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BALANCED BUDGET GOVERNMENT SPENDING IN A SMALL OPEN REGIONAL ECONOMY

BY

PATRIZIO LECCA, PETER MCGREGOR AND KIM SWALES

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GLASGOW

Balanced Budget Government Spending in a Small Open Regional Economy

Patrizio Lecca

Peter G. McGregor*

and

J. Kim Swales

Fraser of Allander Institute

Department of Economics

University of Strathclyde

* Corresponding author. Professor Peter McGregor, Director, Fraser of Allander Institute, Sir William Duncan Building, 130 Rottenrow, Glasgow G4 0GE. (p.mcgregor@strath.ac.uk)

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. 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 even with a high level of congestion; but crowding out effects might arise in the short-run if agents are myopic.

JEL Classifications: H72; R13; R50.
Key words: regional computable general equilibrium analysis, fiscal federalism, fiscal policy.

1. Introduction

There is widespread movement towards at least partial fiscal federalism within the European Union and continuing debate over fiscal autonomy in Scotland. In 2008 the Scottish Parliament, with the support of the UK government, established the Calman Commission on Scottish devolution. The aim of the Commission was not only to review previous experience of Scottish devolution, but also to give comments, suggestions and recommendations on possible changes to "the present constitutional arrangements" that would improve "the financial accountability of the Scottish Parliament" (Commission on Scottish Devolution, Final report, 2009). The Commission recommended endowing the Scottish parliament with greater tax varying powers[1]. At present the Scottish Parliament has the power to vary the basic rate of income tax in Scotland by plus or minus 3 pence in the pound (the Scottish Variable Rate or SVR). However, this power has not so far been used.

Given these developments it is particularly important to understand the probable effect of fiscal policy in regional economies that are endowed with tax varying powers. The Scottish experience represents one of the most interesting cases within the EU. It is engaged in a lively, on-going debate on greater fiscal autonomy and independence, which is politically controversial, especially in respect of tax-varying powers.

The object of this paper is to explore the likely effect of fiscal policy in Scotland in order to evaluate the conditions under which there may be a positive impact of fiscal policy on the regional economy. Furthermore, we wish to identify the scale, as well as the direction, of the effect of a balanced-budget fiscal expansion on the Scottish economy. Of course, there is a large literature on fiscal policy especially in the context of national economies. We focus on a part of the literature of fiscal federalism that has not been treated extensively, since this has mostly concentrated on the analysis of intergovernmental transfers (see section 2).

We attempt to study the impact of fiscal policy, specifically a balanced budget fiscal expansion, in a regional economic context, an area where the literature is sparse relative to

[1] The current UK Government is committed to implement the recommendations of the Calman Commission.

national macroeconomic analysis. In doing so, we use AMOS[2] a regional intertemporal computable general equilibrium (CGE) to study empirically a number of typical shocks affecting a small open economy in a balanced-budget framework.

In light of recent contributions to the literature that we discuss in Section 2, we distinguish between government current and capital expenditure, allowing different treatments of government expenditure according to its nature and purpose. In our model, current government expenditure is considered a simple purchase of goods and services so that its impact is confined to the demand side of the economy, whilst capital expenditures are treated as public investment that contributes to the accumulation of the public capital stock, and consequently affects both the demand side and the supply side of the economy through its impact on productive capacity.

The existing empirical literature is mostly focussed on evaluating the impact of current purchases of goods and services. Indeed, the conventional classification of government spending into current and capital may be problematic in some respects. For example some of "current expenditure" on Education and Health may in fact represent investment in human capital, resulting in the neglect of possible expansionary supply side effects arising from these expenditures.

Public current spending (including, for example, military and police expenditure, health care and education) enters in the representative utility function, as proposed by Linnemann *et al*, (2004), affecting private consumption. Government capital expenditure, through accumulation of public investment in infrastructure, increases the substitution possibilities in production in the spirit of Barro (1990), Futugami *et al*, (1993) and Chen (2007). We also introduce congestion effects consistent with the median voter model that serve to moderate the productivity of government expenditure.

The model we use incorporates regional economic features that differ in some respects from the previous models used to study fiscal policy shocks. The model can be considered an

[2] 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).

applied version of the skeletal model presented in Abel and Blanchard (1983). Investment decisions, that follow a Tobin's q adjustment, are separated from savings decisions. The former reflects the intertemporal optimisation of firms and the latter are the outcome of intertemporal optimisation by households. Following Layard *et al*, (1991) the model also incorporates imperfect competition in the labour market and allows for unemployment and population updating through a net migration function. In the traditional business cycle model employed to describe the national economy, migration is absent and real wages are unrelated to the capacity of workers to restore their purchasing power and/or not associated with the capacity of the firm to use unemployment as "discipline device". Indeed, in neoclassical closures the real wage is equal to the marginal product of labour, and unemployment is not allowed since such closures typically adopt an intertemporal consumption–leisure choice. Furthermore in traditional business cycle models investment is driven by saving.

The paper proceeds as follow. In the next section we briefly review previous research on fiscal policy. In Section 3 we describe the dynamic general equilibrium model used in this study and in Section 4 we explain how congestion effects are introduced into the model. Section 5 outlines the simulation strategy and in Section 6 we discuss the results of the policy shocks. In section 7 these results are subject to sensitivity analysis and finally, in Section 8, we present concluding remarks.

2. Review of the relevant literature.

Several empirical macroeconomic models have tried to identify the possible effects of fiscal expansion. In real business cycle models, such as in Aiyagari *et al* (1992) and Campbell (1994), increases in government purchases lead to a decline in private consumption, showing a negative relationship between government spending and private consumption. Baxter and King (1993) find that increases in government spending significantly reduce private consumption and investment. However if the government purchases are financed by a non distortionary tax the effect on private investment is positive. Furthermore, if government expenditures take the form of capital expenditure, the long-run effects on output, consumption and investment vary significantly depending on the productivity of public capital.

Devereux *et al* (1996), who apply a model with increasing returns and monopolistic competition, where an increase in the level of government spending results in an endogenous increase in total factor productivity, find that government spending shocks increase private consumption. Here, the negative wealth effect of increased taxation on households is more than totally offset by the endogenous increase in total factor productivity.

Perotti (1999) found that in good times (at low levels of debt or deficit) expenditure shocks have positive, or Keynesian, effects. While negative, or non-Keynesian, effects can be found in the opposite circumstances. Blanchard and Perotti (2002), using a VAR approach, found a positive effect of government spending on private consumption and strong negative effect on private investment spending. Estimating a *q* type of investment equation Alesina *et al*, (2002) highlight the important role played by the labour market (the behaviour of wages and the response of labour supply) as a channel of transmission for fiscal policy shocks: government spending reduces private income and increases labour costs reducing profit expectations and so economic activity.

