

# **Feasibility Study on Developing Trade Modelling for Scotland**

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# 1. Introduction

Growing Scotland's export base has been a key objective of successive Scottish administrations. Internationalisation is one of the four principal drivers of growth within the current Scottish Government's Economic Strategy.

However, the UK's decision to leave the EU has the potential to impact on many of Scotland's existing trading patterns in new and perhaps significant ways.

Whilst debate continues over the arguments for and against Brexit, one thing that we can be confident is that, with currently around 45% of international exports destined for the EU, any change in Scotland's trade links with the Single Market has the potential to have far reaching consequences for sectors and firms across the country.

Post-Brexit, new opportunities arising from the UK agreeing trade deals with third countries may also be possible, though this will depend on what is finally agreed regarding the long-term trading relationship with the EU.

In considering how to best support Scottish firms to internationalise, future Scottish Governments are likely to need to take a much more pro-active approach to trade policy, investment attraction and wider business support.

This will include assessing possible risks – including the challenges of being outside the EU Single Market – and identifying new opportunities in growth markets. It will also include measuring the gains from, and limitations of, possible new trade deals with Europe and further afield, at both a national and sector level.

At the same time, the future role of the Scottish Government/Parliament in influencing future UK trade policy has yet to be resolved. But whatever role the Scottish Government/Parliament has in influencing, shaping or assisting in the negotiation of future UK trade deals, it will be important that the Scottish Government has appropriate information and analytical capacity to be able to represent Scotland's economic interests appropriately.

To best prepare for this new environment, the Scottish Government will require a robust evidence base. At the centre of this will be a need for a detailed trade modelling capacity supported by detailed, timely and appropriate data and statistics.

Other policy institutions with trade responsibilities that we have spoken with have

significant (and growing) international trade modelling capabilities.

The aim of this report is to consider options for developing this capacity and to inform resource planning in the Scottish Government.

In particular, it aims to respond to three distinct objectives as set out by the Scottish Government –

*Objective 1: Identify, describe and compare the main trade models used by other countries and to set out the strengths and weaknesses of the specific models identified for different purposes;*

*Objective 2: Review the trade components of existing Scottish Government macroeconomic models and consider how they could be enhanced.*

*Objective 3: Propose a list of options for enhancing trade modelling and to assess their feasibility against agreed criteria.*

This report has been produced by the Fraser of Allander Institute (FAI), the National Institute of Social and Economic Research (NIESR) and InterAnalysis at the University of Sussex.

To assist with the development of the report, we have made contact with a number of institutions who currently undertake trade modelling as part of their day-to-day activities. A list of the organisations that we have spoken with is provided in an appendix.

The report is structured as follows.

In Section 2, we provide a summary of trade modelling and its role in informing economic policy.

In Section 3, we identify a number of key themes for the government to consider based upon the feedback we have received from other academics and policymakers around the world.

In Section 4, we review the most popular trade modelling techniques used today and highlight the strengths and weaknesses of each approach. We group the discussion under the following:

- Analytical approach, key challenges and data requirements;

- Computable General Equilibrium (CGE) modelling;
- Partial Equilibrium (PE) modelling; and
- Macroeconometric modelling.

Section 5 provides our recommendations.

## 2. Why develop a capacity in international trade modelling?

Governments are constantly faced with increasingly complex policy questions. The complexity is enhanced by the need to balance multiple policy objectives simultaneously.

For this reason, in recent years, the need for conducting rigorous scientific policy analysis of the effects of policies on economic outcomes has grown sharply.

These exercises have been made possible by advances in theory and analytical techniques. Rigorous economic models have been developed and used to break down large complex economic problems into a series of smaller problems that can be effectively analysed. Trade modelling is one area that has seen extensive development and has received increasing attention from the policy community.

Indeed, modelling frameworks lie at the heart of all major economic policymaking institutions around the world. This includes governments, central banks and international organisations. In international trade, all governments and institutions with a key role in developing trade policy have modelling teams at the heart of their policymaking capabilities.

Why? In short, because appropriate use of modelling frameworks can help to disentangle complex economic and societal problems and facilitate decision making. Rigorous trade modelling can also lead to improved identification of risks and opportunities and a better knowledge of the potential scale of challenge/opportunity from shifts in trade performance or changes in trade policy.

### *What are international trade models?*

Broadly speaking, international models are analytical representations of a real world economy that are designed to capture the flow of exports and imports across economies.

They combine economic statistics with a series of equations that are designed to capture how economists believe an economy, sector or product operates in practice. Of course, any modelling framework is necessarily a simplification of reality - even the most sophisticated and analytically advanced models are required to make some assumptions about how an economy behaves. Economists, therefore, must make a reasoned choice of

which variables, and which relationships, are most relevant for the purposes of the policy question being assessed.

Across the world, a wide range of institutions use trade modelling in a number of different ways to help inform better policymaking.

Firstly, models can be used to help offer indications of what might happen to international trade patterns in response to a major structural change (such as Brexit). This cannot be done simply by looking at statistics or simple comparative static analysis. In reality, there are clearly a number of different factors involved – e.g. potential change to tariffs, quotas, non-tariff barriers, migration, investment – and many of them are interlinked. By combining up-to-date data, alongside a series of relationships that have held over a number of years, international trade modelling can help capture all such effects and help to illustrate the possible scale and impact of major changes in a country's trading relationships. Rather than seeing the outputs as predictions, the flexibility underlying the modelling framework enables policy makers to assess relative orders of magnitude and directions of change ('precisely wrong, but roughly right').

Secondly, some trade models can capture not just the potential implications for exports and imports of new trade relationships, but also wider issues such as the potential impacts on the industrial mix of an economy, its labour market, government expenditure, monetary and fiscal policy, investment and so on. This means that they can be used to help inform our understanding of how shocks to trade patterns can create ripple effects that flow through an economy and ultimately impact upon growth, prices, labour market outcomes, government budgets and well-being. Importantly, therefore, such models offer the potential to track the impact of trade policies and/or disturbances on the ultimate objectives of policy. This can include targets around economic growth, inequality etc.

Thirdly, by capturing the detailed sector dimensions of trade patterns, international trade models can give an insight into which sectors might be more or less exposed to changes in trading relationships between countries. Note, this is not just about identifying "direct" exposure through immediate trading links, but about "overall" exposure as a consequence also of indirect linkages through product (e.g. supply chains), labour (e.g. migration), and financial markets. This can then be used to help identify sectors that are perhaps exposed to external trade competition, if borders were to become more open (reactive policies), and identify sectors/products where there might be opportunities for growth (pro-active policies).

Fourthly, international models can also capture general time dynamics in our economy to help provide some insight into how quickly changes in trade policy could impact upon the wider economy. The short-run effects of trade policies, or trade disturbances, can generate dynamic responses, for example, in investment and migration that result in quite different longer-term outcomes. This could be crucial, for example, for the sustainability of any policy stance.

Fifthly, one of the most important goals of trade models is to help offer insights into what types of policy – both trade and wider economic/business – might impact upon an economy and its trade performance. This pro-active appraisal work is a key focus of most international institutions.

Sixthly, the interdependence between trade flows and the wider economy is, of course, multi-directional. Many trade models allow, to varying degrees, the ability to explore the impact of non-trade policies and non-trade disturbances on trade flows and trading arrangements. So, for example, financial crises or climate change policies may have a very disruptive impact on trading arrangements. Awareness of these linkages, and their possible scale, is potentially very helpful to the policy community.

Seventhly, many trade models offer the ability to explore the sensitivity of impacts of trade policy, for example, to variations in key assumptions. There is often considerable uncertainty concerning particular parameter values or even behavioural relationships. A key benefit, therefore, of having a suite of modelling frameworks, is that it is possible to modify some of the assumptions – e.g. the cost of trade or the ease in which new markets can be accessed – to see what type of impact this will have on the final results. Similarly, assessing the potential of complementary (or corrective) policy responses – and the scale of possible response – can all be learned from a modelling exercise.

Finally, most of the organisations that we spoke with indicated that they often used their modelling work to undertake ‘what if’ scenario planning. Once constructed, trade models can be used to explore the likely impacts of alternative policies and/or disturbances – actual or hypothetical – through counterfactual simulation. These models provide a potentially extremely powerful (and often flexible) tool through which the impacts of a wide variety of individual policies (and combinations thereof) can be explored. This can be used to help inform risk work, future planning and resource allocation.

