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Scotland – no detriment, no danger: the inter-regional impact of a balanced budget regional fiscal expansion

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Scotland – no detriment, no danger: the inter-regional impact of a balanced budget regional fiscal expansion:

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Abstract

In the Scottish Independence Referendum, the Scottish electorate voted to remain within the UK. However, this did not mean that the institutional arrangements in Scotland would remain unchanged. Legislation already enacted under the 2012 Scotland Act plus the recommendations of the Smith Commission report will give Scotland extensive fiscal powers in the future. However, although there will be a highly devolved structure for taxation and public expenditure, the Scottish economy is closely integrated with the rest of the UK and issues of policy co-ordination and misaligned incentives will almost inevitably arise.

The paper develops an extremely simple two-region demand-driven analytical model, which is used to illustrate the nature of inter-regional interaction that would occur as a result of devolved policy initiatives. Our particular focus is the question of balanced budget fiscal expansions. We construct a set of two-region (Scotland/RUK) Industry by Industry Input Output accounts for 2010. These accounts are taken as the data on which Input-Output and Social Accounting Matrix (as well as Computable General Equilibrium) models can be built to calculate the impact of decentralised and devolved policies. The simulation results highlight the potential significance of inter-regional effects and the requirement for accuracy in the size of inter-regional trade flows and critically the need for a more highly developed policy framework to measure such inter-regional spillover impacts.

1. Introduction

As a result of the 2012 Scotland Act and the proposals of the Smith Commission (2014), in the future Scotland's degree of fiscal autonomy will significantly increase. Within the OECD, at present Scotland is a devolved government having one of the lowest levels of self-financing, but in the near future it will have one of the highest. If the recommendations of the Smith Commission are successfully translated into legislation, as expected, just less than 40% of all public expenditure in Scotland will be directly financed by taxes raised in Scotland (Bell and Eisner, 2014).

This will give the Scottish Government the power to vary the overall level of public expenditure in Scotland, with a corresponding adjustment in devolved taxes. It also means that the Scottish Government benefits directly from growth in the Scottish economy through increased tax revenues but it also renders the Scottish economy more vulnerable to external shocks. As a result, the UK will face for the first time, in perhaps a rather acute form, general issues of asymmetrically devolved fiscal policy making. However, although there will be a highly devolved structure for taxation and public expenditure to Scotland, given that the Scottish economy is closely integrated with the rest of the UK issues of policy co-ordination and misaligned incentives are almost inevitable.

This problem seems to have been anticipated in the Smith Commission report (The Smith Commission, 2014). Under the Pillar 3 Heads of Agreement, Smith discusses problems that might arise where decisions taken by the Scottish or UK Governments affect the fiscal position of the other. The report recommends that for "policy decisions that affect the tax receipts or expenditure of the other, the decision-making government will either reimburse the other if there is an additional cost, or receive a transfer from the other if there is a saving. There should be a shared understanding of the evidence to support any adjustments" (The Smith Commission, 2014, p. 23).

In the process whereby the principles of the Smith Commission report are being translated into legislation, it appears that this "no detriment" principle is being interpreted in a very narrow way (Cuthbert and Cuthbert, 2015; McEwen, 2015).[1] But concern over a more general application of the "no detriment" principle would appear necessary if the process of increased devolution is to work effectively. Where policy decisions in one region generate spill-over effects that influence economic activity in the other, there are *prima facie* efficiency losses if such spillovers are not acknowledged (Oates, 1972).

[1] Essentially, the principle is proposed to be activated if the direct spending and taxation decisions taken by the UK government differentially and directly affect the block grant transfer from the UK government to Scotland determined by the Barnett formula.

In this paper we construct a UK 2-region Social Accounting Matrix (SAM) to identify the trade and income flows between Scotland and the rest of the UK (RUK). We use this accounting framework to construct a purely demand-driven inter-regional SAM model with which to simulate the impact of devolved policies. In this model we assume full-fiscal autonomy for both regions. The primary aims are to identify the likely scale and the determinants of inter-regional spill-over effects in such a model. The work also draws attention to the importance of accurately measuring inter-regional trade if inter-regional spill-overs are to be reliably estimated.

Section 2 develops a stripped-down Keynesian two-region, demand-driven, analytical model. This is used to illustrate the nature of inter-regional interaction that would occur as a result of devolved policy initiatives. Section 3 outlines the construction of the two region (Scotland/RUK) Industry by Industry set of Input Output (IO) accounts for 2010 and the associated Social Accounting Matrix (SAM). These accounts provide the data required to undertake the SAM-based inter-regional modelling reported in Sections 4 and 5. Section 4 shows results from export shocks of the type that are the focus of Scottish Government's key sector policies. Section 5 models the demand-side impact of balanced budget fiscal expansions. Section 6 is a short conclusion.

2. Simple model

In the single-region analysis, Lecca *et al* (2014) identify two effects that accompany a fiscally-neutral expansion in public expenditure. One is an expansionary demand-side stimulus generated by a variant of the conventional balanced budget multiplier. The second is a potential negative supply-side impact coming from reduced competitiveness. This is associated with workers attempting to maintain their real take-home wage in the face of increased taxes. In this paper, for pedagogic reasons, we undertake analysis and simulations that focus solely on the demand-side impacts.[2] We consider first the effect of sector-specific export demand increases of the type that the Scottish Government expects from their key sector and internationalisation policies (Scottish Government, 2011; 2015). We then analyse the impact of a regional balanced-budget fiscal stimulus. This is similar to the kind of adjustment to public expenditure that will be allowed when the Smith Commission recommendations are introduced.[3] These impacts are examined in a two-region setting.

Analytical results are derived initially from a one-sector, two-region model of an economy in which there are no physical supply constraints. A demand-driven, extremely basic, Keynesian model is used where there is unemployed labour and productive capacity at the existing wage and price levels. We assume no savings or investment and no intermediate inputs. We also assume that a given proportion of

[2] Initial analysis encountered difficulty in disentangling the demand and supply-side impacts of fully-funded increases in public expenditure in this inter-region context. We will incorporate supply-side effects in future papers.

[3] For heuristic reasons we actually assume full-fiscal autonomy In these simulations, a more extreme level of self-financing than envisaged in the Smitth Report.

regional income goes to taxes and that there is full fiscal autonomy for each region. As the public sector budget balances in each region, the external sector balances also.

2.1 Basic Model

In this model, output for region *i*, Y_i, is determined by domestic consumption demand together with export demand from the other region, *j*, and the rest of the world, *R*. In the generic equation (1), this is expressed as a linear homogeneous function of the endogenous incomes of regions *i* and *j*, and the exogenous export demand from the rest of the world, X_{iR}:[4]

(1) $$\sum_j a_{ij} Y_j + X_{iR} = Y_i$$

The parameter a_{ij} gives the (combined private and public) consumption demand for the output of region *i* for each unit of income in region *j*. Expressed another way, it is the share of income in region *j* that is spent on the output of region *i*. Therefore for region *i*, $a_{ii}Y_i$ is the domestic regional demand and $a_{ij}Y_j$, the exports to region *j*.

In a two region system, the outputs for regions 1 and 2 can be represented by the familiar matrix expression:

(2) $$Ay + x = y \rightarrow \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} + \begin{bmatrix} X_{1R} \\ X_{2R} \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}$$

Manipulating equation (2) gives regional outputs as a function of endogenous foreign export demands:

(3) $$y = [1 - A]^{-1} x \rightarrow \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} \frac{1 - a_{22}}{Z} & \frac{a_{12}}{Z} \\ \frac{a_{21}}{Z} & \frac{1 - a_{11}}{Z} \end{bmatrix} \begin{bmatrix} X_{1R} \\ X_{2R} \end{bmatrix}$$

where $Z = (1 - a_{11})(1 - a_{22}) - a_{12}a_{21} > 0$

It is clear from equation (3) that these assumptions produce an interregional export-based model, where the level and composition of the rest of the world (ROW) exports determines output in both regions. Using this equation, we can read off directly the changes in output in regions *i* and *j* as a response to an exogenous change in ROW exports in region *i*. These are essentially multiplier values:

(4) $$\frac{\partial Y_i}{\partial X_{iR}} = \frac{1 - a_{jj}}{Z}, \quad \frac{\partial Y_j}{\partial X_{iR}} = \frac{a_{ji}}{Z}$$

---

[4] The exogenous export demand could be expressed, with no reduction in generality, as $X_{iR} = \alpha_{iR} Y_R$, where Y_R is taken as exogenous.