The effect of fiscal spending has also been studied analytically by introducing substitution or complementarities between government and household consumption. Linnemann and Schabert (2004) show that a positive response of private consumption might occur as a consequence of a positive government expenditure shock if the substitution between public and private consumption is sufficiently low. The degree of complementarity between private and public expenditure is identified as a critical parameter governing a positive private consumption multiplier in Ganelli and Tervala (2009).

In the previous works cited above (apart from Baxter and King, 1993 and Devereux *et al*, 1996) government spending is treated as a simple purchase of goods and services so that its effect is confined to the demand side of the economy. Arrow and Kurz (1970) initially proposed allowing public spending to accumulate over time leading to a form of investment. Following this paper a further strand of literature on fiscal policy focuses on the formation of public capital and its impact on output, private capital and consumption. The endogenous growth model of Barro (1990) that introduced government expenditure as an argument in the production function was later extended by Futagami et al, (1993), Baxter and King (1993) and more recently by Chen (2007). Unlike Barro, in these latest contributions public capital expenditures are treated as public investments that contribute to the accumulation of the

public capital stock. Consequently these expenditures affect both the demand and supply side of the economy, through changes in productive capacity.

Many empirical studies have investigated the impact of public investment following Aschauer's work (1989a, b) that found that public capital has a powerful impact on the productivity of private capital. Indeed, while some studies support the idea that public capital has a significant impact on the productivity of private capital others reject it (for the UK, see e.g. Lynde and Richmond, 1993).

Given that public services are characterised by some degree of congestion (Barro and Sala-i-Martin 1995) it is becoming increasingly common to introduce congestion effects in order to reduce the effectiveness of public capital. Studies related to measuring the extent to which local public goods are congestable can be found in Bergstrom and Goodman (1973), and Edwards (1990). Fisher and Turnovsky (1998) analyse the effect of the different degrees of congestion on private capital and the substitutability between public and private capital in production, concluding that there exists a trade off between them.

All the contributions mentioned so far are related to fiscal policy issues that deal with the macro-national perspective. In the regional context very few studies attempt 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). In addition, these approaches mainly follow the national macroeconomic literature in abstracting from local wage bargaining, migration effects and regional amenities; all elements that are now crucial for the analysis of peripheral/and indeed all sub-national regions of the EU.

An example where local amenities are taken into account can be found, for the Scottish economy, in Lecca *et al*, (2010*b*) where the macroeconomic impact of a balanced-budget fiscal expansion is analysed using the bargaining theory of wage extended to incorporate the role of amenities in affecting the real bargaining process and the decision of migrants. In this study the impact of a balanced budget fiscal expansion critically depends on the value that local and potential residents allocate to public amenities. When workers are willing to give up part of their wages in exchange of more public expenditure, the sign of the balanced budget

multiplier is positive, since moderation of local pay claims reduce the labour cost of labour avoiding offsetting effect of positive government expenditure.

Relevant contributions on decentralization focus primarily on intergovernmental transfers such as in the work of Boadway and Keen (1997) where, in a strategic game theory approach, interaction between different level of governments are modelled in order to define the optimal transfer of funds between levels of governments. Works that assume a macro perspective using a bi-regional CGE model but that still focus on intergovernmental transfer are those of Groenewold *et al*, (2000), Groenewold *et al*, (2003) and Groenewold and Hagger (2007).

3. 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.

3.1. *Further characteristics of the model*

Following recent analytical contributions on fiscal spending, in particular the work of Linnemann *et al*, (2004), individuals optimise their lifetime utility function of consumption, subject to a lifetime wealth constraint:

$$\int_0^t \frac{1}{1-\sigma}\tilde{C}^{1-\sigma}e^{-\rho t}dt$$

Subject to the budget constraint:

$$\sum_t^{\infty} \mu(t) Pc_t \tilde{C}_t \leq W \; ; \; \mu(t) = \prod_t (1+r_t)^{-1}$$

[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).

Where σ, ρ and *r*, are respectively the constant elasticity of marginal utility, the constant rate of time preference and the interest rate. The consumption bundle $\tilde{C}$ is defined as a CES combination over private consumption, C, and current public expenditure, G_i^*

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

Using this formulation Linnemann *et al*, (2004) show that if the elasticity of substitution $\varepsilon = \frac{1}{1-\xi}$ 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.

Intermediate inputs (*V*), labour (*L*) and capital (*K*) constitute the production inputs of the model. Total gross output X, is given by Leontief technology:

$$X_{i,t} = \min \left\langle \frac{Y_{i,t}}{a_i^Y}; \frac{V_{i,j,t}}{a_{i,j}^V} \right\rangle$$

Value added, *Y*, is given by a CES combination of Labour, private and public capital stock:

$$Y_i = CES(L_i, K_i, K_{(g)}^d)$$

We maintain constant return to scale, and the aggregated public capital service $K_{(g)}^d$ is treated as an unpaid factor of production that is considered exogenous to the firm and determined by the public stock of infrastructure $K_{(g)}^s$ that accumulates over time subject to depreciation $(\delta_{(g)})$ through capital government expenditure $I_{(g)}$:

$$K_{(g)t+1}^s = K_{(g)t}^s \cdot (1 - \delta_{(g)}) + I_{(g)t}$$

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 given by profit, π_t, less private investment expenditure, *I* subject to the presence of adjustment cost $g(x_t)$ where $x_t = I_t / K_t$:

$$Max \int_0^t \left[\pi_t - I_t (1 + g(x_t)) \right] e^{-\int_0^t r_v dv} \text{ subject to } \dot{K}_t = I_t - \delta K_t$$

The solution of the dynamic problem gives us the law of motion of the shadow price of capital, λ_t and the time path of investment related to the tax-adjusted Tobin's *q* and an adjustment cost parameter *z*:

$$\frac{I_t}{K_t} = \frac{1}{z}\left[\frac{\lambda_t}{Pk_t} - (1 - b - \tau k)\right]; \qquad \dot{\lambda} = \lambda_t(r + \delta) - rk_t - Pk_t\left[\frac{I_t}{K_t}\right]^2 g'(I_t / K_t);$$

where *Pk* is the replacement cost of capital, *rk* is the rate of return to capital and *b* is a calibrated parameter.

No natural population change is assumed, but the labour force 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 and national (w^N/cpi^N) real wages, and negatively related to the gap between the log of national, (u^N) and regional unemployment rates u:

$$m = \varsigma - 0.08\left[\ln(u_t) - \ln(u^N)\right] + 0.06\left[\ln\left(\frac{w_t}{cpi_t}\right) - \ln\left(\frac{w^N}{cpi^N}\right)\right]$$

where *m* is net in-migration as a proportion of the regional population; u_s and u_r are respectively the unemployment rate for Scotland and RUK. Wage setting is determined via a regional bargained real wage function that embodies the econometrically derived specification given in Layard *et al*, (1991):

$$\ln\left(\frac{w_t}{cpi_t}\right) = c - 0.113 \cdot \ln(u_t)$$

where *c* is a calibrated parameter.