As with all economic models, it is important to use them appropriately. Perhaps one of the most useful benefits of trade models is that they offer the opportunity to better understand



the *channels* through which changes in trade policy, or trading relationship, might have an impact on an economy. This can be particularly useful for identifying unintended consequences of policies. Being able to identify these channels, and their effects, is often of greater benefit to policymakers than the final headline result.

Of course, it is critical that any modelling framework avoids becoming a 'black box'. Transparency and openness about the assumptions used, parameters incorporated and data used is vital.

As we document in the report, there are a range of possible international trade modelling techniques available to analysts at the current time. Each has their strengths and weaknesses. Often, one specific model type will be especially well-suited to a particular scenario or policy question.

Examples of the types of questions that can be analysed include –

- What is the potential impact on key economic indicators (GDP, unemployment, household income etc.) of a major shift in Scotland's trading patterns (e.g. from Brexit)?
- What might be the impact of future trade deals with third countries?
- How might a change in tariff/quota/non-tariff barriers impact the Scottish economy?
- What sectors might be most exposed to a particular form of new trading relationship between Scotland and other countries?
- What might be the implications for Scotland of a Trade War between the US and China?
- What sectors might Scotland wish to promote in future trade negotiations with other countries (as having the greatest economic impact)?
- What sectors may Scotland need to adopt a more defensive strategy?
- What devolved policy levers might have the greatest impact upon Scotland's future trade performance?
- How might the Scottish Government's wider business, enterprise and economic policy impact upon future trade prospects?

- What might be the impact of changes in trade policy be on the environment, inequality or inclusive growth?

### 3. Learning from other places

In this section of the report, we provide a brief overview of key themes that we have picked-up from our discussions with trade modelling teams elsewhere.

In practice, the modelling frameworks used by policymakers and academics typically fall into 3 categories:

- Computable General Equilibrium (CGE) modelling;
- Partial equilibrium (PE) modelling; and,
- Time series macroeconometric modelling

There are a range of complementary statistical techniques – notably gravity modelling and a literature on the exporting behaviours of firms using micro-level data – that sit alongside analytical modelling work. For the purposes of this review, we focus on techniques specifically designed to simulate policy changes<sup>1</sup>.

In this section of the report, we identify some recurring themes when considering the feasibility of trade modelling.

#### *Suite of modelling capabilities*

The organisations that we spoke with stressed the importance of developing a suite of modelling capabilities. No single model (or model type) can be expected to answer every question.

The most popular form is CGE modelling. This is because – in many instances – the focus is typically on understanding the long-term dynamics of how an economy might change following a shift in trade policy. CGE models are well-suited to such situations.

But other models have their uses. For example, if a focus is on the potential impact of exchange rate changes on short-term trade patterns, then a CGE model is not of much assistance. Similarly, by aggregating sectors, a CGE model cannot provide the more granular level of detail that can be possible with a PE model.

The UK Government adopts such an approach. Their initial modelling of Brexit relied upon

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<sup>1</sup> Such analysis may be useful however, to try and better understand Scotland's export flows and what drives outcomes – e.g. tariff barriers, historical relationships, gravity, targeted export programmes etc.

a macroeconometric model built around gravity equations<sup>2</sup>. Their latest approach relies upon a CGE style model. For wider macroeconomic analysis they use a variant of NIGEM, including for short-term forecasting. The Department for Environment, Food & Rural Affairs uses an agriculture-specific PE model. DIT, Treasury and BEIS have also started to use the PE modelling framework to inform their work.

Some – including the European Commission – have sought to link or “nest” models to each other.<sup>3</sup>

Ensuring consistency of assumptions, data and inputs across modelling frameworks is widely recognised as a significant challenge. Developing governance arrangements to check for consistency (e.g. different base year data and levels of aggregation etc.) is crucial.

## Outputs

Most models typically focus upon ‘core’ economic variables such as GDP, employment, real wages, tax revenues, household consumption, income and (of course) exports and imports.

These are typically at an aggregate level. For example, most trade models report information about households in aggregate or by income groups (quintiles), and they consider only one labour market or go not that much further than distinguishing between low and high-skilled workers<sup>4</sup>.

Although macroeconomic models typically do not report ‘economic welfare’, there are examples where welfare gains from trade have been measured<sup>5</sup> using approaches such as Equivalent Variation (EV)<sup>6</sup>.

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<sup>2</sup> See [www.gov.uk/government/publications/alternatives-to-membership-possible-models-for-the-united-kingdom-outside-the-european-union](http://www.gov.uk/government/publications/alternatives-to-membership-possible-models-for-the-united-kingdom-outside-the-european-union)

<sup>3</sup> See, for example a paper by the European Commission, “Cumulative economic impact of future trade agreements on EU agriculture” [http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103602/lb-na-28206-en-n\\_full\\_report\\_final.pdf](http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103602/lb-na-28206-en-n_full_report_final.pdf)

<sup>4</sup> See for example the UK Government’s paper on Brexit: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/759763/28\\_November\\_EU\\_Exit\\_Long-Term\\_Economic\\_Analysis\\_Technical\\_Reference\\_Paper.PDF](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759763/28_November_EU_Exit_Long-Term_Economic_Analysis_Technical_Reference_Paper.PDF)

<sup>5</sup> See Ciuriak, D., Xiao, J., (2014), “*The Canada-Korea Free Trade Agreement: A First Look at the Numbers*” <https://ssrn.com/abstract=2491548> or Takeda (2010), “*A computable general equilibrium analysis of the welfare effects of trade liberalization under different market structures*”, *International Review of Applied Economics*, 24:1, 75-93.

<sup>6</sup> See Robichaud (2001) for an explanation of methodology [www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/ev3.pdf](http://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/ev3.pdf)

## Regional analysis

Regional analysis is not unheard of but much less common than national analysis. Work that does exist tends to fall into two categories –

- Be-spoke regional models – typically used when regional authorities have important roles in trade negotiations and/or economic policies – e.g. Canadian Provinces<sup>7</sup>.
- Apportionment analysis – where national impacts are ‘allocated’ to regions based upon shares of economic activity (e.g. employment etc).

## Data issues

The quality of an economic model depends upon the data that underpins it.

Putting together datasets is time-consuming and not straightforward. It is not simply a case of downloading accessible datasets and putting them together. There are often problems with data gaps, definitions, classifications etc. This takes time and expertise.

Measuring international trade is particularly challenging in services, given significant trade asymmetries between countries. A huge amount of collaborative work is ongoing to try to reduce such inconsistencies.<sup>8</sup>

Unsurprisingly, for most of the organisations we talked to, National Accounts and Central Bank data form the starting point. In some cases, product level trade data were also used (e.g. Intrastat and ExtraStat). A number of institutions also use subscription modelling frameworks like the Global Trade Analysis Project (GTAP) or NiGEM to calibrate their models and/or determine exogenous variables.

### Box 1: Global Trade Analysis Project Database

GTAP is a popular multi-region trade modelling framework. Its key strengths are its global coverage and the large user-community that exists around it.

As highlighted above, one of the challenges with trade modelling is pulling together the necessary data required. This is not straightforward, particularly given gaps in key

<sup>7</sup> Data accessibility is key. See GTAP-PROV: [www.gtap.agecon.purdue.edu/resources/download/7434.pdf](http://www.gtap.agecon.purdue.edu/resources/download/7434.pdf)

<sup>8</sup> For example, the ONS have published a series of articles on trade asymmetries:

[www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/articles/asymmetriesintradedata/divingdeeperintoukbilateraltradedata/extendinganalysisofukbilateraltradedata](http://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/articles/asymmetriesintradedata/divingdeeperintoukbilateraltradedata/extendinganalysisofukbilateraltradedata)

export and import statistics.

An advantage of GTAP is that – in principle – the modeller does not need to worry about such issues as this has already been prepared for them by other researchers. This greatly reduces the amount of time and effort required.

That being said, a number of users have cautioned that the GTAP database should be used with some care on occasion (for example the extent to which the database incorporates the latest information<sup>9</sup>).

Scotland has particular challenges in measuring trade flows. Whilst improvements have been made to strengthen the quality and coverage of Scottish economic statistics, it lacks the full suite of data others have access to.

International trade in goods can be measured through HMRC Regional Trade Statistics data<sup>10</sup>. We believe that the Scottish Government does not have access to the micro data for this publication, but this would greatly assist with its understanding of trade flows.