There is a temptation to differentiate these multiplier values with respect to the consumption coefficients to test for their sensitivity. However, we do not immediately follow that route because these parameters are proportions. Their values are governed by the requirements that:

(5) $$a_{ij} \geq 0 \quad \& \quad \sum_i a_{ij} = 1 \quad i = 1,2,R, \; j = 1,2$$

where a_{Rj} is the share of imports from the ROW in the public and private consumption in region *j*. This means that it is never possible to vary just one of these coefficients at a time. If we differentiate the multipliers represented in expression (4) by the individual coefficients in the standard manner each is varying with an equal and opposite change in the corresponding relevant coefficient for the consumption of ROW imports. However, we can more straightforwardly compare the multiplier values.

One interesting exercise is to calculate the impact on the national economy, represented by subscript N, of an increase in the exogenous foreign exports in one region.

(6) $$\frac{\partial Y_N}{\partial X_{iR}} = \frac{\partial Y_1}{\partial X_{iR}} + \frac{\partial Y_2}{\partial X_{iR}} = \frac{1 - a_{jj} + a_{ji}}{Z}$$

Using equations (5) and (6):

(7) $$\frac{\partial Y_N}{\partial X_{iR}} > \frac{\partial Y_N}{\partial X_{jR}} \text{ iff } \quad a_{Rj} > a_{Ri}$$

Inequality (7) shows that in this very simple case, the relative size of the impact on the national economy of a unit export shock in one region depends solely on the relative propensity for that region to consume foreign imports. That is to say, the region with the lower propensity to directly consume foreign imports will generate the bigger national multiplier. Crucially it doesn't depend on the relative size of the two regions or the degree or nature of their interdependence.

A second interest is the extent to which an exogenous demand shock in one region is dissipated to other regions. We again take as an example an exogenous foreign export shock to region *i*. We can define the share of the additional national income going to region *j* as the result of an exogenous foreign export shock in region *i*, σ_{ji}, as:

(8) $$\sigma_{ji} = \frac{\partial Y_j / \partial X_{i,R}}{\partial Y_N / \partial X_{i,R}}$$

Using equations (4), (6) and (8) gives

(9) $$\sigma_{ii} = \frac{1 - a_{jj}}{1 - a_{jj} + a_{ji}}, \; \sigma_{ji} = \frac{a_{ji}}{1 - a_{jj} + a_{ji}}$$

It is clear from equation (9) that region *j* will share some of the benefit that goes to the whole nation as a result of an expansion in the exports of region *i*. Where region *j* is large relative to region *i* we expect a_{ji} and a_{jj} to be relatively large. That is to say, we expect that the larger the region, the lower the proportion of its domestic demands will be supplied by the other region and the higher the expected proportion of its own domestic demand that will be supplied locally. Given that in this case the results are independent of the adjustment made to other parameters, differentiating σ_{ji} with respect to a_{ji} and a_{jj} gives:

$$(10)\ \frac{\partial \sigma_{ji}}{\partial a_{ji}} = \frac{1}{1 - a_{jj} + a_{ji}} \geq 0, \quad \frac{\partial \sigma_{ji}}{\partial a_{jj}} = \frac{a_{ji}}{(1 - a_{jj} + a_{ji})^2} \geq 0$$

Clearly, the larger the second region, the more likely it benefits from an increase in exogenous demand in the first region. The smaller region *i*, the greater will the spillovers to region *j*.[5] The Scottish economy is less than 10% of the size of the economy of the RUK. Do the original Smith recommendations suggest compensation in such cases where a stimulus spills-over to the other region? Of course we need good estimates of inter-regional trade flows to accurately calibrate an inter-regional model that would give reliable results.

2.2 Distinguishing between public and private expenditure

Up to now, we have made no distinction between private and public consumption. If the region's consumption is considered as a composite made up of public and private goods, this would be consistent with this composite remaining invariant as total regional income changes. However, a key concern is to analyse the impact of a fully-funded expansion in public expenditure in one region: that is to say, to investigate the effect on both regions of changing the composition of regional demand between private and public consumption within one region.

We retain all the central assumptions adopted in Section 2.1; each region *i* has an exogenous demand for its exports to the rest of the world, X_{iR}, there is no explicit intermediate demand and no private savings or investment. However, in the present case, each region sets a proportionate income tax rate, t_i, and has a balanced budget. This means that each region's consumption is therefore partly public, t_iY_i, and partly private $(1-t_i)Y_i$. Again the distribution of consumption expenditure, both public and private, is Leontief. The private coefficients take the form $\alpha_{i,j}$ and the public coefficients $\beta_{i,j}$. As in Section 2.1,

[5] The impact on the income of region j will actually be greater than that on region i iff $\partial Y_j/\partial X_{iR} > \partial Y_i/\partial X_{iR}$. This would require $a_{ji} > 1\text{-}a_{jj}$, which implies $a_{ji} > a_{ij} + a_{Rj}$. This would therefore occur if the propensity for consumers in region i to consume from region j is greater than the propensity for consumers in region j to consume from outwith the region (either from outwith the nation or from the other region).

the first subscript represents the region that is supplying and the second subscript the region which is consuming, and the α and β coefficients are again in the nature of shares, so that:

$$(11)\quad \sum_{i=1,2,R} \alpha_{i,j} = 1, \quad \sum_{i=1,2,R} \beta_{i,j} = 1 \quad \forall_j .$$

From the familiar requirement, used earlier in equation (1), that in each region demand equals production:

$$(12)\quad Y_i = \alpha_{ii}(1-t_i)Y_i + \beta_{ii}t_iY_i + \alpha_{ij}(1-t_j)Y_j + \beta_{ij}t_jY_j + X_{iR}$$

Rearranging equation (12) produces:

$$(13)\quad \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} \alpha_{11} + t_1\Delta_{11} & \alpha_{12} + t_2\Delta_{12} \\ \alpha_{21} + t_1\Delta_{21} & \alpha_{22} + t_2\Delta_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} + \begin{bmatrix} X_{1R} \\ X_{2R} \end{bmatrix}$$

where

$$(14)\quad \Delta_{ij} = \beta_{ij} - \alpha_{ij} .$$

We expect $\Delta_{ii} > 0$: that is to say, we expect the local intensity of expenditure on public goods to be greater than that intensity of expenditure on private consumption. We also expect $\Delta_{Ri} < 0$, so that the share of public expenditure going to foreign imports is lower than the share of household consumption that is imported. We are prepared to be ambivalent concerning the sign of Δ_{ji}, but note that given expressions (11) and (14), the accounting identity holds:

$$(15)\quad \sum_i \Delta_{ij} = 0 .$$

Using the familiar matrix inverse:

$$(16)\quad \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} 1-(\alpha_{11} + t_1\Delta_{11}) & -(\alpha_{12} + t_2\Delta_{12}) \\ -(\alpha_{21} + t_1\Delta_{21}) & 1-(\alpha_{22} + t_2\Delta_{22}) \end{bmatrix}^{-1} \begin{bmatrix} X_{1R} \\ X_{2R} \end{bmatrix} = \begin{bmatrix} \dfrac{1-\alpha_{22} - t_2\Delta_{22}}{V} & \dfrac{\alpha_{12} + t_2\Delta_{12}}{V} \\ \dfrac{\alpha_{21} + t_1\Delta_{21}}{V} & \dfrac{1-\alpha_{11} - t_1\Delta_{11}}{V} \end{bmatrix} \begin{bmatrix} X_{1R} \\ X_{2R} \end{bmatrix}$$

where $V = (1-\alpha_{11} - t_1\Delta_{11})(1-\alpha_{22} - t_2\Delta_{22}) - (\alpha_{12} + t_2\Delta_{12})(\alpha_{21} + t_1\Delta_{21})$

Essentially equations (13) and (16) replicate equations (2) and (3) but separately incorporate private and public expenditure. That is to say, with tax rates fixed, a_{ij} in equation (2) corresponds to $\alpha_{ij} + t_j\Delta_{ij}$ in equation (13). Therefore all the results derived in Sections 2.1 apply here if the tax rates remain unchanged. From equation (16):[6]

$$(17)\ \frac{\partial Y_i}{\partial X_{iR}} = \frac{1-\alpha_{jj}-t_j\Delta_{jj}}{V} > 0 \quad \frac{\partial Y_j}{\partial X_{iR}} = \frac{\alpha_{ji}+t_i\Delta_{ji}}{V} > 0$$

The expressions given in (18) replicate those given in equation (4) in Section 2.1. Both regions *i* and *j* gain from an expansion in the demand for exports in region *i* with the relative scale of those increases determined now by parameters which are the weighted sum of their private and public consumption values. However, we are more interested in analysing the demand-side impacts of changes in regional tax rates, with exogenous export demand held constant.

