The Macroeconomic Consequences of Scottish Fiscal Autonomy: Inverted Haavelemo Effects in a General Equilibrium Analysis of the "Tartan Tax"*

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1. INTRODUCTION

In 1997 the Scottish people voted both for the creation of a legislative Parliament and to endow the Parliament with tax-varying powers. The establishment of the Scottish Parliament in 2000 heralded the most radical innovation in the regional fiscal system in modern U.K. history. This development has been the subject of considerable controversy, however, especially in respect of the decision to afford the Parliament the power to alter the basic rate of income tax by up to 3p in either direction. The fact that Scotland, at least according to official data, receives a substantial net fiscal transfer from the rest of the UK, and has traditionally had higher public expenditure *per capita* than England, leads most commentators to believe that the power to change the standard rate will, in practice, be restricted to the power to increase it (Blow *et al*, 1996; McGregor *et al* 1997). Accordingly, while the Parliament allows the use of the power to generate a balanced-budget contraction in expenditure, we focus here on the impact of a balanced-budget fiscal expansion. While Labour, SNP and the Liberal Democrats in Scotland all supported the introduction of a Parliament with tax-raising powers, the Conservatives labelled this scheme the "tartan tax" and claim that its use would be detrimental to Scotland, leading to a reduction in Scottish employment and to net out-migration.

This political controversy, together with the national Labour Party's desire to shed its reputation as a Party of high taxation, in part accounted for the Scottish Labour Party's commitment not to exercise the tax-varying power during the lifetime of the first Scottish Parliament, despite the fact that others have meanwhile been vigorously arguing the case for full fiscal autonomy. In this paper we focus primarily on the consequences for the Scottish economy if the Parliament chooses to exercise the degree of fiscal autonomy that it already possesses. However, the factors that govern the likely macroeconomic impact of a balanced budget change also prove critical to the analysis of any region-specific tax or expenditure change, whether generated as a consequence of, for example, rigorous adherence to the Barnett formula (that, at least in principle, governs the allocation of government expenditure to the devolved authorities in the UK, *et al* 2003, 2007) or movement towards greater fiscal autonomy. Accordingly, we also identify the implications of our analysis for the wider debate on regional fiscal issues in general and greater fiscal autonomy in particular.

While the literature on fiscal federalism provides an obvious reference point for our analysis (e.g. Oates, 1972, 1999; Cornes and Sandler, 1996, chpt. 11) we have two concerns about its direct applicability in the present context. First, those who have sought to apply this approach in a UK context have been careful to note its North American origins (e.g Hughes, 1987; Smith, 1996). In particular, its primary concern with local public goods provision and its tendency to assume perfectly competitive labour markets and instantaneously perfect labour mobility appear severely to circumscribe its direct applicability to the present UK (and European) regional context. Secondly, while the micro-theoretic literature is impressive, it is predicated upon an assumption that greater fiscal autonomy will be neutral in its impact on regional *macro*-economies. There can be no such presumption in the UK regional context with respect either to Scotland's current limited tax varying power or to the full fiscal autonomy advocated by some. Accordingly, we choose to employ a theoretical model, which we outline in Section 2, that is a long-run, regional and explicitly general equilibrium variant of the disaggregated Layard, Nickell and Jackman (1991) model, characterised by the presence of imperfections in the labour market, in particular, and so appears more relevant to the U.K. and European contexts, although we would emphasise the applicability of our approach wherever labour markets are imperfect. Furthermore, the macroeconomic focus of this approach corresponds more closely to the traditional concerns of regional economic analysis in the U.K. and to the central features of the current policy debate, and of course avoids the presumption of macroeconomic neutrality. However, we do augment the model both to accommodate the possibility of the fiscally-induced migration that is emphasised by the fiscal federalism literature, and also to allow for any impact of regional-specific taxes on regional wage determination. This is a factor that tends to be neglected by the North American literature, probably because of its widespread assumption of competitive labour markets.

Our theoretical analysis, in Section 3, identifies the conditions that govern whether employment and population in a small, open region such as Scotland would ultimately be likely to expand as a consequence of the introduction of the "tartan tax". Significantly, our analysis generalises the conventional Keynesian balanced budget multiplier model to allow for supply side effects and for endogenous capital and population stocks in a regional context. We show that negative employment and population balanced budget multipliers are possible, reflecting a regional "inverted Haavelemo effect" of the kind noted in a national context by Knoester and van der Windt (1987). The qualitative outcomes are shown to depend critically on the values of two

key parameters reflecting the marginal valuation of the increased government expenditure (relative to the reduced consumption) by migrants and the extent to which this valuation moderates the degree of "tax-shifting" that occurs in the regional wage bargaining process. These parameters also govern the supply-side impacts of any regional-specific government expenditure or tax change, including, for example, any that may be required to move towards more balanced regional public sector budgets as a consequence of the introduction of greater fiscal autonomy.

While the theoretical analysis is instructive, it is also limited in that: even qualitative results depend on the values of key parameters; it is confined to the single sector case considered by Layard, Nickell and Jackman (1991); it is restricted to the long-run; it is, of course, incapable of offering any estimates of the likely orders of magnitude of responses to the levying of the "tartan tax". While some of these restrictions could, in principle, be explored analytically others cannot be, and it proves more convenient and instructive to examine them numerically, with the help of a computable general equilibrium model (CGE) of the Scottish economy. The use of CGEs to evaluate the likely impacts of fiscal innovations is now well established both at the national (e.g. Shoven and Whalley, 1992) and regional (e.g. Hirte,1998; Jones and Whalley, 1988; Morgan *et al* 1989,1991; Robinson *et al,*1996) levels.[1] In Section 4 we set out the structure of AMOS, our CGE of Scotland, which represents an empirical implementation of (a fleshed out version of) the skeletal theoretical model that we outline in Section 3. In Section 5 we simulate the impact of the tartan tax on long-run equilibria, and in Section 6 we explore a number of extensions. We conclude the paper in Section 7 by identifying the implications of our analysis for future research and for the wider debate on regional fiscal issues.

