

Growth Incentives and Devolved Fiscal Systems*

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Abstract

This paper explores the characteristics of a range of stylised devolved fiscal systems which have been applied, or proposed, as a means of funding the devolved Scottish Government. The central aim is to identify those schemes that most effectively provide incentives for the pursuit of growth promoting policies by the regional government. Using simulations with an intertemporal, computable general equilibrium model for Scotland, it did not prove possible to uniquely rank a range of devolved fiscal systems in terms of the extent of growth incentive that they provide. Moreover, rather counter-intuitively, tax-sharing regimes do not necessarily improve growth incentives relative to more basic block grants.

Keywords: Regional fiscal autonomy; regional fiscal systems; applied general equilibrium; growth incentives.

JEL codes: D58, R13, R15, H24, H71

*The authors are grateful for the comments of three anonymous Referees and an Associate Editor, which have significantly improved the paper. We also acknowledge the comments of participants at the European Regional Science Association Conference, Cork, 2018, and the International Input Output Conference, Glasgow, 2019, for comments on earlier versions of this paper.

Introduction and background

Until recently the budgets for the UK devolved authorities in Northern Ireland, Scotland and Wales were primarily funded through a block grant from the central government. The levels of these grants were unrelated to the tax revenue raised within the associated territories. However, for those policy areas for which they have responsibility, these devolved authorities had, and still have, complete freedom to spend their budgets in ways which match their local priorities.ⁱ There is no imposed ring-fencing. Moreover, the hard budget constraint, together with limited borrowing powers, enforced financial accountability.

Nevertheless, the Scottish Government has argued that this fiscal mechanism restricts Scottish growth. In particular, if Scotland were to raise all its own revenue, in a system of full fiscal responsibility, this "... would provide the Scottish Government with greater ability to capture, and recycle, the benefits of successful policy approaches - in the form of increased tax receipts and reduced welfare payments - providing the opportunity for the full fiscal benefits (or costs) of any major policy changes to accrue to the Scottish budget" (Scottish Government, 2017).

As a result of promises made before the 2014 Scottish Independence referendum, negotiations with the UK government have resulted in an increased degree of devolved revenues. The UK government also have similar, but separate, ongoing negotiations with the asymmetrically devolved Northern Irish and Welsh administrations. There are a number of channels through which fiscal decentralisation could influence economic outcomes. Therefore giving devolved authorities responsibility for funding local expenditure through local taxation could stimulate economic activity (Martinez-Vazquez and McNab, 2003). At the very least, such a system would increase the value that both a rational voter, and a budget-

maximising local politician, would attach to growth-inducing policies as against present public consumption.

With greater fiscal devolution, concern typically centres around the trade-off between incentives, risk sharing and cumulative processes that could deplete the tax base of those regions most in need of public expenditure. However, this paper focusses on a more fundamental issue; even if it were desirable to encourage higher regional growth, would a change in the fiscal mechanism that determines the devolved budget provide appropriate fiscal incentives? Moreover, how big is the incentive that alternative devolved fiscal mechanisms deliver?

In the paper we investigate, in a general equilibrium setting, the impact that generic demand and supply-side growth policies would have on the region's budget under a number of devolved fiscal mechanisms. The analysis employs Computable General Equilibrium (CGE) simulation using a variant of the AMOS stand-alone regional model for Scotland.

We adopt the stand-alone model because the paper's aim is not to derive an optimal federal fiscal mechanism that trades off different considerations important to the national government. Rather the focus is whether actual devolved fiscal procedures encourage local growth policies by rewarding successful regions with additions to their budget. In this respect, from the perspective of a small-region decision maker, motivated by outcomes in its own jurisdiction only, the second order feedback effects from the rest of the country can almost always be ignored.

Both demand- and supply-driven growth policies are analysed because both are used by devolved administrations. We specify these in a generic way to focus attention on the mechanisms that determine the devolved budget. We also assume that these policies are

fiscally neutral. What this really amounts to in the context of the model is that these policies have to be funded through the devolved budget and the cost is in terms of the alternative public goods that have to be given up. We are not suggesting that the simulation results can provide a judgement on whether the devolved authority should go ahead with either or both of these growth policies. Rather, we are concerned with whether the devolved fiscal mechanism in operation increases (or fails to increase) the desirability of the implementation of growth policies.

Whilst these issues have resonance in the UK, they are of importance for an understanding of a key aspect of devolved fiscal systems in general. The analysis has wide applicability in that it considers various degrees of fiscal autonomy, but the specific details of particular fiscal mechanisms and economic conditions can play a key role in determining the impact. Our focus is on an individual UK devolved region, Scotland. All of the schemes analysed in this paper have either been argued for, or actually applied in, Scotland as part of the UK's devolved fiscal arrangements.

Economic outcomes and the fiscal federalism literature

Such has been the growth in research in this area that authors now consider two branches of the field: first and second generation of theories of fiscal decentralisation (Oates, 2005). Hong Vo (2010) gives an excellent summary and Oates (1999) early reflections on this literature. The later work emphasises that the economic effectiveness of decentralisation depends not only on the context in which it is implemented (although regional heterogeneity and spillovers remain crucial), but also on whether the resulting institutional structures incentivise efficient decision making. With that in mind, it is not surprising that empirical analysis of decentralised economic outcomes fails to reach a comprehensive conclusion either way.

Martinez-Vazquez et al. (2016) provides a review including a detailed discussion of the methodological challenges such studies face.

A number of studies have tested for links between decentralisation and economic growth. Evidence for a positive relationship is found in Akai and Sakata (2002), Buser (2011), Iimi (2005) and Gemmell et al. (2013) whereas Baskaran and Feld (2013), Davoodi and Zuo (1998) and Rodriguez-Pose and Ezcurra (2011) suggest a negative link. Other work finds non-linear effects (Thiessen, 2003) or no relationship at all (Thornton, 2007). In summary, the fiscal decentralisation literature does not point unequivocally to the transfer of powers to regional and local governments as automatically leading to better or poorer economic outcomes. Instead, it serves to identify the importance of the appropriate design of the fiscal institutions upon which any system is built.

The present paper seeks to contribute to this literature by developing a general framework to assess the potential incentive effects of different stylised fiscal regimes, and to illustrate its implementation using the case study of Scotland. All the regimes studied have been advocated for, or applied to, Scotland (and to other regions of the U.K. and Europe). To understand the impact of fiscal systems on growth it is necessary to be able to identify the avenues through which incentives are shaped – or can be shaped – by the design of the devolved fiscal mechanisms that facilitate greater decentralisation.