The Global Connections Survey (GCS) remains a crucial source of international destination information for exports<sup>11</sup>. Exports with the rest of the UK are also measured, primarily through the GCS. This has issues with coverage and response rate but the main issue with inter-UK trade can often be that companies do not view sales to the rest of the UK as “trade”, and/or both the company and their sales are pan-UK.

Imports data for Scotland tend not to be collected, although the HMRC Regional Trade Statistics does have estimates for goods. In the Scottish National Accounts, imports are largely estimated by a process of deduction

Two developments have the potential to assist Scottish statistical work:

1. The ongoing Economics and Statistics Centre of Excellence project into inter-regional UK trade<sup>12</sup>.
2. The development of interregional trade linked Input-Output tables for all EU NUTS

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<sup>9</sup> See here for a list of tables and year of submission

[www.gtap.agecon.purdue.edu/databases/contribute/iotables.asp](http://www.gtap.agecon.purdue.edu/databases/contribute/iotables.asp)

<sup>10</sup> [www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/regionalisedestimatesofukserviceexports](http://www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/regionalisedestimatesofukserviceexports)

<sup>11</sup> [www2.gov.scot/Topics/Statistics/Browse/Economy/Exports/ESSPublication](http://www2.gov.scot/Topics/Statistics/Browse/Economy/Exports/ESSPublication)

<sup>12</sup> [www.escoe.ac.uk/projects/improving-quality-regional-economic-indicators/](http://www.escoe.ac.uk/projects/improving-quality-regional-economic-indicators/)

2 regions<sup>13</sup>.

### *Garbage in - garbage out*

It is important to remember that whatever assumptions are put into a model are crucial in determining its outputs.

A number of issues are important in the context of international trade modelling.

Firstly, all trade models revolve around barriers to trade – e.g. tariffs, NTMs, ROOs etc. – having some form of relative price effect upon exports and imports<sup>14</sup>. But the translation of specific formulations of these rules into quantifiable relative price impacts is still largely a matter of judgement. Sensitivity analysis is required to see how robust the results are to different assumptions<sup>15</sup>.

Secondly, as with any modelling, the underlying parameters of each specific framework are crucial. In the context of international trade, one of the most important is the assumption of imperfect substitutability of goods which determines the degree of switching between imports and domestic products (as well as between imports from different sources for different product groups).

In many cases, the assumption is that the adjustment does not vary by country. This is clearly a simplification and can be relaxed.

Ultimately, any counterfactual scenario of policy change should be assessed against the credibility and limitations of its assumptions and calibration of crucial parameters. Extreme assumptions will lead to extreme results.

### *Resourcing*

From our discussions with modelling institutions, the average modelling team is around 3 FTE – although it should be noted that there is significant variation ranging from 0.25 FTE

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<sup>13</sup> <https://ec.europa.eu/jrc/sites/jrcsh/files/jrc115439.pdf>

<sup>14</sup> In some models, including the Scottish Government's own CGE model exports can be shocked directly.

<sup>15</sup> Good 'case studies' to quantify likely effects are few and far between. Most studies rely on results from 'big' trade deals like the North American Free Trade Area (NAFTA) in the 1990s. How accurate these are for the UK or Scottish context is questionable. The UK Government has undertaken a significant amount of work into such effects, particular around non-tariff measures drawing upon the work of Balistreri et al. (2018): "Quantifying Disruptive Trade Policies", [https://ideas.repec.org/p/ces/ceswps/\\_7382.html](https://ideas.repec.org/p/ces/ceswps/_7382.html)

to 7 FTE<sup>16,17</sup>.

A constant message from our discussions has been that whilst a team may have the title ‘trade modelling’, very little of their time is spent on actual modelling. Instead, data collection and the construction of relevant ‘trade shock’ scenarios is where most resources are devoted<sup>18</sup>.

As a result, there may be only 1 or 2 (max) experienced modellers in a team with the remainder made up of more junior colleagues who lead on data input and scenario building. Senior trade experts are also consulted.

Another message was that most ‘trade’ modellers have wider responsibilities across other areas, including domestic policy modelling.

The importance of a close relationship between modellers (e.g. economists) and the data teams (e.g. statisticians) was also stressed. Whilst ‘commissioning’ external bodies to build and run modelling frameworks can have its advantages – particularly in the short-run – there was a general consensus that this often led to longer-term challenges around the sustainability of such work. It was also thought to be more expensive in the long-run. In-house capacity building was by far the most popular approach.

Many of the institutions we spoke with had close relationships with external partners (e.g. academics, research institutes etc). A common theme was the need to build resilience in modelling capability, given the small number of people with an expertise in this area and the time-lags involved in ‘getting up to speed’.

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<sup>16</sup> There are larger organisations such as the World Trade Institute and the World Trade Organisation. It should also be noted that most organisations we spoke to operate as ‘business as usual’ – i.e. estimating a small number of trade agreements at particular points in time. Of course, Brexit and its aftermath will look very different with the possibility of a large number of trade deals – both new and old – needing assessed.

<sup>17</sup> Some general economic modelling teams – which do undertake trade modelling – are even bigger. For example, see Centre of Policy Studies: [www.copsmodels.com/staff.htm](http://www.copsmodels.com/staff.htm)

<sup>18</sup> In practice, trade agreements are written in complex legal text. This includes not just issues of tariff reduction, but also how to incorporate non-tariff barriers (NTBs), Rules of Origin (ROO) requirements etc.



## 4. Summary of approaches to trade modelling

### *Introduction*

In this section, we review the most popular approaches used in the policy world and academic literatures. A great many models have been developed, each with their own particular uses. For this report, we focus upon the models that have been designed for policy applications.

### *CGE modelling*

In our review, CGE modelling is by far the most widely adopted approach.

CGE models capture interlinkages between the private sector, households, government, international trade and the labour market.

At their core are Social Accounting Matrices (SAMs) – data sets which capture the linkages between the sectors of the economy and firms, households, and government. As the name suggests, such models allow shocks or changes in one part of the economy to ripple through to other sectors<sup>19</sup>.

The Scottish Government have two CGE models: a single region and a two region version. In the single region model, Scotland's interaction with the rest-of-the-UK (RUK) and the rest-of-the-World (ROW) is captured through detailed trade and migration flows. However, the external regions are passive.

In the two region model, RUK is endogenous and responds to changes in the economy (and vice versa)<sup>20</sup>. A large number of parameters are calibrated using a SAM for Scotland (and for RUK in the two-region model).

Our review has identified two approaches to CGE modelling for trade purposes –

- Firstly, a number of institutions have developed bespoke modelling frameworks; and,
- Secondly, institutions also share frameworks.

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<sup>19</sup> The need to take into account the simultaneous impact of trade on a wide range of sectors that interact with each other through domestic and international supply linkages is seen as the key advantage of CGE models.

<sup>20</sup> The SAM is constructed based on the analytical Input-Output (IO) tables produced by the Scottish Government - latest version 2013.

## Box 2: Summary of just some of the institutions using CGE models

*OECD*<sup>21</sup>: METRO<sup>22</sup> is a static CGE model of 61 countries and 57 sectors. The core dataset draws upon the GTAP database augmented to include more disaggregated trade flows using OECD sources<sup>23</sup>. The model is built on the GLOBE specification<sup>24</sup>.

*European Commission*: RHOMOLO<sup>25</sup> is a spatial recursive dynamic CGE covering 267 (NUTS 2) EU regions and ten sectors. The model includes wage setting rules that are similar to those in the FAI's modelling framework. The model can capture imperfect substitution among regions and costs associated with trade, such as transportation.

*Copenhagen Economics (CE)*: CE have access to a dynamic multi-region CGE model (in partnership with the World Trade Institute) based upon the GTAP database. This model has been used to estimate the impacts on Ireland of Brexit<sup>26</sup>.

*Centre of Policy Studies (CoPS) University of Victoria*: CoPS have developed a suite of national and regional general purpose CGE models<sup>27</sup>.

*Northern Ireland*: The Northern Ireland Executive model (NICGE) is a single region model developed by the FAI. It has two exogenous transactors - RUK and ROW.

*PWC*: PWC have developed a dynamic UK CGE model<sup>28</sup>. The model has one external transactor, the rest of the World.

*Deloitte*: Deloitte have developed a number of country specific CGE models which draw upon the GTAP database<sup>29</sup>.

<sup>21</sup> The OECD is working to make METRO accessible to analysts outside of the organisation.