2. THE THEORETICAL MODEL

We adopt a long-run, open-economy model of the region which is in the spirit of the disaggregated model developed by Layard, Nickell and Jackman (1991, chpt. 6)(henceforth LNJ), with imperfect competition in the regional labour market and some central government transfers. We employ the small-region assumption that the price of imports and the cost of capital are both determined exogenously in perfectly integrated national markets. However, we do not assume that the law of one price holds for the region's exports but rather employ conventional trade functions (e.g. Armington, 1969; Engle and Rogers, 1996): whilst regional output is produced

under conditions of perfect competition within the region, it is not a perfect substitute for the output of other regions.[2] This permits adjustments in the price of the regional good relative to the price of extra-regional goods and imports, and allows variation in the regional real and nominal wage in the long run. Production occurs under a well-behaved, linear homogeneous production function with two factors, capital and labour. All households are assumed to be homogeneous, so that there is no distinction between workers and voters or migrants and non-migrants. We concentrate here on a comparative-static long-run analysis. This implies that both the regional capital stock and population are optimally adjusted: there is zero net investment and zero net migration in equilibrium states. We adopt the LNJ regional migration function.[3]

We approach the analysis of the balanced budget fiscal expansion (henceforth fiscal expansion) in the following way. At the present time, the precise composition of the additional expenditure to be financed by any use of the tartan tax is of course unknown. In this paper we simply assume that the increased government expenditure generates a regional-specific amenity whose existence is generally reflected in a shift in the zero net migration function (e.g. Tiebout, 1956). We also argue that, in an imperfectly competitive labour market, the fiscal expansion affects the real wage bargaining function. We focus on the key role played by the nature of these migration and real wage bargaining effects in determining changes in aggregate regional activity consequent upon the introduction of the fiscal expansion. We begin with a more detailed specification of our analytical model.

The formal model is given in Table 1. Equation (1) is the zero net migration condition. In this equation, the post-tax real consumption wage (w) is negatively related to the regional employment rate (e) since, across zero net migration equilibria, a high local wage is compensated for by a low local employment rate. The employment rate is the ratio of employment (n) to population (N) and this is expressed formally in equation (2).[4] Equation (1) is rather unconventional in that we divide the post-tax real consumption wage by the term $(1-t)^{\beta}$ where t is the proportionate rate of income tax. This is an attempt to capture the effect on the migration decision of the locally-financed amenity. Where individuals attach a zero value to this amenity, $\beta = 0$ and the standard formulation of the net migration condition applies, with the post-tax real consumption wage governing migration decisions. However if, as is emphasised in the literature on fiscal federalism, there is a positive amenity effect then $\beta > 0$, and the value of this parameter

measures the potential migrant's relative marginal valuation of public expenditure versus private consumption. This implies that, for a given employment rate, the larger the value of β, the lower the post-tax real consumption wage required to preclude net outmigration. When $\beta = 1$ the potential migrant is indifferent between marginal changes in local public expenditure and private consumption so that in this case the pre-tax real consumption wage motivates migration. Where $\beta > 1$ there is a positive marginal preference for local public expenditure over private consumption.[5]

The pre-tax nominal wage (W) is defined in equation (3), where cpi is the regional consumer price index. Equation (4) expresses the regional consumer price index as a function solely of the regional nominal wage. This parsimonious specification is permitted by the import-price and cost-of-capital exogeneity assumptions, together with the linear homogeneous nature of production. Labour demand is given by equation (5). This is taken to be negatively related to the nominal pre-tax wage through competitiveness and factor substitution effects.[6] Labour demand will also be a positive function of the tax rate as a reflection of the operation of the conventional Keynesian balanced budget multiplier, the differential import propensities of public and private consumption expenditure, and the greater labour intensity of public sector activity. Additionally, there is a positive link between labour demand and the level of unemployment via the size of government transfers to the region. It is important to note that equation (5) represents a general equilibrium relationship, constructed on the basis of full income endogeneity.[7] Equation (6) defines the level of unemployment in terms of the population level (N) and the employment rate.

Equation (7) is the regional bargaining function with the real consumption wage positively related to the regional employment rate (LNJ, 1991). In this formulation the local amenity generated by the expenditure is allowed to influence wage bargaining behaviour directly. The parameter α, which takes a value between 0 and 1, reflects the extent to which the value of the amenity is taken into account in the wage bargaining process. The possible amenity effects on the local bargained real wage appear to be neglected in the literature on fiscal federalism. This is partly attributable to that literature's typical presumption of competitive labour markets. Since the amenity is exogenous to the individual worker, it is ignored in the individual's work/leisure choice, so that only the post-tax real consumption wage matters.[8] This corresponds to a situation where the value of α is zero. However, in the bargaining context the scale of the amenity (under

the proposed form of the "tartan tax") is tied directly to income and therefore to the bargained wage, and a union that reflected its members' preferences would be expected to act accordingly. This formulation of the wage-setting function has echoes of the "social wage" that enjoyed some currency under previous Labour administrations, although here the effect is region-specific.