The next section provides an overview of our approach. We then outline a number of stylised fiscal systems, reflecting varying degrees of fiscal decentralisation. There follows a summary of our CGE model of the Scottish economy and we then analyse the impact of generic demand and supply side regional policies on a range of key variables. Next we explore the determination of the devolved government's budget under the alternative fiscal regimes and

then compare the impact of recycling the tax revenues to increase government expenditure across the various fiscal arrangements. Finally, we present our conclusions.

Overview

Our primary focus is the extent to which different devolved systems fiscally reward (and therefore encourage) strategies that increase local economic activity. Envisage j alternative devolved fiscal systems, each delivering a regional budget, b_j , depending on the values of the elements of a vector, $\underline{\rho}$, of local economic and demographic variables, so that:

$$(1) \quad b_j = b_j(\underline{\rho})$$

The variables in the $\underline{\rho}$ vector can be influenced by demand- or supply-side local policy interventions aimed at stimulating economic output. Examples of such policies are: improvements in export promotion; better targeting of skill training; and reductions in commercial red tape.ⁱⁱ

Our concern here is with policies delivered in the context of a specific, fixed tax framework. We do not investigate the effect of a devolved authority's ability to vary exogenously aggregate local public expenditure or to manipulate tax rates. The growth initiatives are therefore financed through the devolved budget with our focus on the fiscal interaction between the devolved regional and the national governments.

The impact of a local growth policy intervention will depend on the strength of the policy and the economic environment in which it is applied. Imagine that we have k types of policy

intervention with their strength identified generically as π_k , and that there are n different economic environments, which we here refer to as model configurations.ⁱⁱⁱ This means that where policy, k , is applied in an economy, n , the outcome in terms of key endogenous variables can be represented as:

$$(2) \quad \underline{\rho} = e_n(\pi_k)$$

Equation (2) is simply a reduced-form representation of whatever economic model is being used, where the exogenous policy shock is represented by π_k and the endogenous response of relevant variables, $\underline{\rho}$. Putting together these two steps, shown in equations (1) and (2), the procedure can be represented as:

$$(3) \quad b_j = b_j(e_n(\pi_k))$$

Equation (3) shows the chain that links the change in policy, k , delivered to a devolved economy configured as n to the impact on the devolved budget under the fiscal mechanism j . An alternative way of expressing this is:

$$(4) \quad \frac{db_j}{d\pi_{k,n}} = \sum_i \frac{\partial b_j}{\partial \rho_i} \frac{\partial \rho_i}{\partial \pi_{k,n}}$$

where ρ_i is the i th element of the vector $\underline{\rho}$ and the dot notation indicates proportionate changes, so that, for example, $\dot{b}_j = \frac{b_{j,t}}{b_{j,0}}$.^{iv} Equation (4) can be expressed in matrix form as:

$$(5) \quad Q = B\Pi$$

In equation (5) Q is a $j \times q$ matrix where j is the number of fiscal schemes and q is the $k \times n$ number of policy/economic model configurations. The entry in the r th row and the s th column in the Q matrix is the value of $\frac{db_r}{d\pi_s}$: that is, the sensitivity of the devolved budget under the

fiscal mechanism r to changes in the strength of economy/policy combination s . B and Π are $j \times i$ and $i \times q$ matrices. The entries in the r th row and the s th column of these matrices are $\frac{\partial b_r}{\partial \rho_s}$ and $\frac{\partial \hat{p}_s}{\partial \pi_r}$ respectively.

In the discussion that follows, we use the matrix form as a convenient way to tabulate the various responses of the devolved budgets and economic variables.

Regional Fiscal Systems: The B Matrix

We locate this analysis within a devolved fiscal system in which responsibility for delivering public goods in the devolved region is divided between the national government and the devolved authority. We focus here solely on the way in which the budget to the devolved authority is determined and in particular on the degree to which this encourages policy decisions that will increase local economic activity. We consider three main devolved fiscal mechanisms; block grant, tax-sharing and full tax autonomy. These capture the main generic mechanisms that have characterised the actual and potential future development of regional fiscal systems in the UK and have been important elements of fiscal decentralisation elsewhere (Kim et al, 2013).^v

In the block grant systems, the devolved authority is funded solely by a transfer from the central government. This transfer is not directly related to the tax revenue raised in the devolved territory. Tax sharing mechanisms are intermediate cases in which some sharing of the local tax base between the national and devolved governments operates in conjunction with an adjusted block grant. Finally, in full tax autonomy we assume that the devolved

authority's collects all the tax revenue raised within its own territory and after returning a fixed amount to the central authorities has the remainder as the devolved budget. We do not consider needs-based grant systems which we take to be antithetical to the encouragement of growth from the standpoint of standard economic theory.

Formulae specifying the particular devolved fiscal mechanisms, including a number of variants, are shown in Table 1, where the absolute value for the initial devolved budget is b_0 . Note that individual fiscal mechanisms are identified by the appropriate subscript. In Table 1: λ^F the full (total) tax base per employee, λ^S is the shared tax base per employee, ε is the employment rate (employee/labour force); γ is the participation rate (labour force/population); p is population; α is the share of budget in the base period covered by the local tax take in the tax sharing simulations, and β is the share of the base year local tax take that goes to the central government as the region's contribution to fund centrally determined public services in the full tax autonomy simulations; and the t subscript indicates time period.

[Table 1 near here.]

It will prove useful to express the appropriate regional tax base in time period t , τ_t^Z , as:

$$(6) \quad \tau_t^Z = p_t \gamma_t \varepsilon_t \lambda_t^Z$$

In equation (6) λ_t^Z is the relevant tax base per employee with the total (full) or shared tax bases identified by the superscripts $Z = F, S$ respectively. The variables on the RHS of the identity given as equation (6) can be thought to comprise the elements of the ρ vector discussed in the previous section.^{vi}

Table 2 identifies the B matrix introduced in equation (5) for the fiscal mechanisms that we studied in this paper. Each row gives the responsiveness of the devolved budget under that fiscal scheme to changes in each of the endogenous local variables which comprise the individual elements, ρ_i , of the ρ vector. In the present paper we take the value of γ , the participation rate, to be fixed, determined by demographic factors. This implies that the percentage changes in the population and the labour force are the same so that we do not need to consider changes in γ .^{vii} We next explain each of the entries in Table 2.

[Table 2 near here.]

Block grant systems

Under the block grant heading we consider two specific schemes. These are the basic block grant and the fixed per-capita grant.

Basic block grant (b_B).

