Balanced Budget Government Spending in a Small Open Regional Economy

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Abstract

This paper investigates the impact of a balanced budget fiscal policy expansion in a regional context within a numerical dynamic general equilibrium model. We take Scotland as an example where, recently, there has been extensive debate on greater fiscal autonomy, and where balanced budget fiscal expansion is feasible under currently devolved powers. In response to a balanced budget fiscal expansion the model suggests that: an increase in current government purchase in goods and services has negative multiplier effects only if the elasticity of substitution between private and public consumption is high enough to move downward the marginal utility of private consumers; public capital expenditure crowds in consumption and investment but crowding out effects might arise in the short-run if agents are myopic. The distinctive results for public capital expenditure suggest that the current restriction on the composition of Scottish government expenditures is a very significant one.

1. Introduction

Scotland is engaged in a lively and on-going debate on greater fiscal autonomy and independence, which is politically controversial, especially in respect of tax-varying powers. The Scottish Parliament has the power to make a balanced-budget adjustment in public expenditure by varying the basic rate of income tax. However, this power has not so far been used. Thus, the object of this paper is to explore and quantify a number of typical balanced-budget government spending shocks. To this end, we use an intertemporal variant of AMOS[1] a computable general equilibrium (CGE) model for Scotland.

Several empirical and analytical macroeconomic models, mostly related with the macro-national literature, have tried to identify the possible effects of fiscal expansion (e.g., Aiyagari *et al.*, 1992, Campbell, 1994, Baxter and King, 1993, Devereux *et al.*, 1996, Perotti, 1999, Blanchard and Perotti, 2002, Chen, 2007). However, there is still no clear consensus about the impact of an expansionary fiscal policy[2].

In a single region or sub-national context, very few studies attempted to analyse the macroeconomic effect of fiscal policy. Previous contributions to fiscal federalism mostly adopt a micro-perspective based on the assumption of the neutral regional macro impact of fiscal autonomy, neglecting the system wide impact of regional policy (McGregor and Swales, 2005). Here we seek to draw on lessons from recent macroeconomic analyses of fiscal policy, but we adapt them to an explicitly regional context. The regional dimension of the analysis is captured through application to a regional economy characterised by: highly open goods markets in which import and export to GDP ratios are much higher than for the national economy; labour markets are

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[1] AMOS is an acronym for a macro-micro model of Scotland parameterised on Scottish data: the Social Accounting Matrix for the year 2004. The model employed here is an intertemporal variant (Lecca *et al*, 2010) of the basic AMOS CGE framework (Harrigan *et al*, 1991).

[2] An extensive literature on fiscal consolidation can be found in Birotti (2005)

highly open characterised by the presence of migration and, potentially, influenced by national and regional wage bargaining institutions; financial markets are perfectly integrated with the national economy with which the region shares a permanently fixed exchange rate. Furthermore, the macroeconomic "closures" of the model are those appropriate to a region, reflecting an institutional structure in which regions are not directly responsible for national debt, and where the system of national transfers moderates the operation of regional adjustment mechanisms.

We carry out a number of experiments using a CGE model that shares some similarities with previous business cycle models, as far as the forward looking dynamic structure is concerned. An important difference is our models of wage setting and allowance for migration. The traditional intertemporal model is augmented with imperfectly competitive features in the labour market and a net-migration model. Unlike the standard model that allows for substitution between consumption and leisure where the representative consumer chooses the quantity of labour to supply according to a flexible nominal wage, our model contains a wage bargaining function sensitive to the movement of the unemployment rate and labour supply increases through population due to in-migration. The regional wage bargaining and migration effects are crucial for the analysis of peripheral and indeed all sub-national regions of the EU.

Initially we investigate the response of an increase in current public purchase of goods allowing imperfect substitution between public and private consumption. Then, we consider the case of an increase in public investment. The results of our simulation experiment suggest that an increase in current government purchase in goods and services has negative multiplier effects only if the elasticity of substitution between private and public consumption is high enough to move downward the marginal utility of private consumers. This result is in line with the theoretical findings present in Linnemann and Schabert (2002). The impact of an unanticipated public capital expenditure shock, in the short and in the long-run, has a positive effect on private consumption and investment. The short-run dramatically diverges for the case in which agents have myopic expectations, under which circumstances there is complete crowding out.

The paper proceeds as follow. In section 2 and 3, we outline the dynamic general equilibrium model used in this study and in Section 4 outlines the simulation strategy. Section 5, 6 and 7 are dedicated to the discussion of the policy shocks. Concluding remarks are in section 8.

2. Key model features

Three domestic transactor groups are incorporated: households, corporations and government; and in this application eleven commodities and activities[3]. Consumption and investment decisions reflect intertemporal optimization with perfect foresight. Real government expenditure is divided into current and capital expenditure. While the former are treated as purchases of goods and services, the latter are explicitly considered as public investment in infrastructure. For a balanced budget fiscal expansion, the local labour income tax is endogenous. In the subsequent subsections we outline briefly the model. The mathematical presentation of the model is kept to a minimum as further details can be found in Lecca *et al.* (2011*a*).

Consumers

Household optimises its lifetime utility function of effective consumption $\tilde{C}_t$, which takes the following form:

$$U = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \frac{\tilde{C}_t^{1-\sigma} - 1}{1-\sigma} ; \qquad (1)$$

where σ and ρ are respectively the constant elasticity of marginal utility and the constant rate of time preference. Following recent analytical contributions on fiscal spending, in particular the work of Linnemann *et al*, (2004), the consumption bundle

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[3] Agriculture, forestry & fishing, (AGR), Mining (MIN), Manufacturing (MAN), Energy and water (ENE), Construction (CON), Distribution & catering (DIS), Transport & communication (TRA), Finance and business (FIN), Public admin etc. (PAD), Education, health and social work (EDU) and Other services (OTH).