2.3 A tax neutral increase in public expenditure in region 1

Equation (16) shows that the regional incomes will depend upon the size of regional exports (the X_{iR} values). However we are also interested in analysing the impact of changes in regional tax rates. In this section, we therefore standardise and solve not for Y_1 and Y_2, but rather for the ratios of each region's output to their exogenous exports. This we define as y_{iR}, where:

$$(18)\ y_{iR} = \frac{Y_i}{X_{iR}}.$$

It is useful to introduce the parameter λ_{ij}, which is the ratio of the ROW exports to region i and j, so that:

$$(19)\ \lambda_{ij} = \frac{X_{iR}}{X_{jR}}.$$

Using equation (16) and (19) produces:

$$(20)\ y_{iR} = \frac{1-\alpha_{jj}-t_j\Delta_{jj}+\lambda_{ji}(\alpha_{ij}+t_j\Delta_{ij})}{V}.$$

Given that V is a function of t_i and t_j, a locally-funded increase in public expenditure in one region will, in general, have impacts on the income levels in both regions.

[6] It is straightforward to establish that V is positive. Using (12) and (16) V can be expressed as $V = [(\alpha_{21}+t_1\Delta_{21})+(\alpha_{R1}+t_1\Delta_{R1})][(\alpha_{12}+t_2\Delta_{12})+(\alpha_{R2}+t_2\Delta_{R2})]-(\alpha_{12}+t_2\Delta_{12})(\alpha_{21}+t_1\Delta_{21})$, which can be rearranged as $V = [(\alpha_{21}+t_1\Delta_{21})+(\alpha_{R1}+t_1\Delta_{R1})](\alpha_{R2}+t_2\Delta_{R2})+(\alpha_{12}+t_2\Delta_{12})(\alpha_{R1}+t_1\Delta_{R1})$. From (15) and the constraints on parameter values, we can deduce that each of the expressions of the form $a_{ij}+t_j\Delta_{i,j}$ in (14) is non-negative, so that V is non-negative. Moreover, for V to be zero requires $t_i, \beta_{ii}=1 \quad \alpha_{ii}=0 \quad \forall_i$. Using a similar argument, we can determine that all the elements of the inverse given in equation (17) are non-negative.

We model such a locally funded increase in public expenditure in region *i* by increasing the proportionate tax rate t_i. Such an increase means that a greater proportion of region *i*'s income will go to public, rather than private, consumption. This affects the proportion of income in region *i* that is spent on commodities produced in region *j* and the ROW, which will influence the total national income and its distribution between regions. Differentiating equation (20) produces:

$$(21)\ \frac{\partial y_{iR}}{\partial t_i} = \frac{-y_i}{V}\frac{\partial V}{\partial t_i}$$

and

$$(22)\ \frac{\partial y_{jR}}{\partial t_i} = \frac{\lambda_{ij}\Delta_{ji} - \Delta_{ii}}{V} - \frac{y_{jR}}{V}\frac{\partial V}{\partial t_i}$$

Using equations (15) and (16):

$$(23)\ \frac{\partial V}{\partial t_i} = -\Delta_{ii}(\alpha_{Rj} + t_j\Delta_{Rj}) + \Delta_{Ri}(\alpha_{ij} + t_j\Delta_{ij})$$

Given that we expect $\Delta_{ii} > 0$ and $\Delta_{Ri} < 0$, then $\frac{\partial V}{\partial t_i} < 0$. This implies that $\frac{\partial y_i}{\partial t_i} > 0$.

Essentially for region *i*, the movement of expenditure from private to public consumption simply increases the multiplier value. This derives from the fall in the propensity to import.

The impact in region *j*, and even the ability to sign $\frac{\partial y_j}{\partial t_i}$, is less straightforward. In the last term on the RHS of expression (22), we observe the same positive stimulus to the output in region j as experienced in region *i*. However, the first term on the RHS of expression (22), $(\lambda_{ij}\Delta_{ji} - \Delta_{ii})/V$, is likely to be negative. We expect Δ_{ii} to be positive and even if $\lambda_{ij}\Delta_{ji}$ is also positive, we would expect a higher share of public expenditure in region *i* to generate a larger shift towards the consumption of region *i* commodities than towards the consumption of goods from region *j*.[7] Therefore the existence of this negative term means that the impact on region *j* is expected to be less than that that on region *i*.

However, given our existing assumptions concerning parameter values, if Δ_{ji} is positive, the impact on region *j* must also be positive. This is supported by intuition. If both Δ_{ii} and Δ_{ji} are positive it implies that an increase in t_i increase the proportion of income in region *i* that goes to region *j* whilst at the same

[7] The weighting of Δ_{ji} here simply adjusts for the lower values of α_{ji} and β_{ji} if region j is small relative to region i.

time reducing the amount that goes to the rest of the world. With no change in the tax rate this must stimulate region *j*.

We here identify the demand-side impact on the region *j* of a fiscal expansion in region *i* in the most rudimentary of inter-regional models. It is evident that without undertaking more detailed simulation with actual figures, it is not possible to quantify the likely scale (and strictly even the sign) of these spill-over effects. If we were attempting to implement a wider Smith "no detriment" rule how could it be applied in this situation and what data would be used? Essentially it is unclear.

3 Construction of the UK inter-regional Social Accounting Matrix (SAM) accounts for 2010

The model in Section 2 is extremely rudimentary. However, even so it is not able to give definitive qualitative results for some key outcomes, which are shown to rest on the values of specific parameters. Therefore in Sections 4 and 5 we use interregional Input-Output (IO) and Social Accounting Matrix (SAM) models, calibrated on data from Scotland and the Rest of the UK, to generate comparable simulation results (Round, 2003). This extends the approach taken in Section 2 by incorporating within a numerical model sectoral disaggregation, intermediate inputs, a range of taxes and endogenous investment. However, conventional IO and SAM models still retain the key characteristics that economic activity is purely demand driven and the economic variables are determined by linear relationships, with excess productive capacity and labour supply.

First, we therefore need to construct a bi-regional Scotland-RUK SAM. At present, there is a dearth of reliable UK inter-regional data. The UK has no official consolidated set of regional Input-Output accounts. In fact the only official symmetric industry-by-industry (IxI) Input-Output table in the UK is for Scotland; there is no official UK table, though there is a Eurostat requirement to provide one. Especially problematic for the present study, the Allsopp Review (2004) recommended that the government should not collect data on UK interregional trade flows and the UK Government followed this recommendation (McVittie and Swales, 2007). There are Scottish international and inter-regional trade data but it is generally recognised that these are amongst the weakest elements of the Scottish aggregate accounts (Cuthbert, 2015). [8]

[8] The accuracy of official trade data for the UK as a whole has recently been subject to criticism. The UK Statistics Authority removed the title "National Statistics" from the Office for National Statistics data on imports and exports in November 2014 (UK Statistics Authority, 2015b). National statistics are characterised as those that "meet the highest standards of trustworthiness, quality and public value" (Financial Times, 2015). The UK Input Output Supply and Use tables have also recently lost the "National Statistics" standard which also means that the Scottish Input Output tables no longer have this status (UK Statistics Authority, 2015a).