This is a fiscal transfer from the central government to the devolved authority that is fixed in nominal terms. Therefore under the basic block grant system the devolved budget in time period t , $b_{B,t}$, is exactly the same as in the base year so that:

$$(7) \quad \dot{b}_B = 0$$

It is important to note that the price level in the rest of the nation, here the rest of the UK (RUK), is the numeraire. The basic block grant therefore transfers to the devolved administration an amount that is constant, measured in RUK prices. Before the recent changes the fiscal transfer mechanism that applied to the devolved UK regions, that is Northern Ireland, Scotland and Wales, was formally driven by the Barnett formula (Keep,

2018). Equation (7) shows how this formula would apply were the economy in RUK unchanging. For the basic block grant the entries in the B matrix are shown in row 1 of Table 2 and all are zero. The grant is unaffected by changes in any of these variables.

Fixed per capita grant, (b_{BC}).

An alternative block grant formulation fixes the per capita block grant. This is particularly relevant here because evidence suggests that this is the actual outcome that the Barnett formula delivered whilst it operated in Scotland (Christie and Swales, 2010). This implies that:

$$(8) \quad \dot{b}_{BC} = \dot{p}$$

From equation (8) we derive, $\frac{\partial \dot{b}_{BC}}{\partial p} = 1$ which is reflected in row 2 of the B matrix, which has only that single non-zero entry. This implies that a proportionate change in population generates an equal proportionate change in the budget, with changes in all other endogenous economic variables having zero impact.

Tax sharing

We consider two tax sharing regimes. In both these schemes the devolved administration is funded partly by retained locally-generated taxes and partly by a direct grant.

Basic tax sharing (b_S).

We denote the most straightforward scheme with the subscript S. In this scheme the devolved taxes make up a share, equal to α , of the base period devolved budget, b_0 .^{viii} In subsequent periods, the block grant element - the transfer from the central government - remains constant and equal to $(1-\alpha) b_0$; the locally funded portion equals $p_t \gamma_t \varepsilon_t \lambda_t^S$. In the present

analysis we assume that the rates at which the devolved taxes are set are fixed. The subsequent changes to its total budget therefore depend on whether the devolved tax base, τ^S , subsequently increases or falls. Formally this can be represented as:

$$(9) \quad \dot{b}_S = (1 - \alpha) + \alpha \dot{\tau}^S = 1 + \alpha[\dot{p}\dot{\gamma}\dot{\epsilon}\dot{\lambda}^S - 1]$$

If the economy is initially in equilibrium, so that the original values of $\dot{p}, \dot{\gamma}, \dot{\epsilon}, \dot{\lambda}^S = 1$, then

$\frac{\partial \dot{b}_S}{\partial \dot{p}}, \frac{\partial \dot{b}_S}{\partial \dot{\epsilon}}, \frac{\partial \dot{b}_S}{\partial \dot{\lambda}^S} = \alpha$. This is represented in row 3 of the B matrix, where the Scottish α value of

0.37 is used.

Per capita tax sharing (b_{SC}).

This tax-sharing scheme is included here as a stylised representation of the formula that ultimately emerged from the Smith Commission (2014), which recommended further devolution of fiscal powers to Scotland, after the unsuccessful vote on Scottish independence in 2014.^{ix} This is the regime that has operated in Scotland since 2016. Again, the formula devolves the revenues from a set of taxes which make up a proportion, α , of the base-year budget. However, in this case the subsequent block grant element does not remain constant, but rather varies with the growth in population. The scheme is given as:

$$(10) \quad \dot{b}_{SC} = (1 - \alpha) + \frac{\alpha \dot{\tau}^S}{\dot{p}} = 1 + \alpha(\dot{\gamma}\dot{\epsilon}\dot{\lambda}^S - 1)$$

The formula has the property that: $\frac{\partial \dot{b}_{SC}}{\partial \dot{\epsilon}}, \frac{\partial \dot{b}_{SC}}{\partial \dot{\lambda}^S} = \alpha$ and $\frac{\partial \dot{b}_{SC}}{\partial \dot{p}} = 0$. This information is shown as

row 4 in the B matrix given as Table 2. If the per capita tax base remains unchanged, the devolved budget is unchanged, independent of changes in population.^x

Full tax autonomy (b_F).

Here we consider the case where the devolved authority has full tax autonomy (but limited borrowing powers). Though there are few examples of regional economies that have such autonomy, a stylised representation of devolved full tax autonomy provides a useful limiting case (one that has been advocated under a “devo-max” label by those who desire further economic devolution without independence). It also represents the early fiscal arrangements that applied in Northern Ireland (Rowthorn, 1981). In this set up the devolved region returns a proportion of the base period tax revenue raised in the region to the central government as its contribution to centrally determined public expenditure. Here this base year payment from the devolved to the central government is expressed as a ratio, β , of the base year budget, b_0 . For the Scottish case the value of β is 0.48. In subsequent periods this payment is maintained at its base-year nominal value. Again the devolved authority is assumed to have no control over tax rates, so that changes in the budget are determined by changes in the total tax base, $\dot{\tau}^F$:

$$(11) \quad \dot{b}_F = (1 + \beta)\dot{\tau}^F = (1 + \beta)\dot{p}\dot{\gamma}\dot{\varepsilon}\dot{\lambda}^F$$

In this case the responsiveness of the *devolved* budget to all the endogenous variables equals 1, so that $\frac{\partial \dot{b}_F}{\partial \dot{p}}, \frac{\partial \dot{b}_F}{\partial \dot{\varepsilon}}, \frac{\partial \dot{b}_F}{\partial \dot{\lambda}^F} = 1 + \beta$. Again, this result is represented as row 5 of Table 2, the B matrix, where all the relevant entries have the value 1.48.

Stimulating the devolved regional economy: The Π Matrix

In the previous section we constructed the B matrix. This reveals how the key endogenous economic variables identified in the $\underline{\rho}$ vector determine the budget under the various devolved fiscal mechanisms. In this section simulation results from a single-region Computable General Equilibrium (CGE) model are used to build a compatible Π matrix for the short- and long-run impacts of generic demand and supply shocks. This matrix shows the effect that policies aimed at stimulating the local economy have on the key endogenous economic and demographic variables that comprise the $\underline{\rho}$ vector.

We identify the impact of two separate policy interventions. The first is a demand-side stimulus in the form of a 5% increase in regional exports; the second, a supply-side 5% improvement in labour productivity in all sectors. Both are permanent step increases applied in the context of a common modelling framework and data base.