$\tilde{C}$ is defined as a CES combination over private consumption, C, and current public expenditure, G_i :

$$\tilde{C}_t = A \cdot \left[a^c C_t^{\xi} + (1 - a^c) G_t^{\xi} \right]^{\frac{1}{\xi}} \qquad (2)$$

Using this formulation Linnemann *et al*, (2004) show that if the elasticity of substitution $\varepsilon = \dfrac{1}{1 - \xi}$ is sufficiently low, an increase in government purchases in goods and services can raise the marginal utility of private consumption and counteract the negative wealth effect on consumption due to an increase in taxation.

The present value of consumption must not exceed total wealth, W. In our configuration we distinguish between financial wealth (*FW*) and non-financial wealth (*NFW*), such that $W_t = NFW_t + FW_t$ and in which:

$$FW_t(1 + r_t) = FW_{t+1} + \Pi_t - S_t \qquad (3)$$

$$NFW_t(1 + r_t) = NFW_{t+1} + (1 - \tau_t) L_t^s \cdot (1 - u_t) \cdot w_t + Trf_t \qquad (4)$$

In equation (3), Π_t and S_t are respectively capital income and saving. The variables L_t^s, w_t, u_t, Trf_t and τ_t in equation (4) are respectively working population, nominal wage rate before tax, the unemployment rate, the rate of income tax and net transfers from other sectors.

Once the optimal path of consumption is obtained, the aggregate consumption is allocated within each period t, for the i commodities.

Firms

Total gross output *X*, is given by combining value added (*Y*) and intermediate inputs (*V*) through Leontief technology:

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$$X_{i,t} = \min \left\langle \frac{Y_{i,t}}{a_i^Y} ; \frac{V_{i,t}}{a_i^V} \right\rangle \qquad (5)$$

where a^Y and a^V are input coefficients. Y is given by a CES combination of labour demand (L^d), private capital (K^d) and public capital services ($K^d_{(g)}$):

$$Y_{i,t} = \Phi_i \cdot \left[a_i K^d_{i,t}{}^{\vartheta} + b_i L^d_{i,t}{}^{\vartheta} + b_i K^d_{(g),t}{}^{\vartheta} \right]^{\frac{1}{\vartheta}} \qquad (6)$$

Where Φ_i is a scale parameter and given ψ the elasticity of substitution, $\vartheta = \dfrac{\psi - 1}{\psi}$. $K^d_{(g)}$ is treated as an unpaid factor of production that is considered exogenous to the firm and determined by the public stock of infrastructure $K^s_{(g)}$ that accumulates over time subject to depreciation $\left(\delta_{(g)} \right)$ through capital government expenditure $I_{(g)}$:

$$K^s_{(g)t+1} = K^s_{(g)t} \cdot (1 - \delta_{(g)}) + I_{(g)t} \qquad (7)$$

Modelling congestion effects

To allow for congestion effects and to take into account the degree of *non-publicness* of public goods (Bergstrom and Goodman, 1973), public capital stock and current government expenditure are adjusted following a simple model consistent with median voter demand studies (see Edwards, 1990 and Fisher and Turnovsky, 1998). The congestion model we use follows the traditional formulation of decreasing marginal congestion. The aggregate public capital service is adjusted for congestion by private capital stock, K, and population, L^s [4]:

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[4] In some studies which hold labour supply fixed, public capital is congested only by private capital (Barro and Sala I Martin, 1993 and Fisher and Turnovsky, 1998). Other formulations may imply congestion only if population increases (Bergstrom and Goodman, 1973 and Edwards, 1990) or by employment and private capital (Glomm and Ravikumar, 1993). Since the model used here allows for unemployment, public capital is congested by private capital and total labour force (which includes the unemployed). In the model we are assuming that all population is working-age population. So we use labour force and population as synonymous.

$$K^{d}_{(g)} = K^{s}_{(g)} \cdot \left[K + L^{s}\right]^{\gamma} \qquad\qquad \gamma = \frac{\eta - 1}{\eta}, \; \gamma \in (0, -\infty) \qquad \eta \in (0,1). \qquad (8)$$

where, γ is the congestion parameter. The increase in private capital and population reduce the effective quantity of public capital stock enjoyable by all firms and the magnitude of this effect depends on the level of η. When $\eta = 1 \, (\gamma = 0)$ we have the case of a pure public good, which is available equally to each firm and its use would not reduce its usefulness to others. In this case the public capital service is non-rival and non-excludable as defined by Samuelson (1954) and firms enjoy full benefits from its use. If $\eta = 0.5 \, (\gamma = -1)$ public capital still remains non-excludable but loses the property of non-rivalry[5]. The quantity of public services available to a producer declines if capital and working population increase. The higher is the use of private factors the lower is the contribution of public capital in production. Such a crowding effect is stronger the lower is η which has the smallest value where there is a situation of "over-crowding" (Edwards, 1990) such that the decline in public services is faster than the increase in growth.

