) national and regional SUTs do not appear to be produced. Rather, the goal is to construct national and regional IOTs. The documentation does not state explicitly whether a top-down or bottom-up approach is used, however, from what we can gather, it seems that a hybrid approach is used with some data collected at the establishment level and some regional figures based on regionalisation of national totals. As in the Canadian case, some activity crosses regional boundaries. In the case of production from fisheries, this was recorded according to the location of the markets where catches were landed rather than the seas in which the fishing took place. In terms of freight transport production, this was recorded according to the location of the enterprise shipping the cargo. In terms of passenger transport, however, this was apportioned using the number of passengers multiplied by the number of kilometres travelled within a given region. As in Canada, construction production was recorded according to the location of construction

[11] Cazcarro et al. (2013) updated tables for these earlier years using the regional statistical institutes' data and data from the National Statistics Institutes' Regional Accounts. For the remaining 2 ACs, tables were built by using tables from geographically similar ACs (see Escobedo and Oosterhaven, 2011).

activities. Unlike Canada, Japanese diplomatic regions were assigned to the Tokyo region rather than an extra-regional territory.

Turning to other Asian case studies, it is possible that in South Korea additional information on the compilation of interregional IOTs is available but not documented in English. Jiang (2011) explains that in the Chinese case, administrative and financial issues at the regional level means that although China's National Bureau of Statistics requires the compilation of regional tables, these cannot be disseminated freely. Instead, by speaking to each regional statistics bureau Jiang (2011) obtained regional IOTs for 1997 for 27 regions (40 sectors) and 2002 for 30 regions (42 sectors) on the basis that the original tables would not be published or shared. There are, however, numerous academic studies constructing Chinese interregional IOTs.

PART B: APPROACHES TO COMPILING NATIONAL AND REGIONAL SUTS AND IOTS IN THE UK

5. Compilation of the UK, NI and Scottish SUTs: Hybrid Approaches

We have discussed: the difference between SUTs and IOTs and how they are used; bottom-up and top-down approaches to producing analytical tables; and the approaches adopted by other countries to produce SUTs and IOTs. In this section, we provide an overview of SUTS in the UK and then look at the main data used to construct the UK, Scotland and Northern Ireland SUTs.

5.1. Business Surveys and Regional Accounts in the UK

We now restrict our focus to the UK, starting by discussing the Inter-Departmental Business Register (IDBR), a key feature of the UK data landscape. We have used several statistical terms in Section 4 of the report which we now formally define. The *sampling frame* gives a list of businesses forming a population from which a sample is taken. *Stratified sampling* occurs when we independently sample from a population which can be divided into different subpopulations or strata (e.g. businesses can be divided into groups according to sector or region). A *sampling unit* or *reporting unit* is a single unit which provides data for a given survey. Put differently, it is the unit to which questionnaires are sent.

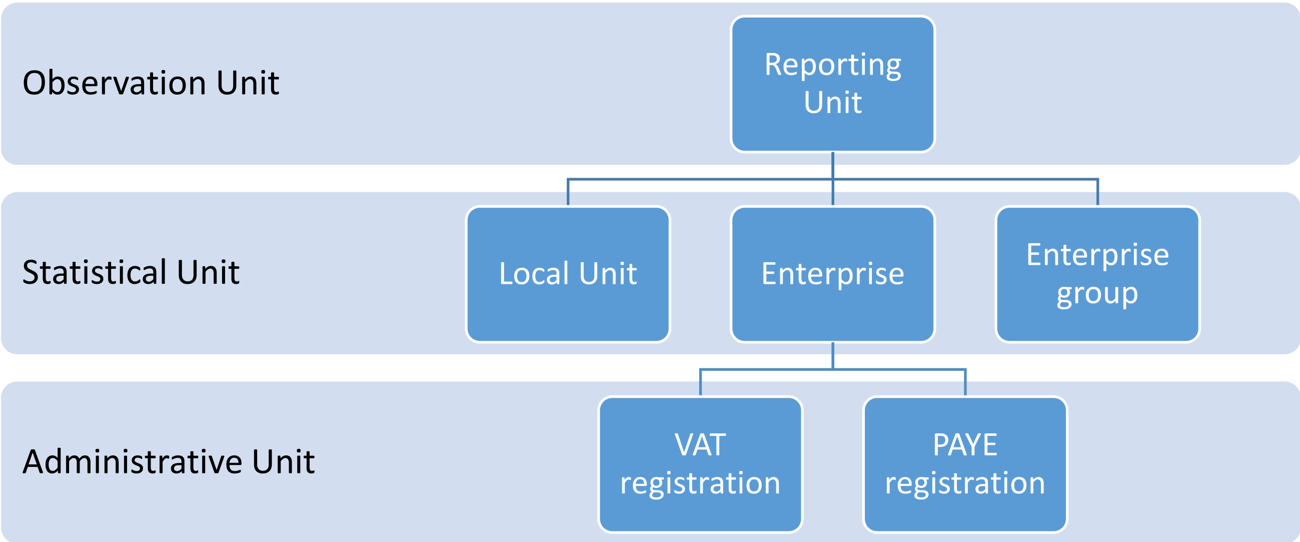
The IDBR, a comprehensive list of UK businesses introduced in 1994, is used as the sampling frame for surveys collecting business data. An important source of challenges facing the different nations when collecting business data are the sampling units on the IDBR. The IDBR sampling units are called reporting units (RUs) and provides data on associated local units (LUs) as shown in **Figure 4**. For instance, the RU for a large chain of retailers will provide data incorporating all its LUs (such as factory, stores, offices).

Key business data is collected at the RU level but there are only two geographical classifications for RUs: Great Britain (GB) and Northern Ireland (NI)[12]. A GB RU can therefore

[12] This is for historical reasons, and because mandatory business surveys in Northern Ireland are carried out through a separate Statistics of Trade Act. The ONS carries out surveys for the GB RUs, and in some cases both GB and NI RUs where agreement between ONS and NISRA is reached. However, in many cases Business Surveys of NI RUs are carried out by NISRA.

have LUs in all three of Scotland, England and Wales. This poses a challenge if we wish to apportion activity out to LUs to obtain, say "Scottish" exports. In general, employment shares are used to apportion activity out to LUs to produce a publication like Scottish Annual Business Statistics[13]. While this seems like a reasonable approach for turnover, it gets a bit more difficult when we start thinking about other regional aggregates. However, in the absence of any other information, this is what is generally used. A further issue with the IDBR is that the LUs associated with an RU may have a different industrial classification to the RU. This is dealt with by classifying the RU based on the dominant industry by employment.

Figure 4: Sampling Units on the Interdepartmental Business Register



Adapted from: ONS

The main business surveys undertaken in the UK are the mandatory Annual Business Survey (ABS) and Northern Ireland Annual Business Inquiry (NI ABI). The ONS administer the former, collecting information on GB RUs while NISRA administer the latter, collecting information on NI RUs on behalf of the ONS. Importantly, though, Scotland and Wales also administer their own voluntary surveys to collect additional data. For instance, Scotland collects data on Scotland's trade with the rest of the world (ROW) and the rest of the UK (RUK) through the Global Connections Survey (GCS). In Wales, they also collect data on ROW and RUK trade through the Trade Survey for Wales (TSW).

[13] https://www.gov.scot/publications/scottish-annual-business-statistics/

In Scotland, Scottish RUs are created by the Scottish Government for the purposes of building the Scottish SUT. A Scottish RU is simply the part of a GB RU which consists of Scottish LUs. For the GCS, the industry of the Scottish RU is then defined by the dominant Scottish LU. In all other cases, the industry of the Scottish RU is defined by the dominant activity across Scottish LUs which is calculated using the “top-down method” described in SIC 2007 documentation (see ONS, 2009, paragraph 40 and Scottish Government, 2012, pp.5-6). Sampling then takes place at RU level as is the norm with RUs providing information on the combined Scottish activity of all their LUs (see Scottish Government, 2012, pp.5-6 for an overview of issues with using LU rather than RU data). In Wales, a similar approach is taken with GB RUs providing information on the activity of their Welsh LUs. Instead of Welsh RUs being created, each RU’s industry reflects the dominant activity across GB LUs rather than Welsh LUs. This means that in practise the Scottish and Welsh approaches only differ in terms of their approach to SIC classification. Both the Welsh and Scottish approaches imply that some RUs with contact addresses outside Wales and Scotland (mainly in England) will be sampled since they have LUs in Wales and Scotland.

The UK Regional Accounts also play an important role in the production of regional SUTs in the UK. These accounts are produced by each member of the EU following NUTS regulation[14]. As discussed in Section 4 there are practical, statistical and conceptual challenges when compiling such accounts which means that EU members focus on covering GVA, GFCF and GDHI. Critically, a top-down approach is used to calculate these figures where the national aggregate is proportioned using a regional indicator, a relevant measure of regional activity. These indicators are obtained from different data sources including survey and administrative data.

5.2. SUTs in the UK

This section lays out some of the input-output and SUTs developed primarily for use by central and local government in the UK. This list is not intended to be exhaustive and is only meant to serve as an example of their use across the UK.

[14] https://ec.europa.eu/eurostat/web/regions-and-cities/overview

The ONS produces UK SUTs and PxP input-output tables on an annual basis. An IxI input-output table has also been produced for the year 2016.

The Scottish Government and NISRA also produce SUTs and input-output tables annually.

Cardiff University have produced analytical IOTs for Wales (most recently published for 2007[15]). However this does not include a full SUTs. This is likely due to data limitations as it is not produced by government.

Other parts of the UK have also created analytical IOTs, including London (latest are for 2013[16]), Glasgow City Region (unpublished – relates to 2016) and Shetland Islands (unpublished – latest relates to 2011, update for 2017 published soon). In the past, areas such as the Western Isles have also had IOTs built. Again, due to data limitations for a non-government producer, these are not typically accompanied by a fully Supply and Use framework.

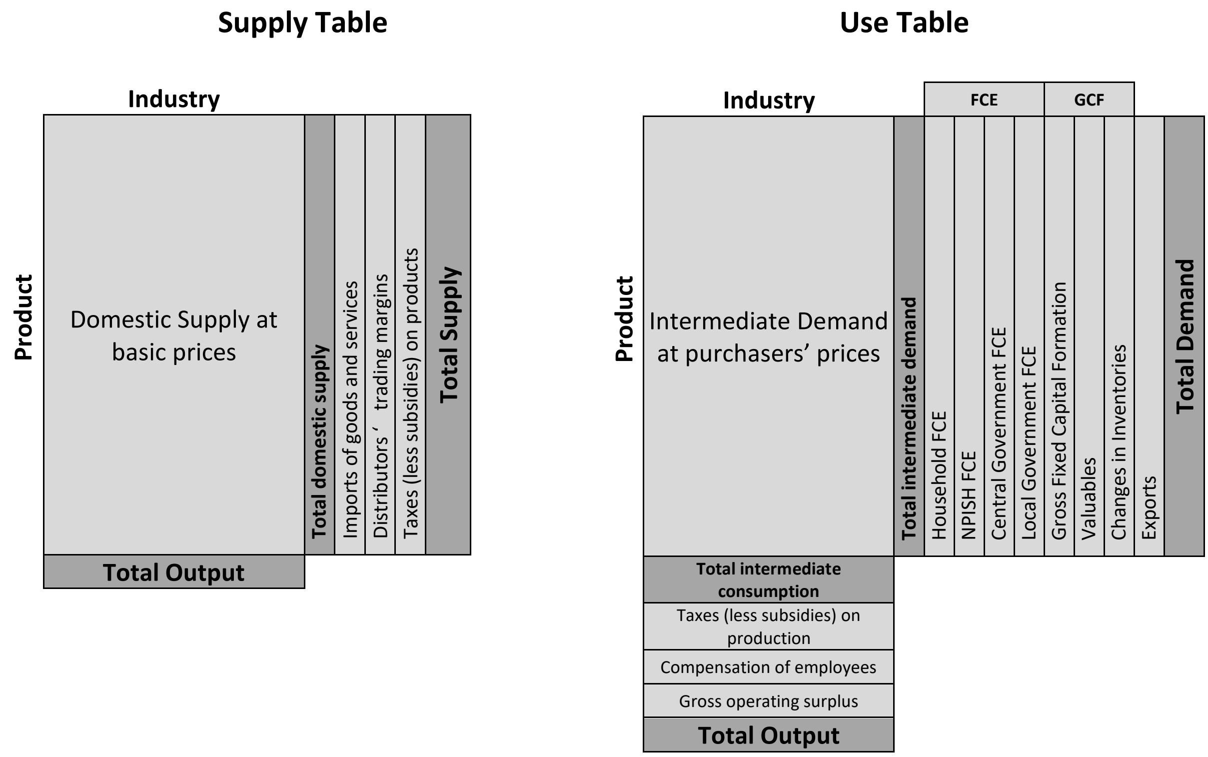
Table 4: Parts of the UK with SUTs or IOTs

Area	Geographical Level	Outputs	Producer
UK	NUTS 0	SUTS , PxP IO, IxI IO	ONS
Northern Ireland	NUTS 1	SUTS, IxI IO	NISRA
Scotland	NUTS 1	SUTS, PxP IO, IxI IO	Scottish Government
Wales	NUTS 1	SUTS, IxI IO	Cardiff University
London	NUTS 1	PxP IO	Greater London Authority
Glasgow City Region	8 local authorities	SUTS, IxI IO	Glasgow City Region / Fraser of Allander Institute
Shetland Islands	NUTS 3	IxI IO	Fraser of Allander Institute

Several of these producers, as well as academia and the private sector have also built upon the input-output analytical tables to create computable general equilibrium models and many other models. For instance, University of Birmingham's Socio-Economic Impact Model for the UK[17]. And projects such as the PBL EUREGIO database[18] build on UK and international data to create an EU regional model.