The simulations use the standard AMOS CGE model for Scotland extended through the incorporation of inter-governmental transfers and a more detailed identification of individual taxes required for studying a variety of stylised regional fiscal regimes. For purely pedagogic reasons, in both cases we abstract from the administrative costs of implementing these strategies and we also initially hold the nominal devolved government expenditure fixed as in the basic block grant scheme, to isolate impacts on devolved budgets. We then identify the consequences of recycling devolved tax revenues through changes in government expenditure. For both policies we analyse the impact in the context of long- and short-run models of the economy. An extended set of results is given in Table 3 and the appropriate Π matrix is shown as Table 4.

The AMOS Model

There has been a wide range of applications of the basic AMOS model. Examples are Lecca et al, (2013, 2014). We therefore provide only a very brief outline here; a full model listing is given in Emonts-Holley et al. (2019). The variant of the model used in this paper is calibrated on a Scottish Social Accounting Matrix (SAM) for 2014, has twenty-five industrial sectors and three domestic institutions; households, firms and government. External institutions are represented by Rest of the UK (RUK) and Rest of World (ROW). Aggregate household consumption is allocated through a CES function. In each sector gross output is generated by a nested CES production function. Each industry produces goods and services that can be exported or sold in the regional market. Intermediate and investment goods that are produced locally (in Scotland) or imported (from RUK and ROW) are considered as imperfect substitutes; export and import demands are determined through Armington functions and are therefore sensitive to relative price changes.

In the short run sectoral capital stocks are fixed but in the long run the capital stocks adjust to their desired levels. These are driven by sectoral outputs and input prices. In the long run the user cost of capital equals the capital rental rate, so that net investment is zero and gross investment just covers depreciation. Interest rates are set in international financial markets and are taken here to be exogenous and fixed. Tax rates are held constant and for the simulations in this section government expenditure is fixed in nominal terms. That is to say, the budget is set by central government through a basic block grant. In the simulations in the next section, the alternative devolved fiscal arrangements outlined above are used and these simulations incorporate the change in public consumption that is assumed to accompany any change in its devolved government's budget.

We do not impose strict constraints on the accumulation of foreign and public debt: the devolved government in effect has no debt because (for simplicity) we assume it has no borrowing power and interregional transfers can sustain perpetual capital flows.^{xi} However, we can track implied foreign and public sector deficits and debts and impose sustainability constraints if required. Also, inter-governmental transfers and welfare payments to households are fixed and indexed to RUK prices.

A key aspect of the model is the operation of the labour market. As with the capital stock, there is an important distinction between the short- and long-run outcomes. In the short run, the labour force is fixed so that employment only adjusts through increasing the employment rate. However, unlike capital, even in the short run labour can move freely across industrial sectors. In the long run, flow equilibrium inter-regional migration operates to adjust the labour force.

In our treatment of the unified labour market, three equations are critical. The first is the widely empirically validated wage curve where in each period the real wage is a positive function of the employment rate (Blanchflower and Oswald, 1994; Layard et al, 1991). This is:

$$(12) \quad \ln \frac{w_t}{cpi_t} = \nu + \theta \ln \varepsilon_t$$

where w_t , cpi_t and ε_t are the regional nominal wage, consumer price index and the employment rate respectively, in period t . In Figure 1, the wage curve, W_0 , shows the positive relationship between the employment rate and the real wage rate. This can be motivated by bargaining or efficiency wage considerations.

The second is the inter-regional migration function (Treyz at al., 1993). We assume the natural population change is zero but that flow equilibrium migration occurs, driven solely by labour market conditions. Specifically:

$$(13) \quad m_t = \mu + \varphi \ln \frac{w_t}{cpi_t} + \phi \ln \varepsilon_t$$

where m_t is the net migration rate in time period t. Equation (13) implies that net in- migration rate is a positive function of the real wage rate and the employment rate.

Finally, for the labour market to be in long-run equilibrium, there must be no net migration.

Setting $m_t = 0$ in equation (13) and rearranging gives the zero net migration (ZNM) function:

$$(14) \quad \ln \frac{w_t}{cpi_t} = -\frac{\mu}{\varphi} - \frac{\phi}{\varphi} \ln \varepsilon_t$$

The ZNM function implies long-run negative relationship between the real wage and the employment rate. The logic is that equation (14) is the locus of all combinations of the real wage and employment rates which generate neither in- nor out-migration. A higher real wage maintained into the long run must be offset by a lower employment rate to generate zero net migration, a condition for long-run equilibrium. The ZNM curve is therefore negatively sloped in employment rate, real wage space as in Figure 1. Points above and to the right of the ZNM curve stimulate in-migration and points below and to the left, out-migration.

Labour market impact of a stimulus

The numerical simulations generate complete adjustment paths where the economy is in temporary equilibrium in each period. We here concentrate on the results for the short- and long-run equilibria. The economy is initially assumed to be in equilibrium. There is then a local policy intervention which provides either a demand- or supply-side stimulus solely to the

devolved region. As stated earlier, we assume that the devolved region is small relative to the nation, so that any feedback from RUK and ROW to Scotland, following a Scottish-specific shock, is negligible.^{xii} We compare the post-shock equilibrium in the devolved region to the region's initial equilibrium.

We consider first a stylised account of how the economy reacts to an exogenous economic stimulus which increases the demand for labour. The labour market is initially taken to be in long-run equilibrium at point A in Figure 1. This is where the regional wage curve (W_0) and the initial labour demand curve (D_0) intersect.^{xiii} Additionally, because the labour force is fully adjusted, net migration is zero so that the ZNM function also passes through A.

[Figure 1 near here]

A stimulus of any sort that increases the derived demand for labour shifts the labour demand curve to the right (here to D_1), moving the short-run equilibrium from A to B. This is associated with an increase in the real wage and employment rate. This stimulates in-migration and the subsequent expansion of the labour force reduces the employment rate producing a backward shift in the demand curve for labour. Given the equilibrium flow migration, this process continues until the labour demand curve returns to D_0 and the labour market equilibrium to point A. The real wage and employment rates therefore return to their original levels, although population and employment are permanently increased.^{xiv} Essentially the ZNM function and the wage curve tie down the long-run wage and employment rates. This is an extremely useful property of the model for our purposes.