The representative firm considers public capital as exogenous and the path of private investment is obtained by maximizing the present value of the firm's cash flow:

$$\text{Max} \; \sum_{t=0}^{\infty} \frac{1}{(1+r)^{t}} \left[\pi_{t} - I_{t}\left(1 + g\left(\omega_{t}\right)\right)\right] \qquad (9)$$

$$\text{subject to } K_{t+1} = K_{t} \cdot (1 - \delta) + I_{t} \qquad (10)$$

The cash flow is given by profit, π_{t}, less private investment expenditure, I_{t}, subject to the presence of adjustment cost $g\left(\omega_{t}\right)$ where $\omega_{t} = I_{t} / K_{t}$:

Government

As we have said above we distinguish between two kinds of government expenditures: G and $I_{(g)}$. Government keeps a balanced budget year to year, so that government

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[5] This corresponds to the case described in Fisher and Turnovsky, (1998) called *proportional congestion*.

expenditures are entirely financed by distortionary taxation. We consider the case where government finance its expenses (current and capital) by raising exclusively the rate of tax on labour income, τ_t.

Population and Labour Market

No natural population change is assumed, but the labour force (L^s) evolves over time through migration:

$$L^s_t = L^s_{t-1}\left[1 + m_{t-1}\right]$$
(13)

where *m* is net in-migration as a proportion of the regional population which adjusts according to the econometrically parameterised regional net migration function reported in Layard *et al.* (1991). The model starts with zero net migration flow and, in any period, migration is taken to be positively related to the gap between the log of regional $\left(rw^R_t\right)$ and national $\left(rw^N\right)$ after-tax real wages, and negatively related to the gap between the log of national, (u^N) and regional unemployment rates, where u^N and rw^N are not time-varying:

$$m_t = \varsigma - 0.08\left[\ln(u_t) - \ln(u^N)\right] + 0.06\left[\ln\left(rw^R_t\right) - \ln\left(rw^N\right)\right]$$
(14)

Wage setting is determined via a regional bargained real wage function that embodies the econometrically derived specification given in Layard *et al.* (1991):

$$\ln\left[rw^R_t\right] = c - 0.113 \cdot \ln\left[u_t\right]$$
(15)

where *c* is a calibrated parameter. Thus, in the regional wage bargaining regime (RB), the labour market is defined by the wage curve (Blanchflower and Oswald, 1994) according to which wages and unemployment are negatively related. Therefore, regional wages are directly related to workers' bargaining power and respond to excess demand for labour.

Domestic and imported inputs are obtained via an Armington link (Armington, 1969). The demands for Scottish goods are determined via an export demand function according to which the quantity of goods exported is related to the relative regional price and price elasticity, given constant prices and income for the Rest of UK and the Rest of the World.

3. Dataset and model parameterization

The benchmark data set is the Scottish Social Accounting Matrix (SAM) for the year 2004 based on the IO Table for 2004 built by the Scottish Government[6] to which we have added the information related to the primary and secondary income distribution using the household's disposal income account[7]. Unfortunately, we do not have data on the level of the Scottish public capital stock, so we have to develop a proxy. The approach we employ to estimate the government public capital stock is the general perpetual inventory method (detailed in Lecca *et al.* 2011), a well-known methodology applied by OECD (2001) and by the U.S. Bureau of Economic Analysis (1999)[8].

The world interest rate is set to 0.04 (which is faced by producers, consumers and investors), the rate of depreciation to 0.1 and the inter-temporal elasticity of substitution is equal to 1.2 (Blundell et al., 1994). For all sectors, trade elasticities are set equal to 2 (Gibson, 1990) whilst production elasticities are equal to 0.3 (Harris, 1989). The wage curve elasticity is set to -0.113, whilst in the migration function, we use the elasticities econometrically estimated by Layard *et al*, (1991).

As for the congestion parameter, in other CGE models, as for example in Alonso-Carrera *et al.* (2009), the congestion parameter is set equal to 0.36 while three levels of congestion parameter (high, medium and low) are analysed in Seung and Kraybill (2001). Since we do not have specifically estimated parameters for the Scottish economy we prefer, in these circumstances to take the intermediate situation of *proportional congestion* ($\eta = 0.5$) as a benchmark. However, we handle the uncertainty

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[6] http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Downloads
[7] http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/SNAP/expstats/GDHI2007
[8] See also Holtz-Eakin 1993 and Kamps, 2004.

associated with the value of this parameter in subsequent sections, where a sensitivity analysis is carried out on the parameter η.

4. Simulation strategy

According to the 2004 HM Treasure Budget estimate, the amount of revenue that the Scottish tax office would be able to collect for one penny rise in the Scottish variable tax rate would be approximately £270 million of additional revenue which represent 1.10% and 12.20% increase in current and capital government expenditure, respectively. We separately analyse the effects of 1.10% and 12.20% increase in current and capital government expenditure respectively.

The increase in current government expenditure affects the marginal utility of consumption to a degree determined by the elasticity of substitution of the consumption bundle defined over private and public consumption. Therefore, our results critically depend upon the value assigned to the elasticity of substitution, ε.

Many studies estimate the degree of substituibilty between private and public consumption (e.g. Kormendi, 1983; Aschauer, 1985; Karras 1994; Ni 1995; Ho, 2001; Fleissing and Rossana, 2003) however the estimates found in the literature vary widely[9]. Moreover, we cannot use previous estimates directly because they are based on parametric specifications that are not consistent with our model. Indeed, most of the estimates are obtained assuming an intra-temporal linear utility function (such as $\tilde{C} = C + \varepsilon \cdot G$) whilst our model is assuming that private and public consumption are imperfect substitutes, to accommodate the analytical findings of Linnemann and Schabert (2002). For this reason we compare three outcomes obtained by imposing $\varepsilon = 0.2$, $\varepsilon = 2$ and $\varepsilon \to \infty$

When we simulate the internally founded 12.20% increase in public investment we set η equal to 0.5 and government current consumption does not enter in the consumer's utility function.

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[9] Some of them show that substituibility would best describe the relationships between public and private spending while others are clearly supporting the case of complementarity.