<sup>22</sup> See [www.oecd.org/tad/policynotes/METRO-OECD-trade-model.pdf](http://www.oecd.org/tad/policynotes/METRO-OECD-trade-model.pdf)

<sup>23</sup> The focus on categories allows an analysis of global value chains (GVCs) by drawing on the OECD-WTO Trade in Value Added (TiVA) database. This is one of the few models to be able to model global value chains.

<sup>24</sup> GLOBE is part of a suite of international CGE models. They use the same notation and share many of the same behavioural relationships, data and code. There are open source variants but which cannot be customised. [www.cgemod.org.uk/GLOBE%20CGE%20User%20Guide.pdf](http://www.cgemod.org.uk/GLOBE%20CGE%20User%20Guide.pdf)

<sup>25</sup> Lecca, P., Barbero, J., Christensen, M., Conte, A., Di Comite, F., Diaz-Lanchas, J., Diukanova, O., Mandras, G., Persyn, D. and Sakkas, S., (2018) RHOMOLO V3: A Spatial Modelling Framework, EUR 29229 EN, Publications Office of the European Union

<sup>26</sup> See <https://dbe.gov.ie/en/Publications/Ireland-and-the-Impacts-of-Brexit.html>

<sup>27</sup> See <https://www.copsmodels.com/models.htm>

<sup>28</sup> PWC, 2016, "Leaving the EU: Implications for the UK economy", prepared for the CBI. URL: <https://www.pwc.co.uk/economic-services/assets/leaving-the-eu-implications-for-the-uk-economy.pdf>

<sup>29</sup> See [www2.deloitte.com/au/en/pages/economics/solutions/cge-modelling.html](http://www2.deloitte.com/au/en/pages/economics/solutions/cge-modelling.html)

These models have the advantage of being flexible. They can be modified to capture the unique characteristics of the economy being studied (including the policy environment)<sup>30</sup>.

Current Scottish Government models could be extended in a number of ways including developing more country variants of the model (e.g. separating out EU exports and imports from ROW), greater sector disaggregation, more sophisticated treatment of FDI flows, migration and an expansion of the domestic policy agenda (e.g. incorporating inclusive growth and the fiscal framework).

The development of bespoke frameworks can help avoid – although does not guarantee against - the criticism that such modelling can be a ‘black box’ or rely on ‘off-the-shelf’ specifications.

There are also disadvantages. Chief amongst them is the fact that they are resource intensive. They require trained staff who can operate the model and understand its strengths and weaknesses.

Alternatives are the commonly shared multi-region modelling frameworks that exist.

A popular approach is the Global Trade Analysis Project (GTAP) approach. GTAP consists of two parts. Firstly, the GTAP database, which includes data on multi-regional trade flows and elasticities. Secondly, the GTAP CGE model<sup>31</sup>.

### **Box 3: Overview of the Global Trade Analysis Project (GTAP)**

GTAP is the most popular multi-regional interregional trade model used today<sup>32</sup>.

The standard GTAP model is a comparative static CGE model<sup>33</sup>. Academics have developed their own dynamic versions of GTAP – e.g. see GTAP – Gdyn<sup>34</sup>.

Unlike the Scottish Government’s CGE model, GTAP first calculates a baseline

<sup>30</sup> This can be particularly important when considering how policy might respond – both endogenously and via a discrete policy change – in the light of a new trade deal or shock to international trade. This is a challenge in larger scale more multi-regional models as the level of domestic sophistication is more limited.

<sup>31</sup> Other variants are available. For example, the GLOBE model is also an open access multi-region CGE model.

<sup>32</sup> For a detailed summary of the GTAP model see <https://jgea.org/resources/jgea/ojs/index.php/jgea/article/view/47/30>

<sup>33</sup> See <https://jgea.org/resources/jgea/ojs/index.php/jgea/article/view/47/30>

<sup>34</sup> See for example “*Brexit Trade Impacts: Alternative Scenarios*”, Ciuriak et al. (2017) [www.gtap.agecon.purdue.edu/resources/download/8782.pdf](http://www.gtap.agecon.purdue.edu/resources/download/8782.pdf).

scenario at a set point of time in the future – using assumptions around population, GDP growth etc. – based upon a ‘do-nothing’ scenario. Policy shocks are then compared to this baseline.

GTAP is a global model<sup>35</sup>. In practice, researchers combine countries into regional aggregates to help solvability. The representation of each region follows a common template, albeit differentiated by data and behavioural elasticities. The core baseline GTAP model has 140 countries and 57 sectors.

A strength of GTAP is the network of agencies, academics and governments that use it. This means that there exists ‘off-the-shelf’ material that can be drawn upon.

The cost of the GTAP database is \$5,940 (circa £4,515)<sup>36</sup>.

The GTAP framework has a number of advantages.

Firstly, the difficult work of compiling trade data is eased significantly as it is built into the GTAP database.

Secondly, the network of academics and practitioners using GTAP provides a way of checking the validity / reliability / robustness of the work. Moreover, given its use, the level of sophistication and robustness of the GTAP framework continues to grow.

Thirdly, in some instances, a multi-regional framework is not only advantageous but a necessity – for example - if estimating the potential impact on Scotland of global shifts in trade (e.g. a trade war between China and the US) or considering a scenario where a number of trade deals are being considered at once.

Fourthly, running GTAP alongside a country-specific CGE can be helpful to cross-check results and to test the sensitivity of different simulations to particular specifications.

#### **Box 4 : GETRADE – the UK Government’s GTAP model**

In November 2018, the UK Government published revised estimates of the long-term

<sup>35</sup> It should be noted that although there is no rest of the world, data of around 20 countries is missing. For these, a common IO structure is assumed.

<sup>36</sup> [www.gtap.agecon.purdue.edu/databases/pricing.asp](http://www.gtap.agecon.purdue.edu/databases/pricing.asp)

impact of Brexit on the UK economy<sup>37</sup>. In this report, they used their new trade modelling capability based upon a variant of GTAP<sup>38</sup> – called GETRADE.

GETRADE includes the core GTAP trade framework, based upon Armington elasticities, and dataset but goes one step further to include ‘New Economic Geography’ elements that incorporate links between trade and productivity and investment. Labour is broken down into five skill levels, earning five different wage rates. It solves for a long-term equilibrium only.

Workers can move between sectors within a country, but cannot move across countries. There are two types of capital, a sector specific element that cannot move between sectors and a generic-purpose element that can.

The model is based upon the GTAP-9 database.

The UK Government has also undertaken work involving gravity modelling to help inform the possible impacts of non-tariff measures (NTMs) to incorporate into the trade shocks that they implement into the model.

But GTAP does have some disadvantages.

Firstly, the country-specific elements of GTAP models tend to be less sophisticated than a bespoke CGE (as their focus is primarily on international trade). This means that elements like the Fiscal Framework, Scottish devolved policies or specific elements of the Scottish economy (e.g. the labour market) will be much less sophisticated.

Secondly, as a multi-region model it relies heavily on datasets sourced from its users. It does not immediately have ‘Scotland’ incorporated and this would require work – although other researchers have developed variants of GTAP<sup>39</sup> with sub-national data (e.g.

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<sup>37</sup> See

[https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/759763/28\\_November\\_EU\\_Exit\\_Long-Term\\_Economic\\_Analysis\\_Technical\\_Reference\\_Paper.PDF](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759763/28_November_EU_Exit_Long-Term_Economic_Analysis_Technical_Reference_Paper.PDF)

<sup>38</sup> See Lanz, B., and Rutherford T. “GTAPINGAMS: Multiregional and small open economy models’ *Journal of Global Economic Analysis*”, 1(2), pp. 1-77, 2016: <http://dx.doi.org/10.21642/JGEA.010201AF> and Balistreri, Böhringer and Rutherford (2018) “Quantifying Disruptive Trade Policies”, [https://ideas.repec.org/p/ces/ceswps/\\_7382.html](https://ideas.repec.org/p/ces/ceswps/_7382.html)

<sup>39</sup> There is a GTAP utility called ‘SplitReg’ that helps to extract regional data from national accounts. However, this may not reflect the structural characteristic of the region or accurately capture inter-regional trade.

[https://www.gtap.agecon.purdue.edu/resources/res\\_display.asp?RecordID=3453](https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3453)

Canada)<sup>40</sup>.

Thirdly, the more regions that are added the more complex it is to solve such models and interpret the results. For example, whilst the RHOMOLO model currently covers 267 NUTS2 EU regions, each region is only disaggregated into five sectors alongside one national R&D sector to ease computation.