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, given constant prices and income for Rest of UK and Rest of the World and a price elasticity of 2.0. Domestic and imported inputs are obtained via an Armington link (Armington, 1969) and are therefore relative-price sensitive with trade substitution elasticities of 2.0 (Gibson, 1990). In all the simulations in this paper we impose a single Scottish labour market characterised by perfect sectoral mobility. All sectors are taken to be perfectly competitive. In production, elasticities of substitution are set to 0.3 (Harris, 1989).

The values of the adjustment cost parameter in the investment function, z is assigned a value of 1.5. 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 1.5. In the benchmark equilibrium the price of capital goods, *Pk*, is set equal to unity since the benchmark prices on the consumption side are set equal to one.

The model parameterization procedure considers the economy to be initially in steady state equilibrium. The benchmark data set is the Scottish SAM for the year 2004 based on the IO for 2004 built by the Scottish Government to which we have added the information related to the primary and secondary income distribution. This information comes again from the Scottish government, specifically by the NUTS 2004, the household's disposal income account. The government fiscal deficit is derived from the Scottish net borrowing account[4]. In this account it emerges that the estimated Scottish fiscal deficit is 12.0 per cent of GDP (excluding oil revenues). As regards the capital inflow, these are obtained as net imports. Once a preliminary SAM is obtained, a Cross Entropy model (Robinson *et al*, 2001) is used to readjust and introduce new information and constraints in some sub matrices of the SAM. The constraint equations allow us to maintain invariant the original IO and the household primary and secondary income distribution, which come from official data. Also constraint equations are used to avoid transfers of income between domestic and foreign institutions affecting the relative composition of the capital account of the balance of payment.

For all sectors, trade elasticities are set equal to 2 whilst production elasticities are equal to 0.3. 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). The benchmark value of *W* corresponds to the discounted flow of current income, *NFW* to the discounted flow of net labour income, and *FW* is obtained by maintaining asset equilibrium.

We apply the usual procedure to solve an infinite time horizon model, by imposing steady state conditions at a specific point in time. In the initial period we impose factor constraints in order to identify short-run impacts.

4. Modelling congestion effects

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

[4] (http://www.scotland.gov.uk/Publications/2006/12/11084016/7)

stock is the general perpetual inventory method (detailed in Appendix 1), a well known methodology applied by OECD (2001) and by the U.S. Bureau of Economic Analysis (1999)[5].

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[6] is adjusted for congestion by private capital stock, K, and population[7] L^s while, current government expenditure, G^*, is congested only by population:

$$\begin{aligned} K_{(g)}^{d} &= K_{(g)}^{s} \cdot \left[K + L^{s}\right]^{\gamma} \qquad & \gamma &= \frac{\eta - 1}{\eta},\ \gamma \in (0, -\infty) \\ G_{i}^{*} &= G_{i} \cdot \left[L^{s}\right]^{\gamma} \qquad & \eta &\in (0,1). \end{aligned} \tag{1}$$

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[8]. 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

[5] See also Holtz-Eakin 1993 and Kamps, 2004.
[6] In some cases when labour supply is 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 in the model we allow for unemployment, public capital is congested by private capital and total labour force (which includes unemployed).
[7] In the model we are assuming that all population is working-age population. So we use labour force and population as synonymous.
[8] This corresponds to the case described in Fisher and Turnovsky, (1998) called *proportional congestion*.

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 effective level of current government expenditure depends only on population, which is endogenous in the model. In no circumstances can the effective level of government service be negative.

5. Simulation strategy

In a regional economic system, normally, regional policy takes the form of an externally financed disturbance. Such a policy, of course, avoids the adverse supply side effect that typically accompanies balanced budget expansion, because the financing occurs at the level of the national economy and we assume the target region is small. While the Scottish Government has the power to vary the standard rate of income tax, it has so far chosen not to do so. It seems reasonable, therefore, in the first instance, to compare the situation under which regional policy is financed outwith the region, with the case in which it is internally financed. Results for a number of short and long-run simulations are reported in Table 1.

The first two columns of Table 1 report the impact of an externally financed increase in government current expenditure. This case is labelled Scenario 1. The remaining Scenarios (2-4, in Table 1) investigate the effect of an exogenous increase in current government purchases and services separately identifying the case in which such an exogenous shock directly affects private agents’ marginal utilities from the case in which current government expenditures do not enter in the consumers‘ utility function. In these simulations, public investment is kept constant and public government expenditure is just seen as an exogenous element of final demand. In the second experiment (Scenarios 5 and 6 in Table 1), public investment expenditures rise exogenously and consequently affect the public capital stock, which enters into the aggregate production function. In Scenario 5, government current consumption is fixed and so there is no effect on the marginal utility of consumption whilst in Scenario 6 we report the results of a simultaneous increase in current and capital government expenditure.

In Scenarios 2-4, income tax rises by the amount necessary to cover a permanent 1.10% increase in current purchases in goods and services, whilst in Scenario 5 the tax rate rises in

order to cover a permanent 12.20% increase public investment. These percentages correspond to the amount of revenue that the Scottish tax office would be able to collect if a one penny rise in the Scottish variable tax rate for the year 2004-05 had been applied. It would imply approximately £270 million of additional revenue.

In Scenario 2, we investigate the effect of an increase in current government purchases in goods and services but imposing a balanced Government budget. In the remaining columns relating to current expenditure (Scenario 3 and 4) we report results for the case in which 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. In this first block of simulations, we are not accounting for congestion ($\eta = 1$). Our results critically depend upon the value assigned to 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 two outcomes obtained by imposing $\varepsilon = 0.2$ and $\varepsilon = 2$.

The last two columns report the short-run and long-run results for the second experiment. Here, public investment is chosen exogenously, and public capital stock is treated as an unpaid factor of production subject to congestion, where $\eta = 0.5$. 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* as a benchmark. However, we handle the uncertainty associated with the value of

[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.

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

6. Policy analysis

6.1. The impact of a permanent, externally funded increase in government expenditure.

We start by considering the outcome of an exogenous, permanent, unanticipated and costless increase in government expenditure. The peculiar operation of this shock can be seen in the long-run. In the new steady state, the economy operates as an extended input output system (McGregor *et al*, 1996) where all prices return to their initial values, the unemployment rate retains its original value and within each sector, output, employment and capital stock expand by the same proportionate amount.

In the short-run the demand disturbance has an expansionary effect on aggregate output (0.16%) and employment (0.25%). As labour demand increases, the unemployment rate falls by 1.87% and the real wage increases by 0.21%. Output does not expand in all sectors and the extensive crowding out of exports results from the increase in regional prices. Whilst the rise in commodity prices also increases the replacement cost of capital, the positive change in the real shadow prices of capital in some sectors contribute to the formation of profit expectations resulting in an increase of aggregate investment.