We also show results of a simultaneous increase in current and capital government expenditure. At present, the Scottish Parliament does not have complete discretion regarding the allocation of the Scottish budget between capital and current spending, which is determined by the UK Government (Report on Scottish Devolution, 2009). So, according to the Government Expenditure and Revenue Scotland (GERS, 2009), only 12% of the budget is allocated to public capital expenditure while the rest is made up of current purchase in goods and services. Here we hypothesize that the increment of revenue that would occur by raising the Scottish variable tax of one penny is allocated 88% to current expenditure and 12% to capital expenditure, which correspond to a permanent increase of 1.03% and 1.07% of current and capital expenditure respectively.

All set of shocks are run considering government balanced budget. So that, income tax should rises by the amount necessary to cover the increase in government expenditure.

5. The impact of a permanent increase in current government spending.

We analyse the effect of 1.10% increase in current government expenditure. Results for different values of ε are reported in Table 1 where we distinguish between the short-run (SR) and the long-run (LR) impact. The short-run corresponds to the first period of the model where we impose capacity constraints; that is in this time interval the supply of all factors of production is fixed. The long-run is the last period of the model where we impose steady-state conditions.

Low elasticity of substitution ($\varepsilon = 0.2$)

For the case of $\varepsilon = 0.2$, the increase in government purchases raises the marginal utility of consumption that counteracts the negative wealth effect, producing a general expansion in regional activity.

In the short run a positive impact on output is accompanied by a rise in investment (0.56%) and consumption (0.77%). The replacement cost of capital is above its

benchmark equilibrium (0.08%) because of capital constraints. The labour force is fixed, though labour demand rises because aggregate demand expands, reducing the unemployment rate (-1.70%). Consequently, the bargaining power of workers increases and so does the real wage (pre-tax, 0.43% and after-tax, 0.19%).

Over time the behaviour of both migration and investment allow total output to rise further. The rise in the real take home wage and the fall in the unemployment rate result in an increase in population. In turn, the growth in labour supply eases the pressure on the wage until the real post tax wage is restored to its original level. Capital stock expands, driven by increases in investment.

The demand side effect of government purchases is reinforced by an increase in the individual's marginal utility that increases consumption offsetting the adverse (supply) effects of an increase in taxation and real labour cost. So the crowding in effect upon private consumption acts as a (demand side) counterbalancing stimulus to profitability thereby raising investment demand and then capital stocks.

In the model, exports are price sensitive. The increase in regional prices generated by the demand shock, through a rise in the nominal wage, has an adverse effect on competitiveness. However, the contraction in RUK and ROW exports, in the short and long run are not enough to offset total output, because production is supported by domestic consumption that stimulates domestic output.

High elasticity of substitution ($\varepsilon = 2$)

When the elasticity of substitution is set to a high value, output, employment and consumption decline in the long run. The results are compatible to a degree with previous business cycle models. Here the positive demand-side effect of an increase in government purchases is unable to outweigh the adverse supply-side effects of an increase in taxation that is made worse by the decline in consumption. In this scenario although government expenditure enters individuals' utility functions, the marginal utility of consumption is prevented from rising by the high degree of substitution

between private and public consumption. Since nominal and real wages rise so as to restore the net of tax wage, Scottish population and employment fall below their initial steady state values.

Turning to a sectoral analysis, we see that only Public administration (PAD) and Education (EDU) exhibit positive change in activity, in the long run. The intensity of government purchases (in the benchmark data) is more marked in PAD and EDU than other sectors, so that, the positive demand effect in these sectors is able to produce capital expansion. However, this is insufficient to counteract the general contractionary effect in all of the other sectors. Figure 1 shows the evolution of the real shadow price of capital for all sectors. Note that only for PAD and EDU the shadow price of capital is higher than the replacement cost of capital, thus stimulating investment with positive effect on output. However, the magnitude of the impact on these sectors is insufficient to produce an overall expansionary effect.

Perfect substitution

The results we would expect when the utility function is defined over a consumption bundle $\tilde{C}$ where perfect substitution between private and public consumption is imposed ($\varepsilon \to \infty$) are those where government purchases do not enter in the individual utility function.

Figure 2 shows the change in gross domestic product (GDP) and consumption for the case where perfect substitution between private and public consumption is imposed and the case where government expenditure does not enter in the consumer's utility function (indicated respectively a and b in the Figure). The change in GDP and consumption when $\varepsilon \to \infty$ approximates the case in which public spending has no direct impact on household utility. From the chart it seems that the percentage changes are almost equal in the two cases and will converge in the new steady state.

Even in this case the response of an income tax-financed expansion in government spending is, both in the short and long-term, contractionary[10]. As the case of $\varepsilon = 2$, the positive demand effect of an increase in government expenditure is more than totally offset by the adverse supply effect that an increase in taxes has on the bargained nominal wage and therefore competitiveness.

6. The impact of a permanent increase in public investment.

In this section, we analyse the effect of a 12.2% increase in public investment (which correspond to the same amount of a 1.10% increase in government purchase of goods and services), again financed by an increase in income taxation. The results are reported in the first column of Table 2.

In the short run, given the capacity constraint for private and public factors of production, the increase in public investment does not correspond to an expansion in the public capital stock by shifting the marginal product schedules, but can be seen as a simple stimulus to final demand. Therefore, in this time frame, we can distinguish two main simultaneous effects: the positive demand side effect associated with an increase in public investment and a negative effect of a resource cost related to an increase in taxation expanding the wedge between before and after tax wage.