Simulation results: 5% export-demand stimulus

In the short run, a demand-side export stimulus increases aggregate demand and shifts the labour demand curve outwards. The proportionate changes for a range of key variables are given in the first data column of Table 3. Employment and the employment rate rise. This produces an increase in the real wage and the capital rental rates, so that regional competitiveness falls, with the result that in the short run exports fail to increase by the full 5%. The stimulus to investment is strong (2.06%) but the short-run increase in GDP is only 0.19%. In terms of the elements of the \underline{p} vector, population change is zero and the employment rate increases by 0.23%. The per capita shared and total tax bases rise by 1.31% and 1.09% respectively, so that the corresponding per employee figures are 1.08% and 0.86%. These results are shown in the first column of Table 4, as elements of the Π matrix.

[Table 3 near here.]

The long-run simulation outcomes are shown in the second column of results in Table 3. As seen in the preceding section, in-migration ultimately restores the real wage and unemployment rates to their original levels. Continuing investment also optimally adjusts the capital stock such that the initial capital rental rates are also reinstated. The outcome is a substantial increase in GDP, employment and investment of 2.50%, 2.31% and 2.72% respectively, accompanied by no changes in prices. This implies that in the long run exports expand by the full 5% stimulus and population increases by 2.31% with no change in the employment rate.

In the long run this CGE model operates in response to an exogenous demand shock as a linear fix-price, economy-wide model of an extended Input-Output (IO) or Social Accounting

matrix (SAM) type. However, although the model is linear, this does not imply that all key variables expand by the same proportionate amount. Exports are comparatively capital-intensive, hence the proportionate increase in investment and GDP are greater than the increase in employment and population, so that there is an increase in GDP per capita of 0.19%. Also because inter-regional transfers are assumed fixed, household consumption rises by less than wage income and GDP.

These differences are reflected in the differential growth rates across the various regional tax bases. Some are growing faster than population, such as indirect taxes and corporation tax, whilst others grow more slowly, such as Council Tax and VAT.^{xv} Moreover, we find that as a result of the export shock, the long-run shared and total per capita tax bases both fall by 0.39% and 0.61% respectively. In this case the per employee and per capita proportionate change figures are the same. The relevant results are entered in the second column of Table 4.

[Table 4 near here.]

Simulation results: productivity-driven supply stimulus

Many of the options open to the devolved government increase economic activity through supply-side stimuli. These typically seek to improve regional competitiveness by increasing efficiency. We consider here the effects of raising labour productivity across all sectors by 5%, which could be achieved through, for example, an expansion in the local provision of further and higher education.

The analysis of a supply-side shock of this type is more complex than that of the demand-side stimulus considered earlier. We characterise the improvement in efficiency as an increase,

measured in efficiency units, in the labour services delivered by each employee. This means that with a given wage per worker, the cost of labour in efficiency units falls. This improvement in competitiveness stimulates output but the fall in input prices also generates complex substitution and efficiency impacts on the use of inputs.

The stimulus to productivity generates a substantial short-run boost to economic activity, as shown in the third results column of Table 3. GDP increases, by 2.19%, as also do total exports and investment, by 2.11% and 6.71% respectively. However, the short-run fixity of capital causes the demand for labour to be wage-inelastic over this time interval, meaning that although the price of labour falls in efficiency units, the rise in labour demand, again in efficiency units, is not enough to increase employment in physical units. Employment is reduced by 0.90% in the short run, generating a corresponding fall in the employment rate, the real wage and household consumption.

A central observation here is that whilst output is increasing in real terms, income tax and national insurance fall in nominal terms by 3.33% and VAT and Council Tax by 0.94% and 0.53% respectively. Whilst Corporation Tax and Indirect Taxes show increases of 4.85% and 0.61%, the changes in per capita total and tax-sharing devolved tax bases are both negative at -1.21% and -2.60%, with the corresponding per employee figures at -0.31% and -1.70%. These results are reflected in the entries in the third column of the Π matrix, shown here as Table 4.

In the long run, the increase in competitiveness associated with the rise in labour productivity generates a substantial boost to regional economic activity. Export and government price indices are reduced by -3.09% and -4.00% respectively, producing an increase in exports, GDP and employment in turn of 6.47%, 5.80% and 1.57%. Given that the labour market is in long-

run equilibrium, the employment rate returns to its initial value so that population increases by 1.57%, in line with employment. Again, because of the reduction in regional prices, per capita nominal tax take falls; the reduction in total tax take per head and per employee is -1.34%, less than the -2.16% fall for those taxes devolved under the tax-sharing mechanisms. These results are entered in the fourth column in Table 4. We have therefore derived the 4 X 4 Π matrix for these two generic shocks applied to the two economy formulations.

Variation in the impact on the devolved budgets of different policy initiatives: The Q Matrix

Multiplying the B and Π matrices, as specified in equation (5), generates the (5 X 4) Q matrix shown as Table 5. Each element, $q_{r,s}$, is the proportionate budget change under tax-sharing scheme r that would be generated by the stimulus/economy combination s . Therefore, for example, the entry in the second row and second column indicates that under the per capita block grant scheme, implementing the 5% export increase generates a 2.31% long-run increase in the devolved budget. Recall that in the construction of the Q matrix government expenditure is actually held constant. This means that each entry shows how much the budget would change under alternative fiscal schemes but does not yet incorporate the general equilibrium impact of that change in expenditure.^{xvi}

[Table 5 near here.]

Looking at the B matrix, represented in Table 2, it might seem that the relative effectiveness of different devolved fiscal mechanisms should be reasonably straightforward to determine and stable across different policies. It might appear that all options are better than the basic block grant; that full tax autonomy dominates a per capita block grant; and that increasing degrees of tax sharing sees greater budget impacts. However, the Q matrix (Table 5) reveals

that when these fiscal mechanisms are operated together with a range of possible policy initiatives and time periods that none of these statements is necessarily true.

The reason for these seemingly paradoxical results can be seen from the Π matrix. There are a number of zero entries, so that many of the policy shocks influence only a restricted subset of the key variables. Further, almost half of the non-zero policy impacts on endogenous economic variables are negative. Clearly, a consistent ordering of the policies by the size of their impact on devolved budgets becomes much less likely. This difficulty is illustrated very directly in Table 5. If any two fiscal schemes are compared, the only unambiguous ordering that can be made is that the per capita block grant weakly dominates the basic block grant. Note that this means that each of the tax-sharing schemes is dominated by the basic block grant in at least one of the scenarios reported here.

It could be argued that the long-run results should carry more weight, given that the case for greater fiscal incentives is that they stimulate growth. However, even if we focus solely on the long-run impacts, which are those shown in columns 2 and 4 of Table 5, there are still unexpected results. There is no strategy that dominates all others in generating the highest budget increase. With the export shock, full tax autonomy delivers the largest long-run increase, at 2.53%, whilst for the efficiency improvement the per capita block grant dominates, with a figure of 1.57%. In the long run all the fiscal mechanisms dominate the per capita tax sharing scheme which reports negative budget changes of -0.14 % and -0.80 % for the demand- and supply-side stimulus respectively in this time period.