[15] https://www.cardiff.ac.uk/__data/assets/pdf_file/0010/698869/input-output-tables-2007-final-30-6.pdf
[16] https://www.london.gov.uk/business-and-economy-publications/london-input-output-tables
[17] https://www.birmingham.ac.uk/schools/business/research/research-projects/city-redi/socio-economic-impact-model-for-the-uk.aspx
[18] https://data.overheid.nl/dataset/pbl-euregio-database-2000-2010

5.3. Producing SUTs in the UK



We have approached this from the view of a person constructing these tables by individually covering the different unbalanced satellites that make up the SUTs. These satellites include:

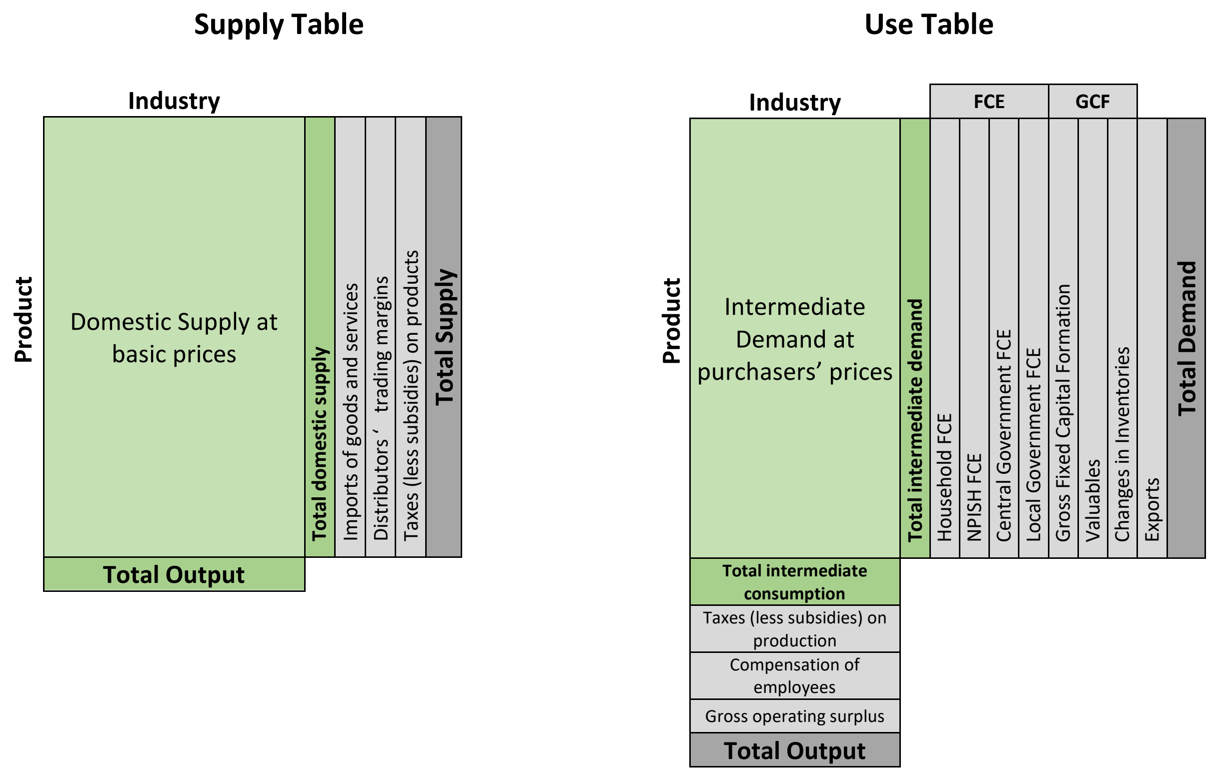
1. Domestic Supply and Intermediate Demand
2. Central Government
3. Local Government
4. NPISH
5. Household
6. Gross Capital Formation
7. Trade
8. Distributors' Trading Margins
9. Taxes less Subsidies on Products

We primarily focus on the data sources of the Northern Ireland and Scotland tables as these suit the UK nations / NUTS 1 focus of this report and both have large amounts of documentation.

The UK tables do not have documentation on data sources, however we have supplemented the section with UK data sources obtained from a discussion with the ONS.

While tables do exist for Wales, these were not included in this section. These were produced in academia and so faces challenges in obtaining data that a government producer would not have.

5.4. Domestic Supply and Intermediate Demand



Domestic supply and Intermediate demand tables are covered together since there are significant similarities in the data sources used for the totals. **Table 5** and **Table 6** show the data sources for each industry for the Northern Ireland and Scotland tables respectively.

Table 5: NI data sources used for industry totals in the domestic supply and intermediate demand tables

Industry	Supply	Use
01-03: Agriculture, forestry and fishing	DAERA Aggregate Agricultural Accounts & Statistical Review of Northern Ireland Agriculture, ABI, ONS Regional Accounts, UK Supply Table	DAERA Aggregate Agricultural Accounts & Statistical Review of Northern Ireland Agriculture, ABI, ONS Regional Accounts, UK Use Table, Annual Purchases Survey
05-09: Mining and quarrying	ABI, ONS Regional Accounts, UK Supply Table	ABI, ONS Regional Accounts, UK Use Table, Annual Purchases Survey
10.1-33 Other: Manufacturing	ABI, ONS Regional Accounts, PRODCOM	ABI, ONS Regional Accounts, UK Use Table, Annual Purchases Survey
35: Electricity, gas, steam and air conditioning supply	ABI, ONS Regional Accounts, PRODCOM	Annual Purchases Survey
36-39: Water supply; sewerage, waste management and remediation activities	HMT OSCAR database, DOE Final Outturn data, ABI, ONS Regional Accounts, UK Supply Table	HMT OSCAR database, DOE Final Outturn data, ABI, ONS Regional Accounts, UK Use Table, Annual Purchases Survey
41-43: Construction	HMT OSCAR database, ABI, ONS Regional Accounts, PRODCOM	HMT OSCAR database, ABI, ONS Regional Accounts, UK Use Table , Annual Purchases Survey
45-47: Wholesale and retail trade; repair of motor vehicles and motorcycles	ABI, ONS Regional Accounts, UK Supply Table	ABI, ONS Regional Accounts, UK Use Table , Annual Purchases Survey
49-53: Transportation and storage	ABI, ONS Regional Accounts, UK Supply Table, Translink	ABI, ONS Regional Accounts, UK Use Table, Annual Purchases Survey
55-56: Accommodation and food service activities	ABI, ONS Regional Accounts, UK Supply Table	ABI, ONS Regional Accounts, UK Use Table , Annual Purchases Survey
58-63: Information and communication	ABI, ONS Regional Accounts, BBC National Accounts	ABI, ONS Regional Accounts, BBC National Accounts , Annual Purchases Survey
64-66: Financial and insurance activities	ONS Regional Accounts, UK Supply Table	ONS Regional Accounts, UK Use Table, Annual Purchases Survey
68: Real estate activities	ONS Regional Accounts, UK Supply Table, UK Intermediate Consumption Table, UK Final Demand Table, NICVA State of the Sector	ONS Regional Accounts, UK Intermediate Consumption Table, UK Final Demand Table, UK Use Table, NICVA State of the Sector, Annual Purchases Survey
69-75: Professional, scientific and technical activities	ONS Regional Accounts, UK Supply Table, UK Intermediate Consumption Table, UK Final Demand Table, NICVA State of the Sector	ONS Regional Accounts, UK Intermediate Consumption Table, UK Final Demand Table, UK Use Table, NICVA State of the Sector, Annual Purchases Survey
77-82: Administrative and support service activities	ONS Regional Accounts, UK Supply Table, UK Intermediate Consumption Table, UK Final Demand Table, NICVA State of the Sector	ONS Regional Accounts, UK Intermediate Consumption Table, UK Final Demand Table, UK Use Table, NICVA State of the Sector
84: Public administration and defence; compulsory social security	ONS Regional Accounts, UK Supply Table, HMT OSCAR, DOE Final Outturn data	ONS Regional Accounts, UK Use Table, HMT OSCAR, Annual Purchases Survey
85: Education	ONS Regional Accounts, UK Supply Table, UK Intermediate Consumption Table, UK Final Demand Table, NICVA State of the Sector, Universities Financial Statements, HMT OSCAR	ONS Regional Accounts, UK Intermediate Consumption Table, UK Final Demand Table, UK Use Table, NICVA State of the Sector, Universities Financial Statements, HMT OSCAR, Annual Purchases Survey
86-88: Human health and social work activities	ONS Regional Accounts, UK Supply Table, UK Intermediate Consumption Table, UK Final Demand Table, NICVA State of the Sector, HMT OSCAR	ONS Regional Accounts, UK Intermediate Consumption Table, UK Final Demand Table, UK Use Table, NICVA State of the Sector, HMT OSCAR, DOE Final Outturn data, Annual Purchases Survey
90-93: Arts, entertainment and recreation	ONS Regional Accounts, UK Supply Table, UK Intermediate Consumption Table, UK Final Demand Table, NICVA State of the Sector, HMT OSCAR	ONS Regional Accounts, UK Intermediate Consumption Table, UK Final Demand Table, UK Use Table, NICVA State of the Sector, HMT OSCAR, DOE Final Outturn data, Annual Purchases Survey
94-96: Other service activities	ONS Regional Accounts, UK Supply Table, UK Intermediate Consumption Table, UK Final Demand Table, NICVA State of the Sector, HMT OSCAR, DOE Final Outturn	ONS Regional Accounts, UK Intermediate Consumption Table, UK Final Demand Table, UK Use Table, NICVA State of the Sector, HMT OSCAR, DOE Final Outturn data, Annual Purchases Survey
97: Activities of households as employers	ONS Regional Accounts, UK Supply Table, HMT OSCAR, DOE Final Outturn data	ONS Regional Accounts, UK Use Table, HMT OSCAR, Annual Purchases Survey

Table 6: Scotland data sources used for industry totals in the domestic supply and intermediate demand tables

Scotland Industry	Supply	Demand
01: Agriculture	Scottish Government; Scottish Agriculture Output, Input and Income Statistics, Components of Total Income from Farming (TIFF), Non-Agriculture spread using UK supply patterns	Scottish Government; Scottish Agriculture Output, Input and Income Statistics, Components of Total Income from Farming (TIFF), Farm Accounts Survey. (Inter-farm, Non-farming and Non-farm based farming estimated from UK data)
02: Forestry planting and harvesting	ABS and Forestry survey 2001	ABS and Forestry survey 2001
03.1: Sea fishing	Marine directorate of the Scottish Government, Scottish based fishing vessel landings, ABS and UK Supply Table	Marine directorate of the Scottish Government, Scottish based fishing vessel landings, ABS and UK Use table
03.2: Fish farming	Marine directorate of the Scottish Government, Scottish Fish Farms Annual Production Survey, ABS and UK Supply Table	Marine directorate of the Scottish Government, Scottish Fish Farms Annual Production Survey, ABS and UK Use table
05-09: Mining	ABS and UK Supply Table	ABS, ABS Purchases Inquiry and UK Use table
10-37: Manufacturing, energy	ABS, Prodcom and UK Supply table	ABS, ABS Purchases Inquiry and UK Use table
38-39: Waste and remediation and management	Scottish Local Authority Financial Returns, ABS and UK Supply table	Scottish Local Authority Financial Returns, ABS and UK Use table
41-43: Construction	ABS, Prodcom and UK Supply table	ABS, ABS Purchases Inquiry and UK Use table
45-63: Distribution, catering, transport & communication	ABS and UK Supply table, BBC Annual Accounts	ABS and UK Use table, BBC Annual Accounts
64-68: Banking & Finance, real estate, estate agents	ONS Annual Survey of Hours and Earnings and UK Supply table	ONS Annual Survey of Hours and Earnings and UK Use table
69-82: Professional, scientific and technical activities; administrative and support activities	ABS and UK Supply table	ABS and UK Use table
84: Public administration	Online System for Central Accounting and Reporting (OSCAR) spending database where possible, Government Expenditure and Revenue Scotland, Public Sector Employment statistics, UK Defence Statistics. ABS and UK Supply table	Online System for Central Accounting and Reporting (OSCAR) spending database where possible, Government Expenditure and Revenue Scotland, Public Sector Employment statistics, UK Defence Statistics. ABS and UK Use table
85: Education	Scottish Local Government Financial Statistics, Scottish Funding Council, Higher Education Statistics Agency, Scottish Council of Independent Schools. ABS (Service Trades) and UK Supply table	Scottish Local Government Financial Statistics, Scottish Funding Council, Higher Education Statistics Agency, Scottish Council of Independent Schools. ABS (Service Trades) and UK Use table
86: Human health services	NHS Annual Accounts. ABS and UK Supply table	NHS Annual Accounts. ABS and UK Use table
87-92, 94: Residential care services; social work services; creative and cultural services	Scottish Local Authority Financial Returns, ABS and UK Supply table	Scottish Local Authority Financial Returns, ABS and UK Use table
93: Gambling	ABS and UK Supply table	ABS and UK Use table
95-96: Other service activities	ABS and UK Supply table	ABS and UK Use table
97: Activities of households	ONS Regional Accounts, UK Supply table	ONS Regional Accounts

5.4.1. Construction of the Initial Supply Table: Totals

In general, the total output at basic prices by industry are sourced from the ONS ABS for the Scotland tables and the NI ABI for the Northern Ireland tables. For instance, NISRA used the sum of GVA plus intermediate consumption to calculate the total output of industries.