HM Treasury and HMRC have commissioned a multi-sectoral four-region Computable General Equilibrium model of the UK economy (PwC Economics and Policy Team, 2014).[9] The model has subsequently been used to generate simulation results quantifying the impact on the Scottish economy of a potential balanced budget corporation tax change made by the Scottish Government (HM Treasury, 2014, p. 48). But the data base on which the model is calibrated is not in the public domain, moreover the constructed interregional trade data between the rest of the UK and Scotland do not appear to be consistent with the figures in the official Scottish Input Output accounts (PwC Economics and Policy Team, 2014, p. 13).[10]

In our own data set, we begin with the construction of the UK SAM. This is based on a UK Industry by Industry (IxI) analytical Input-Output Table. Unfortunately, the UK Office for National Statistics (ONS) does not supply the Input-Output accounts for the UK in this form. Furthermore ONS does not give access to a full set of Supply and Use tables that would enable the straightforward construction of the IxI table. The ONS only publishes a full Product by Product (PxP) IO table, a Use table and an incomplete Supply Table, where some of the entries are supressed due to disclosure and confidentiality issues (ONS, 2015). Therefore, to obtain a full IxI IO table, we use the reverse model transformation of Supply and Use tables to symmetric input-output tables following approach of Eurostat (2008).

Initially we derive the Supply Table using the information provided by the ONS:

$$(24)\ \mathrm{S} = \mathrm{A}^{-1}\mathrm{U}$$

where, *S* is the supply matrix (*P*x*I*), U is the Use matrix (*P*x*I*) and *A* is the matrix of coefficients obtained using R, which is the product by product transaction matrix. Therefore:

$$(25)\ \mathrm{A} = \mathrm{R}\hat{\mathrm{q}}^{-1}$$

where *q* is a vector of product output.

The resulting *S* matrix contains negative entries since *R* is a transaction matrix based on industry technology assumptions. We therefore proceed by transforming negative entries into positive values and rebalancing the matrix to maintain the original industry and product outputs in each sector. The balancing process is done by minimizing an entropy measure of distance matrix coefficients where prior information is given from the unbalanced S matrix.

[9] The four regions are Northern Ireland, Scotland, Wales and the rest of the UK (RUK).

[10] PwC Economics and Policy Team (2014) compare the direction of trade (whether Scotland is a net exporter or importer with the Rest of the UK) as identified in their initially estimated trade flows against the information given in the Scottish Input Output accounts. Their estimated trade flows differ in direction from those in the official Scottish data in 8 of the 19 industries. These sectors cover 20% of the trade volume and 39% of GDP. This is the only metric that has been made publically available.

Once S is balanced we can produce an industry-by-industry transaction matrix T based on fixed product sales structure assumption:

(26) $\mathrm{T} = \mathrm{DU}$

where

(27) $\mathrm{D} = \mathrm{S}\hat{\mathrm{g}}^{-1}$

and g is a vector of industry output. The following step to convert the products by final demand components matrix, Y, into an industry by components matrix, F, is as follows:

(28) $\mathrm{F} = \mathrm{DY}$.

Value added components and import vectors do not need to be treated given that they are already defined by industries from the Use matrix. The SAM blocks related to the allocation of primary income, secondary income distribution and savings are obtained from the UK income and capital accounts for households, government, corporation and rest of the world (ONS, 2014).

The second step is to construct the SAM for Scotland. A number of difficulties are faced in the compilation of some specific sub-matrices because the existing system of regional accounts is not comprehensive in its coverage, especially the regional income accounts. The starting point is the 2010 Input-Output Table for Scotland produced by the Scottish Government (2014). Data from the households and government income accounts given by the Scottish National Accounts Programme (SNAP, 2014) are used to fill the sub-matrices of the SAM. These sources are sufficient to obtain a detailed SAM. However, the lack of data on the secondary distribution processes inhibits a proper assembly of the sub matrix of income transfers between institutions in comparison to what is available for the UK. Therefore, where the information coming from the Scottish sources described above is not sufficient to split payments and receipts among institutions, we use shares derived from the UK SAM to determine the missing values.

Finally the SAM for the Rest of the UK (RUK) is obtained as a residual, meaning that the Scottish SAM is extracted from the UK SAM. Initially, some entries in the RUK transaction matrix were negative. This is most probably because the approaches used by the Scottish Government in building the IO Table for Scotland and by the ONS in the construction of the relevant UK accounts are not necessarily the same. Furthermore, we have had to construct the UK IO IxI Table using partial information and the rebalancing process applied to the UK Supply matrix increases the likelihood of negative values in the RUK Transaction matrix. In order to eliminate negative entries in the transaction matrix, we have aggregated the production activity in the final Scotland/RUK SAM into 18 economic sectors[11] and have shared value added at factor cost between labour income and operating surpluses. The latter is the non-labour value added at factor cost and includes rent, profit and other capital income. Domestic final demand

[11] Sectoral aggregation and classification is given in Appendix A, Table A1.1

comprises household and government consumption plus capital formation whilst external relationships are divided into interregional and international (the Rest of the World) categories.

4 Simulation results: ROW export shocks

In this section we report simulations using 2-region (Scotland/RUK) linear demand-driven models based around the data whose construction is detailed in Section 3. These models are rather more complex than the simple Keynesian analysis applied in Section 2, but they operate in a similar manner. All are models where prices are held fixed, no capacity or labour market constraints are imposed and economic activity is driven by changes in exogenous final demand. The various models used here all access the same data sources. These are the two-region IO and SAM accounts for 2010 shown in Tables A1.2 and A1.3 in the Appendix. The models all have 18 production sectors and identify savings and taxation, as well as imports, as expenditure withdrawals. They differ in the extent to which elements of final demand are treated as endogenous.

There are three conventional Input-Output models. The first is a standard Type I model. In this model household expenditure is held constant, so that the only element of endogenous expenditure is the indirect demand for intermediate inputs. That is to say, if demand in one sector increases, the output in sectors producing intermediate inputs will increase generating a Type I multiplier effect (Miller and Blair, 2009).

In Type II IO models, part or all of household expenditure is also endogenised. In these models the change in employment that accompanies a final demand disturbance is allowed to affect household income and to lead to subsequent induced changes in household consumption. Recall that these changes in household (and also government) consumption are the central elements of the basic Keynesian model used in Section 2. In the Type II IO model where only part of household consumption expenditure is endogenised, there is explicit recognition of non-wage elements of household income and these are assumed to remain constant (Emots-Holley et al, 2015). Where all household consumption is endogenised in the IO approach, household income is linked solely to economic activity which is proxied by wage income (Miller and Blair, 2009). Full endogenisation of household consumption necessarily generates larger multiplier values than partial endogenisation.

In the Social Accounting Matrix (SAM) models, household income is determined in a more complete way than is possible under IO because endogenous household income coming from both wages and (directly and indirectly) other value added is tracked (Emots-Holley et al, 2015; Round 2003). This implies that household consumption is always partially endogenised because the household consumption funded by transfers is held constant. However, in SAM models other elements of demand can be endogenised too. In the first, government expenditure is held fixed but investment is endogenised being driven in each sector by changes in the output of that sector.[12] In the second, we also endogenise government expenditure by recycling all changes in the local tax take to finance corresponding changes in public expenditure.

In Table 1 we report results from entering a £100 million export demand shock from the rest of the world (ROW) to each sector in the model. Given that there are 18 sectors, for each model we undertake 36 separate simulations. In each simulation we introduce the export shock in one sector in one region and report the total output effects in both the initiating region, the second region and for the UK as a whole. The full sets of results are given in Tables A1.5 to A1.8 in the Appendix. Table 1 summarises these results, reporting the average sectoral values for each model. Therefore, for example, with the IO Type I model, the average impact of a £100 million ROW export demand injection in Scotland is an increase in Scottish output of £146.7 million, RUK output of £36.9 million and UK output of £183.6 million.

As we would expect, as the degree of endogeneity increases, the multiplier values rise. There are big jumps in the multiplier values as household consumption is partially and then fully endogenised. There is a further large rise with the endogenous incorporation of government expenditure.[13] However, we are most interested in the comparison of the impacts within models across locations. Table 1 identifies clear and consistent patterns. In all models, the average UK impact of the exogenous demand shock is greater where the shock is applied to Scotland rather than the rest of the UK. Also, again in all models, the average spill-over demand effects from Scotland to RUK are proportionately greater than the corresponding spill-overs from RUK to Scotland.