When we allow the labour force to adjust through migration and the capital stock updating through investment, the economy gradually approaches the long-run equilibrium. The region returns to a zero net migration steady state position and investment approaches the level required to just cover depreciation. At this point, real wages and prices return to their original values and the unemployment rate is invariant with respect the initial steady state. These results are driven by the combination of the zero net migration and real wage bargaining function. As migration increases due to a fall in unemployment and rise in real wages, the labour force expands. During the transitional path, variation in the employment-labour force ratio declines gradually and returns to its original level where migration ceases to rise and unemployment returns to its benchmark value. As in-migration increases the real wage is subject to downward pressure, until the labour market achieves its long-run equilibrium

where the positive change in employment is totally absorbed by migrants. So that the real wage is restored to its steady position and the price of goods are fully adjusted.

Relaxing the capital constraint, capital stock increases with investment which in turn, is affected by its real shadow price. As aggregate demand rises, prices increase and so do firms' profit expectations. This leads to an increase in investment that is moderated by the replacement cost of capital until Tobin's q is again equal to 1 and accumulation is complete. In the long-run the system behaves "as if" it were an extended input-output system because across such equilibria there is effectively an infinitely elastic supply of labour and capital (Batey and Madden, 1983; McGregor *et al*. 1996).

6.2. *The impact of a permanent increase in current government spending*

We next consider the case that shows the response of the regional economy to an increase in current government expenditure that is financed by an increase in labour income tax. Public capital is fixed and current government purchases of goods and services do not enter in the household utility function.

In our results (see Table 1, Scenario 2, RB), the response of an income tax-financed expansion in government spending is, both in the short and long-term, contractionary. This result contrasts with the externally financed disturbance where the distortionary effects of income tax are not present. In the short-run with fixed capacity, key variables such as output, consumption, employment and investment decline. The positive demand effect of an increase in government expenditure is more than totally offset by the adverse supply effect of an increase in taxes which lower income and consequently consumption. With the general contraction in activity the response of labour demand is also negative, reducing employment (-0.09%), increasing the unemployment rate (0.67%) and generating a reduction in the after tax real wage (-0.07%).

Over time population and capital adjustment come into play. The fall in the real after tax wage and the increase in unemployment encourage out-migration in this case, in contrast to the case of external funding. Population continues to fall until the real after tax wage is restored and unemployment returns to its initial steady state position. The increase in nominal and real pre-tax wage increases the production cost of labour reducing profit expectations, so

that negative investments exacerbate the direct and negative wealth effect due to a cut in individual resources, which implies a further fall in output.

Turning to a sectoral analysis, we see that only Public administration (PAD) and Education (EDU) exhibit positive variation, in the long-run. The intensity of government purchases (in the benchmark) is more marked in PAD and EDU than other sectors. So 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. As we can see from Figure 1 the real shadow price of capital increases only for PAD and EDU. For these sectors, the shadow price of capital rises more than its replacement cost, stimulating investment with positive effect on output (see Figure 1). However, the magnitude of the impact on these sectors is insufficient to produce an overall expansionary effect.

6.3. *The impact of a permanent increase in current government spending: the case of effective consumption.*

We obtain quite different results in Scenario 3 in which we account for effective consumption and the elasticity of substitution between C and G is set equal to 0.2 (the low elasticity case). In the short-run a positive impact on output is accompanied by a rise in investment (0.56%) and consumption (0.77%). Indeed, by allowing for substitution between C and G the increase in government purchases raises the marginal utility of consumption that counteracts the negative wealth effect, producing a general expansion in regional activity.

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%) and, unlike the case of Scenario 2, 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 dynamic effect of fiscal policy on investment is very different

from scenario 2. Here 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 in the long-run are not enough to offset total output, because production is supported by internal consumption that stimulates domestic output.

When the elasticity of substitution is set to a high value, as in Scenario 4, 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. But, because G is valued, the reduction in C is less than in the base case Scenario 2. Indeed, 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.

The size of the crowding out effect in Scenario 4 is smaller than that in Scenario 2, which corresponds to the case of perfect substitution between private and public consumption. In order to show this and to evaluate the accuracy of the model we compare the base case scenario with the case in which government purchases enter in the individual utility function but with a degree of substitution between C and G, that tends to infinity. From Figure 2 we see that the change in GRP and consumption when $\varepsilon \to \infty$ (perfect substitution) approximates the case in which public spending has no 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.

6.4. *The impact of a permanent increase in public investment.*

In this section[10] we analyse the effect of a 12.20% increase in public investment, again financed by an increase in income taxation. The results are reported in the Scenario 5 columns of Table 1.

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 which also enlarges the wedge between before and after tax wage, given that we are dealing with distortionary tax. 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 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.

[10] In this model a choice was made to consider public capital as one of the three inputs in a CES function allowing substitution with the other conventional inputs (labour and capital). It could be argued that it would be better to use a hierarchical production function by nesting a series of CES functions where, for example, at the lower level a composite input is the result of substitution between private and public capital and at the upper level the composite is a substitute for labour. Of course it would also have been possible to perform an opposite example where the composite input is given by labour and private capital. Assuming one of the possible hierarchical specifications it would also imply that we are aware of the exact form and relationship to assign. However, we do not attempt to estimate econometrically all the possible relationships. For this reason we prefer to use the CES formulation keeping the elasticity of substitution between inputs low and equal to 0.3. In fact, independently of the position of public capital in different levels of the hierarchy, if we maintain the same value of the elasticity of substitution in the nests, the results do not change since it would be the same as a single nest.

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. Labour cost is still high in the first three periods where the substitution effect dominates the output effect. The latter effect seems to prevail with a positive impact on labour input only after period three in which 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.

The short-run results obtained here share similar features with the short-term outcomes of Scenario 2, our base case scenario, where we run an increase in government expenditure where there is assumed to be no direct effect of government expenditure on the marginal utility of private consumers. In both cases, 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.

If, for example we run the model using a myopic dynamic structure, the results we obtain are quite similar to the short-run outcome of the base case scenario, since agents take decisions abstracting from future conditions. Simulation results for agents with myopic expectations suggests that in the short-run GRP and employment decline respectively by 0.06% and 0.15% and the reductions in private consumption and investment are of the order of 0.51% and 0.26% respectively. These figures are still a bit different in quantitative terms with respect to the short-run results of Scenario 2 because, unlike capital expenditure, where the propensity to import is relatively high, government current expenditure is mostly purchases of domestic goods and services.

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 with the capital rental rate, and disinvestment is the consequence of the absence of rational expectations. Indeed, investment, in the myopic model is the result of the gap between actual and desired capital stock which is obtained within period.

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. Investors decide on the basis of profit expectations which are stimulated by the amplification effect of public capital stock. So, consumers and producers expect, from the outset, a positive multiplier due to the output effect that arises when public capital accumulates over time, as discussed above.

6.5. *A simultaneous increase in current and capital government expenditure*

We now simulate the impact of a simultaneous increase of both current and capital public 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 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.