The impact of alternative devolved fiscal schemes with recycled devolved tax revenues.

The argument in favour of greater fiscal autonomy is not just that it provides appropriate incentives for growth promotion but that the subsequent additional revenues can be recycled to increase government expenditure, for example, further stimulating activity in the local economy. In the analysis in the previous two sections, concerning the construction of the Π and Q matrices, we record the notional budgets that would have been generated but do not adjust the level of government expenditure in the simulations. That is to say, the results recorded in Tables 3, 4 and 5 do not incorporate the impact of any local recycling of changes to the budget.

Such recycling can occur in a wide range of ways. In this section we make the most straightforward adjustment. Government expenditure is varied linearly to match changes in the devolved government's budget, with public expenditure retaining the same sectoral composition. Tables 6 and 7 report the GDP and employment change respectively generated by the CGE simulations for the demand- and supply-side stimuli and the various fiscal schemes.^{xvii} These results therefore endogenise devolved government expenditure in an extremely conventional way.

Recall that there is no change in the budget under the basic block grant scheme whose entries can therefore be taken as reference points (so that the results reported in the first row of Table 6 correspond to those in the first row of Table 3). The deviation in results from these benchmarks indicates the impact on economic activity generated by the change in public expenditure under the different fiscal schemes. Again it is useful to concentrate on the long-run effect, shown in the second and fourth columns.

[Table 6 near here.]

The GDP results are given in Table 6. Incorporating the change in public expenditure is generally positive and can significantly enhance the simulated impact of the policy. For the export stimulus, full tax autonomy generates the greatest additional impact. The GDP percentage point changes are 0.32% and 3.47%, against the corresponding short and long-run benchmark (basic block grant) values of 0.19% and 2.50%. The full tax autonomy figures therefore improve on the benchmark values by around 70% and 40% in the short and long runs respectively. The long-run percentage point increase with the per capita block grant is also large, at 3.37%. However, note that under the long-run per capita tax sharing scheme GDP actually falls below the benchmark value, though we would expect this given the negative entry in the Q matrix.

With the labour efficiency shock, the impact of the additional devolved expenditure on the GDP figure is much more mixed. In the short run, endogenising government expenditure using these schemes has a zero or negative impact. In the long run, under the full tax autonomy and per capita block grant schemes the effect is positive but small, increasing the overall impact by just less than 3% and just over 10% respectively (from 5.80% benchmark to 5.96% and 6.42%).

[Table 7 near here.]

For the employment effects, as shown in Table 7, the impact pattern is similar but the percentage point changes are slightly greater. With the export demand shock, the full tax autonomy scheme increases the short-run employment change from the benchmark 0.23% to 0.43%, an 87% increase. In the long run the per capita block grant and the full tax autonomy schemes increase the employment effect by 45% to 50%. For the labour efficiency improvement, the additional employment effects in the short run are never positive and in

the long run the per capita block grant again increases the employment effect by 45%, but the increase with full tax autonomy is still only around 10% and there are reductions in the impact on employment relative to the benchmark level with the tax-sharing schemes.

Conclusions

The range of growth policies available to devolved authorities generate differing types of economic response. These are differentially rewarded by alternative forms of devolved fiscal mechanisms in terms of the impact on the devolved region's budget. The illustrative simulations reported here reveal how diverse this fiscal feedback can be.

In the present paper the analytical framework that we develop is formulated to replicate the major devolved fiscal arrangements that have featured in UK debates about the funding of the devolved Scottish Government. Similarly, the model used to simulate the wider policy impacts is calibrated on Scottish data and is a CGE model that is very similar to one used by the Scottish Government. However, the conceptual approach is completely general and could be set up to accommodate any type of economic modelling, such as microsimulation models, and any form of devolved fiscal arrangements. This applies as long as the economic and fiscal models are compatible. That is to say, the economic model must simulate or predict the impact on the relevant variables that determine the devolved budget.

Our simulations reveal that the results depend critically on endogenous interaction between demographic and economic change. This is particularly the case as two key fiscal arrangements are specified in per capita terms. In future work we therefore plan to investigate the fiscal implications of varying both the size and nature of migration response to the economic stimuli. Similarly, there is compelling evidence supporting the adoption of a

regional wage curve relationship, such as that used in our analysis. However, over the longer term, experience since the Great Recession suggests that this may have broken down and we explore the possible consequences of this in an Appendix, which shows that this does not impact our main conclusion. A further labour market extension would be to incorporate a degree of skill disaggregation in the analysis, which would have potential wage setting and migration implications.

In the results given here we report only short- and long-run impacts. It would be valuable to track the outcomes in more detail using a period-by-period analysis to investigate the adjustment paths to the long-run equilibria which are the primary focus of this paper. This would also provide information concerning the impact of alternative fiscal regimes on the resilience and stability of regional economies.

Finally, for our analysis we have adopted a single region, stand-alone model. We judge this to be appropriate given the issue that we address: the incentive that the devolved fiscal mechanism gives to devolved regions to adopt growth policies. If the focus were much wider, say concerning the optimal devolved system from a national point of view, incorporating a range of efficiency versus equity objectives, then a multi-regional model would be required.

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Data availability statement.

The core data used in this study is the Scottish Input Output table for 2013. The Scottish Government produced tables can be downloaded from here: <https://www.gov.scot/publications/input-output-latest/>