Table 1: The average change in output for a £100 million increasing in Rest of World exports to each sector, with different degrees of demand endogeneity(£, million).

	Scottish simulations			RUK simulations		
	Scotland	RUK	UK	Scotland	RUK	UK
IO Type I	146.7	36.9	183.6	2.5	167.7	170.1
IO Type II (Partial)	178.2	67.4	245.6	4.3	214.4	218.7
IO Type II (Full)	211.5	114.6	326.1	7.2	276.2	283.4
SAM (Investment Endogenous)	222.9	123.2	346.0	7.9	278.2	286.1
SAM (Public Sector Endogenous)	347.8	308.8	641.6	18.7	480.5	499.2

[12] This is an accelerator mechanism generating a super-multiplier (Hicks, 1950). An alternative way to endogenise investment is to link investment expenditure to saving.
[13] The SAM multipliers which endogenise investment expenditure generate a smaller increase over the full Type II IO values for two reasons. First, investment expenditure makes a smaller contribution to final demand than household and government expenditure. Second, the SAM multiplier will not fully endogenise household consumption as the full Type II IO model does.

In comparing the total UK impact in more detail, for the IO Type I model there are 3 sectors where the impact is higher when the export shock is applied to the RUK rather than Scotland. These are the "Other primary", "Electricity transmission and distribution" and "Gas distribution etc." sectors. However, in the Type II and the SAM models, in every single sector the UK system-wide impact from a Scottish demand stimulus is greater than from an RUK stimulus.

Also the differential impact of the Scottish and RUK export shocks on the UK economy increases with greater endogeneity. For the IO Type I model, the average UK impact across sectors from exogenous Scottish demand shocks is 8% higher than for comparable RUK shocks. However, with the SAM model with endogenous government expenditure, the UK impact of the Scottish shock is now 29% higher than the comparable RUK figure.[14]

For the spill-overs to other regions, total Scottish output is 8.5% of the RUK output, so that for the same proportionate effects we would expect the impact from Scotland to RUK to be 11 times the impact from the RUK to Scotland. However, on average this figure is higher. In the IO Type I model, the Scottish spill-over is 14.9 times the RUK one and in the SAM model with endogenous government this is increased to 16.5 times.[15]

Also as the degree of endogenisation increases, the share of additional output that spills over to the second region increases. This interacts with the larger scale of the RUK economy, relative to Scotland, producing the position that in the simulations with the endogenous- government SAM model, on average the impact on the RUK economy is 48% of the total impact on the UK as a whole. This would mean that attempts by the Scottish Government to increase Scottish exports would deliver a demand stimulus to the RUK economy only slightly lower than the impact on the Scottish economy.

The compressed RUK and Scottish SAMs are given as Tables A1.2 and A1.3 in Appendix 1. A striking difference between the two tables concerns the trade relationships. For Scotland, the proportion of expenditure on intermediate inputs, household consumption, and capital formation that goes to imports from the rest of the world is much lower than for the RUK. On the other hand, the proportion that goes on RUK imports is greater than we would expect, just given the differences in the relative sizes of the two regions. The analysis in Section 2 strongly points to this as accounting for the differences in the size of the UK impacts and the distribution of these impacts across regions. However, we know that the reliability of the trade data at the regional level is suspect.

[14] The corresponding figures for the alternative models are: Type II (Part) = 12%, Type II (Full)=15% and SAM (Investment Endogenous) = 21%

[15] The Type II (Full) figure is 15.9 and the SAM (Investment Endogenous) is 15.6

5 Simulation results: balanced budget government expenditure shocks

We now consider a balanced-budget expansion in government expenditure of £100 million in each region in turn, using the SAM model with endogenous investment and government expenditure. In Section 2 we model a balanced budget expansion by increasing the share of aggregate expenditure going to public, as against private, consumption. In Section 4 we held the tax rates constant and varied the government expenditure as tax revenues changed. In this section, in order to standardise the initial shock, in each case we treat government expenditures as exogenous and vary the tax rates so as to generate a corresponding change in government revenue.

This implies that in each of the two simulations, in the target region government expenditure is exogenously increased by £100 million. With no change in tax rates, the regional government would be in deficit. The region's income tax rate is therefore increased until the additional tax revenue is raised to cover the additional expenditure, taking into account endogenous changes in economic activity. In the second region, government expenditure is held fixed but exports to the first region will be affected by the changes in activity in that region. The subsequent change in tax take in the second region will lead to an adjustment in its income tax rate again until the revenue collection returns to the original level.

Table 2 gives the distribution of public and household expenditure across the sectors and imports. Though there are some differences between the two public consumption vectors, both are heavily concentrated on the public admin, education and health sector. This sector has multiplier values a little higher than the average for this model but the general pattern of results is similar to the average. However, note that no government expenditure goes directly on imports from the rest of the world or the other region.[16]

For household consumption the situation is very different. Again the composition of expenditure on locally produced goods and services is very similar in the Scottish and rest of the UK economies. In both cases the top three categories are Real Estate, Construction and Wholesale and Retail and in both regions these three sectors make up around 60% of total household consumption expenditure on local goods. However, there are major difference is in the scale and composition of imports. In the rest of the UK 14.3% of household consumption is on foreign imports: in Scotland this is reported as 6.6%. However, for Scotland inter-regional imports (imports from the rest of the UK) make up 19.4% of household consumption, whilst for the rest of the UK this figure, which comprises imports from Scotland, is 1.2%.

[16] All public expenditure goes to domestic sectors but these sectors clearly import intermediate inputs.

Table 2: Distribution of £100m public expenditure across sectors for Scotland and RUK (%)

	Public sector		Households	
	RUK	Scotland	RUK	Scotland
Agriculture, forestry and fishing	0.00	0.00	0.82	1.26
Other primary	0.13	0.00	2.53	2.93
Food and drink	0.13	0.00	0.39	0.89
Textile, Leather, Wood, Paper, Printing	0.06	0.00	0.98	1.22
Chemicals and Pharmaceutical	0.07	0.00	0.15	0.39
Rubber, Cement, Glass, Metals	0.01	0.00	0.15	0.26
Electrical Manufacturing	0.13	0.00	0.75	1.17
Mechanical and Other Manufacturing (incl Repair)	0.16	0.00	2.26	2.73
Electricity, transmission and distribution	0.00	0.00	1.07	0.61
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	1.47	1.58	1.29	1.20
Water, sewerage and Waste	0.03	0.00	0.33	0.47
Construction - Buildings	0.58	0.07	17.86	16.20
Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	1.44	0.00	12.36	10.00
Information and Communication	0.30	0.39	2.71	2.02
Financial services, insurance and services	0.05	0.00	7.14	4.23
Real Estate, professional act., R&D	0.77	0.13	22.67	17.74
Pub. Admin, Education and Health	85.73	87.84	5.88	4.12
Other services	8.94	10.00	5.24	6.53
Interregional import	0.00	0.00	1.15	19.43
International import	0.00	0.00	14.27	6.62
Total	100.00	100.00	100.00	100.00

The difference is not that the percentages of household consumption expenditure made up of imports in the two cases are particularly out of line. If Scotland had the same foreign import propensity as the rest of the UK, and its inter-regional imports were proportional to the rest of the UK imports from Scotland, its household consumption import share would be 25.5% whereas the recoded import share is 26.1%. The big difference is the composition, with Scotland much more heavily weighted towards imports from the rest of the UK, and much smaller weight to imports from the rest of the World, than would be expected.