Two different methods are used to give the total private industry domestic supply at basic prices (the industry totals in the supply table, excluding government and NPISH). NISRA first scales the components of GVA (technically approximate GVA – 'aGVA') by industry from the ABI so that they match those in ONS Regional Accounts. Intermediate consumption is then scaled so that the same ratio of intermediate consumption to GVA from the ABI is maintained.

The Scottish Government and ONS also use the output of industries from the ABS. There are many similarities between the ABS and ABI business datasets, including in the data challenges. For instance, both surveys exclude Government and NPISH output, as well as a number of industries in general. The main excluded industries in the ABS are:

- Parts of agriculture (SIC 01.1 - 01.5)
- Parts of financial activities (SIC 64, 65.3, 66)
- Rents are imputed (Part of SIC 68)
- Public administration and defence (SIC 84)
- Activities of households as employers; undifferentiated goods and services-producing and Activities of households for own use (Section T)
- Activities of extraterritorial organisations and bodies (Section U)

This list is similar for the ABI. The Scottish Government, ONS and NISRA therefore include a number of additional data sources to cover these missing sections. These additional data sources tend to be specific to the IOT. For instance, the Scottish IOT has a greater focus on fishing, with Fishing (SIC 03.1) and Aquaculture (03.2) separated. Data from Marine Scotland has been used to achieve this. Data on agriculture is also required to be sourced. The ONS uses DEFRA data for this, while the Scottish Government and NISRA use their own sources. Finally, the ONS also incorporate additional data on air transport – currently extrapolating Civil Aviation Authority data – and data from BEIS' DUKES[19] for energy industries (including oil and gas extraction).

[19] https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2020

The National Accounts measurement of the output of the banking sector is called Financial Intermediate Services Indirectly Measured (FISIM). When looking at borrowing from banks, this is measured as the difference between the interest rate paid and what would have been paid at a reference rate (e.g. Bank of England base rate). When looking at deposits with banks, this is measured as the difference between the interest received and what would have been received at the reference rate. The ONS uses a range of surveys of financial corporations such as insurance companies and securities dealers as well as banking data from the Bank of England.

Both the Scottish Government and NISRA use GVA figures from Regional Accounts and allocate these to industries using UK proportions. Intermediate consumption was estimated using the UK ratio of GVA to intermediate consumption.

Imputed rents are the amount that an owner of a property would need to pay if they had to rent their own property. These are calculated using the data from the Household section.

Sources for local and central government and NPISH also differ. This is covered in sections 5.5 – 5.7.

5.4.2. Construction of the Initial Supply Table: Allocation to Products

With industry totals estimated, the next step is to allocate these to product classifications. The ONS uses the UK Manufacturers' Sales by Product (PRODCOM[20]) for the sales by product of manufacturing industries. The Annual Survey of Goods and Services[21] is also used to provide the product breakdown of industry output totals. The Gross Domestic Expenditure on Research and Development survey (GERD)[22] is used for research and development.

Both NISRA and the Scottish Government use the same product split by industry as the corresponding industry in the UK Supply Table.

20 https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/ukmanufacturerssalesbyproductprodcom

21 https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/annualsurveyofgoodsandservicesasgs

22 https://www.ons.gov.uk/businessindustryandtrade/business/businessinnovation/methodologies/ukgrossdomesticexpenditureonresearchanddevelopmentqmi

They also both use PRODCOM to allocate manufacturing totals to products where there is a sufficient proportion of an industry covered. The Scottish Government then applies data from ONS GERD to the UK supply of R&D to produce estimates for Scotland of the Research and Development product. Otherwise, the Scottish Government also uses the same proportions as the corresponding industry in the UK Supply Table. This includes checks against the UK Supply Table to make sure that no cells are unreasonably large or small. If necessary, these are adjusted.

5.4.3. Construction of the Initial Use Table

The ONS uses the Annual Purchases Survey[23] to distribute non-government, non-financial intermediate consumption to products.

The data sources NISRA used for total intermediate consumption for all industries are very similar to those used in the supply table. Where possible, NISRA use Annual Business Inquiry aggregates and Annual Purchases Survey proportions to allocate values to products. Otherwise they apportion the expenditure on goods and services of government industries to products using UK SUTs proportions.

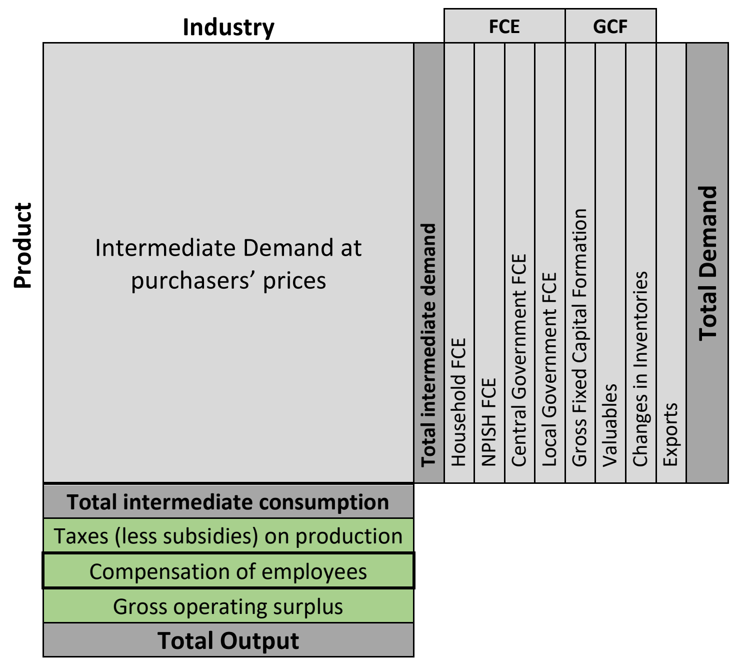
NISRA mentions that using the ONS Annual Purchases Survey (APS) is the preferred method, however some industries are not covered and sample sizes can be very small at NUTS 1 level. Instead, ABI data on the purchases of goods, materials, energy and services were used with allocations to product categories using UK intermediate consumption matrix proportions.

The Scottish Government obtained total purchases of goods and services from the ABS, which also provides details for estimating the intermediate consumption total, plus totals for intermediate consumption of broad product categories. Underneath this level of detail, these intermediate consumption totals are allocated to SUTs product groups using UK proportions. These are compared to values in the UK Use Table to ensure they do not look unreasonably large or small.

[23] https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/annualpurchasessurvey

5.4.4. Primary inputs

Use Table



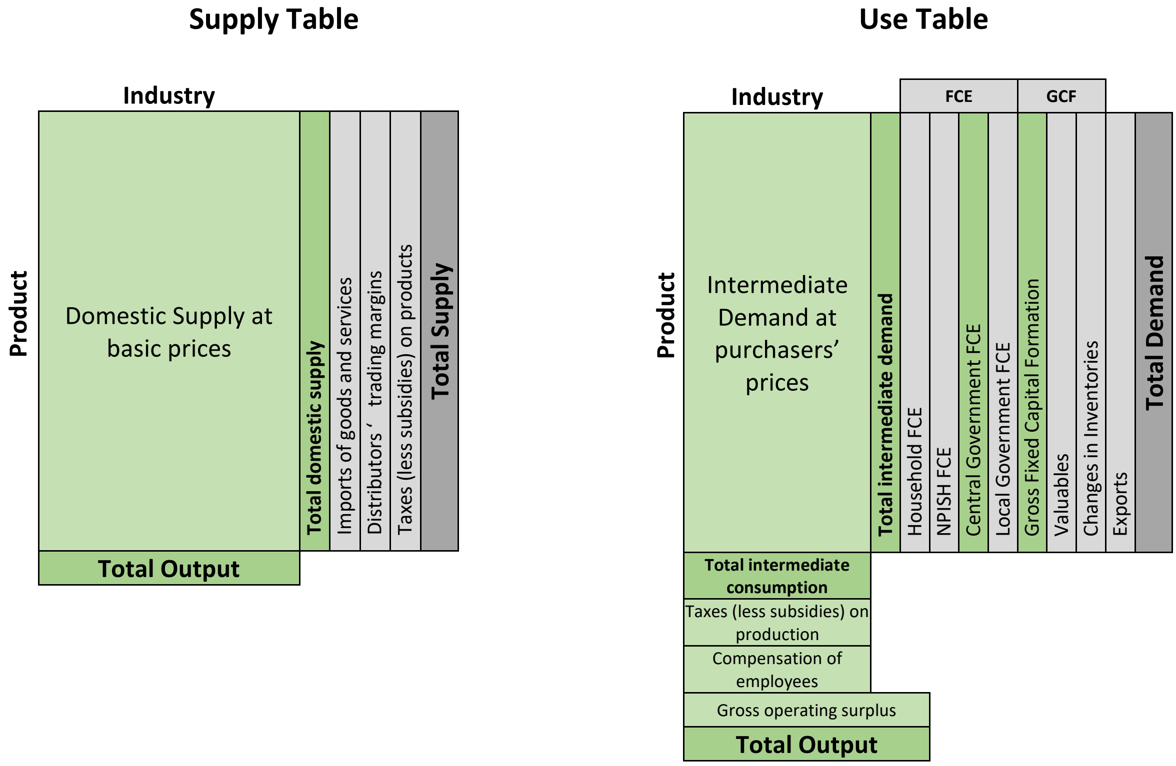
The ONS mostly use HMRC data for gross operating surplus by industry and mixed income data covering the self-employed. HMRC data is also used for the compensation of employees total and is combined with Labour Force Survey and Average Weekly Earnings data to create industry totals. And the Capital Stocks and Fixed Capital Consumption Survey[24] is used to measure the gross operating surplus of non-market sectors.

For non-government industries, NISRA and the Scottish Government sourced primary income components from the ABI and ABS respectively. In addition, NISRA used DAERA Aggregate Agricultural Accounts for the agriculture industry. Data on NI government industries and further education was sourced from HMT OSCAR and annual accounts. NISRA constrains total GVA, compensation of employees, gross operating surplus, mixed income and taxes less subsidies by industry section to ONS Regional Accounts.

24 https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/capitalstocksandcapitalconsumptionqmi

The Scottish Government also constrain GVA to ONS Regional Accounts however data is used from the ABS where they believe that the top-down Regional Accounts estimates aren't appropriate. Currently, Agriculture, forestry & fishing and Water supply, sewerage & waste sectors are adjusted[25].

5.5. Central Government



Government and NPISH output can be broken down into three categories:

- Market output
- Output for own final use
- Non-market output

Market output includes services provided by government at economically significant prices.

Output for own final use includes output for own final consumption (e.g. in-house training) and output for own GFCF (e.g. in-house IT development).

[25] https://www.gov.scot/publications/about-supply-use-input-output-tables/pages/developments/

A large amount of government (and NPISH) output is non-market output. This is output which is provided either free or at economically insignificant prices and is produced by NPISH or government (e.g. NHS, defence). It is therefore difficult to value using standard methods. Instead it is valued according to the inputs used in its production.

These non-market outputs are not consumed by firms, instead it is consumed by government as final consumption. That is, government consumes the non-market output it creates.

Separate matrices for central and local government are created. These are summed with the non-government matrices to provide the final tables.

The table below shows the industries that include central and local government contributions to intermediate consumption in the Scottish tables. Note that this table does not include items such as Government GFCF in construction.

Table 7: Contribution of central and local government to industries

Industry (SIC)	Industry Description	Central Government	Local Government
36, 37	Water and sewerage		✓
49.3 – 49.5	Other land transport		✓
52	Support services for transport	✓	
59, 60	Film, video & TV etc; broadcasting	✓	
84	Public administration & defence	✓	✓
85	Education	✓	✓
86	Health	✓	✓
87, 88	Residential care and social work	✓	✓
90	Creative services		✓
91	Cultural services		✓
93	Sports & recreation		✓

Source: Scottish Government

Government FCE includes the non-market output of government by product. That is, government is the consumer of its own non-market output. These are equal to the row total in the government Supply Tables of the non-market output. For instance, government produces non-market output in industry 84 – public admin and defence – but no other industry is buying this output. In order for the tables to balance, the final consumption expenditure of government on industry 84 is therefore equal to the government supply.

The ONS sourced all government data from the Public Sector Finances data[26]. This includes data on central government, local government and public corporations. Data is collected from UK Government departments, the Scottish Government, the Welsh Government, the Northern Ireland Executive, the Bank of England, the OBR and public sector banks. All tax information is provided by the Treasury.

For Northern Ireland, central government data was mostly sourced from the OSCAR database[27]. This is mapped from COFOG to SUT codes to create estimates of Final Consumption Expenditure, GVA and its components, intermediate consumption and GFCF.

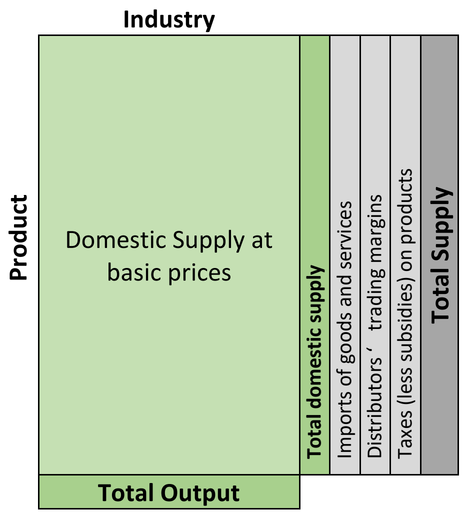
COFOG codes are mapped to the SUT codes 36, 42, 84, 85, 86, 87, 91, 93. This is similar but not identical to the Scottish Government table above. Expenditure is mapped to GFCF for parts of Construction, Civil Engineering, Plant and Machinery, Vehicles and Equipment, and Software.