Finally, as highlighted above, the datasets within GTAP require careful use and interpretation (particularly given some time lags and aggregation issues in their compilation).

In the recommendations, we highlight some areas where the Scottish Government may wish to develop its CGE modelling capabilities.

### *Partial Equilibrium modelling*

A number of institutions have developed Partial Equilibrium (PE) frameworks to complement more general macroeconomic models.

Partial equilibrium (PE) models focus on predicting the *direct* effects on key economic outcome variables (for example prices, tariff revenues, trade volumes) in response to market/sector specific policy changes. The underlying frameworks share similar features to a CGE model.

In contrast to macroeconomic models, PE models focus only on the market (or sector) directly affected by a given policy. A key assumption, therefore, is that this specific market has no impact on other markets and vice versa. In a similar vein, such models do not incorporate factor markets, such as the labour market.

They have a particular application for occasions where the short-term or immediate impact of a policy change is important.

We understand the Scottish Government has more limited experience of developing a PE model, although we do know that they have been commissioned in the past<sup>41</sup>.

At least in terms of frequency of use, the application of PE modelling is more limited than

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<sup>40</sup> <https://dx.doi.org/10.2139/ssrn.2594581>

<sup>41</sup> See, for example “*Seafood Trade Modelling Research Project – Assessing the Impact of Alternative Fish Trade Agreements Post EU-Exit*” published June 2018 by Marine Scotland. [www.gov.scot/publications/seafood-trade-modelling-research-project-assessing-impact-alternative-fish-trade/](http://www.gov.scot/publications/seafood-trade-modelling-research-project-assessing-impact-alternative-fish-trade/)

CGE modelling. There appear to be a few reasons for this:

- Firstly, in trade modelling the macroeconomic impacts – including spill-overs between sectors – are what capture the interests of many policymakers;
- Secondly, researchers have told us that ‘back-of-the-envelope’ calculations can often be a good approach given resource constraints; and,
- Thirdly, the data requirements can be demanding such that applicability of PE models at an appropriate disaggregated level is not straightforward.

That being said however, the benefits of PE modelling are increasingly recognised<sup>42</sup>.

In terms of specific models –

- An accessible PE model is based on the World Integrated Trade Solutions (WITS) software provided by the World Bank<sup>43</sup>. This allows users to access data on trade and tariffs and within WITS, there is a PE model – SMART. This models the impacts of tariff changes on trade flows, revenues, and welfare. However, it only contains trade and not domestic production data, which can be a drawback.
- A more detailed and bespoke PE model is the Trade Analysis Partial Equilibrium Sussex (TAPES) model, developed at the University of Sussex<sup>44</sup>. This model has been designed to analyse the impact of changes in trade policies (tariffs, non-tariff measures etc.) on trade and includes domestic production data<sup>45</sup>. The model has also been extended to create a Partial General Equilibrium (PGE) model which incorporates intermediate input linkages.
- The FAPRI-UK model<sup>46</sup> (created and maintained by staff in AFBI-Economics<sup>47</sup>) is a PE agricultural model of England, Wales, Scotland and Northern Ireland.

For product markets that are covered by the main PE models (SMART, TAPES, FAPRI) it

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<sup>42</sup> Agriculture and Fisheries have traditionally been a key area of interest for PE modelling – see FAPRI UK funded by DEFRA and the devolved administrations.

[www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/FAPRI-UK%20Brexit%20Report%20-%20FINAL%20Clean.pdf](http://www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/FAPRI-UK%20Brexit%20Report%20-%20FINAL%20Clean.pdf)

<sup>43</sup> <https://wits.worldbank.org/>

<sup>44</sup> <https://blogs.sussex.ac.uk/uktpo/>

<sup>45</sup> An example of TAPES is a recent study by Marine Scotland (2018).

<sup>46</sup> See [www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/FAPRI-UK%20Brexit%20Report%20-%20FINAL%20Clean.pdf](http://www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/FAPRI-UK%20Brexit%20Report%20-%20FINAL%20Clean.pdf) for a discussion.

<sup>47</sup> [www.afbini.gov.uk/area-of-expertise/economics](http://www.afbini.gov.uk/area-of-expertise/economics)

should be possible to develop a Scottish bespoke extension (similar to the FAPRI-UK extension developed by DEFRA).

### **Box 5: Step-by-step guide to PE modelling**

*1. Determine whether a PE model is appropriate*

The key advantage of a PE model is that they can provide granular sector or product-specific results. They are also useful for estimating direct or short-term impacts. If the policy interest is in wider macroeconomic impacts PE models are of less value.

*2. Choose the appropriate economic framework for the product in question*

All PE models contain a core analytical framework that capture import demand and export supply dynamics for the countries and sector(s) in question. This typically follows a standard demand/supply framework with relevant elasticities and domestic vs. international preferences.

*3. Collect data on trade (trade flows, tariffs, tariff equivalents) and production (values, prices, costs) for each sector(s)/product(s)*

Data on trade and production then need to be collected. Depending upon the framework this will be on a country-by-country basis or a regional trading bloc basis.

*4. Select values for the key parameters (e.g. elasticities)*

Elasticities determine how relative price changes (e.g. tariffs) lead to changes in trade. Examples include: elasticity of demand, elasticity of supply, and the elasticity of substitution between countries. Such values are not determined within the model but are entered by the research team, typically based upon evidence from other studies.

*5. Solve the model*

Calibrate the model so that all data is incorporated alongside key parameters – making manual adjustments where required.

*6. Change policy parameters and trace impact on prices and trade volumes<sup>48</sup>*

Input new values - e.g tariffs - and simulate the model to calculate new prices and trade volumes under different scenarios. Final step is to compare results to the baseline.

Overall, given their relatively simple theoretical structure the results are transparent and

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<sup>48</sup> It is possible to build supply-chain effects into such models. This is currently something that the team at Sussex are developing.



sensitivity analysis is easy. Solving the models is fast and more straightforward than for larger macroeconomic models.

The approach does have some challenges, however.

Firstly, whilst requiring a relatively small amount of data in principle, even then it can often be difficult to get the information required at a sufficiently disaggregated level. See Box 5.

Secondly, their very feature – the partial nature of their work – whilst a strength is also a weakness. Wider structural or feedback effects are typically not incorporated. So, for example, they do not capture how changes in employment in some sectors might affect other sectors through their impact on wages; or how changes in agriculture might affect food manufacturing etc.

#### **Box 6: Data in Partial Equilibrium modelling**

PE models require data on production, bilateral trade flows and trade costs.

For some sectors – particularly agriculture – this data will be available for Scotland. Indeed, such a study has already been completed for Marine Scotland looking at key fish stocks<sup>49</sup>.

For larger more integrated sectors, such as manufacturing the situation is more complex. At a national level, both production and trade data will be available but will be collected differently: while production data are collected on an activity basis trade data will be collected on a commodity basis. In Gasiorek et al. (2018), this issue is reconciled through the use of concordance tables and in some cases using data from secondary sources (such as the World Input-Output Database and the UN Comtrade database).

However, as already discussed above, there may be issues with the underlying data used to estimate these off-the-shelf data sources which should always be considered if these are being used. The judgements that are used to compile these international data sources can mean that the data for individual countries is adjusted to ensure consistency.

It is, of course, in principle, possible to link PE and more macro models together.

One approach is to take the results from a PE model (by product) and incorporate the

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<sup>49</sup> [www.gov.scot/publications/economic-impacts-scenarios-scottish-uk-seafood-industries-post-eu-exit/pages/3/](http://www.gov.scot/publications/economic-impacts-scenarios-scottish-uk-seafood-industries-post-eu-exit/pages/3/)

changes in that product into a wider macroeconomic model. This was the approach adopted in Marine Scotland (2018) – albeit, rather than using a CGE framework, standard IO multipliers were used.

Of course, it is possible to approach the same question from the other angle by first estimating macroeconomic impacts and then the more granular direct effects via a PE model – see for example, Boulanger et al. 2016<sup>50</sup>. Dr Carmen Hubbard at the University of Newcastle is working on a project to link PE and CGE models in agriculture<sup>51</sup>.

In the recommendations, we highlight some areas where the Scottish Government may wish to develop its PE modelling capabilities.

### *Macroeconometric modelling*

Many of the institutions we have talked to maintain macroeconometric models alongside CGE and PE models.

In contrast to CGE and PE models, the focus of macroeconometric frameworks is to study the effects of a given scenario on a range of variables beyond trade – particularly the responses of fiscal and monetary policy after a trade-related shock.