We run the simulation by setting the congestion parameter equal to 0.5 and excluding current government purchases from the household utility function. Results for the short-run and long-

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

run are reported in the last columns of Table 1, labelled Scenario 6. In these circumstances given that the percentage increase of government expenditure is very close to the base case scenario the capacity of public capital to overwhelm the adverse supply side effect typically encountered in Scenario 2 does not arise in the short-run, but a partial offsetting occurs in the long-run where all factors of production completely adjust allowing for a supply side response of private factors and an amplification effect due to the expansion in public capital stock.

Note that in this case, in contrast to Scenario 2, the balanced-budget output and employment multiplier are positive both in the short and long-run. Initially, as explained previously, government investment works like basic government purchases, labour input increases slightly due mainly to a substitution effect 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.

7. Sensitivity analysis

7.1. *The sign of the balanced budget multiplier under a fixed nominal wage*

The results analysed in Section 6.1 are obtained under a regional bargaining function. However, the sign of the balanced budget multiplier is sensitive to labour market assumptions. Under a fixed nominal pre-tax wage, NB (National Bargaining) in Table 1, GRP, employment and investment increase in both short and long-runs. A characteristic of this simulation is not only a positive balanced budget multiplier in the short and long-run but also the long-run zero price changes with the unemployment rate below its benchmark.

With the before tax nominal wage fixed an increase in government expenditure reduces the after tax wage to below its base year value because of a resulting increase in taxation. The impact on the wage has the effect of decreasing labour costs and in turn stimulating investment. However, adverse effects are still apparent in consumption.

During the adjustment path, the stimulus for in-migration is driven mainly by a fall in the unemployment rate. Indeed, while the real wage has fallen the reduction in unemployment rate is enough to boost in-migration. Migration will rise until the fall in unemployment rate offsets the impact of decline in real consumption wage on migration flows.

It is worth noting the impact on competitiveness. In the short-run the crowding out of exports in the sheltered sectors and construction are the result of increased regional prices in these

sectors where public spending is concentrated, but once prices adjust fully, in the new steady state exports are unchanged in every sector[12].

7.2. *Congestion effects for public current spending*

In the preceding sections we have only accounted for the possibility of public spending being valued by consumers, and varied the elasticity of substitution between private and public consumption. Here, we assume that congestion also applies to public current spending. We show the impact of varying η for alternative values of ε. In Table 2 we report the long-run percentage change in private consumption resulting from changing the level of the elasticity of substitution ε from 0.2 to 2 and the level of congestion parameter that lies in the range 0.2 to 1. Since the model does not take into account natural population growth, only in-migration can increase population density that in turn reduces the public services available per worker. If consumers value positively high government expenditure this, on the one hand, has a positive effect on migration since, as we have seen in the preceding analysis, the real take home wage rises and the unemployment rate declines making migration possible, but on the other hand this would reduce the effectiveness of public services because these are subject to congestion.

For high levels of ε (ε=2) consumption declines for every η whilst increases with very low level of ε (0.2 and 0.8) although, η, that defines the effective level of current public expenditure is set to its low level (0.2). This analysis, in effect, suggests that, for a balanced budget fiscal expansion, the critical value here is the substitution elasticity between private and current public spending; the changes in value of the parameter η impact as to amplify the direction of the effect imposed by setting ε.

7.3. *Responses to different values of η and different ways of congesting public capital.*

In section 6, we assume that the effective level of public capital is crowded out with increasing working population and private capital stock, for $\eta = 0.5$. However, we know that

[12] Clearly, we could adopt a wage function that exhibited a degree of nominal inflexibility in the short-run, but bargaining property in the long-run. This would be likely, *ceteris paribus*, to increase the probability of a positive balanced budget multiplier in the short-run.

for a given congestion specification (as specified in Eq. (1)) by increasing η we reduce the magnitude of congestion while simultaneously increasing the productivity of public capital. Furthermore, since other formulations of congestion are possible the effective level of public capital might also be congested in different ways. Here, we study the short-run and long-run responses of key economic variables under different levels of the crowding out parameter η and alternative specifications of congestion. We report results in Table 3.

We distinguish between three types of congestion specification of the same general form as in Eq. (1): a) is the one used in the analysis of the previous section; b) public capital stock is congested only by working population; and c) public capital stock is congested by GDP per capita.

For all three cases and for all levels of η (except $\eta = 1$) the change in output is negative in the short-run for the same reason seen above and is 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 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.

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.

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 crowding out effects on consumption are present under specifications *a* and *c*. In the short-run, instead, consumption and investment fall in all three cases for the lowest level of η but consumption and investment begin to become positive for $\eta = 0.2$ respectively for the case *c* and *a*. In the short-run, because of fixed capital and labour, if the model is run without jumping variables

the results in *a* and *b* are expected to be the same. In fact, running the model with myopic dynamic structure the inconsistency between *a* and *b* disappears.

8. Conclusions

In this paper we explore the likely impact of fiscal policy in a regional economy. The numerical CGE simulations suggest that there may be important potential welfare benefits to Scotland as a result of endowing the Scottish parliament with greater tax varying powers.

The model we employ shares some similarities with previous business cycle models, as far as the forward looking dynamic structure is concerned. The main difference is on wage setting and migration. The traditional intertemporal model is augmented with imperfectly competitive features in the labour market and a net-migration model (Layard et al, 1991). 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.

We carry out a number of experiments. 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 and finally both shocks are performed simultaneously. If private and public consumption are perfect substitutes 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 approach we have used here is, in some respects, unconventional if compared with the literature of fiscal federalism where models allow for fiscally induced migration and regional wage determination are directly affected by regional taxation. For instance, Lecca *et al*, (2010*b*) show the impact of a balanced budget fiscal expansion, in a model in which the local amenity generated by the government expenditure is allowed to influence wage bargaining behaviour and net-migration is specified in order to capture the effect on the migration

decision of the locally financed amenity. Furthermore, public expenditure is valued by workers during the wage bargaining process making workers to some extent willing to give up part of their wages to obtain more public expenditure and not directly affecting the marginal utility of consumers as we do in the present paper.

In the present model instead the decision of migrants is independent of the productivity and the size of government spending, however these variables indirectly affect migration decisions through the expected wage and the probability of being employed. Moreover, fiscal policy is not a variable or a parameter that enters in the wage bargaining process. Here we use a different perspective according to which, if consumers value government expenditures as complements (or close) in their consumption, the impact of a balanced budget multiplier is positive and there is no crowding out effect on consumption and investment.

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. 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.

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 discretion 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.

Our analysis is conducted for the case of a single region. A natural extension of our analysis would be to develop an explicitly interregional analysis of fiscal policy effects. This would allow a fully analysis of regional fiscal reform in the UK, and facilitate an analysis of any

gains from coordination of fiscal policies across devolved regions. A further extension would accommodate the potential impact of elements of public expenditure on migration decisions.