Our results suggest a negative impact on employment and GDP but a positive impact on consumption and investment. In this simulation, therefore, the decline in regional activities does not correspond to a reduction in welfare. GDP declines by 0.03% as a result of a reduction in employment of 0.07% with respect to the base year. This is the result of an increase in the production cost of labour. Indeed, in the regional bargaining process, workers make adjustment in their pre-tax income after government expansion, which has implied a 1.94% increase in income tax. However, workers are unable to claim more, to maintain the same level of purchasing power, so the real wage after tax

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[10] The sign of the balanced budget multiplier is sensitive to labour market assumptions. Indeed, under a fixed nominal pre-tax wage what we would expect is a positive balanced budget multiplier in the short and long-run. Further details on this shock can be found in Lecca *et al*. (2011).

declines by 0.06%. With the fall in labour demand, unemployment rises, reducing the worker's bargaining power and so the real take home wage. Private investment expenditures are positively driven by the demand side of the economy. The expected future income related to the rise in commodities prices shifts up the real shadow price of capital reflecting profitability.

After the first period the situation changes significantly. In addition to the demand stimulus of an increase in investment and to a negative supply side effect of the distortionary tax, we also have an increase in the public capital stock that produces positive supply side effects. All capacity constraints are relaxed allowing public and private capital stock to accumulate over time while migration increases the working population. Turning to the dynamics in the labour market, (see Figure 3) only after the third period does total employment begin to rise. Wages are still high in the first three periods so that, we have a positive impact on labour input only at the beginning of period forth. The combined effect of a rise in the real wage after tax and reduction in unemployment rate encourage in-migration. Simultaneously, in-migration puts downward pressure on the real wage which gradually returns to its benchmark value. The labour market clears, at this point, where the change in employment equalizes the change in working population, and consequently the unemployment rate comes to rest at its original position.

From inspection of Figure 4 we can see that consumption increases relative to the initial steady state, although the average income tax rate is above its initial equilibrium. This reflects the important impact of the public capital stock: it produces a positive supply-side multiplier, by which increases in capital expenditure and tax rates induce a rise in output that in turn does not require additional increases in tax rates. As we can see from the chart the change in the average tax rate is positive but its magnitude decreases period by period coming to rest gradually at 0.47%. This is not an unexpected result since even in the very short-run we were able to see that the output effect of an increased public capital stock is able to offset the adverse resource cost effect of taxation. In other words, given the nature of public capital stock, its accumulation acts as an induced structural change that encourages private factors on the supply side of the

economy, which ultimately more than totally mitigates the the distortionary cost of taxation.

The representative agent increases investment since the accumulation of public capital stock stimulates a strong rise in the marginal product of capital. Furthermore, the increase in private capital stock puts downward pressure on the capital rental rate, producing a system wide efficiency stimulus lowering commodity prices, which in turn puts downward pressure on the replacement cost of capital relative to the change of the shadow price of capital, so that Tobin's q moves procyclically, ultimately encouraging additional investment.

In the long-run, where all factors of production are fully adjusted, private investment increases by 0.61%, which is different from the percentage increase in output, implying that, the capital coefficient is not the same as the initial steady state. Consumption and employment rise by 0.38% and 0.50% respectively.

Given fixed capital stock in the first period, the short-run results obtained here share similar features with the short-run outcomes that corresponds to the scenario where we run an increase in current government expenditure where there is no direct effect of government expenditure on the marginal utility of private consumers ($\varepsilon \to \infty$). In both cases, and only in the short-run, the experiment is configured as a demand side shock of the same magnitude. So, *ceteris paribus*, we would expect the same short-run outcome as the base case, where the demand side effect is not able to offset the negative adverse supply side effect of the increase in taxation. However, this expectation is not fulfilled, most obviously because consumption and investment are forward looking with rational expectations.

Difference between forward looking and myopic agents

Thus it seems useful to compare results with that obtained running the model with myopic expectations. So that, in Figure 5 we show the evolution of consumption and investment for the forward looking (FL) and myopic case (MYP). In the myopic case initially consumption and investment, are below the original steady state level and only when public capital expands does investment increase while for consumption it takes 6 periods to achieve a positive proportionate change. Of course, consumption and investment in both models finally converge to the same steady state equilibrium. In the new steady state, as intuitively we would expect, regardless of dynamic structure, both myopic and forward looking model must reach the same long-run equilibrium[11].

The main difference between the myopic and forward looking cases is in the adjustment towards the new steady state. Consumption in the myopic model is determined, period by period, by current household income. This decreases in the initial periods because nominal wages fall and the income from physical assets dramatically decline. Private capital initially falls as a result of disinvestment generated by the falling capital rental rate.

In the forward looking model, consumers base consumption decisions on expected future income and in the dynamic path there is no fixed link between consumption and current income. Investment is determined by profit expectations which are stimulated by the amplification effect of the increase in public capital stock. So, consumers and producers expect, from the outset, a positive stimulus due to the output effect that arises when public capital accumulates over time, as discussed above.

Results under different levels of the crowding out parameter η

We study also the short-run and long-run responses of key economic variables under different levels of the crowding out parameter η and the results are reported in Table 3. For all levels of η (except $\eta = 1$) the change in output is negative in the short-run however positive in the long-run. When $\eta = 1$, we get the highest impact since in this situation public capital is considered non rival and non-excludable. By increasing η the

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[11] This particular outcome has not always been recognised in CGE models; see Lecca et al. (2010).

negative impact on the short-run level of output is reduced while in the long-run the positive impact on output rises. Of course these results were expected given that by raising the level of *publicness* of public capital the greater is the response of private factors to the stimulus to public investment. The supply side multiplier rises, increasing labour input and capital stock and simultaneously offsetting the adverse effect of additional taxation.