Table 3. Output, GDP and employment impact of a £100 million balanced budget public expenditure shock in each region (£ million) Balanced budget

	Scottish stimulus			RUK stimulus		
	Scottish	RUK	Total UK	Scottish	RUK	Total UK
Output	73.73	-12.82	60.91	-1.81	57.41	55.60
GDP	44.80	-5.53	39.28	-0.86	34.90	34.03
Employment FTE	1613	-150	1463	-19	1486	1467

With the present model, the impact of a balanced-budget expansion in either region leads to an increase in UK output and the output of the home region, whilst delivering a negative demand shock to the second region. This is particularly marked for Scotland, where a £100 million expansion in government expenditure generates an increase in output and GDP of £60.9 million and £39.3 million respectively in Scotland, but reduces RUK output and GDP by £12.8 and £5.5 million. There are similar, though less extreme effects on employment: in both cases the employment in the region with the balanced budget expansion and employment in the UK as a whole increases, whilst employment in the second region falls. It is clear that just considering demand effects, a fiscal expansion in one region has negative impacts on the second region. With present data this is particularly marked for expansions in Scotland.[17]

6 Conclusions

There are clear moves within the UK in favour of a greater decentralisation of economic policy making to the devolved governments of Northern Ireland, Scotland and Wales. There is also a stated aim to geographically rebalance the English economy through initiatives such as the Northern Powerhouse (Financial Times, 2014 HM; Treasury, The Right Hon. George Osborne, 2014). However, spill-overs between regional economies can lead to sub-optimal outcomes where decision making is devolved. This is highlighted by the "no detriment" requirement recommended by the Smith Commission in the operation of the enhanced fiscal powers recommended for the Scottish Parliament.

The UK is ill-prepared to model or track economic inter-regional interaction. Policy concern by successive UK governments has been ambivalent about the degree and nature of such interaction between regions (HM Government, 2010; Hildreth and Bailey, 2013). However, we know that the regional development literature emphasises inter-regional trade and factor flows and that there are many theories of regional growth which suggest positive or negative feedback effects between regions

[17] Interestingly if the parameter values implied by the inter-regional IO accounts are introduced into the simple Keynesian model outlined in Section 2 the results are shown in Appendix 1. In this case the impact on activity in the passive region is zero.

(Gardiner et al., 2013). In this paper we outline a very simple inter-regional demand-side model and attempt to use UK data to measure the size of regional policy spill-over effects within such a model. A primary aim of this exercise is to open up a discussion about the data and theory requirements for effective decentralised decision making in general and for operating the proposed devolved settlement between Scotland and the rest of the UK in particular.

One key result from our analysis in Section 4 is that the size of inter-regional interaction effects generated in the demand-driven IO and SAM models is large and increases with the endogenisation of government expenditure. The Smith Commission proposals give the devolved Scottish Government increased control over public expenditure but linked to a much greater degree of local funding. The problem here is that the incentive to undertake costly policies that generate a positive stimulus to the local economy will be discouraged if much of the benefit is actually felt elsewhere. With the existing data this seems to apply particularly to Scotland.[18] A widely interpreted no detriment rule would seem to imply compensation to the region providing the stimulus.

Section 5 suggests that the demand-side impacts of a fiscal expansion in one region are negative for the other region. In particular, for output and GDP, the negative impact on RUK is over 17% and 12% respectively of the positive impact on Scotland. Here it is important to note that for such policy direct supply-side (competitiveness) effects would be expected in the region undertaking the fiscal expansion as the tax rate would rise and this is likely to have impacts on the nominal wage and therefore prices. These supply-side effects are therefore expected to have impacts that operate in the opposite direction to those on the demand side. However, these IO and SAM simulations are enough to identify concern about the degree of regional interaction and potential negative spill-overs. Again, a more widely interpreted no detriment rule would seem to be applicable here.

In the inter-regional IO and SAM based models we identify significant and asymmetric impacts. Specifically, using the existing data, the Scottish economy seems particularly closely integrated through trade with the economy of the rest of the UK. If this reflects real differences in regional trade patterns, then this is important and needs to be reflected in decisions made by the devolved authorities. However, as we discuss in Section 3, the regional data, and especially regional trade data, are suspect. We make public here our set of inter-regional accounts with the hope that they can be improved upon by other researchers, the UK Office of National Statistics (ONS) or some other official UK Government source.[19] A key point in our analysis is that if the UK is to operate the proposed devolved settlement between Scotland and the rest of the UK successfully a more highly developed policy framework is required than is available at present. This involves more detailed and accurate inter-regional data and modelling. In this paper we take the first steps in constructing such a framework.

[18] However, the incentive to favour growth policies will be greater than under the present UK devolved fiscal arrangements.
[19] Copies of the inter-regional SAM Accounts are available from the authors.

References

Allsopp, C. (2004), *Review of Statistics for Economic Policymaking – Final Report, by Christopher Allsopp*, HM Treasury, HMSO, 2004.

Bell, D. and Eisner, D. (2014), *Scotland's Fiscal Future in the UK*, Stirling Management School Economic Research Reports, University of Stirling, Scotland, UK.

Cuthbert J. and Cuthbert, M. (2015), *Smith Commission: Why the Economic and Fiscal Arrangements Need to be Changed*, The Jimmy Reid Foundation, Glasgow.

Cuthbert, M. (2015), *Growing the Scottish Economy: is Scotland well served on international trade and development*, The Jimmy Reid Foundation, Glasgow.

Emonts-Holley, T. Ross, A. and Swales, J.K. (2015), "Type II errors in IO multipliers"**,** Strathclyde Discussion Papers in Economics, 15-04, Department of Economics, University of Strathclyde.

Eurostat (2008), "Eurostat Manual of Supply, Use and Input-Output Tables. Methodologies and Working Papers", 2008 Edition Eurostat, European Commission.

Financial Times (2014), "Supercity of North to Rival London Wins More Backing" October 21, 2014.

Financial Times (2015), "Office for National Statistics Under Fire Over Data Errors", June 1, 2015

Gardiner, B., Martin, R., Sunley, P. and Tyler, P. (2013), "Spatially Unbalanced Growth in the British Economy", *Journal of Economic Geography*

HM Government (2010), *Local Growth: Realising Every Place's Potential*, Cm 7961, HM Government.

HM Treasury (2014), *Scotland Analysis: Fiscal Policy and Sustainability*, HM Treasury, 2014,

HM Treasury, The Right Honourable George Osborne (2014), Chancellor, *We need a Northern Powerhouse*, speech delivered 23 June 2014, HM Treasury.
www.gov.uk/government/speeches/chancellor-we-need-a-northern-powerhouse

Hicks, J.R. (1950), *A Contribution to the Theory of Trade Cycle*, Oxford Economic Press, Oxford.

Hildreth, P. and Bailey, D. (2013), "The Economics Behind the Move to "Localism" in England", *Cambridge Journal of Regions, Economy and Society*, vol. 6, pp. 233-249.

Lecca, P., McGregor, P.G., Swales, J.K. and Yin, Y.P. (2014), "Balanced Budget Multipliers for Small Open Regions within a Federal System: Evidence from the Scottish Variable Rate of Income Tax", *Journal of Regional Science*, vol. 54, pp. 402-421.

McEwen, N. (2015), Wriitten Submission to the Scottish Finance Committee,
http://www.scottish.parliament.uk/S4_FinanceCommittee/General%20Documents/Professor_Nicola_McEwen.pdf

McVittie, E.P. and Swales, J.K. (2007), "The Information Requirements for an Effective Regional Policy: A Critique of the Allsopp Report", *Urban Studies*, vol. 44, pp. 425-438.

Miller, R. and Blair, P. (2009), *Input Output Analysis: Foundations and Extensions*, Cambridge University Press, Cambridge, UK.

ONS, 2014. United Kingdom Economic Account. http://www.ons.gov.uk/ons/rel/naa1-rd/united-kingdom-economic-accounts/index.html

ONS, 2015. Input-Output Supply and Use Tables. 2013 Edition. http://www.ons.gov.uk/ons/rel/input-output/input-output-supply-and-use-tables/index.html

Oates, W. E. (1972), *Fiscal Federalism*, New York: Harcourt Brace Jovanovich.

PwC Economics and Policy Team, (2014) *A multi-regional computable general equilibrium model of the UK economy: A report by PwC for HM Revenue and Customs*

Round, J. (2003), "Social Accounting Matrices and SAM-based Multiplier Analysis", Chapter 14 in F. Bourguignon and L.A. Pereira da Silva eds., *Techniques and Tools for Evaluating the Poverty Impact of Economic Policies*, World Bank and Oxford University Press.

Scottish Government (2011), *The Government Economic Strategy*, The Scottish Government, Edinburgh.