Appendix 1

Estimates of Government Capital Stocks

At present there is no available information concerning regional public investment, so the first step is to estimate the overall series of Scottish public investment. For the period 1963-2004, Scottish public investment is obtained proportionally to the UK EUROSTAT indicator (2009)[13], defined as total gross fixed public capital formation (GFCF) expressed as a percentage of GDP. Once the aggregate series of Scottish public investment[14] is obtained this is split into four subcategories of capital expenditure available from the Government Expenditure and Revenue Scotland (GERS)[15] 2007-2009: Common services and other public utilities, Health and Education, Infrastructures and Other Utility. Unfortunately GERS (2009) does not supply a sectoral breakdown that follows the NACE.Rev-1 classification. Thus, sectoral public investment is obtained according to the sectoral classification of private investment. In order to apply the inventory approach we also need information relating to the initial public capital stock for the year 1963. To do so, we construct an artificial investment series for the years 1862-1962, which is the result of assuming that investment increased by a given growth rate a year during this period[16]. Now the capital stock can be updated and the rates of depreciation we use differ among subcategories: 15% for infrastructure and 5% for all other sub-categories.

[13] http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/dataset?p_product_code=TEC00022

[14] The data for the Scottish GDP series are supplied by the Scottish Government, http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/GDP/Download.

[15] See table 6.3 at: http://www.scotland.gov.uk/Publications/2009/06/18101733/8.

[16] The rate of growth is obtained using a simple discrete growth formula applied for the period 1862-1963, that allow us to reach the observed level in 1963. The initial value of investment for the year 1862 is equal to 1. A similar approach is used in Kamps 2006 in order to estimate the initial capital stock for 22 OECD countries.

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Table 1

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

	Externally financed		*Balanced budget finance*											
	Current government expenditure shock										*Capital government expenditure shock*		*Current and capital government expenditure*	
	Scenario 1		**Scenario 2 (baseline)**				**Scenario 3**		**Scenario 4**		**Scenario 5**		**Scenario 6**	
Key parameters			$\varepsilon \to \infty$				ε=0.2		ε=2		η =0.5		$\varepsilon \to \infty$ η =0.5	
Labour market closures	**RB**		**RB**		**NB**		**RB**		**RB**		**RB**		**RB**	
Time	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR	LR
Income tax	0.00	0.00	2.83	3.57	2.02	2.15	1.33	1.53	2.15	2.61	1.94	0.47	2.56	2.34
GRP Income measure	0.16	0.37	-0.06	-0.75	0.15	0.12	0.15	0.27	0.03	-0.27	-0.03	0.65	0.04	0.09
Consumer Price Index	0.05	0.00	-0.03	0.08	-0.01	0.00	0.11	0.03	0.03	0.06	0.05	-0.10	0.04	0.03
Unemployment Rate	-1.87	0.00	0.67	0.00	-1.76	-0.28	-1.70	0.00	-0.40	0.00	0.51	0.00	-0.38	0.00
Total Employment	0.25	0.42	-0.09	-0.72	0.24	0.18	0.23	0.29	0.06	-0.25	-0.07	0.45	0.10	0.10
Nominal Gross Wage	0.27	0.00	0.39	0.70	0.00	0.00	0.53	0.30	0.45	0.51	0.33	-0.02	0.53	0.44
Nominal Wage after Tax	0.27	0.00	-0.10	0.08	-0.35	-0.37	0.30	0.03	0.08	0.06	-0.01	-0.10	0.09	0.03
Real Gross Wage	0.21	0.00	0.42	0.62	0.01	0.00	0.43	0.27	0.42	0.46	0.28	0.08	0.49	0.41
Real Wage after Tax	0.21	0.00	-0.07	0.00	-0.34	-0.37	0.19	0.00	0.05	0.00	-0.06	0.00	0.04	0.00
Replacment cost of capital	0.05	0.00	0.01	0.06	0.01	0.00	0.08	0.03	0.04	0.04	0.04	-0.10	0.10	0.06
Working population	0.00	0.42	0.00	-0.72	0.00	0.14	0.00	0.29	0.00	-0.25	0.00	0.45	0.00	0.10
Households Consumption	0.26	0.34	-0.96	-1.12	-0.37	-0.38	0.77	0.81	-0.18	-0.22	0.17	0.39	-0.23	-0.22
Gov Consumption	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.00	0.00	1.03	1.03
Investment by Origin	0.56	0.29	-1.28	-0.82	0.08	0.01	0.56	0.23	-0.43	-0.33	0.22	0.61	-0.09	0.03
Public investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.20	12.20	1.07	1.07
Output														
Agriculture	-0.03	0.11	-0.11	-0.99	-0.01	-0.09	-0.06	-0.05	-0.09	-0.55	-0.01	0.90	-0.02	0.09
Mining	*-0.16*	*0.07*	-0.28	-1.16	0.01	-0.01	-0.33	-0.33	-0.30	-0.77	-0.02	0.90	-0.03	0.09
Manufacturing	*-0.13*	*0.06*	-0.22	-1.72	0.00	-0.01	-0.26	-0.59	-0.24	-1.19	-0.09	0.80	-0.15	-0.13
Energy	*-0.02*	*0.17*	-0.10	-0.90	-0.01	-0.07	-0.03	0.08	-0.07	-0.44	-0.01	0.87	-0.02	0.07
Construction	*0.09*	*0.29*	-0.27	-0.91	0.11	0.11	-0.01	0.05	-0.15	-0.46	0.06	0.99	-0.04	0.05
Distribution	*0.04*	*0.28*	-0.51	-1.18	-0.14	-0.27	0.17	0.47	-0.20	-0.41	-0.01	0.61	-0.16	-0.14
Transport	*-0.04*	*0.24*	-0.29	-1.07	-0.03	-0.08	-0.07	0.16	-0.19	-0.49	-0.05	0.77	-0.10	-0.03
Financial	*-0.02*	*0.22*	-0.14	-0.94	-0.01	-0.08	-0.05	0.18	-0.10	-0.42	-0.04	0.64	-0.09	-0.12
Public admin	*0.99*	*1.04*	0.95	0.93	0.99	1.01	0.98	1.03	0.97	0.98	0.00	0.13	0.78	0.86
Education	*0.66*	*0.85*	0.41	0.34	0.61	0.69	0.69	0.87	0.54	0.59	-0.04	0.29	0.36	0.47
Other services	*0.01*	*0.30*	-0.28	-0.88	-0.02	-0.05	0.02	0.32	-0.15	-0.32	-0.03	0.80	-0.06	0.03
Total Export (RUK+ROW)														
Agriculture	-0.11	0.00	0.28	-0.45	0.10	0.00	-0.28	-0.19	0.03	-0.33	-0.08	0.79	0.09	0.22
Mining	-0.21	0.00	-0.28	-0.70	0.00	0.00	-0.40	-0.30	-0.33	-0.51	-0.01	0.68	0.00	0.15
Manufacturing	-0.19	0.00	-0.14	-1.74	0.01	0.00	-0.38	-0.74	-0.25	-1.27	-0.14	0.76	-0.15	-0.14
Energy	-0.15	0.00	0.28	-0.26	0.07	0.00	-0.32	-0.11	0.01	-0.19	-0.05	0.74	0.07	0.18
Construction	-0.57	0.00	0.25	-0.52	-0.30	0.00	-0.59	-0.22	-0.14	-0.38	-1.13	-0.19	-0.47	-0.18
Distribution	-0.51	0.00	0.71	-0.73	0.36	0.00	-1.23	-0.31	-0.17	-0.53	-0.47	0.69	0.03	0.01
Transport	-0.29	0.00	0.06	-0.70	0.06	0.00	-0.60	-0.30	-0.24	-0.51	-0.17	0.68	-0.07	0.03
Financial	-0.28	0.00	0.35	-0.58	0.09	0.00	-0.56	-0.25	-0.07	-0.42	-0.21	0.44	-0.05	-0.15
Public admin	-1.35	0.00	-1.43	-0.58	-1.06	0.00	-1.62	-0.25	-1.52	-0.43	-0.46	2.45	-4.89	-2.76
Education	-1.02	0.00	-1.01	-1.01	-0.54	0.00	-1.49	-0.43	-1.22	-0.74	-0.46	1.16	-2.02	-1.31
Other services	-0.47	0.00	0.14	-0.79	0.04	0.00	-0.91	-0.34	-0.34	-0.58	-0.28	1.01	-0.17	0.00