Turning to consider consumption and investment, in the long-run even for the lowest level of η the proportionate changes in investment are positive whilst consumption is crowding in only for $\eta > 0.1$. In the short-run, instead, consumption and investment fall for the lowest level of η but they both become positive for $\eta > 0.2$.

7. A simultaneous increase in current and capital government expenditure

We run the simulation by setting the congestion parameter equal to 0.5 and assuming perfect substitution between private and public consumption ($\varepsilon \to \infty$). Results for the short-run and long-run are reported in the last column of Table 2.

The balanced-budget output and employment multiplier are positive both in the short and long run. Initially, government investment works like basic government purchases, labour input increases slightly, in turn lowering unemployment and rising real wages. There is also absorption of private resources reflected in the decline of private consumption and a slight decrease in private investment. Indeed, a permanent increase in government purchases (which is the dominant effect in this time frame) has a negative wealth effect on private individuals and despite the increase in employment and output, the drop in marginal product of private capital, due to a relatively dramatic increase in the replacement cost of capital, does not stimulate additional demand side expansionary effects and furthermore the fixed capacity prevents potential multiplier effects, so the effect is a decline in private investment.

The drain of private resources is only temporary as far as investment is concerned. In fact, during the transition path one more effect comes into play, which is, however, not

able wholly to counteract the negative wealth effect of an increase in government purchase on private consumption. But the accumulation of public capital, although adjusted for congestion, has a positive impact on private investment. In the long-run investment is 0.03% above its initial steady state but consumption still remains crowded out, coming to rest at 0.22% below its benchmark value.

It is interesting to analyse the impact of relaxing the constraint imposed by the UK Government on the split between capital and current expenditure. This allows the Scottish Government to choose the optimal share between the two categories of expenditure, to avoid crowding out effects on private resources. It turns out that in order to avoid the crowding out effect on private consumption the share of the budget spending allocated to current expenditure should be dropped to circa 60% (from the actual 88%) and consequently the share of public investment should increase from 12% to 40%. The level of shares necessary to avoid crowding out would change if, for example, we allow consumers to value current government expenditure.

If government purchases enter in the consumer's utility function, even with a high elasticity of substitution, (ε), private consumption goes up immediately. The parameter that governs the magnitude of the congestion effect has very little impact in this case and even with $\eta = 1$ crowding out effects on consumption are still apparent.

8. Conclusions

The aim of the paper is to evaluate and quantify the impact of endowing the Scottish Parliament with greater tax varying power given current debate on greater fiscal autonomy in Scotland and UK. To this end we we carry out a number of experiments using an intertemporal CGE model for Scotland.

Broadly speaking, the numerical simulations suggest that, in particular circumstances, there may be important potential welfare benefits to Scotland by endowing the Scottish parliament with greater tax varying powers.

Similarly to the analytical findings found in Linnemann and Schabert (2004) if private and current public spending are perfect substitutes ($\varepsilon \to \infty$) we have crowding out, whilst if the intra-temporal elasticity of substitution is sufficiently low (the case for $\varepsilon = 0.2$) an increase in government purchases is able to raise the marginal utility of consumption so as to outweigh the adverse effect of the increase in income tax rate.

The impact of an unanticipated public capital expenditure shock under perfect foresight, in the short and in the long-run, has a positive effect on private consumption and investment. The short-run dramatically diverges for the case in which agents have myopic expectations, under which circumstances there is complete crowding out.

From the sensitivity analysis we have performed we can conclude that independently of the magnitude of congestion, in the long-run the balanced budget output and employment multipliers are positive, with private consumption and investment crowded-in. However, the short-run response can be sensitive to the congestion parameter. For very low level of congestion parameter, results suggest crowding out effects on consumption and investment whilst for a large level only with myopic agents does crowding out arise. This result to some extent confirms previous analyses of public investment. For example in Baxter and King (1993), even with a low level of productivity of public capital the long-run effect of public investment on output is positive.

Our analysis also has implications for the debate related to the breakdown between government current and capital expenditure. At present the Scottish Government does not have total control over the two types of expenditure. Fiscal autonomy without total discretionary, over the composition of spending might not achieve the desired effect as far as the Scottish Parliament is concerned. Furthermore, current constraints on the composition of public expenditure may prevent the regional government from achieving higher levels of output and employment.

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Table 1

Short-run and long-run results for key variables. Current expenditure shock. Percentage change with respect to the initial steady state.