The Scottish Government currently has access to the Scottish Government Global Econometric Model (SGGEM). However, the discussion points below are applicable to a wider representation of large-scale macroeconometric models. SGGEM is also the framework used by the Scottish Fiscal Commission to forecast Scottish GDP as part of the fiscal framework.

SGGEM is based upon the National Institute's Global Econometric model, NiGEM.

NiGEM is an estimated macro-econometric model of the global economy. It has a 'New-Keynesian' framework, which means that the agents are forward-looking, but nominal rigidities affect the adjustment process following any external events. The economies are linked through trade and competitiveness (relative prices) relationships, financial markets and the holdings of international stocks of assets.<sup>52</sup>

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<sup>50</sup> [http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103602/lb-na-28206-en-n\\_full\\_report\\_final.pdf](http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103602/lb-na-28206-en-n_full_report_final.pdf)

<sup>51</sup> <https://research.ncl.ac.uk/esrcbrexitproject/people/drcarmenhubbard.html>

<sup>52</sup> Most OECD countries are modelled individually and there are also separate models for a number of other countries. The rest of the world is modelled through a series of regional blocks.

SGGEM is an extension to NiGEM, equipped with both a forecast and simulation mode<sup>53</sup>.

SGGEM consists of the three parts: Scotland Onshore (SO), the North Sea (NS) and the Rest of the UK (rUK).

The long-term dynamics in both NiGEM and SGGEM are driven by a series of supply-side equations, whereas the short and medium term dynamics are governed by the demand-side. External trade in both NiGEM and SGGEM directly affects the demand-side of the model.

The macro-econometric framework of NiGEM has been used extensively to study a wide variety of issues. Recent examples include modelling of the impact of a slow-down in the pace of growth of the Chinese economy or the assessment of the impact of changing financial regulation on the UK economy.

In the context of trade, the NiGEM framework has been used to study the impact of trade-related shocks on the domestic economy and to study the responses of monetary and fiscal policy, taking into account direct and indirect cross-country links and dynamic propagation of those shocks.

The model allows for analysis of the responses of the various aggregate real economy variables: output, investment, wages, consumption, etc. Recent trade-related applications include:

- The study of the impact of trade wars between US and China on third countries;
- Trade-related impact of Brexit; and,
- The role of services trade liberalization in the rebalancing of the global current account imbalances.

The NiGEM/SGGEM framework has a number of strengths.

First, it constitutes a rich modelling environment to investigate the macroeconomic policy responses to trade-related shocks and their impact on a wide range of macroeconomic variables. For example, it can be used to assess the impact of uncertainty on domestic business investment, which is beyond the scope of CGE or PE models.

Second, SGGEM is highly flexible and allows the user to impose and test different

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<sup>53</sup> NiGEM offers two main functionalities: a forecasting and a simulation mode. In the forecasting mode all of the model predictions are backward-looking. The simulation mode is forward-looking, where all variables respond to the predicted future paths of the model components. The simulation mode is the main framework used for policy analysis.

assumptions or judgements regarding the underlying model equations. All parameters and elasticities can be directly altered by the user. Moreover, SGGEM allows to explicitly model the time pattern of a given policy scenario – that is to decide on its magnitude and the phasing-in period<sup>54</sup>. A good example of tailoring an equation in SGGEM is the addition of the uncertainty variable (SOUNCERT). This was performed by the Scottish Government who modified the equation for Scotland on-shore business investment (SOIB) to assess the impact of uncertainty on the Scottish economy<sup>55</sup>.

Last, but not least, an increasing number of NiGEM users link the model to more disaggregated models in order to provide a tailored framework for policy questions. NiGEM has been linked to small open economy models as well as to CGE-type modelling.

One of the institutions we have talked to is developing a regional satellite model for their in-house small open economy model, which in turn is linked to NiGEM model. Their aim is to feed national-level forecasts (from NiGEM) into a disaggregated regional framework (without any feedback effects from regions). There are a number of advantages stemming from this approach. First, the global shocks from SGGEM represent a rich picture of cross-country dependencies, including both trade and financial linkages. Second, such a linking of models could allow for an analysis of sector-level changes that impact the whole domestic system. However, there are also some limitations to SGGEM applications.

First, SGGEM does not provide a detailed sectoral split as it includes a relatively simple industrial apportionment. Moreover, in the basic version of the model, trade flows of goods and services are modelled as a single aggregate. In principle, those trade flows could be modelled separately. This could allow for a better assessment of trade agreements that differ in their treatment of goods and services.

Second, given its level of granularity SGGEM does not allow for a direct translation from trade agreements - in terms of tariff lines changes or the non-tariff measures - into model parameters. The variable paths that are assumed for a given scenario (e.g. for Brexit-related analyses) are typically based on the predicted changes in trade flows from the literature, that is from analysis outside of the SGGEM framework.

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<sup>54</sup> See for example Liadze (2018) - [www.niesr.ac.uk/publications/trade-war-saga-continues](http://www.niesr.ac.uk/publications/trade-war-saga-continues)

<sup>55</sup> See [www.gov.scot/publications/state-economy/](http://www.gov.scot/publications/state-economy/)

## 5. Recommendations

From the research we have undertaken for this report, we make seven high level recommendations that the Scottish Government may wish to consider when assessing the feasibility of trade modelling for Scotland.

We then highlight some specific areas for possible model extension and development. We also provide an approximate indication of the likely resource requirement.

### *High level recommendations for trade modelling*

1. If the Scottish Government wishes to develop a proactive approach to international trade and investment policy post-Brexit, then we believe that it will be essential to invest in a robust analytical capacity to inform such work. This is the approach taken in other countries and institutions. Investment will be required in three key areas –
  - Economic modelling;
  - Expertise in the economics of international trade; and,
  - Collecting Scottish international data and statistics.

Whilst we appreciate that resourcing requirements are a decision for the Scottish Government, based upon what other institutions have told us, it would seem a reasonable approximation that any analytical capacity should be 5% to 10% (max) of the total resource allocated to trade policy.

2. In our view, the Scottish Government should consider investing in a suite of modelling capabilities rather than just one particular model. The Scottish Government already has an impressive modelling capability to build upon. Ideally, this capacity should be coordinated across different model types to ensure that – where possible – any differences in results, assumptions and methodologies are understood. We recommend that this analytical capability should be built around three broad ‘types’ of models each with their own distinctive characteristics and applicability to certain policy questions –
  - Computable General Equilibrium modelling;
  - Partial Equilibrium modelling; and,
  - Macroeconometric modelling

3. On data, the Scottish Government currently does not have access to the full suite of trade information that other (independent) governments can draw upon. It is, therefore, crucial that the Scottish Government gains access to as much data and statistical information as possible, particularly from HMRC and ONS.
4. In developing its modelling capacity, it will be important that the Scottish Government can capture as many 'Scottish specific' elements as possible, particularly given the likely interest in areas where Scotland's priorities may differ from the rest of the UK. Data are one important part of this, but this should also include Scottish-specific trade elasticities and developing the domestic elements of Scottish trade models (e.g. to include the possibility to model inclusive and sustainable growth objectives, the Fiscal Framework etc). This will ensure that the modelling captures the distinct features of the Scottish economy and policy landscape and, therefore, adds the most value.
5. Developing a comprehensive trade modelling capacity will take time. The government will, therefore, need to prioritise which areas to develop. Mapping of short, medium and long-term policy priorities alongside model development timelines will help to ensure that the right frameworks are developed for the appropriate policy questions.
6. There is a large (and growing) community undertaking trade research both in academia and in the public and private sectors. If the Scottish Government wishes to develop a high level of expertise, then it will be important to invest time in becoming part of that community – e.g. attending conferences, publishing research outputs, secondments, and working with academics and partner governments both in the UK and internationally.
7. Finally, it will be vital that any modelling capacity that the government develops is undertaken in an open and transparent manner. This will not only encourage comment and feedback on the work but doing so will ultimately improve its quality and confidence amongst stakeholders.

In terms of specific options, the tables overleaf provide an overview of the key possibilities we have identified so far. We focus upon the three key analytical frameworks that we have reviewed in the report, Computable General Equilibrium modelling, Partial Equilibrium modelling and Macroeconometric modelling (with a particular focus upon the

Scottish Government's Global Econometric Model, given its use as the core macroeconomic model within the Scottish Government).