Scottish Government (2015), *Scotland's Economic Strategy, March 2015*, The Scottish Government, Edinburgh.

Scottish Government (2014). Input Output Tables.
http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads
SNAP (2014) Scottish National Accounts Programme.
http://www.gov.scot/Topics/Statistics/Browse/Economy/SNAP

The Smith Commission (2014), *The Smith Commission: Report of the Smith Commission for further devolution of powers to the Scottish Parliament*, The Smith Commission, Edinburgh.

UK Statistics Authority (2015a), *Assessment of Compliance with the Code of Practice for Official Statistics, The UK National Accounts: Supply and Use Tables and Input-Output Tables (produced for the Office of National Statistics)*, UK Statistics Authority, London.

UK Statistics Authority (2015b), *Assessment of Compliance with the Code of Practice for Official Statistics, Statistics on UK Trade (produced for the Office of National Statistics)*, UK Statistics Authority, London.

Appendix: The impact of tax changes where $\beta_{ii} = 1$.

In the Scottish Input-Output accounts, the public sector purchases only from the home region (Scotland). This implies that $\beta_{ii} = 1$ and $\beta_{ij}, \beta_{Ri} = 0$. Imposing these values produces the following versions of equation (13):

$$(29)\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} \alpha_{11} + t_1(1-\alpha_{11}) & \alpha_{12} - t_2\alpha_{12} \\ \alpha_{21} - t_1\alpha_{21} & \alpha_{22} + t_2(1-\alpha_{22}) \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} + \begin{bmatrix} X_{1R} \\ X_{2R} \end{bmatrix}$$

Through the conventional matrix inversion:

$$(30)\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} \frac{(1-\alpha_{22})}{(1-t_1)Z} & \frac{\alpha_{12}}{(1-t_1)Z} \\ \frac{\alpha_{21}}{(1-t_2)Z} & \frac{1-\alpha_{11}}{(1-t_2)Z} \end{bmatrix} \begin{bmatrix} X_{1R} \\ X_{2R} \end{bmatrix}$$

Where Z is as in equation (3) but here the parameter values apply only to the composition of the private consumption.

Equation (30) can be restated, using equations (18) and (19), as:

$$(31)\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} \frac{(1-\alpha_{22}) + \lambda_{21}\alpha_{12}}{(1-t_1)Z} \\ \frac{(1-\alpha_{11}) + \lambda_{12}\alpha_{21}}{(1-t_2)Z} \end{bmatrix}$$

Therefore:

$$\frac{\partial y_1}{\partial t_1} = \frac{y_1}{1-t_1}, \quad \frac{\partial y_2}{\partial t_1} = 0.$$

In this case there is no net feedback from tax changes in one region to activity in the second. Although the proportion of the income from region 1 that goes on the output of region 2 will fall, this will be just offset by the increase in total output in region 1.

Appendix A

Table A1.1: Sector classification

SIC 2007 (106 sectors)	Description
1-4	Agriculture, forestry and fishing (all primary)
8-18	Food and drink
19-24	Textile, Leather, Wood, Paper, Printing
5,25-29, 31-32	Chemicals and Pharmaceutical
33-39	Rubber, Cement, Glass, Metals
40-41	Electrical Manufacturing
42-51	Mechanical and Other Manufacturing (incl. Repair)
52	Electricity, transmission and distribution
53	Gas; distribution of gaseous fuels through mains; steam and air conditioning supply
54-57	Water, sewerage and Waste
58	Construction - Buildings
59-60	Wholesale and Retail Trade
62-70	Transportation and Storage, accommodation, food and services
71-73	Information and Communication
74-76	Financial services, insurance and services
77-92	Real Estate, professional act., R&D
93-95	Pub. Admin, Education and Health
96-106	Other services

Table A1.2: One sector RUK SAM, 2010, £ million

	Sectors	Labour income	Gross operating surplus	Net indirect taxes	Households	Corporation	Government	Capital formation	Stock	Rest of Scotland	Exports to ROW	Totals
Sectors	913149	0	0	0	681838	0	305522	158215	1457	47529	391311	**2499021**
Labour income	737407	0	0	0	0	0	0	0	0	-2040	1097	**736464**
Gross operating surplus	465142	0	0	0	0	0	0	0	0	0	2	**465144**
Net indirect taxes	72950	0	0	0	73376	0	-910	8033	25	0	7695	**161169**
Households	0	734978	165461	0	1542	176655	231103	0	0	61	-7903	**1301897**
Corporation	0	0	288407	0	101805	108881	40967	0	0	0	6414	**546474**
Government	0	0	11276	161169	283164	43077	168	0	0	-20426	199	**478625**
Capital formation	0	0	0	0	35779	217862	-98224	0	0	7718	39542	**202677**
Stock	0	0	0	0	0	0	0	2175	0	0	0	**2175**
Rest of Scotland	21887	0	0	0	9310	0	0	1599	46	0	0	**32842**
Rest of the World	288486	1486	0	0	115083	0	0	32655	647	0		**438356**
Totals	**2499021**	**736464**	**465144**	**161169**	**1301896**	**546474**	**478625**	**202677**	**2175**	**32842**	**438356**	

Table A1.3: One sector Scottish SAM, 2010, £million

	Sectors	Labour income	Gross operating surplus	Net Indirect taxes	Households	Corporation	Government	Capital formation	Stock	Rest of the UK	Exports to ROW	Totals
Sectors	62632	0	0	0	52835	0	31016	14179	-192	32842	18847	**212159**
Labour income	64389	0	0	0	0	0	0	0	0	2040	0	**66429**
Gross operating surplus	39356	0	0	0	0	0	0	0	0	0	0	**39356**
Net Indirect taxes	5671	0	0	0	7541	0	910	1903	0	0	0	**16025**
Households	0	66429	11300	0	0	15455	23070	0	0	-61	-2879	**113314**
Corporation	0	0	23832	0	7125	0	9652	0	0	0	0	**40609**
Government	0	0	4224	16025	21747	2709	0	0	0	20426	-484	**64649**
Capital formation	0	0	0	0	5453	22444	0	0	0	-7718	477	**20656**
Stock	0	0	0	0	0	0	0	2	0	0		**2**
Rest of the UK	30143	0	0	0	13885	0	0	3362	139	0		**47529**
Rest of the World	9968	0	0	0	4728	0	0	1210	55			**15962**
Totals	**212159**	**66429**	**39356**	**16025**	**113315**	**40609**	**64649**	**20656**	**2**	**47529**	**15962**	

Table A1.4: IO Type I, absolute changes, £ millions

	Scottish Simulation			RUK simulation		
	Scott	RUK	UK	Scott	RUK	UK
Agriculture, forestry and fishing	159.00	53.97	212.97	3.36	175.09	178.44
Other primary	153.31	43.91	197.22	4.05	199.73	203.78
Food and drink	158.82	42.60	201.42	1.97	155.11	157.08
Textile, Leather, Wood, Paper, Printing	119.52	63.71	183.23	4.87	139.47	144.34
Chemicals and Pharmaceutical	148.71	37.83	186.54	2.13	158.47	160.60
Rubber, Cement, Glass, Metals	139.09	32.33	171.42	1.84	162.17	164.02
Electrical Manufacturing	151.18	40.69	191.87	2.60	177.22	179.82
Mechanical and Other Manufacturing (incl. Repair)	212.36	37.22	249.58	4.64	224.15	228.80
Electricity, transmission and distribution	127.64	55.89	183.52	3.37	197.07	200.44
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	132.39	25.81	158.20	1.92	169.48	171.39
Water, sewerage and Waste	170.04	33.30	203.34	2.12	179.15	181.27
Construction – Buildings	141.92	30.18	172.10	1.77	163.84	165.61
Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	143.02	32.52	175.54	2.02	165.50	167.52
Information and Communication	133.71	27.12	160.83	1.25	143.55	144.80
Financial services, insurance and services	141.06	29.82	170.88	1.84	155.95	157.79
Real Estate, professional act., R&D	134.26	29.40	163.66	1.79	153.45	155.24
Pub. Admin, Education and Health	130.76	24.98	155.74	1.06	140.35	141.41
Other services	144.14	22.18	166.32	1.87	158.05	159.91
Average	*146.72*	*36.86*	*183.58*	*2.47*	*167.66*	*170.13*
weighted average	*144.66*	*32.49*	*175.13*	*2.12*	*160.02*	*162.23*