3. THE THEORETICAL ANALYSIS OF THE TARTAN TAX AND OTHER FISCAL INNOVATIONS

If equations (1) - (7) in Table 1 are expressed in total differentials with the appropriate initial normalisation, we can solve for the change in the seven endogenous variables dn, dN, de, dcpi, dw, dW and dU, given the change in the value of the exogenous tax rate, dt.[9] If we combine equations (1), (3) and (4) and set dt = 0, we can derive the initial zero net migration (ZNM) function in nominal pre-tax wage-employment rate space. This is represented by the curve Z_0 in Figure 1, which has a slope equal to $w_e/(1\text{-}cpi_W) < 0$. Similarly, with dt = 0 equations (3), (4) and (7) generate the initial bargained real wage function (BRW) in the same space, with a slope equal to $b_e/(1\text{-}cpi_W) > 0$. This is curve B_0 in Figure 1. These two curves are sufficient to tie down the initial nominal wage and employment rate W_J and e_J. Where a local income tax increase of dt is levied, the ZNM function moves upwards by an amount equal to $((1\text{-}\beta)/(1\text{-}cpi_W))dt$. The local income tax increase also shifts up the BRW function, but by $((1\text{-}\alpha\beta)/(1\text{-}cpi_W))dt$. Note that, for the range of possible values for α and β, $(1\text{-}\alpha\beta)dt$ is greater than or equal to $(1\text{-}\beta)dt$. Given the positive sign of $(1\text{-}cpi_W)$, the upward movement of the ZNM function is never greater than the upward shift of the BRW function.[10] It proves useful to establish some benchmark cases in Figure 1.

Consider first the case where β is zero, so that $\alpha\beta$ is similarly zero. This is where the additional public expenditure produces an amenity which has no value to local residents. Under these conditions, both the ZNM and the BRW functions shift upwards by $dt/(1\text{-}cpi_W)$ to B_1 and Z_1 respectively. In each of these nominal functions the shift is such that at any given employment rate, the post-tax real consumption wage remains unchanged. This implies an adjustment in the nominal wage which is greater than the tax to take into account the increase in the regional cpi and this is determined by the term $(1\text{-}cpi_W)^{-1} > 1$. The new equilibrium is at K. The employment rate remains unchanged and the nominal pre-tax wage increases by $dt/(1\text{-}cpi_W)$, reducing regional

competitiveness.

The situation where $\beta = 0$ is an extreme case. Where β takes positive values, so that the increased local public expenditure generates a valued amenity, and where α takes a positive value, so that this is reflected, at least partly, in the wage bargain, the upward movement of the two functions is reduced. As another benchmark, consider the situation where $\alpha = \beta = 1$. This is where the value of the increased public expenditure to local residents just equals the forgone private consumption implied by the higher taxes, and this is fully incorporated into the wage bargain. Under these circumstances there is no movement in either curve. The equilibrium remains at J. There is simply a transfer of a part of the pre-tax wage to public expenditure: there is no change in the employment rate and no loss of competitiveness through higher nominal wages.

For any β, where $\alpha = 1$ both the ZNM and the BRW function shift by the same amount and the employment rate remains unchanged. Where $\alpha < 1$, the BRW function shifts upwards by more than the ZNM function, so that the new equilibrium involves a reduction in the employment rate and a corresponding rise in the unemployment rate. For example, where $\beta = 1$, so that the relevant ZNM curve is Z_0, the equilibrium lies on the line segment LMJ. The equilibrium is closer to J, the closer α is to unity. The equilibrium after the fiscal expansion will therefore be located somewhere in the shaded areas to the right of the B_1 curve and to the left of the vertical line KJe_J. Where $\beta < 1$, the equilibrium lies within the darker-shaded triangle JKL; where $\beta > 1$ the equilibrium lies somewhere in the lighter-shaded area to the south-west of the line LMJ. Note that where $\beta < 1$, the nominal wage must rise in long-run equilibrium, irrespective of the value of α, with a resultant loss of regional competitiveness. Also, where the wage bargain does not reflect the increase in local amenities ($\alpha = 0$), the bargained wage function is B_1. In this case, the ZNM function has to drop to Z_2, associated with a β value substantially above unity, before a loss of competitiveness accompanying the fiscal expansion is avoided. A competitive labour market effectively precludes a non-zero value for α in the labour supply function because it contains no mechanism by which the benefit of the publicly provided externality could be internalised.

The zero net migration and bargained real wage functions tie down the wage and employment rate. But whilst these are important variables, it is the change in employment and

population which are the main subject of current debate. From equations (2), (5) and (6) we can derive expressions which link the changes in employment and population to the changes in the nominal pre-tax wage, the employment rate and the tax rate:

$$dW = \left[\frac{n_U}{n_W n_1}\right] de + \left[\frac{n_1 - n_U(1 - e_1)}{n_W n_1}\right] dn - \left[\frac{n_t}{n_W}\right] dt \qquad (8)$$

$$dW = \left[\frac{1 + n_U}{n_W}\right] de + \left[\frac{n_1 - n_U(1 - e_1)}{n_W}\right] dN - \left[\frac{n_t}{n_W}\right] dt \qquad (9)$$

where n_1 and e_1 are the initial values of the employment level and the employment rate, with $n_1 = e_1 < 1$ through the normalisation procedure. In equation (8) the coefficients on the total employment, employment rate and tax rate change variables are all negative.[11] This has the implication that employment change is positively related to increases in the tax rate and negatively related to increases in the nominal wage and the employment rate. The direct causal links between employment change and the nominal wage and tax rate changes are as argued in section 2. The negative relationship between employment change and the change in the employment rate operates through the effect on the level of unemployment and government welfare payments funded outwith the region.