Table 2

The impact on consumption of an increase in current government expenditure. Long-run percentage change.

		ε			
		0.2	*0.8*	*1.4*	*2*
η	*0.20*	0.550	0.259	0.100	-0.001
	0.40	0.598	0.261	0.075	-0.042
	0.60	0.650	0.263	0.050	-0.086
	0.80	0.713	0.265	0.017	-0.140
	1.00	0.807	0.268	-0.030	-0.219

Table 3

The impact of an increase in government capital expenditure. Simulation results of changing the congestion parameter of public capital stock using different congestion specifications

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												
a)	-0.046	0.174	-0.042	0.304	-0.033	0.534	-0.024	0.766	-0.014	1.041	0.000	1.416
b)	-0.047	0.000	-0.043	0.414	-0.037	0.630	-0.021	0.843	-0.012	1.090	0.000	1.416
c)	-0.008	0.176	-0.010	0.613	-0.008	0.990	-0.006	1.180	-0.003	1.311	0.000	1.416
Consumption												
a)	-0.192	-0.131	-0.093	0.011	0.081	0.263	0.256	0.516	0.463	0.816	0.744	1.225
b)	-0.100	0.000	-0.005	0.132	0.160	0.368	0.313	0.600	0.499	0.870	0.744	1.225
c)	-0.175	-0.128	0.149	0.349	0.428	0.760	0.569	0.968	0.666	1.111	0.744	1.225
Investment												
a)	-0.001	0.150	0.047	0.277	0.160	0.501	0.291	0.727	0.460	0.996	0.703	1.361
b)	-0.408	0.000	-0.543	0.384	-0.778	0.595	0.443	0.802	0.545	1.043	0.703	1.361
c)	-0.182	0.152	0.053	0.578	0.299	0.945	0.455	1.131	0.582	1.259	0.703	1.361

a) Public capital stock is congested by population and private capital stock
b) Public capital stock is congested by population
c) Public capital stock is congested by GDP per capita

Figure 1

Shadow price and replacement cost of capital. Scenario 2

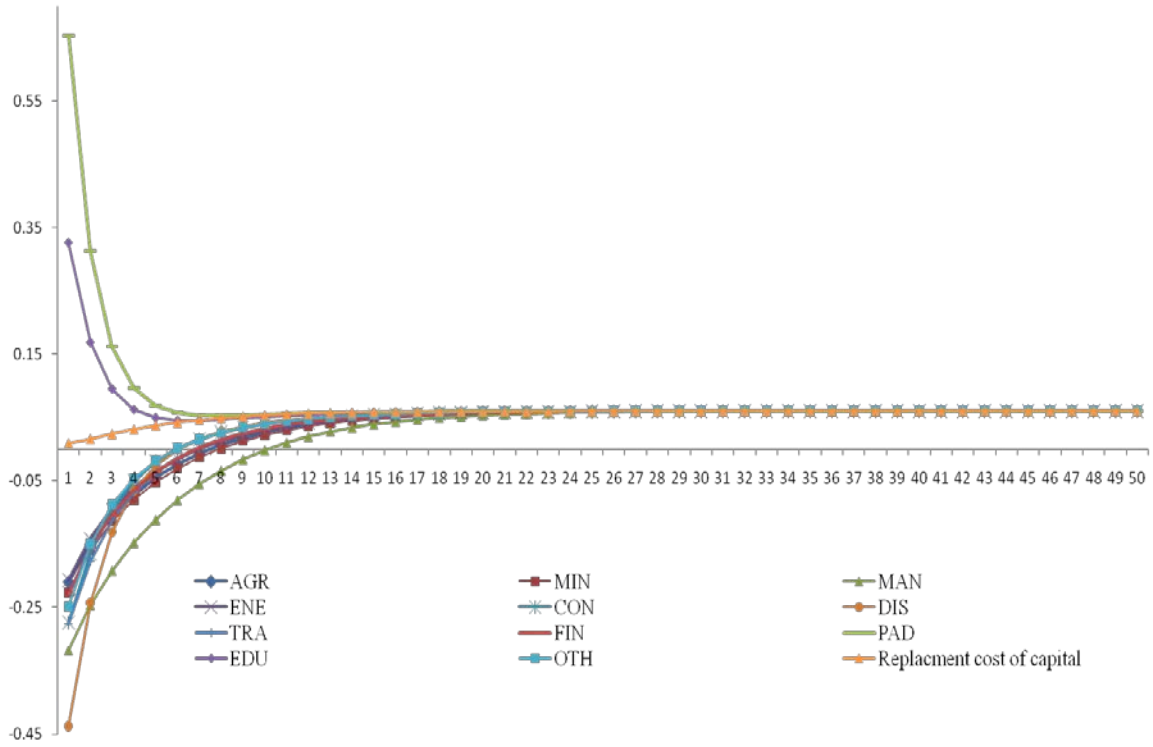

Figure 2

Consumption and investment comparison between the base case scenario and perfect substitution.