In the tables for Scotland, government inputs use the data sources listed in table 6. These provide the data for the government contribution to intermediate consumption in the Use Table. The proportionate split of government output between market output, output for final use and non-market output is first sourced from the UK tables. Market output and non-market output is then recorded in the relevant cell in the government supply table. These are all recorded as the principal products of industries. The output for own final use is split between the construction product and computer & related activities product using UK proportions.

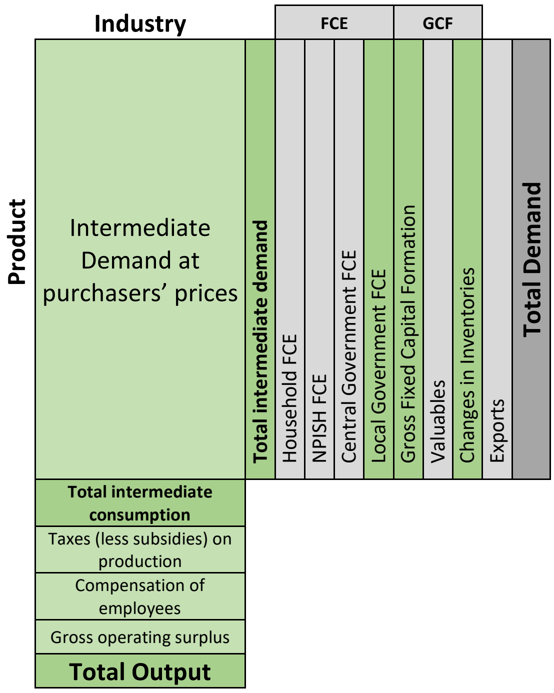
[26] https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/publicsectorfinance/methodologies/publicsectorfinancesandgovernmentdeficitanddebtunderthemaastrichttreatyqmi
[27] https://www.gov.uk/government/collections/hmt-oscar-publishing-from-the-database

5.6. Local Government

Supply Table

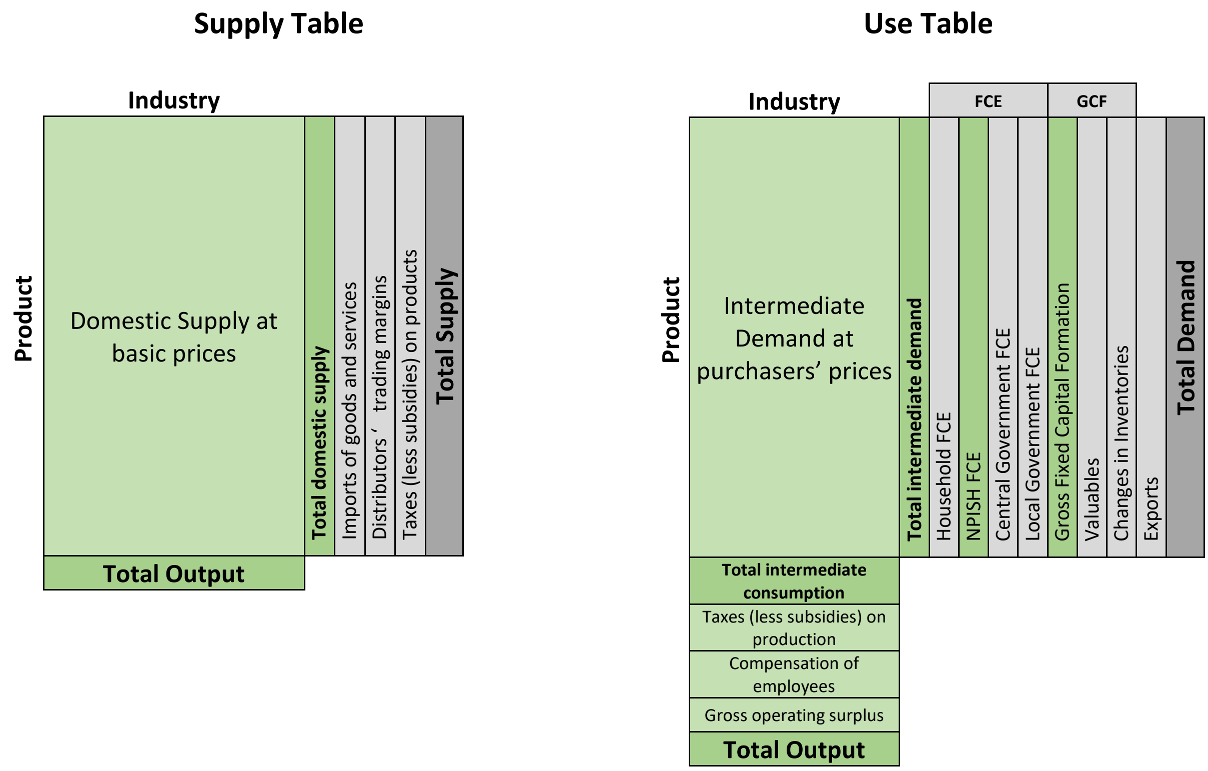


Use Table



The ONS sources local government incomes and expenditures from the Scottish Government, Welsh Government, Northern Ireland Executive and the Department for Communities for English data. NISRA sourced local government data from Department of the Environment (DOE) outturn data and local council financial statements. The DOE data are used to construct the Local Government FCE. The FCE data are mapped to SUT codes 38, 39, 84, 91, 93.Local council financial statements are then used to estimate capital expenditure by asset class for GFCF and work in progress. Work in progress includes output that takes more than one period (e.g. shipbuilding) and is not yet completed. A start year and end year position is compared. This provides an input to inventories.

5.7. NPISH



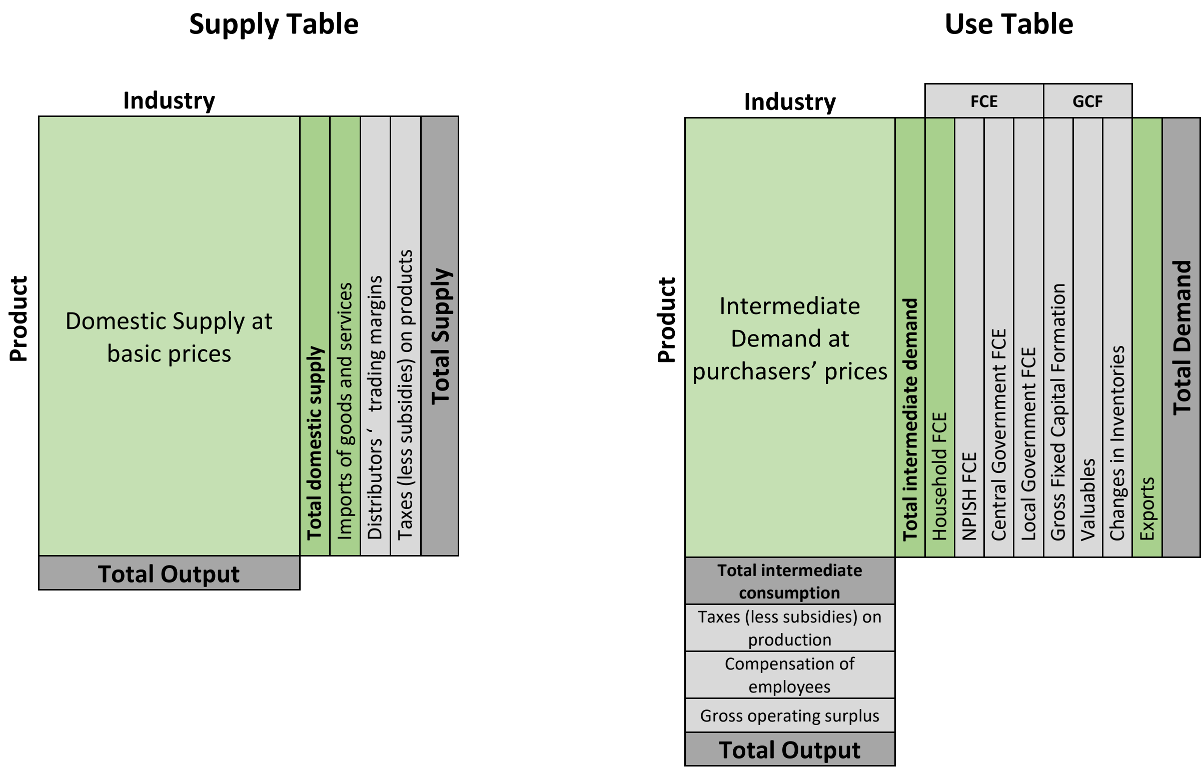
Data on NPISH tends to be very limited. Like government, NPISH also consumes the non-market output it creates. The FCE also includes their purchases of goods and services. This is included in FCE as they are provided to the population without transformation.

For universities, NISRA took data from university annual accounts. ONS Higher Education Research and Development (HERD) data was used for research and development costs. Universities were allocated to the education industry.

For membership organisations, a population share was taken of the UK final consumption expenditure for SIC 94 'Services furnished by membership organisations'. For community and voluntary organisations, expenditure and income was taken from the State of the Sector Survey by the Northern Ireland Council for Voluntary Action. These were allocated to product codes using data from the UK SUTs.

The Scottish Government sets the final demand for the education product equal to the output from Higher Education institutions and private schools. NISRA is still investigating how best to capture data from private schools however this sector is relatively small in Northern Ireland compared to other parts of the UK. The remainder of NPISH is estimated in line with the UK tables.

5.8. Households



5.8.1. Household Final Consumption Expenditure (HHFCE)

The ONS sources household expenditure data from the ONS Living Costs and Food Survey (LCFS), the Retail Sales Inquiry and supplementary information from HMRC on heavily taxed items such as alcohol and tobacco[28].

For the ONS, HHFCE is equal to UK resident expenditure in the UK and UK resident expenditure abroad. For devolved nations, HHFCE is equal to residents' expenditure in their country, residents' expenditure in the rest of the UK and residents' expenditure abroad.

NISRA's sources household expenditure is from the LCFS, university halls of residence costs (multiplying number of beds by costs data from university websites), rental data (NI Census and NIHE Rental Prices), ONS UK SUT data and tourism data (NI Passenger Survey, ONS

[28] https://www.ons.gov.uk/economy/nationalaccounts/satelliteaccounts/methodologies/consumertrendsuk

International Passenger Survey, NISRA Continuous Household Survey). This is mapped to SUT codes using proportions from the UK SUTs and is used for the estimates of household final consumption expenditure, imputed rent and trade data. LCFS data for Northern Ireland is mapped to 3 digit COICOP codes and CPA codes. These are then allocated to SUT product codes. Some of these COICOP codes are one-to-one mappings while others are generally split in line with UK proportions. Since the UK HHFCE totals do not match the UK LCFS, the data for Northern Ireland are scaled to account for this.

The Scottish Government uses a top down estimate derived from the UK SUT HHFCE table. LCFS data is the main regional indicator and is combined with some additional data sources (e.g. Scottish Water annual accounts) which can provide more accuracy than the LCFS. Imputed rent estimates are based on ONS Regional Accounts GVA and the UK GVA to Output ratio is maintained to estimate Scotland's imputed rent output (imputed rent output is equal its HHFCE). Finally, data from the International Passenger Survey is used as the regional indicator for Scottish residents' expenditure in the rest of the world.

5.8.2. Non-resident household expenditure

For the Northern Ireland SUTs, non-resident household expenditure includes the expenditure of visitors from abroad or the rest of the UK to Northern Ireland. It is included in the export part of the use table. The NI Passenger Survey (NIPS) provides six broad categories of expenditure for visitors from Great Britain, the Republic of Ireland, the Rest of the EU and the Rest of the World. This is combined with External Overnight Trips to Northern Ireland (EOTNI) data to estimate the expenditure of visitors by reason of visit and visitor source. EOTNI is derived from NIPS, Survey of Overseas Travellers (SOT) conducted on behalf of Fáilte Ireland and the CSO Household Travel Survey.

Rest of world non-residents' expenditure in Scotland is calculated by using a share of UK tourist exports. This share is derived using data from the ONS International Passenger Survey. Rest of UK non-residents' expenditure in Scotland is estimated from the GB Tourism Survey, GB Day Visitor Survey and Northern Ireland Tourism Survey.

The ONS uses the International Passenger Survey which includes expenditure by non-UK residents in the UK.

5.8.3. Domestic resident household expenditure abroad

Estimates of residents' expenditure abroad is included in the import of services and a component of HHFCE.

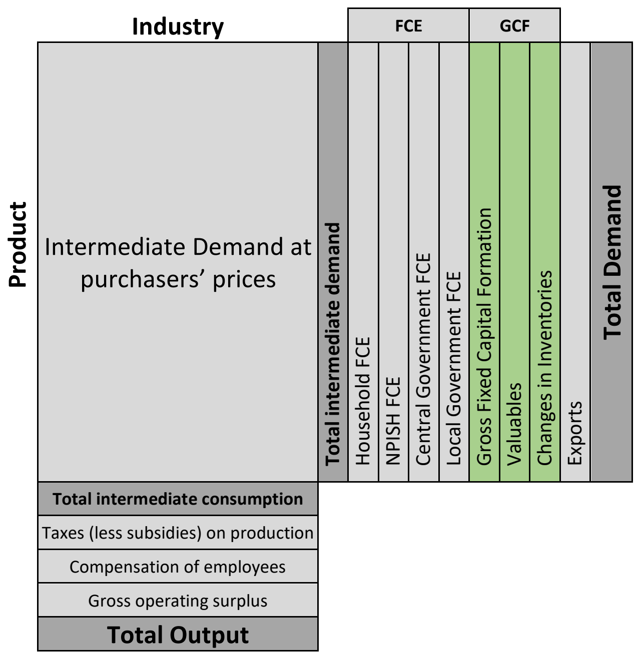
NISRA source this data from both NISRA's Continuous Household Survey and the ONS International Passenger Survey. The former is used to create NI resident household expenditure in Great Britain and Republic of Ireland by 9 broad categories. These 9 categories are allocated to SUT categories using UK SUTs data. The latter is used for rest of EU and rest of world spend and allocated to SUT categories using UK SUTs data.