We know from the previous discussion that the introduction of the tax is accompanied by a non-positive change in the employment rate. Therefore if there is a fall in the nominal pre-tax wage, there will be an unambiguous increase in employment. However, where the pre-tax nominal wage rises, the change in employment will depend on the trade-off between the positive stimuli, coming through the aggregate demand and employment rate effects, and the negative stimulus from higher wages leading to a loss of competitiveness and the substitution of capital for labour. This analysis echoes that of Knoester and van der Windt (1987) who argue that, at a national level, forward tax shifting by workers produces a fall in competitiveness and therefore a possible inverted Haavelmo effect; that is, a negative balanced budget multiplier. In equation (9) again the coefficients on all the variables on the right hand side are negative, which makes

population also negatively related to the nominal wage and the employment rate and positively related to the tax rate. This reflects the identity, expressed as equation (2), that population change equals the proportionate employment change minus the proportionate change in the employment rate.

If dn and dN are set to zero, equations (8) and (9) can be used to construct zero employment change (ZEC) and zero population change (ZPC) functions in nominal wage-employment rate space which can be plotted in Figure 1. To avoid cluttering the diagram we restrict ourselves to presenting the ZPC function, though the corresponding employment function can be generated in an identical manner. The ZPC function is given by P_1. It lies above the initial equilibrium J by an amount $-(n_t/n_W)dt$ which is positive, given the negative sign of n_W. The slope of P_1 is negative and equals $(1+n_U)/n_W$.[12] Equilibrium points that lie above the ZPC function are associated with a fall in population and therefore negative balanced budget population multipliers. Points below the ZPC function experience increased population and therefore positive balanced budget population multipliers. Figure 1 reinforces the argument made above. Post-tax equilibria involving no increase in the pre-tax nominal wage are unambiguously associated with an expansion in population (and employment). This includes the point J, which would be attained where $\alpha = \beta = 1$. Moreover there is a range of equilibria where the pre-tax nominal wage is rising and regional competitiveness is declining, but welfare improvements, as reflected in increased population, would occur. These are equilibria in the area JPMQN.

Analytical attempts to identify more precisely the conditions under which employment and population rise after the introduction of the tax prove to be unhelpful. Expressions can be obtained but they provide no additional insight and include as arguments derivatives of what are general equilibrium relationships. However, the present theoretical framework can be adapted to analyse the consequences of any change in regional-specific tax rates or government expenditures. For example, a move to full fiscal autonomy from an initial position of a significant structural public sector deficit would create pressure for some combination of tax rises and government expenditure cuts. Suppose fiscal balance is improved through a rise in the tax rate. In this case the tax rise is not associated with any increase in expenditures, there is no amenity effect and β is zero as is $\alpha\beta$. Accordingly, a rise in the tax rate to reduce a pre-existing public sector deficit would induce adverse supply effects, in this case in addition, of course, to the adverse demand effects. A

cut in government expenditures (except where β is zero), stimulates an upward shift in the ZNM function, and in the bargaining function (provided α is non-zero). Thus any cut in expenditures to balance the budget following a move to greater fiscal autonomy may have important adverse supply side effects additional to the impact on aggregate demand. Similar supply effects may accompany the demand effects implied by rigorous adherence to the Barnett formula. (Ferguson *et al*, 2003, 2007 explore the demand effects.) Of course, if the maintenance of overall fiscal balance allows expenditure increases or cuts in the tax rate, these supply side effects would act to reinforce the beneficial demand side impact on the Scottish economy. Actual and projected public sector financial balances are therefore potentially important in any analysis of the likely macroeconomic impact of further fiscal autonomy.

It would be possible to derive the bargained real wage function explicitly from the microeconomic theory of wage determination in the presence of trade unions (e.g. Oswald, 1982). Under perfectly competitive labour markets individual workers recognise that their action has no impact on the scale of the amenity effect associated with government expenditures, and so α is zero. Under a monopoly union it would be possible for the union wholly to internalise the amenity effect and incorporate it fully into its bargaining behaviour, with α and β here, for example, reflecting the marginal valuation of the median voter. Such a framework could accommodate endogeneity of the values of α and β with respect to a range of influences, including public policy. For example, if, as seems likely, the median voter's preferences vary across different types of expenditures, then through partial hypothecation to expenditures that are particularly highly valued, the Parliament may be able to influence the scale of the amenity effect associated with any particular use of tartan tax revenues. Furthermore, while discussions with union leaders centred on the notion of a social wage are no longer a characteristic of the UK institutional structure, there may be scope for such activity at the regional level, given Scots' traditionally stronger preferences for public expenditure. This could influence the extent to which wage claims are moderated in response to higher public expenditures and taxes (the value of α).

The outcomes in the presence of multiple unions and a combination of national and regional bargaining systems in a repeated games context would be complex. However, it seems clear that such an analysis would not lead to substantial further restriction on the values of α and β: a range of outcomes would be feasible depending on individual worker preferences and the

precise nature of the bargaining system(s). Accordingly, we do not pursue these possible extensions here, but rather explore the implications of plausible ranges of values for both values of α and β through simulation.