## Trade modelling options

<b>Computable General Equilibrium modelling (CGE)</b>						
<i>NB: Baseline assumption is that investment required of 3 or 4 economists/statisticians in core modelling and trade analysis team. The estimates of the resources required are of course subject to some margin of error, dependent on e.g. the skill level of the staff at the beginning of any project. These timescales have been estimated based on a fairly high level of skill to begin with, and if capacity or skills need to be built up then timescales may need to be longer.</i>						
<b>Extensions</b>	<b>Value added</b>	<b>Policy relevance</b>	<b>Type of modification (including data)</b>	<b>Scale of up-front investment</b>	<b>Scale of running costs (once built)</b>	<b>How quick to operationalise</b>
<i>Purchase GTAP database licence and GTAP baseline model</i>	<ul style="list-style-type: none"> <li>Estimates of the effects of trade deals on UK</li> </ul>	<ul style="list-style-type: none"> <li>UK results of trade shocks (e.g. Brexit, new trade deals) 'regionalised' for Scotland</li> </ul>	<ul style="list-style-type: none"> <li>New model use (GTAP)</li> </ul>	<ul style="list-style-type: none"> <li>\$5,940</li> </ul>	<ul style="list-style-type: none"> <li>Likely incorporation of day-to-day activities of analytical unit</li> </ul>	<ul style="list-style-type: none"> <li>Straightforward (given usability of GTAP)</li> </ul>
<i>Incorporate Scotland and rUK into baseline GTAP-model</i>	<ul style="list-style-type: none"> <li>Estimates of the effect of trade deals, export policy etc. on Scotland using broad-brush CGE model</li> </ul>	<ul style="list-style-type: none"> <li>Scottish estimates of different trade deals – e.g. WTO rules post-Brexit</li> </ul>	<ul style="list-style-type: none"> <li>Purchase of base GTAP database &amp; use of Scottish SUTs to replace UK with Scotland vs rUK (like GTAP-PROV)</li> </ul>	<ul style="list-style-type: none"> <li>2 FTE working 3 to 4 months (estimated) to build dataset for GTAP Scottish variant</li> <li>Purchase GTAP database</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>Ongoing data building</li> </ul>	<ul style="list-style-type: none"> <li>3 to 4 months (estimated) of prep work</li> <li>Assistance from other modellers important</li> </ul>



<p><i>Deepen the geographical coverage of external trade component of existing SG CGE model</i></p>	<ul style="list-style-type: none"> <li>• Increase detail of destination/origin (e.g. EU/non-EU), treating them as exogenous.</li> <li>• Retain Scot specific economic characteristics and policy levers plus comparability with domestic SG CGE</li> </ul>	<ul style="list-style-type: none"> <li>• Detailed treatment of EU trade shocks</li> <li>• Scottish estimates of multi-region trade deals</li> <li>• Able to analyse SG policy responses</li> </ul>	<ul style="list-style-type: none"> <li>• Data disaggregation</li> <li>• Minor modification of underlying SG CGE model and re-calibration</li> </ul>	<ul style="list-style-type: none"> <li>• 1 FTE 6 months</li> <li>• Possible to commission externally or work jointly with external partner</li> </ul>	<ul style="list-style-type: none"> <li>• Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>• Ongoing data building</li> </ul>	<ul style="list-style-type: none"> <li>• 6 months(+) to allow for testing, scoping/tender</li> <li>• Once up and running, significant flexibility and responsiveness</li> </ul>
<p><i>Incorporate GTAP database into existing SG CGE model</i></p>	<ul style="list-style-type: none"> <li>• Further enhance the detail of destinations and origins of trade on significant scale (with additional endogenous regions as required)</li> <li>• Retain Scot specific economic characteristics and policy levers plus comparability with core domestic SG CGE</li> </ul>	<ul style="list-style-type: none"> <li>• Detailed treatment of 3rd country trade shocks</li> <li>• Scottish estimates of multi-region trade deals</li> <li>• Able to analyse SG policy responses</li> </ul>	<ul style="list-style-type: none"> <li>• Purchase of GTAP database</li> <li>• Major modification of underlying SG CGE model and re-calibration</li> </ul>	<ul style="list-style-type: none"> <li>• 2 FTE 9 to 12 months</li> <li>• Possible to commission externally or work jointly with external partner</li> </ul>	<ul style="list-style-type: none"> <li>• Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>• Ongoing subscription to GTAP database</li> </ul>	<ul style="list-style-type: none"> <li>• 9 to 12 months(+) to allow for testing &amp; scoping/tender</li> <li>• Once up and running, give max flexibility &amp; responsiveness</li> </ul>

<p><i>Build a new bespoke multi-regional CGE model of Scotland (perhaps using GTAP database)</i></p>	<ul style="list-style-type: none"> <li>Estimates of the effect of trade deals, export policy etc. on Scotland using new Scottish-specific CGE model</li> </ul>	<ul style="list-style-type: none"> <li>Produce Scottish estimates of multi-region trade deals</li> <li>Depending upon sophistication, opportunity to analyse SG policy responses</li> </ul>	<ul style="list-style-type: none"> <li>Build new SG CGE model including multi-regional trade</li> </ul>	<ul style="list-style-type: none"> <li>2 FTE 12 (+) months of model development</li> <li>Require external support</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>Possible ongoing data/consultancy subscriptions</li> </ul>	<ul style="list-style-type: none"> <li>12 months(+) to allow for testing &amp; scoping/tender</li> <li>Long-term investment</li> <li>Once up and running, give max flexibility &amp; responsiveness</li> </ul>
<p><i>Develop greater sector disaggregation</i></p>	<ul style="list-style-type: none"> <li>Develop greater sector detail (current SG CGE has 21 sectors)</li> </ul>	<ul style="list-style-type: none"> <li>Allow for more disaggregated / specific shocks</li> </ul>	<ul style="list-style-type: none"> <li>Model modification</li> <li>Data disaggregation</li> </ul>	<ul style="list-style-type: none"> <li>Depending on sector(s) 1 FTE 2-4 months</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>Ongoing data building</li> </ul>	<ul style="list-style-type: none"> <li>2 to 4 months work(+) to allow for testing</li> <li>Entirely possible to do in-house</li> </ul>
<p><i>More sophisticated treatment of FDI</i></p>	<ul style="list-style-type: none"> <li>Extend SAM database and CGE to differentiate between domestic and foreign firms</li> </ul>	<ul style="list-style-type: none"> <li>Better understanding of FDI exposure to trade deals</li> </ul>	<ul style="list-style-type: none"> <li>Data extension to include more detailed treatment of FDI and capital stock statistics</li> </ul>	<ul style="list-style-type: none"> <li>1 FTE 12 months (subject to data access/quality)</li> <li>Uncertainty about data</li> <li>May need to buy data/extend agreements)</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>Ongoing data building (including licence costs)</li> </ul>	<ul style="list-style-type: none"> <li>12 months (+)</li> <li>Uncertainty around deliverability given data quality issues</li> </ul>
<p><i>Improving coverage of international/inter-regional trade data</i></p>	<ul style="list-style-type: none"> <li>Improve / get access to better trade data (as in case of N. Ire)</li> </ul>	<ul style="list-style-type: none"> <li>Trade flow data by commodity (HMRC) would improve model of trade flows and give more accurate results</li> </ul>	<ul style="list-style-type: none"> <li>Data development</li> <li>Incorporation of new data and re-parameterisation</li> </ul>	<ul style="list-style-type: none"> <li>1 FTE 3 months (subject to data access)</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>Ongoing data access agreements required</li> </ul>	<ul style="list-style-type: none"> <li>3 months (+)</li> <li>Uncertainty around deliverability given data access issues</li> </ul>