The Scottish Government uses the ONS International Passenger Survey and the Great Britain Tourist Survey. The International Passenger Survey data is applied to the UK HHFCE table to provide rest of world estimates.

The ONS also uses the International Passenger Survey for the expenditure by UK residents outside the UK.

5.9. Gross Capital Formation

Use Table



Gross Capital Formation includes:

- GFCF – the purchase and disposal of fixed assets (e.g. machinery and plant, software, new dwellings, improvements to buildings, roads, research and development)
- Acquisitions less disposals of valuables – stores of value such as art, antiques and jewellery.
- Changes in inventories – work in progress, materials and fuel, finished goods which have not yet been sold.

5.9.1. Gross Fixed Capital Formation

GFCF includes government (central and local), private sector and NPISH components. ONS source their GFCF data from the Quarterly Acquisitions and Disposals of Capital Assets Survey[29]. For Northern Ireland, the main GFCF sources for central and local government have been laid out in their respective sections. Previously, GFCF totals from the ABI was the main data source for the private sector, with data for capital expenditure on buildings, plant and machinery, and vehicles. These were allocated to products using the UK GFCF industry by product table. However, this has since been replaced with GFCF total spend by product from the ABI.

For agriculture, DAERA's survey of agriculture was used. For product 72 (Research & development), GFCF from ONS Business Enterprise Research and Development (BERD) is used. Additional data was also included from the construction sector as the costs of dwellings and transfer costs for land and dwellings are taken into account for GFCF. This is sourced from NISRA's Quarterly Construction Enquiry. The categories in the QCE were mapped to the construction categories in the SUTs. Any housing related work (building and maintenance) was mapped to product 41, while any infrastructure related work was allocated to 42. Although it is mentioned elsewhere that dwellings and transfer costs are instead allocated to products using proportions from the UK SUTs.

When totalling together all the data sources, the remaining non-dwelling and transfer cost GFCF in products 41-43 are constrained so that consistency is maintained with the QCE.

Similarly to NISRA, the Scottish Government mostly sources GFCF by industry from net capital expenditure data in the ABS. The ABS does not provide complete coverage of industries such

29 https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/quarterlyacquisitionsanddisposalsofcapitalassetssurvey

as Agriculture (SIC 01), Forestry (SIC 02), Financial Intermediation (64-66), and Public Sector, Government and Other (94-97). For these industries, excluding agriculture, the Scottish to UK Gross Operating Surplus proportions are used.

The Scottish Government also supplements the data on the agriculture industry with data from the Total Income from Farming data. GFCF on new dwellings was sourced from new housing and repair and maintenance of housing in ONS Output of the Construction industry. GFCF on capitalised transfer costs on land was taken from ONS Regional Accounts. Industry totals for GFCF are then allocated to products using proportions from the UK GFCF industry by product table. Sources on Government GCF are unclear but likely to include data from OSCAR.

5.9.2. Valuables

Valuables were not estimated for Scotland or Northern Ireland due to its very small size.

The ratio of net change in valuables to total output for the UK is applied to total output levels for Scotland. This is then apportioned to products using UK proportions.

5.9.3. Inventories

The ONS sources inventories from the Quarterly Stocks Survey[30].

Change in inventories for NI was calculated by applying the UK GDP deflator to stocks at the start and end of the year. This gives the change in inventories at end of year prices. This was then apportioned to product groups using UK SUTs proportions.

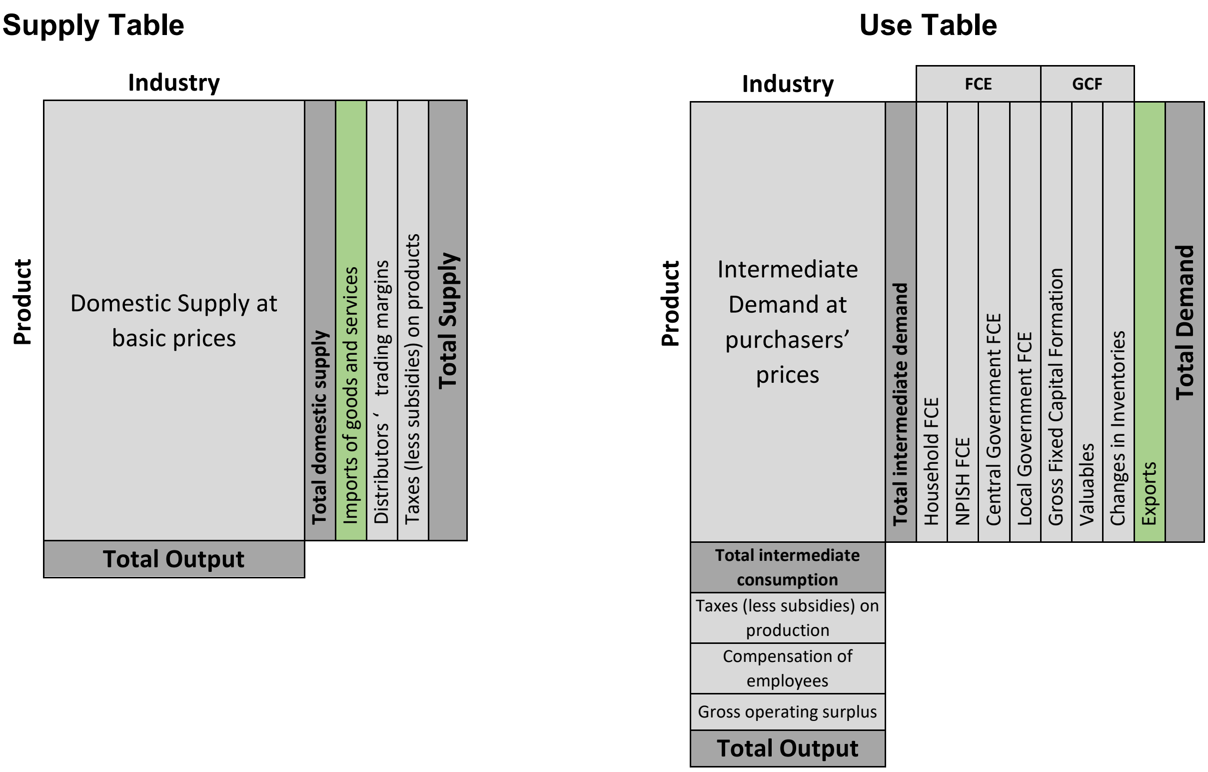
The Scottish Government sourced data for manufacturing industries from the ABS on start year and end year stocks of material and fuels, and combined work in progress and finished goods. Unspecified UK data from 2004 is used to calculate the split between combined work in progress and finished goods. And UK data is used to split all inventory components for service industries.

Deflators are applied to start and end year stocks to calculate the change in inventories valued in the average prices of the year. Inventory deflators from the ONS are used where available. If these are not available then the average of the available deflators for that industry is used,

[30] https://www.ons.gov.uk/surveys/informationforbusinesses/businesssurveys/quarterlystockssurvey

or average deflators for the IOC which includes the industry. If there is no Scottish data for an IOC available then UK data are used.

5.10. Trade



The ONS uses HMRC trade data for both exports and imports of goods by product. Trade in services is mainly sourced from the International Trade in Services Survey as well as a number of administrative sources[31] however the ONS mention that the attribution of these is more difficult and more trust is placed in the goods data when balancing.

5.10.1. Exports

Both the Scotland and Northern Ireland tables split their exports up by destination. These include exports destined for the rest of the UK, the rest of the world and non-resident expenditure (e.g. tourism to Scotland or Northern Ireland).

[31] https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/methodologies/uktradeqmi

The primary data source of exports for Northern Ireland is NISRA's Broad Economy Sales Exports Survey (BESES). The BESES data is provided by industry, and it is mapped to products using detailed HMRC data trends[32]. There are no principal products of industries 45-47 (retail and wholesale), and these are instead redistributed. 4 digit SIC data is used to identify the most appropriate product for these to be redistributed to. The BESES data is combined with DAERA agriculture data for agricultural exports – covering products 1 and 3. HMRC Regional Trade Statistics were used for product 2 due to the lack of other data sources. Imports from Northern Ireland to the Republic of Ireland is sourced from the CSO and taken as the export to the Republic of Ireland.

Scottish Exports by industry to the rest of the world and rest of the UK are sourced from the Scottish Government's GCS. These totals are apportioned to products using the domestic Supply Table at basic prices.

5.10.2. Imports

One of the most challenging parts of the SUTs for Scotland and Northern Ireland are imports – particularly those from the rest of the UK. These columns are therefore heavily adjusted during the manual balancing.

NISRA obtains the total imports figure from BESES data. However, since an industry can import any type of product, the BESES data is not mapped to products. Instead it is allocated to products using data trends from the HMRC and Republic of Ireland trends.

As BESES does not include live animals, values for live animal imports are sourced from DAERA and set as the imports for product 1.

HMRC data does not include data on services. NISRA have instead taken the total values of imports from the three origins of interest and apportioned these using the UK Supply table. Some manual adjustments were also made. For instance, imports of veterinary services were assumed to be from ROI rather than GB.

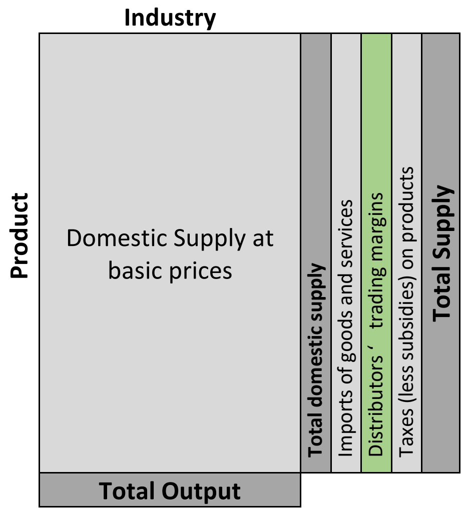
The Scottish Government also uses HMRC Regional Trade Statistics for the imports of goods and it uses the ONS International Trade in Services publication for the imports of services

[32] This was previously mapped to products by assuming that an industry exports its principal product.

from the rest of the EU and rest of the world. Rest of UK imports are apportioned to products using data from the Scottish Government's GCS.

5.11. Distributors' Trading Margins

Supply Table



Three components are needed to convert domestic supply at basic prices to total supply at purchasers' prices:

- Distributors' trading margins
- Taxes on products
- Subsidies on products

The difference between the prices at which distributors buy their products (purchasers' prices) and sell their products (basic prices) is included in the distributors' trading margins column.

Of course, any payment for costs like transport will be made to other industries (a gain for them). So distributors' trading margins reallocates these transactions from the industries that gained back to the industries that lost. The sum of this column is therefore zero.

Three types of margins are estimated:

- Wholesale and retail margins on vehicles
- Wholesale excluding vehicles
- Retail excluding vehicles

The ONS calculates distributors' trading margins using questions from the ABS.

NISRA calculates the distributors' trading margin as a percentage of demand (total intermediate, FCE, GFCF and exports) for each product from the UK Supply table and applies these proportions to Northern Ireland demand estimates. As it requires the NI demand estimates, this is carried out after the initial supply and demand tables have been created.

A grossing factor is then applied to the total DTM for each product.

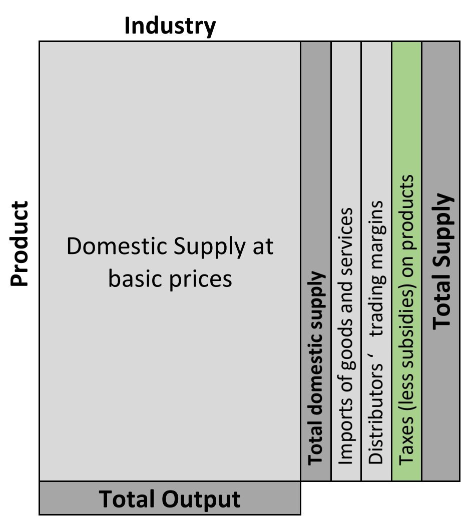
The DTM are recalculated after the supply and demand tables are balanced as their values are based on the demand for products.

UK product by industry margin factors are applied to the Scottish Use Table to give a matrix of margin estimates. These estimates are also then scaled to match the total output of each margin for Scotland.

They are scaled by using the corresponding ratio of total margin to total output from the UK tables and applying this to Scottish output totals for that product. The rows of the matrix are summed to give a vector, and this vector is the margins column used in the supply table.

5.12. Taxes less Subsidies on Products

Supply Table



Taxes (less subsidies) on products includes VAT, taxes on imports and other taxes on products and they represent another wedge between the price that products are sold at, and the price that products are purchased at.

Since the domestic supply part of the supply table is given in basic prices, including both the distributors' trading margins column and the taxes (less subsidies) on products column converts the total supply from basic prices into purchasers' prices.

The Scottish Government first estimates a matrix of VAT rates. This is calculated by obtaining the UK Use Table VAT matrix, which includes the value of VAT for each cell in the purchasers' price Use Table, and dividing this through by the corresponding values in the UK Use Table.

Initial Scottish estimates of VAT are then obtained by applying this matrix to the Scottish Use Table at purchases' prices. These estimates are then scaled so that their total matches the VAT receipts attributable to Scotland from the Scottish Government's Government Expenditure and Revenue Scotland (GERS) publication.

Similarly to VAT, other product taxes are estimated by deriving rates from the UK Use Table and then constraining these to the totals from GERS.