Further analytical work with the theoretical model we employ here does not help a great deal in identifying the likely impact of regional fiscal innovations, including a balanced budget expansion. A knowledge of the empirical values of α and β is insufficient, in general, to tie down qualitative outcomes, although such knowledge is, of course, critical in any attempt to determine the likely quantitative effects of the tartan tax, or indeed any fiscal changes, regardless of their source (such as strict adherence to the Barnett formula or further fiscal autonomy). Unfortunately, there is very little evidence on the values of these parameters. Existing UK empirical work on regional earnings and migration functions offers no direct evidence, since we have no experience of a local income tax. Furthermore, there is no consensus as to the nature of long-run tax effects on the bargained real wage even at the national level (Church *et al*, 1993), and the relevance of such evidence to the present regional context is, in any case, questionable. Finally, whilst there is evidence from other countries on values of α and β, the results are extremely mixed and appear to depend on the composition of public expenditures. (Bartik, 1992; Cebula, 2002; Dahlberg and Fredriksson, 2001; Dalenberg and Partridge, 1995; Mofidi and Stone, 1990; Day, 1992; Fisher, 1997; Feld and Kirchgassner, 2002; Gabe and Bell, 2004; Helms, 1985; Wallace, 1993). While the available empirical evidence therefore does not allow us to tie down the values of α and β at all precisely, our reading of the literature is that the tendency of conventional neoclassical analysis to ignore the potentially beneficial impacts of regional public expenditures is rejected by those studies that provide a balanced treatment of tax and expenditure effects (e.g. Gabe and Bell, 2004). Furthermore, the suggestion that the composition of expenditures influences the values of key parameters implies that they are sensitive to policy choices.

Against this background, the case for progressing the analysis via numerical simulation is compelling. Qualitative results, at least for employment and population change associated with balanced budget changes, as well as quantitative effects, typically depend upon the entire empirical general equilibrium system, as well as the values of α and β. Using a regional CGE counterpart to the analytical model of this section, we are able to estimate the likely size of employment and population effects via simulation over a plausible range of values for α and β.

This allows us to identify the combinations of these parameter values associated with positive and negative balanced-budget employment and population multipliers. The use of a CGE also permits us to extend the analysis of this section in a number of respects, notably to: capture the major sectoral effects resulting from the reduction in consumption and increase in government expenditures; examine the short-run effects of the tax changes; explore the impact of alternative assumptions about the nature of the net migration and wage bargaining processes; consider the possible impact of the tartan tax on the assigned budget of the Scottish Parliament; conduct a formal sensitivity analysis on the likely qualitative and quantitative effects of the tartan tax.

4. AMOS: A MACRO-MICRO MODEL OF SCOTLAND

AMOS is a CGE modelling framework parameterised on data from a UK region, Scotland.[13] Essentially, it is a fully specified, empirical implementation of the skeletal theoretical general equilibrium model developed in the preceding section. It has three domestic transactor groups, namely the personal sector, corporations and government; and three commodities and activities, manufactures, non-manufacturing traded and a sheltered sector.[14] 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 and produce using multi-level CES production functions with elasticities of substitution of 0.3 (Harris, 1989). We do not explicitly model financial flows, our assumption being that Scotland is a price-taker in competitive UK financial markets.

There are four major components of final demand: consumption, investment, government expenditure and exports. Of these, real government expenditure is equal to the base year level plus an additional amount which just exhausts the increment to tax revenue raised by the local income tax. This implies that government expenditure becomes dependent on the entire general equilibrium of the system, which is exactly what would happen if the tartan tax were to be implemented. Consumption is a linear homogeneous function of real disposable income. Exports (and imports) are determined via an Armington link (Armington, 1969) and are therefore relative-price sensitive with trade substitution elasticities of 2.0 (Gibson, 1990). Investment is a little more complex, in that the model can be run to produce either period-by-period short-run equilibria or a single long-run equilibrium. In the long-run simulations capital stock is endogenous and

determined on cost-minimisation criteria, with investment equal to depreciation at the optimal capital stock.[15] In the period-by-period simulations, investment in each sector equals depreciation plus some fraction of the gap between the desired and the actual level of capital stock.[16]

Population is endogenous in the simulations reported here and is updated from period to period in a similar way to the capital stock using the econometrically parameterised regional net migration function reported in LNJ (1991), augmented to accommodate the amenity effects discussed above. This has the form

$$m = a - 0.08(\ln u_s - \ln u_r) + 0.06(\ln w_s - \beta \ln(1 - t) - \ln w_r)$$

where: m is net inmigration as a proportion of the regional population; u is the unemployment rate; w is the real consumption wage; t is the additional income tax rate; a is calibrated on base year data; β is the relative valuation of the public expenditure; and the subscripts s and r indicate Scottish and rest-of-the UK (RUK) values. In the long-run, there is an implied zero-net-migration condition which yields estimates of the optimal spatial distribution of population. This is:

$$\ln w_s = b + 1.33 \ln u_s + \beta \ln(1 - t)$$

where b again is a calibrated parameter. Wage setting is determined by a regional bargained real wage function that embodies the econometrically derived specification given in LNJ (1991), again augmented by amenity effects:

$$\ln w_s = c - 0.113 \ln u_s + \alpha\beta \ln(1 - t)$$

where α represents the extent to which the amenity effect is reflected in the wage bargain and c is a calibrated parameter.

We present a compact form of the model in the appendix.[17] AMOS in fact comprises a set of several hundred non-linear (in level and logs) simultaneous equations.[18] We solve AMOS

in level form, using the Levenberg-Marquardt method, which is an algorithm that varies smoothly between inverse Hessian and steepest descent methods. More detail on the algorithm, together with a full model listing is available in Harrigan *et al* (1991).