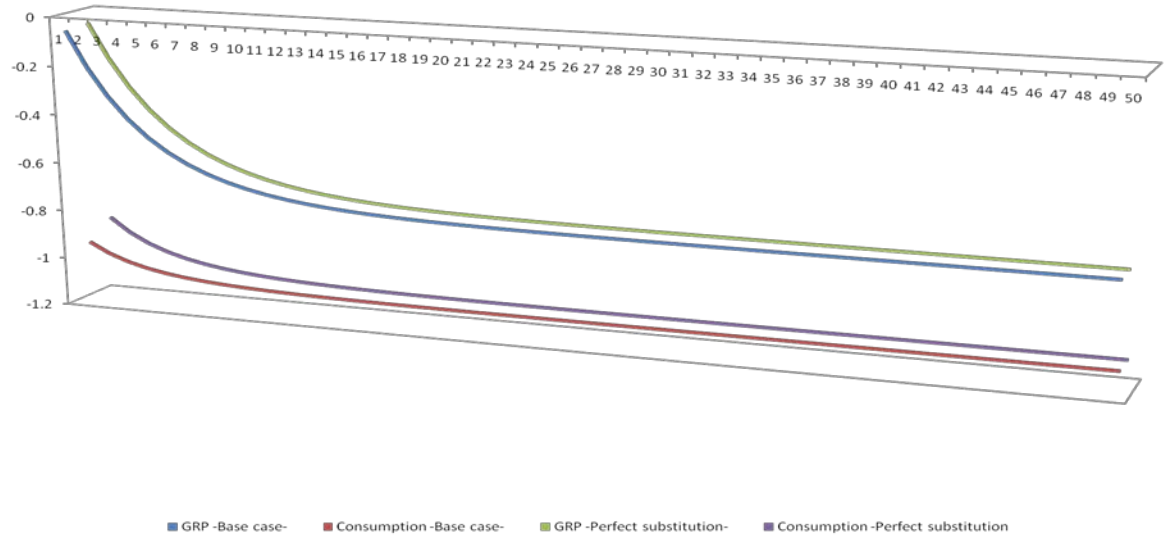

Figure 3

Labour market. Scenario 5

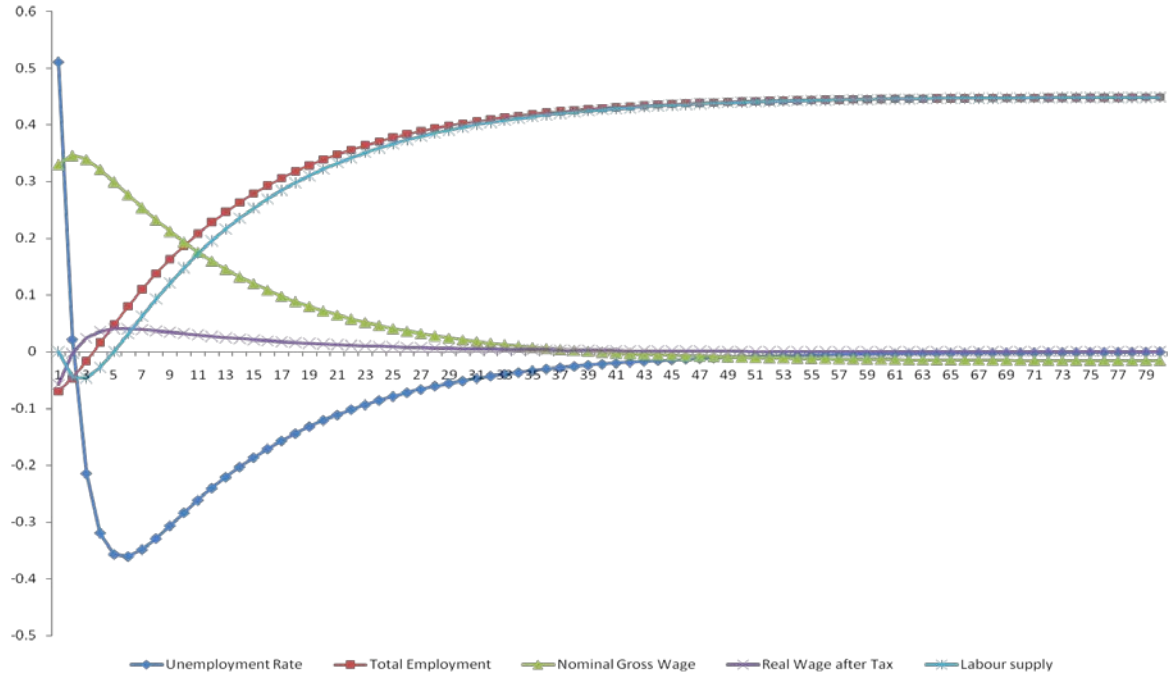

Figure 4

Consumption, Investment and Income tax evolution. Scenario 5

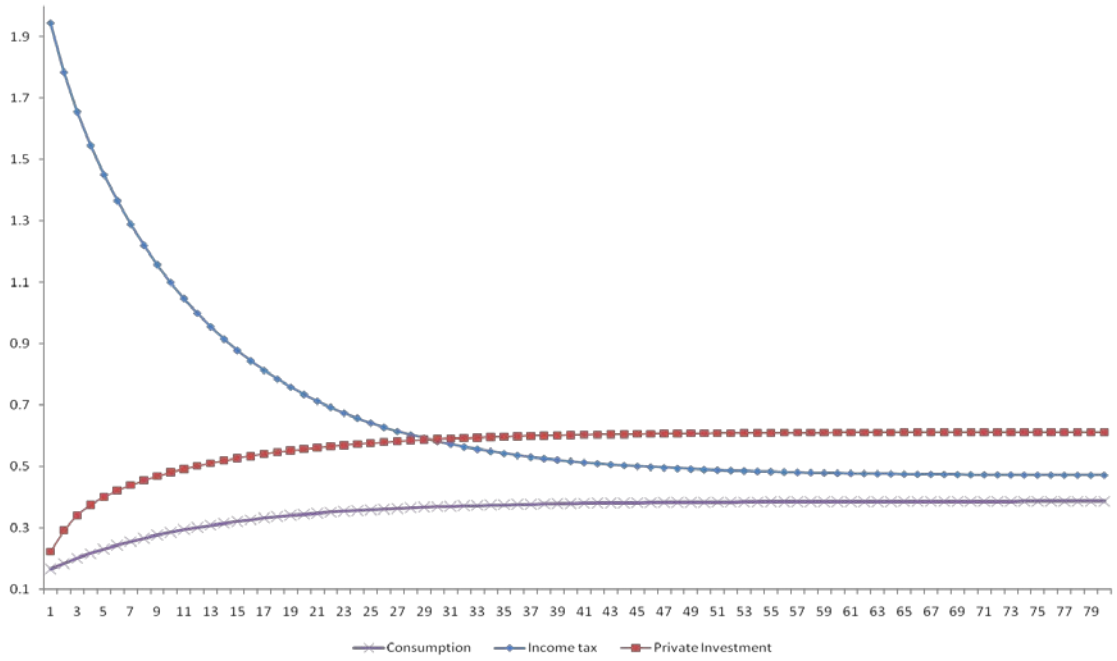

Figure 5

Myopic vs. forward looking: private consumption and investment. Scenario 5.