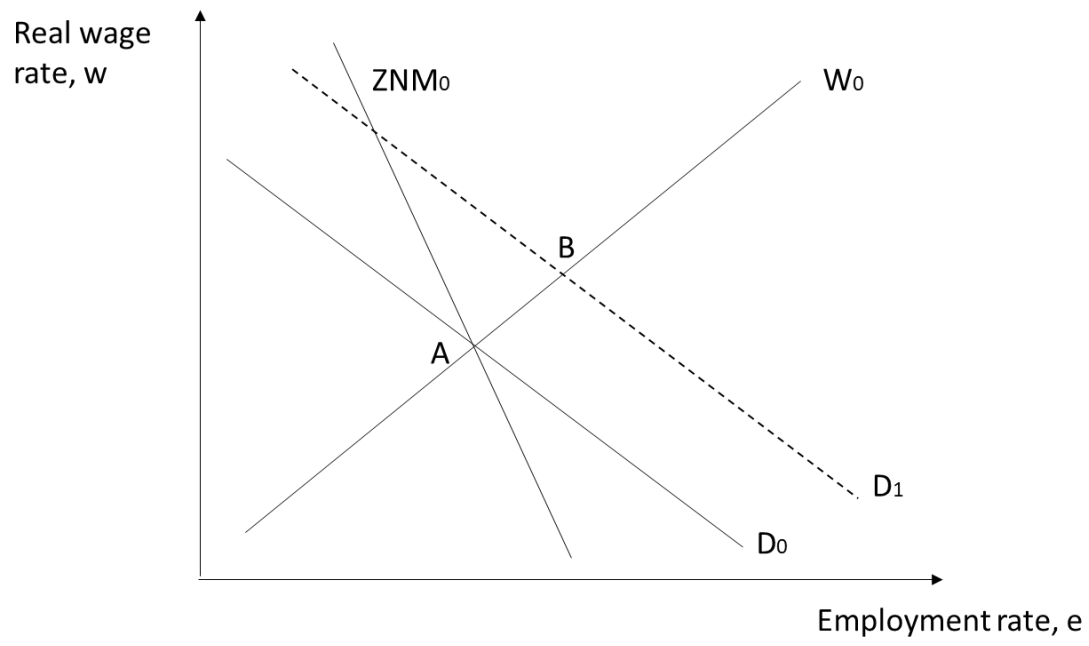


Figure 1

Table 1. Stylised regional fiscal regimes

<i>Name</i>	<i>Symbol</i>	<i>Formula ($b_{z,t}$)</i>	<i>General Description</i>	<i>Scottish Example</i>
Basic block grant	$b_{B,t}$	b_0	Fixed nominal budget	Barnett
Per capita block grant	$b_{BC,t}$	$b_0 \frac{p_t}{p_0}$	Fixed per capita nominal budget	Barnett plus influence
Basic Tax sharing	$b_{S,t}$	$b_0 \left[1 + \alpha \left[\frac{p_t \gamma_t \varepsilon_t \lambda_t^S}{p_0 \gamma_0 \varepsilon_0 \lambda_0^S} - 1 \right] \right]$	Partial devolved tax base with no regional population adjustment	Treasury Block Grant Adjustment
Per capita Tax sharing	$b_{SC,t}$	$b_0 \left[1 + \alpha \frac{p_t}{p_0} \left[\frac{\gamma_t \varepsilon_t \lambda_t^S}{\gamma_0 \varepsilon_0 \lambda_0^S} - 1 \right] \right]$	Partial devolved taxes base adjusted for changes in regional population.	Smith Block Grant Adjustment
Full Tax Autonomy	$b_{F,t}$	$b_0 \left[(1 + \beta) \frac{p_t \gamma_t \varepsilon_t \lambda_t^F}{p_0 \gamma_0 \varepsilon_0 \lambda_0^F} - \beta \right]$	Budget determined solely by local tax take	Scottish Government Aspiration

Table 2: The B matrix: The sensitivity of the budgets under alternative devolved fiscal mechanisms to proportionate changes in elements of the ρ vector.

Endogenous variables ($\dot{\rho}_i$)		\dot{p}	$\dot{\epsilon}$	$\dot{\lambda}^S$	$\dot{\lambda}^F$
Budget sensitivity ($\partial \dot{b}_Z / \partial \dot{\rho}_j$)					
Block Grant Schemes	$\frac{\partial \dot{b}_B}{\partial \dot{\rho}_i}$	0	0	0	0
	$\frac{\partial \dot{b}_{BC}}{\partial \dot{\rho}_i}$	1	0	0	0
Tax sharing	$\frac{\partial \dot{b}_S}{\partial \dot{\rho}_i}$	0.37	0.37	0.37	0
	$\frac{\partial \dot{b}_{SC}}{\partial \dot{\rho}_i}$	0	0.37	0.37	0
Full Tax Autonomy	$\frac{\partial \dot{b}_F}{\partial \dot{\rho}_i}$	1.48	1.48	0	1.48

Note: For the Scottish data devolved taxes as a share of the devolved budget in the base year is 0.37 (i.e. $\alpha = 0.37$). This figure is calculated as base year (Income Tax + 50% of VAT + Council Tax + Landfill Tax)/Devolved Public Expenditure. β is the ratio of Scottish tax revenues returned to the UK Treasury in the base year. Its value is 0.48 and the value of $(1 + \beta)$ entered in Table 2 is 1.48. The initial values of the elements of the ρ vector are as follows: $p = 3.53$ million; $\gamma = 0.79$, $\epsilon = 0.73$, $\lambda^S = 4186$ (£/employee); $\lambda^F = 9617$ (£/employee).

Table 3: The impact of 5% improvements in exports and in productivity under the basic block grant system (% changes from base.)

Time period	Export shock		Productivity shock	
	Short run	Long run	Short run	Long run
GDP (£m)	0.19%	2.50%	2.19%	5.80%
GDP per capita	0.19%	0.19%	2.19%	4.17%
Household Consumption	0.29%	1.36%	-0.54%	1.68%
Investment	2.06%	2.72%	6.71%	5.14%
Total Exports	2.07%	5.00%	2.11%	6.47%
Total Imports	1.93%	2.32%	0.44%	0.83%
WAGES:				
Post tax nominal wage	1.24%	0.00%	-2.45%	-2.24%
PRICES:				
CPI	0.81%	0.00%	-0.98%	-2.24%
Govnt price index	0.84%	0.00%	-2.68%	-4.00%
Export price index	1.43%	0.00%	-1.03%	-3.09%
Repl cost of capital	0.72%	0.00%	-0.65%	-1.78%
User cost of capital	0.72%	0.00%	-0.65%	-1.78%
LABOUR MARKET:				
Unemployment level	5.78%	6.00%	6.85%	6.00%
Unemployment Rate (pp difference)	-0.22%	0.00%	0.85%	0.00%
Employment	0.23%	2.31%	-0.90%	1.57%
Population	0.00%	2.31%	0.00%	1.57%
NOMINAL TAX REVENUE:				
Income Tax and National Insurance	1.48%	2.31%	-3.33%	-0.71%
Corporation Tax	2.42%	2.72%	4.85%	3.27%
VAT Revenues	0.93%	1.02%	-0.94%	-0.42%
Council Tax	0.29%	1.36%	-0.53%	1.69%
Total taxes/ head	1.09%	-0.61%	1.21%	-1.30%
Tax-sharing taxes / head	1.31%	-0.39%	-2.60%	-2.16%
SCOT GOV SPENDING:				
Real Scottish Government Consumption	-0.84%	0.00%	2.75%	4.16%