5. SIMULATION RESULTS

In this section, we use AMOS to conduct simulations to illustrate the long-run effects of the tartan tax on the Scottish economy. The White Paper (Scottish Office, 1997a, p23) estimated that the tartan tax would raise £450 million at 1997 prices, which represents a 1.45 percentage point rise in average personal income tax in AMOS.[19] In Table 2 we report the long-run proportionate changes in population after the introduction of such a tax for combinations of α and β where α lies in the range 0 to 1 and β in the range 0 to 2.[20] Figure 2 illustrates these results graphically. Table 2 and Figure 2 indicate not only that the tartan tax can produce positive or negative population effects, dependent upon the values taken by the bargaining and migration parameters, but also that, for plausible values of α and β, the tax could have a significant impact on aggregate economic activity in Scotland.

The numerical results in Table 2 and Figure 2 are consistent with our theoretical analysis. For a given value of α, the proportionate change in population increases as β increases. That is to say, the more the electorate value the amenity created with the revenues from the additional income tax, the greater the increase (or the lower the decrease) in regional activity and welfare. However, the extent to which the amenity effect is incorporated into wage bargaining is also a key determinant of the welfare impact of the tartan tax. Take the situation where $\beta = 1$, so that Scottish residents are indifferent between marginal increases in private consumption and public expenditure. If $\alpha = 1$, then as our theoretical analysis suggests, population will rise. This implies that if workers wish to make no adjustment in their pre-tax income after the introduction of the tax, the net effect on the Scottish economy will be expansionary. This case generates results that are similar to those identified with the standard Keynesian balanced budget multiplier, although here the result is, of course, critically dependent upon endogenous population and investment effects. However, if α lies below 0.73, population declines. This is represented by point M in Figure 1. As β increases, the range of values for α which generate population increases expands. However, note that if the amenity has no moderating effect on tax-shifting in the regional wage

bargaining process, so that $\alpha = 0$, even a β value of 2 generates significant proportionate population losses.

In Table 3 we give the proportionate changes in a more comprehensive set of economic variables for four particular combinations of α and β. This allows a fuller investigation of the economic forces at work in each of these cases. The results in the first column are derived where $\beta = 0$. This corresponds to a situation where the amenity funded by the tax revenue has no value to Scottish residents and is represented by equilibrium at point K in Figure 1. In this simulation there is no change in the post-tax real consumption wage. The nominal pre-tax wage increases by 1.75%, the full extent of the tax plus the rise in the consumer price index. This results in an increase in value added prices in all sectors and a corresponding reduction in exports. Scottish GDP declines by 1.33% and employment and population by 1.41%. The percentage fall in investment is less than that in output and employment, reflecting the long-run substitution of capital for labour.

It is important to note that the circumstances reported in column 1, where $\beta = 0$, is the "worst-case" scenario for the tartan tax (as is clear from Table 2). In the second column we report results from simulations where $\alpha = \beta = 1$. This is represented by the equilibrium at point J in Figure 1. The key characteristic of this simulation is that there is no change in either the pre-tax nominal wage or the employment rate. This implies that there are no adjustments in long-run value-added prices, the cost-minimising choice of technique or exports. Essentially the economy operates as an input-output system with output, employment and capital stock in each sector varying by the same proportionate amount. The demand disturbance comes through the replacement of a proportion of private consumption expenditure by public expenditure. As argued already, this has a general expansionary impact on the regional economy and produces an increase in Scottish GDP of 0.48% and in employment and population of 0.46%. However, the adjustment in consumption and government demand has an uneven effect across sectors. Activity in the sheltered sector, which is most strongly represented in government expenditure, increases by 1.22% whilst the changes in activity in the other two sectors are very small and is actually negative in non-manufacturing traded, where consumption expenditures are concentrated. In effect, the results reflect the impact of an extended input-output system that is subjected to partially offsetting negative consumption and positive government expenditure changes.

The importance of the parameter α is illustrated in the figures presented in column three which are for a simulation where $\alpha = 0$ and $\beta = 1$. This simulation corresponds to the equilibrium represented by point L in Figure 1. Here private consumption and public expenditure are equally valued at the margin but this is not reflected in the bargained wage. We know from the previous analysis that the nominal pre-tax wage and the unemployment rate will rise, by 1.62% and 0.81% respectively in this case. The results in this simulation are very similar to those where $\beta = 0$. There are strong negative competitive effects as exports fall in all sectors and this swamps any expansionary impacts coming through the final demand shifts and population effects. Scottish GDP, total employment and population fall by 1.19%, 1.26% and 1.18% respectively, and this reduction in activity affects all sectors, though particularly the non-sheltered sectors.

The final simulation, reported in column four, adopts the parameter values $\alpha = 0.80$, $\beta = 1.20$ and represents an equilibrium lying in the area JMQN in Figure 1 where both population and the nominal pre-tax wage increase. The 0.28% rise in the pre-tax nominal wage following the introduction of the tartan tax reduces exports in all sectors. However, the other expansionary demand impacts produce a more than offsetting effect on overall Scottish aggregate activity. Therefore, although employment falls in the manufacturing and non-manufacturing traded sectors, by 0.24% and 0.49% respectively, employment in the sheltered sector rises by 2.31% producing an aggregate increase in employment of 0.66% and an increase in population of 0.72%.