Key parameters	ε=0.2		ε=2		ε→∞	
Time	SR	LR	SR	LR	SR	LR
Income tax	1.33	1.53	2.15	2.61	2.83	3.57
Gross Domestic Product	0.15	0.27	0.03	-0.27	-0.06	-0.75
Consumer Price Index	0.11	0.03	0.03	0.06	-0.03	0.08
Unemployment Rate	-1.70	0.00	-0.40	0.00	0.67	0.00
Total Employment	0.23	0.29	0.06	-0.25	-0.09	-0.72
Nominal Gross Wage	0.53	0.30	0.45	0.51	0.39	0.70
Nominal Wage after Tax	0.30	0.03	0.08	0.06	-0.10	0.08
Real Gross Wage	0.43	0.27	0.42	0.46	0.42	0.62
Real Wage after Tax	0.19	0.00	0.05	0.00	-0.07	0.00
Replacment cost of capital	0.08	0.03	0.04	0.04	0.01	0.06
Working population	0.00	0.29	0.00	-0.25	0.00	-0.72
Households Consumption	0.77	0.81	-0.18	-0.22	-0.96	-1.12
Government Consumption	1.10	1.10	1.10	1.10	1.10	1.10
Private Investment	0.56	0.23	-0.43	-0.33	-1.28	-0.82
Public investment	0.00	0.00	0.00	0.00	0.00	0.00
Output						
Agriculture	-0.06	-0.05	-0.09	-0.55	-0.11	-0.99
Mining	-0.33	-0.33	-0.30	-0.77	-0.28	-1.16
Manufacturing	-0.26	-0.59	-0.24	-1.19	-0.22	-1.72
Energy	-0.03	0.08	-0.07	-0.44	-0.10	-0.90
Construction	-0.01	0.05	-0.15	-0.46	-0.27	-0.91
Distribution	0.17	0.47	-0.20	-0.41	-0.51	-1.18
Transport	-0.07	0.16	-0.19	-0.49	-0.29	-1.07
Financial	-0.05	0.18	-0.10	-0.42	-0.14	-0.94
Public admin	0.98	1.03	0.97	0.98	0.95	0.93
Education	0.69	0.87	0.54	0.59	0.41	0.34
Other services	0.02	0.32	-0.15	-0.32	-0.28	-0.88
Total Export (RUK+ROW)						
Agriculture	-0.28	-0.19	0.03	-0.33	0.28	-0.45
Mining	-0.40	-0.30	-0.33	-0.51	-0.28	-0.70
Manufacturing	-0.38	-0.74	-0.25	-1.27	-0.14	-1.74
Energy	-0.32	-0.11	0.01	-0.19	0.28	-0.26
Construction	-0.59	-0.22	-0.14	-0.38	0.25	-0.52
Distribution	-1.23	-0.31	-0.17	-0.53	0.71	-0.73
Transport	-0.60	-0.30	-0.24	-0.51	0.06	-0.70
Financial	-0.56	-0.25	-0.07	-0.42	0.35	-0.58
Public admin	-1.62	-0.25	-1.52	-0.43	-1.43	-0.58
Education	-1.49	-0.43	-1.22	-0.74	-1.01	-1.01
Other services	-0.91	-0.34	-0.34	-0.58	0.14	-0.79

Table 2

Short-run and long-run results for key variables. Current and capital expenditure shock.

Percentage change with respect to the initial steady state.

	Capital government expenditure shock		Current and capital government expenditure	
Key parameters	η =0.5		ε→∞ η =0.5	
Time	SR	LR	SR	LR
Income tax	1.94	0.47	2.56	2.34
Gross Domestic Product	-0.03	0.65	0.04	0.09
Consumer Price Index	0.05	-0.10	0.04	0.03
Unemployment Rate	0.51	0.00	-0.38	0.00
Total Employment	-0.07	0.45	0.10	0.10
Nominal Gross Wage	0.33	-0.02	0.53	0.44
Nominal Wage after Tax	-0.01	-0.10	0.09	0.03
Real Gross Wage	0.28	0.08	0.49	0.41
Real Wage after Tax	-0.06	0.00	0.04	0.00
Replacment cost of capital	0.04	-0.10	0.10	0.06
Working population	0.00	0.45	0.00	0.10
Households Consumption	0.17	0.39	-0.23	-0.22
Government Consumption	0.00	0.00	1.03	1.03
Private Investment	0.22	0.61	-0.09	0.03
Public investment	12.20	12.20	1.07	1.07
Total Export (RUK+ROW)				
Agriculture	-0.08	0.79	0.09	0.22
Mining	-0.01	0.68	0.00	0.15
Manufacturing	-0.14	0.76	-0.15	-0.14
Energy	-0.05	0.74	0.07	0.18
Construction	-1.13	-0.19	-0.47	-0.18
Distribution	-0.47	0.69	0.03	0.01
Transport	-0.17	0.68	-0.07	0.03
Financial	-0.21	0.44	-0.05	-0.15
Public admin	-0.46	2.45	-4.89	-2.76
Education	-0.46	1.16	-2.02	-1.31
Other services	-0.28	1.01	-0.17	0.00

Table 3
Sensitivity analysis: changing the congestion parameter. Short-run and long-run percentage change from initial steady-state

Congestion	0.10		0.20		0.40		0.60		0.80		1.00	
	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
GDP	-0.046	0.174	-0.042	0.304	-0.033	0.534	-0.024	0.766	-0.014	1.041	0.000	1.416
Consumption	-0.192	-0.131	-0.093	0.011	0.081	0.263	0.256	0.516	0.463	0.816	0.744	1.225
Investment	-0.001	0.150	0.047	0.277	0.160	0.501	0.291	0.727	0.460	0.996	0.703	1.361

Figure 1

Shadow price and replacement cost of capital.