For Scotland, these taxes include:

- Aggregates levy
- Agriculture levies
- Air passenger duty
- Alcohol duties
- Betting, gaming and lottery duties
- Channel 4 funding
- Climate change levy
- Fossil fuel levy
- Gas levy
- Hydro benefit tax
- Hydrocarbon oils duty
- Insurance premium tax
- Landfill tax
- Lottery fund
- Protective duty on imports26
- Renewable obligation certificates
- Stamp duties
- Strategic Rail Authority rail franchise premia
- Sugar levy
- Tobacco duty

For subsidies, UK Table proportions of subsidy to total use are applied to the Scottish Use Table.

Average rates of protective duty by product are calculated using UK rest of world imports and protective duty. These are applied to Scotland's rest of world imports to get protective duty by product.

NISRA used the ONS Country and Regional Public Sector Finances revenue tables for the majority of tax data. HMRC data is also used for land stamp duties.

Tobacco duties are estimated using the Public Sector Receipts data.

For estimating VAT, the unpublished UK Supply table and unpublished data on the implied VAT paid on UK products is provided by the ONS.

Data on subsidies is provided by Translink using a freedom of information request. This includes annual public transport financial support for bus and rail services.

Taxes less subsidies are recalculated after the supply and demand tables have been balanced, as values from these tables are used.

6. Producing Regional IOTs for the Four Nations: A Top-Down Approach

In this section, we will demonstrate how regional IOTs for Scotland, Wales, England and Northern Ireland can be derived from the UK IOT published by the ONS. We will contrast this analysis with bottom-up approaches for compiling Scottish IOTs discussed in Section 5. Importantly, we do not draw on data sources compiled by the Scottish Government or NISRA, instead demonstrating how a fully top-down approach could be implemented. Additionally, we impose the constraint that the regional totals must match the overall UK total.

6.1. Data and Method

There are three fundamental data inputs needed for the UK regional IOTs:

- UK IOT
- Regional employment by industry
- Regional GVA by industry

The UK IOT [33] used for regionalisation was the 2016 industry-by-industry table developed by ONS with 64 economic sectors. Final demand is separated into several components including – households, NPISH, government, GFCF, valuable, change in inventory and exports (both EU and Non-EU). Other sectoral inputs, in addition to intermediates, are taxes less subsidies; compensation of employees, gross operating surplus and imports.

Regional GVA estimates were taking for the NUT-1 GVA annual estimates from ONS and employment data from the UK Business and Employment Survey (BRES). Both the GVA and BRES information were aggregate to match the 64 economic sectors of the UK IOT.

The first step in regionalisation of the UK was to estimate sectoral output and final demand for each of the four nations. For sectoral estimate, the initial assumption is that the sectoral GVA to output intensity was the same across all regions and match that of the published UK tables. Combining these intensities with the regional GVA information, we are able to estimate the regional output by economic sector. This assumption, while significant, was

[33] Available from https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/ukinputoutputanalyticaltablesindustrybyindustry

made in part due to constraints in the data available[34]. Currently the ONS do not publish regional output by sector thus we use the GVA as a proxy. In future work a key focus would be investigating supplementary data sources which may be useful for adjusting these GVA shares to account for regional specialisation.

Population shares were to estimate regional final demand totals (excluding households and exports). For regional final household consumption, we used the Household Final Consumption Expenditure (HHFCE) data. In line with the literature, ROW exports are in same proportion of output as the national table. RUK exports were used as the balancing item ensuring total output matched the estimated value.

Regional **A** matrices for each of the four nations were developed using the FLQ method detailed in Section 4.2. As published output data is unavailable at the regional level, we instead use sectoral employment as a proxy in the calculation of LQs and set the δ value to 0.3. Other factors of production (ROW imports, subsidies, etc) for the regions were in the same proportion of total input as the national tables. We used RUK imports as balancing, calculated as the residual value ensuring that total inputs matched with the estimated value.

Following these initial calculations, due to the assumptions, some balancing of the regional tables is required. The fundamental assumption of the top-down regionalisation method is that GVA to output intensity is same for each of the regions as the national table, but this is unlikely to hold across all sectors and regions. This assumption leads to the RUK exports in some regional sectors to become negative. To overcome this problem, for sectors with negative RUK exports, we adjust the output as the population share of national output instead of the GVA intensity. A second smaller adjustment is needed to sectoral output, RUK exports and RUK imports to ensure that summation of the regional outputs and final demands do not exceed that from the published national IOTs [35].

[34] This can be problematic for sectors which a nation specialises in. It is likely that this constraint results in the overestimation of output as the GVA to output ratio is likely to be lower. A clear example of this would be in the oil and gas sector in Scotland.
[35]The output may be lower than the published national IOT as there the UK IOT contains information of the economy out with the 4 nations.

6.2. Results

There are several key aggregates identifiable through the development of regional IOTs. **Table 8** contains several of the key sectoral aggregates for across the four nations, with **Table 9** outlining key household aggregates.

Table 8: Key sectoral aggregates for each of the four regional tables, £m.

	Scotland	Wales	England	NI
Output	247,555	113,888	2,686,470	73,369
GVA	122,134	55,569	1,375,322	36,278
Intermediate consumption	50,956	18,294	1,017,195	10,401
RUK exports	63,662	29,184	127,730	23,635
ROW exports	30,890	15,309	403,697	9,290

Table 9: Household consumption in each of the four regional tables, £m

	Scotland	Wales	England	NI
Local consumption	49,856	22,976	579,436	12,759
RUK imports	21,586	13,506	195,746	9,954
ROW imports	18,417	9,405	199,835	5,855
Taxes	8,960	4,575	97,219	2,849
Total	98,819	50,462	1,072,236	31,417

From **Table 8** we find that as the size of the region increases so does output, GVA, intermediate consumption and exports. Regional Sectoral GVA is available from the ONS however, the total regional GVA from our analysis differs slightly from the published value as imputed rent and activities on households as employers are not included in the regional IOTs. These have zero values in the BRES database used to estimate the LQ and FLQs. As to be expected, England has the largest proportion of intermediate sectoral demand[36] at 37.2% followed by Scotland (20.6%), Wales (16.1%) and NI Ireland (14.2%).

In absolute terms, England also has the largest total RUK exports; however, as a proportion of output these are much lower than the other three regions. England only exports[37] 4.8% of its total output to the rest of the UK compared with Scotland at 25.7%, Wales 25.6% and NI 32.2%. The fundamental reason for this is the relative size of the regions and the need for

[36] Calculated from Table 8 local consumption/Output
[37] Table 8 (RUK exports/ROW exports)/Output

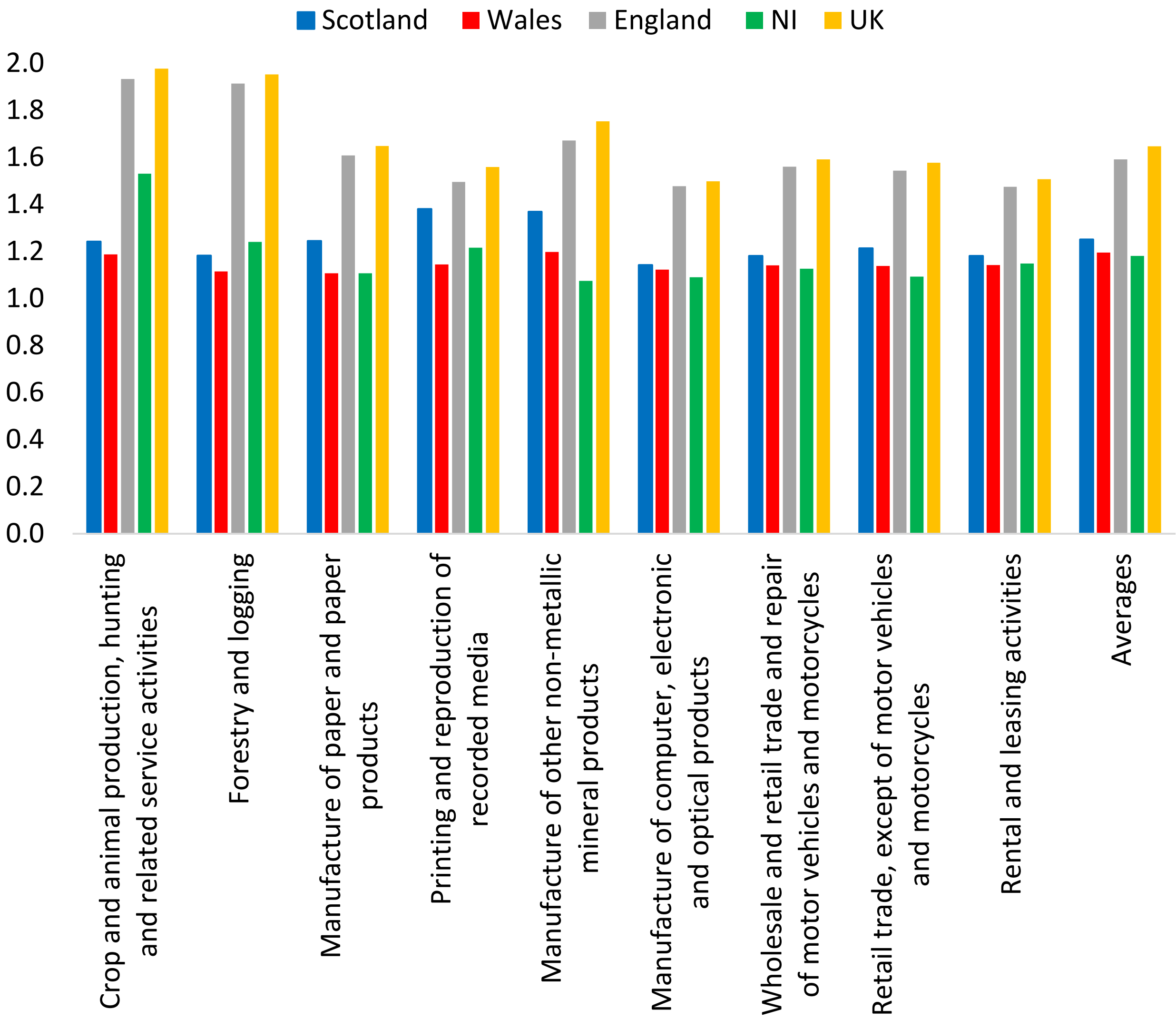
trade, the English population of 84.1% of UK total indicates that the RUK in the England IOT is a much smaller region when compared to the other three regions table. If the England IOT were regionalised further to the NUTS 1 level, the expectation would be that RUK exports for these regions would be on similar scale to Scotland, Wales and NI. The initial assumption was that regional sectoral ROW exports were in the same proportion of output as the UK average. From most cases this assumptions holds but for some sectors, to balance the tables, we updated ROW exports. This leads to small differences in the proportion of total ROW exports[38] – Scotland (12.5%), Wales (13.4%), England (15%) and NI (12%).

We use the HHFCE for Total regional household consumption (ONS,). From Table 9, due to the methodological assumption, the share of taxes and ROW imports to total household consumption is the same for each of the four regions. To estimate household intermediate consumption we apply LQs to the UK proportion, with the results being that households in larger regions consume more locally sourced products. 54% of English household consumption[39] was from the region, with this dropping to 50%, 46% and 41% in Scotland, Wales and Northern Ireland respectively. By using RUK imports as the balancing item, we find the opposite to be true to intermediate consumption with smaller regions relying more on inter-regional imports.

One of the primary applications of IOTs is in the use of IO modelling with multipliers being a key component of this analysis. **Figure 5** displays the Type 1 multipliers for a select number of sectors, along with an economy-wide average, for each of the four regions and published UK IxI table.

[38] Table 8 Row Exports/Output
[39] Table 9 Local consumption/Total

Figure 5: Type 1 multipliers for the four regions



In general, as would be expected, the value of the Type 1 multipliers are depending on the size of the regions with England having the largest Type 1 multipliers followed in descending order by Scotland, Wales and Northern Ireland.

6.3. Discussion: How Do Our Results Compare to Bottom-Up Approaches

The Scottish Government publish IOTs on an annual basis enabling us to compare with our top-down method. **Table 10** shows key input aggregate results using both methods.

Table 10: Comparison of inputs between the Scottish top-down and bottom-up approaches, £m

	Regional IO	Government IO	Government IO excluding
Output	247,555	242,414	228,817
GVA	122,134	133,268	121,847
Taxes and subsides	2,009	2,362	2,362
COE	73,426	74,738	74,520
GOS	46,699	56,168	44,965
RUK import	53,170	28,387	27,939
ROW imports	16,354	14,272	14,151
Intermediate	50,956	60,730	60,730

Column one reports the results for the regionalised Scottish IO with column two the bottom-up Scottish IO aggregates and the final column being the aggregates for the bottom-up approach excluding the imputed rents and households as employees sectors. From the results we find that, with the two sectors excluded, total GVA using the top-town and bottom-up approach are similar with the difference being 0.2%. This is somewhat expected as we calibrate the regional IO using ONS GVA information however, there is a significant (8.2%) difference in the output between the two methodologies. In the regionalising methodology we assume (apart from a few small number of sectors were balancing is required) that the GVA to output intensity for the Scotland was the same as that of the UK, which, from the bottom-up approach is not the case. Using the bottom-up approach the overall GVA intensity for Scotland is higher than the UK. Other data sources (such as the ABS) were explored for a region specific GVA intensities but these are not viable.

The difference between gross operating surplus and COE using the two methods is less than 5% with there being a slightly (1.5%) increase in COE when using the bottom-up approach and a reduction in the GOS (3.9%). Indicating slightly higher wage rates but lower profits per unit of output. Using the regionalisation there is a 14.9% lower tax less subsidies value of £2.01 billion.