6. ADDITIONAL ISSUES

6.1 National Wage Bargaining

Up to now we have adopted a local real wage bargaining framework for the determination of the regional wage. However, it is often argued that within the UK the regional wage is set at the national level, either by national bargaining or through company-wide wage setting in multi-plant firms. This would imply that the pre-tax nominal wage is exogenous to the region and that the bargaining function B_0 in Figure 1 can be replaced by a fixed pre-tax nominal wage line F_0. In Figure 1, as long as the ZNM function cuts F_0 at a point below the zero population function, population will rise. Essentially, with national wage bargaining there are the familiar

expansionary demand effects associated with the shift from private consumption to public expenditure, but no adverse competitiveness impacts. The only potential contractionary effect is where $\beta < 1$ so that the employment rate must rise to satisfy the zero net migration condition. However in the AMOS model, for all values of β, under national bargaining population increases with the introduction of the tartan tax.[21]

6.2 The Scottish Assigned Budget

In the analysis undertaken in this paper so far we assume that the tax-raising powers of the Scottish Parliament will not affect the level of the subsidy that will come to Scotland from Westminster in the form of the assigned budget (formerly the "block grant"). Since the present government insists that the Barnett formula will continue to govern the regional allocation of government expenditure, this seems a reasonable assumption.[23] However, there is some concern in Scotland, fuelled by the considerable attention focussed on the Barnett formula by representatives of some English regions (e.g. Groom and Buxton, 1997), that even the limited fiscal autonomy that Scotland possesses may ultimately lead to a corresponding reduction in U.K. central government support. Since there would be no net amenity effect if the tartan tax revenues merely replace existing subventions, this is similar to the case where $\beta = 0$, so that the nominal wage would rise by the full amount required to maintain the post-tax real consumption wage. However, rather than a demand stimulus coming from the replacement of private consumption by public expenditure, there is now simply a contraction in Scottish private consumption. Within AMOS, the introduction of the tartan tax without a corresponding increase in Scottish government expenditure generates a reduction in employment and population of 2.21%.[24] This is, of course, the type of change that could be associated with further Scottish fiscal autonomy that required some rise in tax revenues to improve the public sector deficit. However, the scale of the deficit implied by current official data would imply much greater contractionary effects if the budget had to be balanced by this means.

6.3 Time Period of Adjustment

The analysis in the paper deals with long-run equilibria. However, it is also important to consider the adjustment process so as to identify the length of time for equilibrium to be attained

and the relevant shorter-run impacts. In Figure 3 we plot the period by period percentage changes for population and employment disaggregated by sector for the introduction of the tartan tax where α and β are both unity. Note that the adjustment process, which depends on the interaction of migration and investment decisions, is rather protracted, as others have found in a U.K. context (e.g. Pissarides and Wadsworth, 1989). It takes over 10 years for 75% of the long-run equilibrium total employment and population increase to be achieved. Also the short-run movements in sectoral employment in the manufacturing and non-manufacturing traded sectors differ markedly from their long-run solutions. In both these sectors there is initially a sharp decline in employment. This is because, with the general expansion in activity which in this case accompanies the introduction of the tartan tax, there will be an initial rise in the pre-tax bargained nominal wage, reflecting the initial reduction in the unemployment rate and the rise in the regional cpi. The increased nominal wage has adverse competitiveness effects for these relatively open sectors. Over time, in-migration moves the unemployment rate back towards its original level and positive net investment eases capacity constraints so that regional prices move back towards their initial values. Therefore non-manufacturing traded initially overshoots its long-run fall in employment whilst it is not until period 24 that employment in manufacturing rises above its base-year level.

6.4 Migration

There may be some concern at the central role played by migration in our analysis up to this point, particularly given that UK regional problems are often linked to restrictions in labour mobility. Notice, first, that there is no necessary conflict between the bargained real wage function and the zero net migration condition, as appears to be implied in Blanchflower and Oswald (1994). Indeed, in the original LNJ (1991) model of disaggregated labour markets the interaction of these two functions is critical in determining real wage and unemployment rates, and this is also true of our model. However, Blanchflower and Oswald's (1994) objection to the Harris-Todaro (1970) function (on which LNJ's net migration function is based) does reflect the conventional wisdom in the UK that labour mobility is very low (although the objection is not based on estimated net migration functions, while LNJ's analysis is.) It may therefore be worth noting the consequences of the limiting case of zero labour mobility. In fact the theoretical analysis of this case is conceptually similar to that with migration. Employment change under

zero labour mobility is positive as long as $dW < -(n_t/n_W)dt$. However, in this case the wage is determined by the interaction of the BRW with the labour demand function, rather than the ZNM function. If we suspend the estimated LNJ net migration function and instead impose the assumption of zero labour mobility, the employment effects of the tartan tax are considerably dampened under regional bargaining, with employment change ranging from a fall of 0.59% ($\alpha = 0$) to a rise of 0.94% ($\alpha = 1.0$, $\beta = 2.0$).

6.5 Sensitivity Analysis

One criticism of CGE models is that they are not econometrically estimated and that the results might be very sensitive to imposed parameter values. There are three broad groups of elasticities in AMOS: the sectoral capital stock speed of adjustment parameters, the CES production substitution elasticities and the substitution elasticities in intermediate and final demand. In this sensitivity exercise, the values of these parameters are selected from the ranges (0.2 - 0.8); (0.1 - 0.5); and (0.1 - 4.0) respectively. We assume that all the elasticities have uniform distributions that are symmetric about their means (which are the default point estimates in AMOS). Following the method of Harrison and Vinod (1992), we divide the distribution into 4 equal intervals and take the mean of each interval for perturbation. Since there are 39 elasticities selected, the set of all possible parameter perturbations is 4^{39}. However, we follow a complete randomized factorial design and selected only a subset (1000) of the possible configurations. Each of the 1000 simulations is run for 50 periods.