Figure 2

30
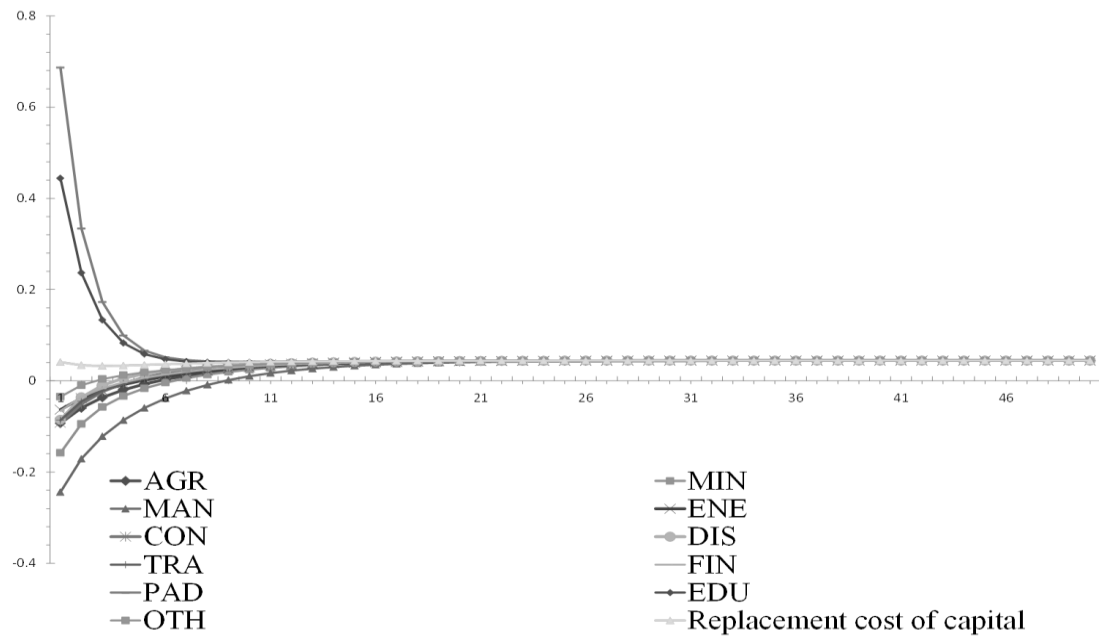
Consumption and investment
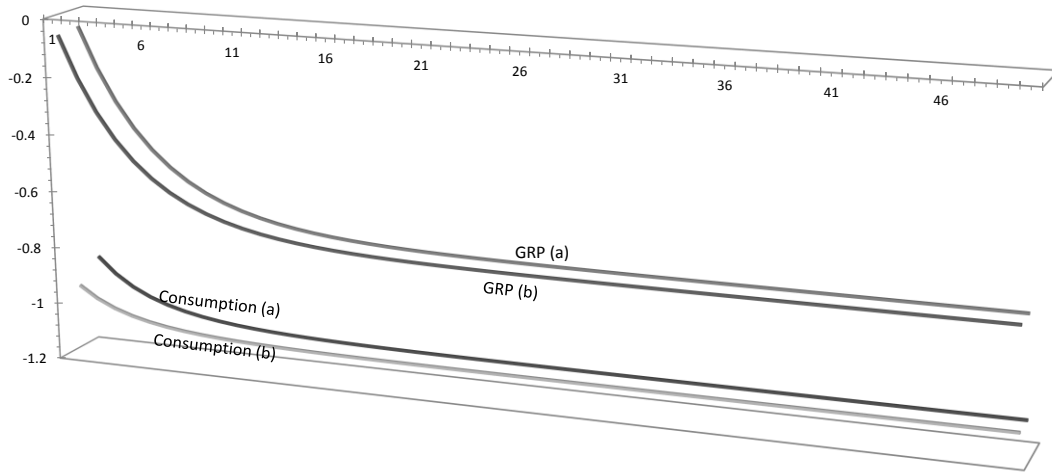
Figure 3

Labour market dynamic

Unemployment Rate — Total Employment — Nominal Gross Wage
Real Wage after Tax — Labour supply

Figure 4

Consumption, Investment and Income tax evolution.

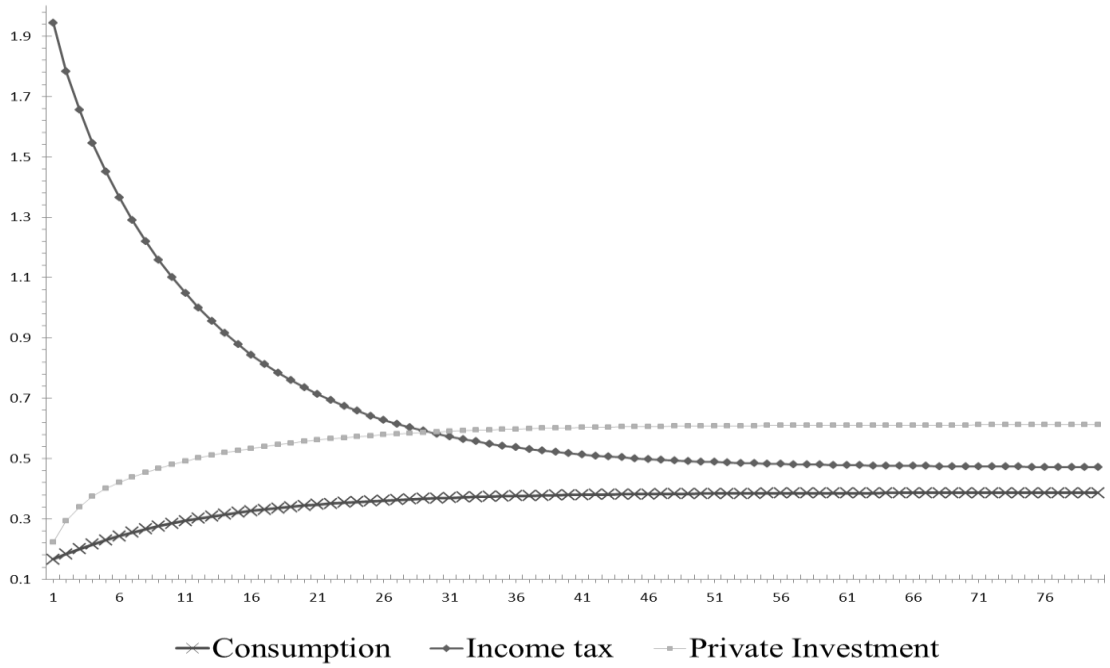

Legend: —✕—Consumption —◆—Income tax —▪—Private Investment

Figure 5

Myopic vs. forward looking: private consumption and investment.

Legend: ·····◆·····Consumption MYP —▪—Investment MYP –▲–Consumption FL —✕—Investment FL