<p><i>Sophistication of treatment of migration</i></p>	<ul style="list-style-type: none"> <li>• Migration flows extended from current Scotland and rUK net flows to interregional and international gross flows</li> </ul>	<ul style="list-style-type: none"> <li>• Impacts of migration on sectors and/or different UK-wide/Scottish migration policies</li> </ul>	<ul style="list-style-type: none"> <li>• Data development</li> <li>• Sector specific framework</li> <li>• Incorporation of new data and re-parameterisation</li> </ul>	<ul style="list-style-type: none"> <li>• 1 FTE 6 to 9 months (subject to data access and quality)</li> </ul>	<ul style="list-style-type: none"> <li>• Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>• Ongoing data building</li> </ul>	<ul style="list-style-type: none"> <li>• 6 to 9 months (+)</li> <li>• Uncertainty around deliverability given data quality issues</li> </ul>
<p><i>More advanced domestic economy characteristics to capture impacts of future trade relationships – e.g. inclusive growth</i></p>	<ul style="list-style-type: none"> <li>• Broader assessment of outcomes – including inclusive growth objectives</li> </ul>	<ul style="list-style-type: none"> <li>• More sophisticated treatment of impacts in different types of households</li> </ul>	<ul style="list-style-type: none"> <li>• Model development</li> <li>• Data development – e.g. from FRS</li> </ul>	<ul style="list-style-type: none"> <li>• Depends upon model extension (e.g. household quintiles in existing models so could be accessed quickly)</li> <li>• Other internal extensions: (on average 1½ FTE 3 to 9 months)</li> </ul>	<ul style="list-style-type: none"> <li>• Links to wider capacity in SG – issues not trade specific</li> <li>• Once built - could be incorporated as part of day-to-day activities of analytical unit</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively quick for some extensions given prior work</li> <li>• More sophisticated and/or new work 3 to 9 months (+)</li> </ul>
<p><i>More sophisticated local policy environment – e.g. Fiscal Framework</i></p>	<ul style="list-style-type: none"> <li>• Devolved policy responses</li> </ul>	<ul style="list-style-type: none"> <li>• Assess effects of fiscal framework on stabilising ‘trade shocks’</li> <li>• Assess ability of SG tax and spending policy to ‘offset’ trade shocks</li> </ul>	<ul style="list-style-type: none"> <li>• Model development</li> </ul>	<ul style="list-style-type: none"> <li>• Depends upon model extension (e.g. fiscal framework in latest FAI model)</li> <li>• Other internal extensions: (on average 1½ FTE 3 to 9 months)</li> </ul>	<ul style="list-style-type: none"> <li>• Links to wider capacity in SG – issues not trade specific</li> <li>• Once built - could be incorporated as part of day-to-day activities of analytical unit</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively quick for some extensions given prior work</li> <li>• More sophisticated and/or new work 3 to 9 months (+)</li> </ul>

Feasibility study on developing trade modelling for Scotland

<p><i>Regional Modelling</i></p>	<ul style="list-style-type: none"> <li>• Create a sub-Scotland version of CGE model</li> </ul>	<ul style="list-style-type: none"> <li>• Assess the impact of trade deals on different parts of Scotland</li> </ul>	<ul style="list-style-type: none"> <li>• Regional data modification</li> <li>• Model development – e.g. apportionment or full-scale inter-regional model</li> </ul>	<ul style="list-style-type: none"> <li>• Simple apportionment little investment (1 FTE 1 month)</li> <li>• Full-scale inter-regional model major investment (2 FTE 12 months +)</li> </ul>	<ul style="list-style-type: none"> <li>• Links to wider capacity in SG – issues not trade specific</li> <li>• Once built - could be incorporated as part of day-to-day activities of analytical unit</li> </ul>	<ul style="list-style-type: none"> <li>• Easy to apply apportionment shocks</li> <li>• Full-inter regional model (12 months +)</li> </ul>
<p><i>Precision of modelling trade "shocks" in CGE models &amp; Scottish estimates of key trade parameters</i></p>	<ul style="list-style-type: none"> <li>• Develop Scotland specific parameters for trade models</li> </ul>	<ul style="list-style-type: none"> <li>• Estimation of NTMs specifically for Scotland</li> </ul>	<ul style="list-style-type: none"> <li>• Econometric analysis</li> </ul>	<ul style="list-style-type: none"> <li>• 3 months FTE per project</li> </ul>	<ul style="list-style-type: none"> <li>• Ongoing model development</li> </ul>	<ul style="list-style-type: none"> <li>• Relatively quick for some extensions</li> <li>• Can be incorporated into work programme as and when time permits</li> </ul>

<b>Partial Equilibrium modelling</b>						
<b>Extensions</b>	<b>Value added</b>	<b>Policy relevance</b>	<b>Type of modification (including data)</b>	<b>Scale of up-front investment</b>	<b>Scale of running costs (once built)</b>	<b>How quick to operationalise</b>
<i>Building of a PE model – or suite of PE models – on sectors of interest for Scotland</i>	<ul style="list-style-type: none"> <li>Detailed examination of effects on different product groups</li> </ul>	<ul style="list-style-type: none"> <li>Already been undertaken for fish and agriculture by SG</li> </ul>	<ul style="list-style-type: none"> <li>New model built</li> <li>Detailed product data collection</li> </ul>	<ul style="list-style-type: none"> <li>Development of new model (likely to require external support)</li> <li>3 to 6 months</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> </ul>	<ul style="list-style-type: none"> <li>3 to 6 months (+) with external support</li> </ul>
<i>Develop an approach to nest results of PE modelling within CGE</i>	<ul style="list-style-type: none"> <li>Allow product specific effects to be nested within wider macro effects</li> </ul>	<ul style="list-style-type: none"> <li>Short-run effects of PE to be combined with long run dynamic effects of CGE</li> </ul>	<ul style="list-style-type: none"> <li>Detailed product data</li> </ul>	<ul style="list-style-type: none"> <li>1 month FTE (once PE model developed)</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> </ul>	<ul style="list-style-type: none"> <li>1 month FTE (+) - relatively straightforward once PE and CGE models developed</li> </ul>

<b>Scottish Government Global Econometric Model (SGGEM)</b>						
<b>Extensions</b>	<b>Value added</b>	<b>Policy relevance</b>	<b>Type of modification (including data)</b>	<b>Scale of up-front investment</b>	<b>Scale of running costs (once built)</b>	<b>How quick to operationalise</b>
<i>Disaggregation of total trade into separate services and goods flows</i>	<ul style="list-style-type: none"> <li>Model separately goods and services trade in SGGEM</li> </ul>	<ul style="list-style-type: none"> <li>Differentiate between of the impacts of goods and services trade on the macro variables</li> </ul>	<ul style="list-style-type: none"> <li>Model modification (split of trade matrix into services and goods components)</li> </ul>	<ul style="list-style-type: none"> <li>3 month FTE</li> <li>Extension could be developed by NIESR under SGGEM subscription</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>Model training included in NiGEM/SGGEM subscription</li> </ul>	<ul style="list-style-type: none"> <li>1-2 months FTE</li> <li>Once extension developed for the main NiGEM model</li> </ul>
<i>Extension of the industrial disaggregation in SGGEM</i>	<ul style="list-style-type: none"> <li>Adopt a bottom-up approach to industry-level modelling</li> </ul>	<ul style="list-style-type: none"> <li>Analyse shocks originating in separate industries and their impact on Scottish economy</li> </ul>	<ul style="list-style-type: none"> <li>Development of a new model segment</li> <li>Framework design and coding</li> <li>Will depend upon data access from SG</li> </ul>	<ul style="list-style-type: none"> <li>3 month FTE</li> <li>Extension could be developed by NIESR under SGGEM subscription.</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> <li>Model training included in NiGEM/SGGEM subscription.</li> </ul>	<ul style="list-style-type: none"> <li>Dependant of the desired 'ease of use'</li> <li>1-2 months FTE.</li> </ul>
<i>Linking SGGEM to the other models</i>	<ul style="list-style-type: none"> <li>Link SGGEM to other models, such as the CGE model</li> </ul>	<ul style="list-style-type: none"> <li>Analyse the impact of global shocks on specific sectors of the economy</li> </ul>	<ul style="list-style-type: none"> <li>Model modification</li> <li>Potential re-labelling of model variables</li> </ul>	<ul style="list-style-type: none"> <li>Dependant of the complexity of the linked model</li> <li>2 to 4 month FTE (once models developed)</li> </ul>	<ul style="list-style-type: none"> <li>Once built - could be incorporated as part of day-to-day activities of analytical unit</li> </ul>	<ul style="list-style-type: none"> <li>Dependant of the complexity of the linked model</li> <li>3 to 6 months (+)</li> </ul>

## Appendix A: List of organisations

Scottish Government

HM Treasury

Department for Environment, Food & Rural Affairs

Economic & Social Research Institute

World Trade Organisation

Global Trade Analysis Project

KOF Swiss Economic Institute

European Trade Study Group

ETLA – Research Institute of the Finnish Economy

London Economics

PWC

Bank of England

OECD

World Trade Institute

DeNederlandscheBank

European Commission

Deloitte

Department for International Trade

BanqueDeFrance

Centre of Policy Studies

Netherlands Bureau for Policy Analysis