The three final factors of production are RUK imports, ROW imports and intermediate inputs, all of which have significant difference between the two approaches. There is a nearly £10 billion (16.1%) difference in the intermediate purchases between the two approaches, indication that the FLQ method is underestimating the interregional linkages. The difference in the ROW is 15.6% with the regionalisation methodology overestimating imports to the rest of the world as we use UK averages. By far the largest difference is for the RUK imports with the regionalisation method overestimating imports from the rest of the UK by more than £25 billion, an increase of 90.3% from the published tables. This is a result of RUK imports being the primary balancing item for input. As previously outlined using UK GVA to output intensity for regionalising over estimates the Scottish output, which when combined with the underestimation of intermediates purchases from the FLQ method, requires a high level of balancing impacting RUK imports. **Table 11** outlines the final demand calculated using both the top-down and bottom-up approaches.

Table 11: Comparison of outputs between the Scottish top-down and bottom-up approaches

	Regional IO	Government IO	Government IO excluding
Intermediate	50,956	60,730	60,730
Households (local purchases)	49,856	53,985	40,389
Households (total purchases)	98,819	94,774	94,774
NPISH (local purchases)	3,283	3,132	3,132
NPISH (total purchases)	3,797	3,132	3,132
GOV (local purchases)	29,965	36,786	36,786
GOV (total purchases)	31,410	37,592	37,592
GFCF (Local purchases)	18,666	14,963	14,963
GFCF (Total purchases)	28,2956	24,617	24,617

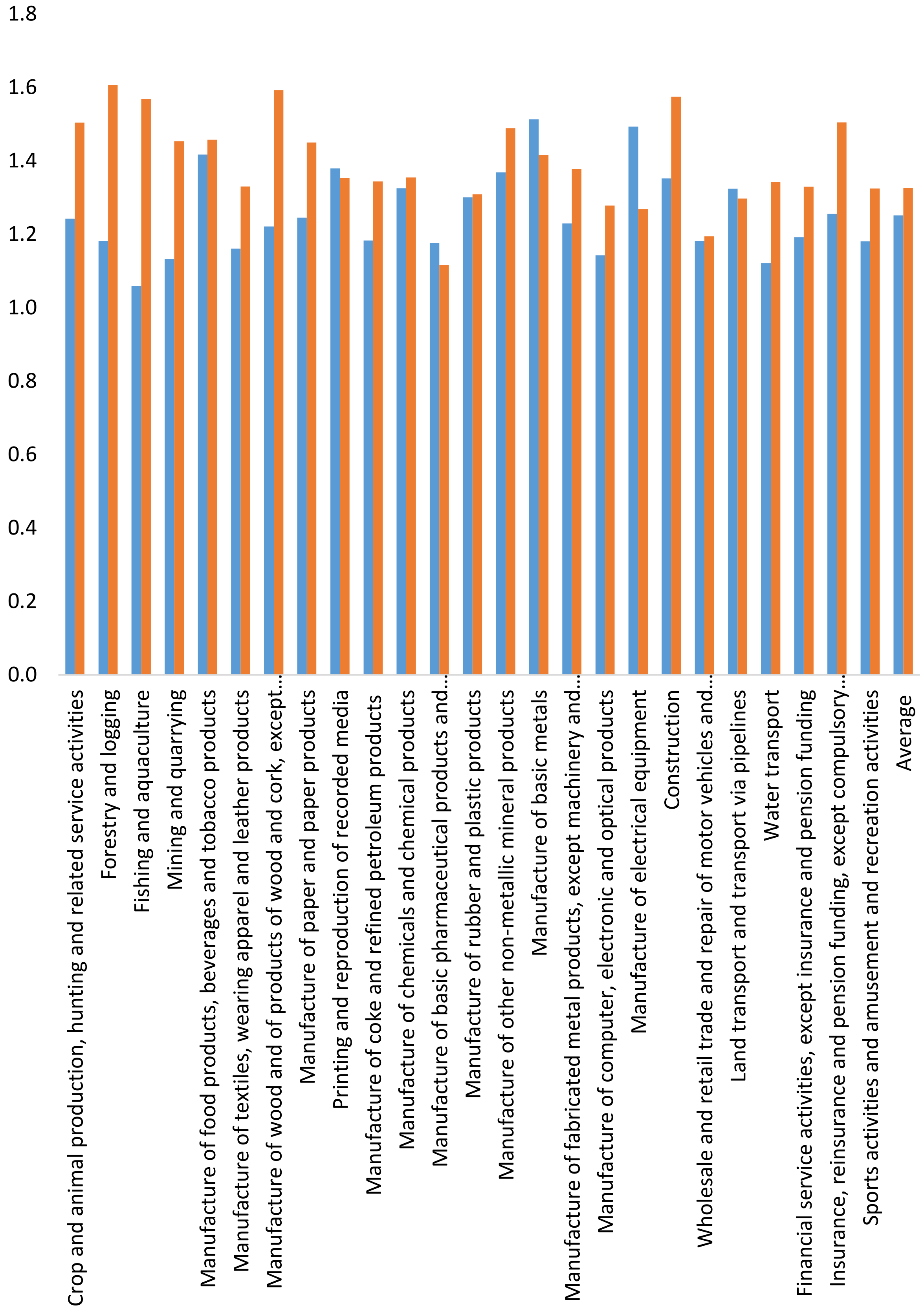
Again, the above table is separated into three column, for the regional top-down approach, Scottish Government table and the Scottish Government table minus the two identified sectors. In the top-down approach, we use the HFCE for household consumption and Scotland population share for government, NPISH and GFCF total. ROW exports are initially assumed to be in the same proportion to output as the UK table and RUK exports are used as the primary balancing items[40]. From **Table 11** we find that there is less than a 5% difference between the total household consumption however, there is significant different (19%) in local purchases when compared with the table excluding imputed rent and households of as employees. From **Table 11** we find that using population shares under estimates government spending by nearly 20% when compared with the published Scottish IO, indicating that there is more government spent per head in Scotland than the UK as a whole. GFCF is the opposite with the top-down method over estimating the consumption.

ROW exports are 9.1% higher in the regionalised table indicating that overall Scotland is not as export intensive as the UK as a whole. As with the inputs, RUK exports are much larger (36.8%) in the Scottish regionalised IOT when compared with the bottom-up approach. Again, this driven by the larger output in the regional table and the fact that RUK exports were used as the primary balancing item.

We have seen that in aggregate there are some significant differences when using a top-down and bottom-up approach. When we investigate by sector this is amplified with the differences in sales and purchases between the two approaches becoming larger. For example, for the agriculture sector, household consumption is 84.7% lower in the regionalised table while RUK and ROW exports are 46.1% and 42.1% larger. In a similar vein to **Figure 5**, **Figure 6** reports on the differences in Scottish Type 1 multipliers using both approaches.

[40] Some small changes are made to intermediate household, government and GFCF purchases to ensure the 4 regional totals match with UK tables.

Figure 6: Type 1 Multipliers for Scotland using Bottom-up (Orange) and Top-down (Blue) Approaches



On average Type 1 multipliers are only 0.07 larger using the bottom-up IO when compared with the regionalised method, driven by the higher level of intermediate purchases. However, from **Figure 6** we find that there are significant differences when investigating individual sectors. For some sectors, such as printing and recording and land transport, the Type 1 multiplier for the regionalised IO is larger than the published IO. However, for the vast majority of sectors the top-down approaches produces smaller Type 1 estimates which would lead to differences in IO model outputs. Two of the sectors with the largest multiplier differences are agriculture and fishing which may be consequences of how the employment in these sectors is measured the BRES database.

In this section we have shown that while producing regional IOTs from the published UK table is possible, care must be taken as there are significant differences to bottom-up approach. There are a few issues with the methodology of producing regional IOTs. The first is the assumption that the GVA to output intensity is the same across all regions as the national average. In the case of the Scottish regional IOT this leads to an unrealistic amount of RUK imports and exports.

The second issues is that using the FLQ method produces much smaller intermediate sales and purchases than the bottom-up approach. To overcome this we did try to use sectoral GVA instead of employment for the LQ proxy but this made no qualitative difference to the results. Instead the intermediate purchases are being driven by the δ value, which we set to the standard 0.3. Any future research using LQs in a UK context should focus on this parameter and its importance to producing regional IOTs for the UK base.

PART C: RECOMMENDATIONS FOR COMPILING REGIONAL SUTS FOR THE UK NATIONS

7. Recommendations

While the regional SUTs and IOTs produced by the Scottish Government and NISRA are driven by different users' needs, our role is to reconcile these different approaches and outline our recommendations for formulating a strategic UK-wide approach to producing SUTs and IOTs for the four nations.

7.1. An Overview of Scenarios Considered in Our Recommendations

When making recommendations we refer to two scenarios. The first scenario sets out how four SUTs for Scotland, Northern Ireland, Wales and England could be constructed using a predominately bottom-up approach. While this scenario is ambitious, it is also pragmatic and sets out how a bottom-up approach could be developed using the existing sampling frame, the IDBR, and existing business surveys administered by the ONS and devolved administrations.

A bottom-up approach would lead to the four nations adopting similar data collection strategies facilitating comparability and compatibility. This brings a number of advantages. First, it would allow users to understand: (i) the production structure of a given UK nation, (ii) differences in production structure across UK nations and (iii) the production structure of the UK as a whole. This meets the needs of policymakers in the devolved administrations and policymakers in central government concerned either with differences between regions or the UK economy as a whole. Second, with a view to the future, these SUTs could be combined with interregional trade statistics to produce a multi-regional SUT which fully captures how different nations in the UK interact with one another. Third, the multi-regional SUT could then be aggregated to produce the national UK SUT. This implies that resources used to construct the UK SUT could eventually be diverted to construct a full set of regional SUTs. In doing so, the need for Regional Accounts currently produced using top-down methods would also be eliminated. Fourth, the development of a bottom-up English SUT has the additional advantage that NUTS 1 SUTs for the 9 English regions derived using the English SUT are more likely to contain economically meaningful information than if the English SUT being regionalised was constructed using a hybrid approach.

The second scenario is more modest and sets out how four SUTs could be constructed using a hybrid approach. This would involve using the Scottish and Northern Irish approaches as a starting point to develop a framework to produce SUTs for the four nations. Ultimately, this approach would allow users' to understand the production structure of a given nation but accuracy declines perhaps rendering comparisons across the SUTs of different nations more problematic. Unlike a bottom-up approach, a hybrid approach may not facilitate similar data collection strategies across nations with an imposition of consistency potentially preventing regions from incorporating useful nation-specific data sources. Regional SUTs are also typically constrained to the UK Regional Accounts produced using top-down methods. Adopting this approach also renders the possibility of producing a multi-regional SUT less feasible. While NUTS 1 SUTs for the 9 English regions could be derived from the English SUT, such estimates are likely to be relatively less precise.

The critical difference between the first and second scenario, is that the first scenario would require a review of the current processes for producing the national and regional SUTs. It is also likely to more resource intensive particularly in the short-run. The second scenario, on the other hand, follows on naturally from current practise.

7.2. Reporting Units

If undertaking a bottom-up approach, a new consistent approach to statistical sampling will be required for surveys issued by the ONS on behalf of all four nations (or the GB nations). Such surveys include the ABS and Annual Purchases Survey. One option is to adopt the approach used in Scotland where SUT compilation deviates from the IDBR by utilising Scottish RUs. The advantages of this approach are that Scottish RUs may better reflect local activity in Scotland.

Alternatively, another option is to adopt the approach undertaken in the Welsh TSW by asking GB RUs (which can be located in Wales, England and Scotland) to report on the activities of their Welsh, Scottish and English LUs. The advantage of this approach is that it easily builds on the IDBR framework. The disadvantage of this approach might be that the industrial classification of the RU, which is based on the dominant industry by employment, may not correspond to the industrial classification of the relevant LUs. Importantly, what this means is that it may bear no relation to the actual economic activity taking place in Wales.

Another issue is that it may be easier for, say, Welsh RUs to report on Welsh activity than, say, English or Scottish RUs. However, data provided by the Welsh Government on the TSW indicates that of the 8000 businesses sampled, businesses headquartered in the rest of the UK were more likely to respond than businesses headquartered in Wales. Similarly, businesses which were not entirely Welsh were more likely to respond than entirely Welsh businesses. These findings may relate to business size with entirely Welsh businesses, which are likely to be smaller, finding it more difficult to quantify their trade. It could also be that having offices in multiple nations within the UK incentivises firms to understand their trade better. Overall, these results are promising and give some indication that asking GB RUs to quantify the activity of their Scottish, English and Welsh LUs is not infeasible and could be a means to ensure consistency in the treatment of RUs across the four nations. This approach may also prove more promising if we wish to eventually gain information from LUs at the NUTS 1 level since it may prove difficult to “create” NUTS 1 level RUs.

A bottom-up approach would imply that business surveys issued by the ONS should collect data on Scottish, English and Welsh activity so that GB activity would not need to be regionalised. While creating bespoke RUs which reflect local activity may be feasible for an individual nation, if adopted across the four nations, it would ultimately result in inconsistencies with the IDBR, something we consider infeasible. Going forward, we therefore recommend that the TSW approach to quantifying regional activity be investigated further. In particular, it would be beneficial to gain a deeper understanding of whether English RUs can report on the activity of their Scottish and Welsh LUs as evidence from the TSW seems to indicate. We feel that if producing regional SUTs and interregional trade statistics from a bottom-up perspective, this approach could strike the right balance between accurately capturing regional activity and compatibility with the IDBR and the UK SUT currently produced. The main compromise is that the industry of the RU may not reflect the industry of the LU and Northern Ireland will remain the only nation with dedicated RUs. That said, in the SUT and IOT matrices, primary classification may be less important since atypical activities can be captured on the off-diagonal cells. This may, however, make interpretation slightly harder for those without detailed local knowledge.