Table A1.5: IO TYPE II (partial), absolute changes. £ millions

	Scottish simulation			RUK simulation		
	Scottish	RUK	UK	Scottish	RUK	UK
Agriculture, forestry and fishing	181.27	82.50	263.77	5.15	215.73	220.88
Other primary	182.66	75.02	257.69	6.31	251.19	257.49
Food and drink	192.35	76.86	269.22	3.75	202.26	206.01
Textile, Leather, Wood, Paper, Printing	131.89	84.30	216.19	6.72	165.32	172.04
Chemicals and Pharmaceutical	185.23	72.57	257.80	3.92	204.93	208.85
Rubber, Cement, Glass, Metals	172.57	64.06	236.63	3.70	212.02	215.72
Electrical Manufacturing	187.59	76.51	264.10	4.64	227.71	232.35
Mechanical and Other Manufacturing (incl. Repair)	228.33	56.32	284.66	6.21	252.65	258.86
Electricity, transmission and distribution	145.21	78.09	223.30	4.85	226.18	231.02
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	158.87	50.47	209.34	3.55	211.96	215.51
Water, sewerage and Waste	208.30	68.08	276.38	3.95	225.58	229.53
Construction – Buildings	180.86	65.00	245.86	3.84	221.57	225.41
Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	181.20	67.32	248.51	4.06	220.74	224.80
Information and Communication	176.16	63.73	239.89	3.08	196.72	199.81
Financial services, insurance and services	171.53	58.99	230.52	3.59	202.07	205.66
Real Estate, professional act., R&D	160.92	55.53	216.46	3.36	194.14	197.50
Pub. Admin, Education and Health	181.11	65.65	246.77	3.33	209.80	213.13
Other services	180.60	52.78	233.38	4.04	218.05	222.09
Average	*178.15*	*67.43*	*245.58*	*4.34*	*214.37*	*218.70*
weighted average	*179.50*	*64.56*	*241.95*	*4.04*	*210.49*	*214.65*

Table A1.6: IO TYPE II (full), absolute changes. £ millions

	Scottish simulation			RUK simulation		
	Scottish	RUK	UK	Scottish	RUK	UK
Agriculture, forestry and fishing	205.03	124.97	330.00	7.85	269.54	277.39
Other primary	213.84	122.46	336.30	9.70	319.32	329.02
Food and drink	227.95	129.38	357.33	6.56	264.63	271.19
Textile, Leather, Wood, Paper, Printing	145.18	114.12	259.30	9.18	199.70	208.89
Chemicals and Pharmaceutical	223.95	126.36	350.31	6.74	266.38	273.12
Rubber, Cement, Glass, Metals	208.05	113.22	321.28	6.64	277.95	284.59
Electrical Manufacturing	226.21	131.69	357.90	7.80	294.51	302.31
Mechanical and Other Manufacturing (incl. Repair)	245.35	85.00	330.34	8.43	290.45	298.88
Electricity, transmission and distribution	163.96	111.19	275.15	6.97	264.76	271.73
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	186.93	88.78	275.70	6.12	268.16	274.28
Water, sewerage and Waste	248.83	122.31	371.15	6.80	287.00	293.79
Construction – Buildings	222.09	119.45	341.54	7.17	297.89	305.06
Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	221.63	121.57	343.20	7.31	293.79	301.10
Information and Communication	221.09	121.31	342.39	6.07	267.01	273.08
Financial services, insurance and services	203.84	104.13	307.96	6.35	263.06	269.42
Real Estate, professional act., R&D	189.20	95.83	285.03	5.83	247.96	253.79
Pub. Admin, Education and Health	234.34	130.34	364.68	7.10	301.58	308.68
Other services	219.16	101.13	320.29	7.52	297.40	304.92
Average	*211.48*	*114.62*	*326.10*	*7.23*	*276.17*	*283.40*
weighted average	*216.42*	*114.45*	*328.66*	*7.09*	*277.25*	*284.47*

Table A1.7: SAM (Investment Endogenous), absolute changes. £ millions

	Scottish Simulation			RUK Simulation		
	Scottish	RUK	UK	Scottish	RUK	UK
Agriculture, forestry and fishing	252.88	161.18	414.06	9.92	302.40	312.32
Other primary	228.30	133.80	362.10	10.06	302.23	312.29
Food and drink	227.07	126.41	353.48	6.46	247.52	253.98
Textile, Leather, Wood, Paper, Printing	162.30	139.15	301.45	11.22	236.38	247.60
Chemicals and Pharmaceutical	215.38	115.73	331.10	6.39	242.40	248.80
Rubber, Cement, Glass, Metals	197.86	102.21	300.07	6.48	260.49	266.97
Electrical Manufacturing	216.85	121.90	338.75	7.44	270.04	277.47
Mechanical and Other Manufacturing (incl. Repair)	281.09	118.83	399.92	10.21	314.04	324.24
Electricity, transmission and distribution	179.65	133.84	313.49	8.51	288.43	296.94
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	222.15	114.09	336.24	7.70	297.23	304.93
Water, sewerage and Waste	257.37	122.47	379.84	7.78	302.55	310.33
Construction – Buildings	227.19	117.91	345.10	7.31	287.33	294.64
Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	217.89	116.46	334.34	7.43	280.91	288.34
Information and Communication	218.27	118.00	336.26	6.43	262.89	269.32
Financial services, insurance and services	225.76	123.70	349.46	7.65	283.87	291.52
Real Estate, professional act., R&D	235.42	127.44	362.86	8.08	297.83	305.91
Pub. Admin, Education and Health	212.93	108.93	321.86	5.89	252.84	258.73
Other services	232.90	114.90	347.81	7.48	278.31	285.79
Average	*222.85*	*123.16*	*346.01*	*7.91*	*278.20*	*286.12*
weighted average	*227.02*	*120.77*	*345.58*	*7.66*	*278.88*	*286.57*

Table A1.8 SAM (Public Sector Endogenous) absolute changes. £ millions

	Scottish simulation			RUK simulation		
	Scottish	RUK	UK	Scottish	RUK	UK
Agriculture, forestry and fishing	312.66	323.63	636.29	19.59	456.56	476.15
Other primary	329.50	315.51	645.01	21.01	493.11	514.13
Food and drink	335.41	313.29	648.70	15.76	427.40	443.16
Textile, Leather, Wood, Paper, Printing	224.28	285.29	509.57	22.19	390.89	413.08
Chemicals and Pharmaceutical	329.43	300.16	629.59	15.47	415.81	431.28
Rubber, Cement, Glass, Metals	293.32	260.68	554.00	16.09	448.09	464.18
Electrical Manufacturing	322.24	302.82	625.07	17.43	455.42	472.85
Mechanical and Other Manufacturing (incl. Repair)	381.43	290.08	671.51	20.30	475.64	495.93
Electricity, transmission and distribution	253.29	287.13	540.42	18.21	453.39	471.60
Gas; distribution of gaseous fuels through mains; steam and air conditioning supply	352.12	313.81	665.93	19.58	531.36	550.94
Water, sewerage and Waste	378.23	318.98	697.21	19.32	526.66	545.98
Construction – Buildings	361.61	324.48	686.09	19.28	530.12	549.40
Wholesale and Retail Trade, Transportation and Storage, accommodation, food and services	350.58	319.97	670.55	19.00	511.57	530.56
Information and Communication	346.82	319.82	666.64	16.97	476.80	493.77
Financial services, insurance and services	351.23	327.39	678.62	19.37	513.14	532.52
Real Estate, professional act., R&D	354.52	327.57	682.09	19.68	517.93	537.61
Pub. Admin, Education and Health	350.75	311.40	662.15	17.40	502.30	519.70
Other services	363.71	315.63	679.34	19.62	522.60	542.22
Average	*332.84*	*308.76*	*641.60*	*18.68*	*480.49*	*499.17*
weighted average	*347.48*	*316.03*	*661.68*	*18.96*	*498.84*	*517.83*

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