Table 4: Π Matrix : impact of devolved growth strategies on key endogenous variables, elements of the ρ vector (% changes)

	5% export demand increase		5% increase in labour efficiency	
	Short run	Long run	Short run	Long run
	$\pi_{D,S}$	$\pi_{D,L}$	$\pi_{S,S}$	$\pi_{S,L}$
$\frac{\partial \dot{p}}{\partial \pi}$	0	2.31	0	1.57
$\frac{\partial \dot{\varepsilon}}{\partial \pi}$	0.23	0	-0.90	0
$\frac{\partial \dot{\lambda}^S}{\partial \pi}$	1.08	-0.39	-1.70	-2.16
$\frac{\partial \dot{\lambda}^F}{\partial \pi}$	0.86	-0.61	-0.31	-1.30

Note. The dot notation represents the proportionate change in the variable. The tax bases are measured on a per employee basis, so that the changes in per capita tax bases reported in Table 3 have to be adjusted for any changes in the employment rate in the same simulation. This impacts the short run results for the total and shared tax base in Table 4. (Long-run results are unaffected because the employment rate is invariant over that interval.) For example, from the first column of Table 3, total taxes per head rise by 1.09%, but the employment rate rises by 0.23%, so that the tax base per employee rises by $(1.09 - 0.23) = 0.86\%$.

Table 5: Q Matrix: Impacts on devolved budgets of local growth strategies across devolved fiscal schemes (% changes)

		5% export demand increase		5% increase in labour efficiency	
		Short run	Long run	Short run	Long run
Block grant schemes	b_B	0.00	0.00	0.00	0.00
	b_{BC}	0.00	2.31	0.00	1.57
Tax sharing	b_S	0.48	0.71	-0.96	-0.22
	b_{SC}	0.48	-0.14	-0.96	-0.80
Full Tax Autonomy	b_F	1.61	2.53	-1.79	0.40

Table 6: GDP impacts across policies, time scales and fiscal schemes

		5% export demand increase		5% increase in labour efficiency	
		Short run	Long run	Short run	Long run
Block grant schemes	b_B	0.19	2.50	2.19	5.80
	b_{BC}	0.19	3.37	2.19	6.42
Tax sharing	b_S	0.23	2.79	2.09	5.76
	b_{SC}	0.23	2.49	2.09	5.58
Fiscal Tax Autonomy	b_F	0.32	3.47	2.01	5.96

Table 7: Employment impacts across policies, time scales and fiscal schemes

		5% export demand increase		5% increase in labour efficiency	
		Short run	Long run	Short run	Long run
Block grant schemes	b_B	0.23	2.31	-0.90	1.57
	b_{BC}	0.23	3.35	-0.90	2.28
Tax sharing	b_S	0.29	2.65	-1.02	1.52
	b_{SC}	0.29	2.29	-1.02	1.32
Full Tax Autonomy	b_F	0.43	3.47	-1.14	1.74

ENDNOTES

ⁱ The nature and extent of devolved powers differs across the three devolved UK regions. For Scotland the areas of responsibility transferred to the Scottish Parliament include: agriculture, forestry and fishing; education and training; health and social services; tourism and economic development; housing; law and order; local government and sport and the arts. Powers reserved to the Westminster Parliament include defence, foreign policy and immigration. Details on the Scottish budget can be found here: <https://www.gov.scot/publications/scottish-budget-2020-21/pages/2/>.

ⁱⁱ All of these options are, or have been, used by the devolved Scottish Government.

ⁱⁱⁱ Different model configurations could include aspects such as the economy's openness to trade, the nature of the labour market (e.g. allowing for skill differentiation) or the determination of investment. In the present paper only the time scale under consideration is varied.

^{iv} Essentially, it is more convenient in our analysis to express equation (1) and (2) in terms of indices.

^v See also OECD's up-to-date database which contains measures of levels of decentralisation: <https://www.oecd.org/tax/federalism/fiscal-decentralisation-database/>

^{vi} This is simply a decomposition. The tax base is expressed in this way for analytical convenience. It could be decomposed in greater detail or in a different way.

^{vii} This means that employment reacts to short-run variations in labour demand only through changes in the employment rate (with a corresponding change in the unemployment rate). The demographic characteristics of migrants are also assumed to be the same as those of the initial regional population.

^{viii} The basic tax sharing regime was the option favoured by the UK government during negotiations to establish a new fiscal framework for Scotland (HM and Scottish Governments, 2016). However, following concerns from the Scottish Government around demographic pressures, the per capita tax sharing regime (considered below) was implemented, though the framework is due to be reviewed by the end of 2021.

^{ix} The proposals of the Smith Commission (2014) were agreed by HM Government and the Scottish Government (2016). This established Scotland's new fiscal framework. Bell et al (2016) and Eiser (2017) provide an analysis of this scheme together with comparison with the basic tax sharing scheme favoured by HM Treasury.

^x It is thought that in negotiations around the formula the Scottish Government were concerned about future reductions in the Scottish population, relative to the UK as a whole.

^{xi} Public expenditure per capita is significantly higher in Scotland than in RUK. The associated implicit public sector deficit in Scotland is effectively financed by taxpayers in RUK. The Scottish Government has very limited independent borrowing powers.

^{xii} The effects tend to be small (McGregor et al, 1999) because Scotland represents less than 7.5% of UK GDP.

^{xiii} The labour demand curve is a general equilibrium relationship which incorporates all of the effects of a change in real wages, including those on consumption demand. While not inevitable, the labour demand curve for an open regional economy is expected to be negatively sloped, where competitiveness effects dominate the income effects of wage changes. The theoretical framework is developed more formally in Lecca et al (2014).

^{xiv} Had the initial shock reduced labour demand the labour demand curve would initially move to the left. But again long-run equilibrium reinstates the original employment and real wage rates, but in this case through outmigration.

^{xv} Council tax is a system of property taxation that is levied locally on each domestic property in Scotland. Each council sets its own rate for its local authority area and spends the revenue on the provision of local public services.

^{xvi} As shown in the next section of the paper, if under the per capita block grant scheme the 2.31% increase in the budget is spent with the same sectoral composition, economic activity would increase. This generates a further population increase so that the total improvement in the devolved budget would be 3.50%.

^{xvii} We assume for simplicity that the government expenditure has no direct supply-side impacts, such as might be expected to accompany increased expenditure on education and health, for example.