If undertaking a hybrid approach which supplements top-down estimates with bottom-up data collection, our recommendations differ slightly. Under this scenario, the production of regional SUTs still relies on regionalising UK data collected by the ONS from GB and NI RUs. When collecting supplementary bottom-up data, there are then two options. First, Scotland, England and Wales could consider the TSW approach to RUs ensuring that all nations adopt a broadly similar strategy. This would facilitate comparability and a reconciliation process between the regional SUTs, UK Regional Accounts and national UK SUT, something we will discuss in greater detail in a later recommendation.

Alternatively, if comparability across the regional SUTs is not a priority it may be feasible for Scotland to continue to pursue the practise of creating bespoke Scottish RUs which can reflect local activity. While this approach is more likely to accurately reflect regional activity, it reduces comparability if Wales and England pursue the TSW approach. Moreover, it does not facilitate a reconciliation process between regional SUTs, the UK Regional Accounts and UK SUT.

7.3. Statistical Sampling

Regardless of whether a bottom-up or hybrid approach is adopted, sample sizes must be adequate for accurate estimation of the regional SUTs. Currently, surveys such as the APS, may not have a large enough sample when considering the UK nations or regions. As noted in Section 4.3, if each region's sample allocation is proportional to its size, this may result in good precision at the national level but poor precision at the regional level, particularly for smaller regions. Conversely, if each region's sample allocation achieves nearly equal precision across regions this may cause the quality of national precision to fall.

One option is for the four nations to boost ONS sample sizes through undertaking additional data collection exercises. However, we instead recommend the second option whereby business surveys administered by the ONS are tailored to also meet regional requirements through power allocation (Bankier, 1988) where regional estimators of nearly equal precision are obtained while minimising the reduction in precision of the national estimator. Put differently, resources currently used to boost UK surveys on an ad hoc basis could instead be used to ensure that ONS surveys meet the needs of regional users.

7.4. Extra-Regio, Central Government and Head Office Output

If moving towards a bottom-up approach to producing regional SUTs which are comparable and compatible, where possible, it is important to improve sampling decisions to minimise distortions of regional activity. The Canadian case provides several important learning points. We will not repeat industry-specific examples here but will instead focus on broader issues which could distort GDP.

First, we recommend that it would be beneficial to construct a SUT for a fifth extra-regional region as in the Canadian case and the most recent Finnish regional SUT exercise undertaken in 2002. This can account for foreign production, for instance, by embassies, armed forces overseas and offshore oil and gas extraction. The Whole of Scotland Economic Accounts Project which produces SUTs capturing offshore oil and gas extraction in and around the North Sea would act as a starting point for this fifth SUT.

Second, output of central government and taxes collected by central government must be allocated across the four nations. While this could be undertaken on a per capita basis, in Canada they allocate expenditures according to where production takes place, something we would also recommend. In practise, this depends on where wages are paid, intermediate inputs are used and physical capital is consumed. Canadian consumption taxes collected in all regions are regionalised according to where the taxable products are consumed for intermediate use or purchased as final use. In the UK, the ONS has produced experimental public sector revenue and expenditure statistics for each NUTS 1 region which could act as a useful starting point. UK expenditure data comes from HM Treasury's country and regional analysis with allocation reflecting (i) where the expenditure actually took place (expenditure "in" a region) and (ii) who the benefits of the expenditure accrue to (expenditure "for" a region). Where expenditure takes place is more relevant for national accounting, reflecting where goods and services are used to produce government output. Currently, UK revenue data is regionally apportioned using an indicator variable, reflecting the location of the individual or enterprise where the revenue is raised (residence-based approach) rather than the individual's place of work (workplace-based approach). In terms of developing regional SUTs, while the residence-based approach to allocation may be appropriate for taxes where the consumer bears the burden, other taxes on products should reflect where these products are consumed and purchased for intermediate and final use.

Third, head offices should also be considered carefully since, as in the Finnish case, we expect the headquarters of several industries to be located in certain regions in the UK, implying that industry structures differ across regions. In Canada, rather than creating a separate head office industry, the industrial classification of head offices depends on the industry of the primary establishment. To allocate GVA associated with the head office to the region in which it resides, the output of head offices (intermediate expenses, staff compensation and, where data is available, consumption of fixed capital) is shown as an input purchased by establishments which the head office serves. We recommend that this approach be investigated for the UK case.

If undertaking a hybrid approach, these recommendations still hold. However, excluding foreign production from the regional SUTs rather than constructing a fifth SUT may be sufficient.

7.5. Addressing Data Gaps

Our thought experiment in Section 6 revealed several important data gaps in the construction of IOTs using a top-down approach. Importantly, though, the revealed data gaps also have important implications for the construction of regional SUTs. With the ABS and APS not covering the full range of industries, even if a predominately bottom-up scenario is preferred, top-down approaches will need to be used for some industries.

First, while our analysis assumed that GVA to output intensity is same for each of the regions as the national table, this is unlikely to hold across all sectors and regions. It would be beneficial to explore using ABS microdata to develop regional GVA to output intensities.

Second, current data on household consumption is by product alone. However, it would be beneficial to map household consumption to industries using the Living Costs and Food Survey. This would provide an alternative scalar to regionalise household consumption.

Third, data on regional exports is also needed. Data on both these aspects is collected by Northern Ireland and Scotland in part via the NI ABI and Scottish GCS trade survey. These data are utilised in Northern Ireland's Broad Economy Sales and Exports Statistics and Export Statistics Scotland. Wales also collects Welsh trade data via the TSW. As recommended in Davidson and Spowage (2021) these data collection exercises require harmonisation which could be achieved through a GB wide trade survey. This data could then be used to inform the development of regional SUTs.

Fourth, further analysis of data on internal tourism is also required. While there are several sources of data, their comparability requires investigation . An important source of data is the GB Tourism Survey which captures the value and volume of domestic overnight tourism trips and which superseded the UK Tourism Survey produced till 2010. Another GB survey is the GB Day Visit Survey. Both are commissioned by Visit Scotland, Visit England and Visit Wales (the Tourism Department of the Welsh Government). Both GB surveys consider NI trips/visits although this data is not routinely published. NISRA separately produces statistics on overnight and same day visits taken outside of Northern Ireland from two different sources , the NISRA continuous household survey and the Northern Ireland Passenger Survey. Further investigation would be needed to determine which source is most closely aligned with the GB surveys and appropriate for use for SUTs.

7.6. SUT Compilation

Under the bottom-up scenario, we would recommend that the four nations agree on the minimum number of industries and products to include in their respective published SUTs, although each nation could choose to compile a more detailed regional SUT for their own use.

While it would be preferable for each nation to compile SUTs for the 101 industries and products considered in the UK SUT, to begin with it is perhaps more realistic for the four nations to agree between 64 industries and products (as in the current Northern Irish case) and 97 industries and products (as in the Scottish case). Importantly, more disaggregation may be pertinent for one nation. For instance, in Scotland, fishing is broken into two sectors. However, in instances such as this, further disaggregation using nation specific data sources would be an additional voluntary step. Given the flexibility this recommendation affords, we also consider that it would be beneficial in the hybrid scenario and would not hamper individual nations in tailoring the SUTs to meet their needs.

Finally, regardless of the scenario considered, we would also recommend that all nations follow a common timeline and produce regional SUTs on an annual basis as is already the case of the UK, Scottish and Northern Irish SUT. Additionally, while we will discuss in greater detail how IOTs can be produced on a more timely basis, we note that there is a growing literature on SUT projection. This means that while SUTs for a given reference year are only available with a lag, if SUTs are needed for policy analysis it is possible to produce a SUT for, say, 2019 based on the 2018 SUT.

7.7. Reconciling Regional SUTs, the Regional Accounts and the UK SUT

Ultimately, a bottom-up approach may mean that the regional SUTs are used to construct the national UK SUT eliminating the need for benchmarking and reconciliation. Currently, NISRA constrains total GVA, compensation of employees, gross operating surplus, mixed income and taxes less subsidies by industry section to UK Regional Accounts produced using top-down methods. The Scottish Government also constrain GVA to ONS Regional Accounts however data is used from the ABS where they believe that the top-down Regional Accounts estimates aren't appropriate. It seems unfortunate that some of the information acquired through a bottom-up approach is lost in the constraining process. It would be good to investigate further the scale of this constraining effect and the industries most affected. Ideally, data collected from the regional SUTs should gradually replace the Regional Accounts which met EU regulation but did not deliver bottom-up estimates of regional activity.

If, however, a hybrid approach is pursued we recommend that a reconciliation process take place between the regional SUTs, UK Regional Accounts and UK SUTs. The devolved administrations should identify where Regional Accounts estimates are inappropriate. This should result in a revision of the Regional Accounts. This reconciliation process means that constraining will only take place when appropriate. It will be important to identify where these differences are simply because of LU/RU classification differences and where they are due to other factors which can be reconciled.

7.8. IOT Compilation

In our recommendations, we have focussed on the production of annual regional SUTs for the four nations. Regardless of whether a bottom-up or hybrid approach is adopted, IOTs can then be derived. An important recommendation we make is that all four nations also produce IxI IOTs annually since these tables are a crucial input for regional economic modelling.

There are, however, a number of options surrounding by which method this tables could be produced. The first option is to derive regional IOTs from the regional SUT. However, in the short-run, production of regional IOTs through regionalisation of the UK SUT could be automated. This would involve building on the methods described in Section 6 and using improved data sources detailed in the previous recommendation.

8. Conclusion

In this report, we develop a strategic framework for the production of SUTs across the four UK nations. For those unfamiliar with SUTs and IOTs and the difference between them, we began by introducing these table and discuss how they are used by economists and statisticians in policy and academia. We then described bottom-up and top-down methods for producing regional SUTs and IOTs. While bottom-up approaches required detailed data collection, top-down approaches involved regionalising the national UK SUT or IOT using an indicator variable.

We then focussed on the UK data landscape, discussing the UK's sampling frame, the IDBR, and the UK's Regional Accounts. We discussed how regional SUTs and IOTs are compiled in Scotland and Northern Ireland using a combination of regionalised UK data and nation-specific data sources.

We demonstrated how regional IOTs for the four nations can be produced by regionalising the UK IOT using LQs. While producing regional IOTs from the published UK IOT is possible, there are some significant differences between our IOT and those produced using the bottom-up approach.   The first key issue is the assumption that the GVA to output intensity for each region is the same as the national average, meaning regional differences are ignored. Ideally future work would rely on published regional output figures. In the absence of this, work should be carried out to supplement the GVA to output ratios with other data for more robust regional estimates. The second issues is that using the FLQ method produces much smaller intermediate sales and purchases than the bottom-up approach, which can lead to overestimation of interregional exports and imports.

In our recommendations for compiling regional SUTs for the UK nations we consider two scenarios. The first scenario sets out how four SUTs for Scotland, Northern Ireland, Wales and England could be constructed using a predominately bottom-up approach. The second scenario is more modest and sets out how four SUTs could be constructed using a hybrid approach. To address these two scenarios we have a number of recommendations.

First, when collecting data on Scottish, Welsh and English activity the feasibility of asking Great Britain Reporting Units (RUs) to report on the activity of their Scottish, Welsh and English Local Units (LUs) should be investigated further given that this approach has proven successful in Scotland and Wales, for example, when collecting interregional trade data. Taking this one step further, it may be possible to "create" regional RUs whose industrial classification reflects the dominant activity across regional LUs.

Second, surveys issued by the ONS such as the ABS and APS should have sample sizes which facilitate the estimation of statistics for the four UK nations as well as the UK as a whole.

Third, building on the Whole of Scotland Economic Accounts Project, a fifth SUT could be used to capture foreign production as well as offshore oil and gas extraction preventing the distortion of regional activity.

Fourth, we recommend that the Canadian approach to allocating central government and head office output be investigated in relation to the UK again to prevent distortions of regional activity.

Fifth, recognising that for some industries a top-down approach to regionalisation will be required, we recommend strengthening existing data sources by: exploring the possibility of developing regional GVA to output intensities using ABS microdata; mapping household consumption to industries; and collecting data on internal trade and regional exports, both of which are currently collected by the Scottish Government and NISRA.

Sixth, given the issues associated with LQ based top down regionalisation, in particular, the underestimation of interregional exports and imports, we recommend a review of top-down regionalisation methods with respect to the UK IOT. Lahr et al (2020) note that the lack of subnational trade data has been a key stumbling block in the production of regional IO models. The authors analyse the effectiveness of a regional purchase coefficients (RPC) to estimate intra-regional trade in 28 EU countries, finding the method outperforms LQs and CHARM. In our unique policy context, it would be beneficial to assess how different top-down methods perform when other regional data (for example, data on interregional trade available from some the devolved administrations) is used to inform the regionalisation process.

Seventh, we would recommend that the four nations publish SUTs annually following a common timeline. The UK SUT, however, could be published earlier each year since the regional SUTs may need to utilise proportions derived from the UK SUT. We also recommend that the four nations agree on the minimum number of industries and products to include in their respective published SUTs. The 64 industries and products used in NI may act as a useful starting point which would not result in any disclosure issues for NI or Scotland. That said, each nation could choose to compile a more detailed regional SUT for their own use.

Eighth, bottom-up data should, where possible, gradually replace the Regional Accounts produced using top-down methods. Where this is not possible, a reconciliation process should take place between the regional SUTs, UK Regional Accounts and UK SUTs with the devolved administrations identifying where Regional Accounts estimates are inappropriate.

Last, we recommend that all four nations also produce industry by industry IOTs annually since these tables are a crucial input for regional economic modelling. In the short-run, this process could be automated through regionalisation of the UK SUT and strengthened data sources as detailed above.

9. References

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