In Figures 4 and 5 we report the results of systematic sensitivity analysis on the period-by-period simulations for two of the (α, β) combinations reported in Table 3: (1,1) and (0.8, 1.2). In each period the graphs show the mean solution value of the percentage increase in total employment of the 1000 simulations together with the plus-or-minus-one-standard-deviation range of results. Note that, in general, the one standard deviation confidence limits are small and fall over time. This is because in these two cases, migration and investment reduce the price deviations upon which the production and demand elasticities bite. This is particularly apparent in the simulation where α and β are both unity. In this case we know that in the long-run Input-Output results hold, so that there are no relative price changes and the confidence range ultimately collapses to a single point (McGregor *et al*, 1996b).

7. CONCLUSIONS

In this paper we focus primarily on the potential welfare effects of the Scottish Parliament exercising its current limited degree of fiscal autonomy through the exercise of its tax-varying powers. Algebraic and geometric analysis, using a regional general equilibrium variant of the Layard, Nickell and Jackman (1991) model, provide powerful conceptual insights, including extension of conventional balanced-budget multiplier analysis to accommodate the supply side in a long-run, regional context. However, apart from a limited set of special cases, they do not give easily signed and comprehensible results for the variables central to the current policy debate: the change in employment and population. Numerical CGE simulation suggests that the welfare success of the policy will depend crucially not only on the value of the resulting amenity to the local population but also on the extent to which this is reflected in a moderation of local pay claims. Such moderation would not be available in a perfectly competitive labour market where there is no mechanism to internalise the benefit of the publicly provided externality, and our simulations suggest that the balanced budget employment and population multipliers would be negative in such circumstances. However, in an imperfectly competitive labour market, where unions are concerned with the general welfare of their members, or where the nominal wage is set exogenously, such inverted Haavelemo effects may not be apparent. Rather, there may be significant potential welfare benefits to Scotland from the introduction of this fiscal innovation.

Our analysis also has implications for the wider debate on regional fiscal issues. If Scotland (and Wales and Northern Ireland) in fact has a significant structural public sector deficit, as official data and most commentators maintain, greater fiscal autonomy that necessitated some movement towards balance in regional public sector budgets may be associated with significant risks to economic activity in the peripheral economies of the UK, and therefore to regional equity. Even under the present fiscal arrangements, continuing commitment to the Barnett formula would exert a real resource squeeze on the peripheral regions of the UK. In these cases the contractionary impact on aggregate demand is reinforced by non-positive supply side influences operating through a combination of reduced amenity and increased tax effects on migration and wage bargaining. While the microeconomic case for the efficiency and other beneficial effects of greater fiscal autonomy may be considered persuasive (although see e.g. Gordon, 1983, Donahue,

1997 and Rodden, 2002), the macroeconomic consequences should not be neglected since our analysis here suggests that these may be substantial. Efficiency gains from full fiscal autonomy would have to be substantial to outweigh the probable adverse macroeconomic consequences. Our analysis suggests that further reform of the system of regional public finance should proceed with caution, and that some form of equalisation mechanism should be in place to mitigate any adverse macroeconomic consequences for the peripheral regions of the UK.

Future research could usefully extend the analysis in at least two directions. First, we have concentrated primarily on the consequences of exercising the existing degree of Scottish fiscal autonomy. While we have noted the relevance of this analysis to the wider debate on greater fiscal autonomy in the UK, many detailed aspects of such autonomy, including the possibility of greater tax-varying powers, remain to be explored. Secondly, the single region context of our current analysis abstracts from any induced spillover and feedback effects, and is clearly incapable of providing an analysis of the UK devolution programme as a whole. For a UK-wide perspective we believe that it is important to develop an explicitly interregional approach that will facilitate, *inter alia*, investigation of the potential for gains through economic policy coordination among devolved authorities.

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Table 2. Long-run % change in population after the introduction of the "tartan tax"

α / β	0.00	0.20	0.40	0.60	0.80	1.00
0.00	-1.41	-1.41	-1.41	-1.41	-1.41	-1.41
0.20	-1.36	-1.30	-1.23	-1.17	-1.10	-1.04
0.40	-1.32	-1.19	-1.06	-0.93	-0.80	-0.67
0.60	-1.27	-1.08	-0.88	-0.69	-0.49	-0.30
0.80	-1.22	-0.97	-0.71	-0.45	-0.18	0.08
1.00	-1.18	-0.86	-0.53	-0.20	0.13	0.46
1.20	-1.13	-0.74	-0.35	0.04	0.44	0.84
1.40	-1.09	-0.63	-0.18	0.29	0.75	1.22
1.60	-1.04	-0.52	0.00	0.53	1.06	1.60
1.80	-0.99	-0.41	0.18	0.78	1.38	1.99
2.00	-0.95	-0.30	0.36	1.03	1.70	2.38

Table 3: Long-run % change in key economic variables following the imposition of the "tartan tax"

	Regional Bargaining			
	$\beta=0$	$\alpha=\beta=1$	$\alpha=0$ $\beta=1$	$\alpha=0.8$ $\beta=1.2$
GDP (@ income measure)	-1.30	0.47	-1.16	0.44
Consumption	-1.65	-0.71	-1.56	-0.73
Govt expend.	2.40	2.70	2.42	2.69
Investment	-0.99	0.48	-0.88	0.45
Nominal pre-tax wage	1.75	0.00	1.62	0.04
Real post-tax consumption wage	0.00	-1.16	-0.09	-1.14
Total employment (000's):	-1.41	0.46	-1.26	0.42
Manufacturing:	-1.78	0.02	-1.64	-0.02
Non-Manu traded:	-2.20	-0.07	-2.03	-0.11
Sheltered:	-0.43	1.22	-0.29	1.19
Unemployment rate (%)	0.00	0.00	0.81	0.19
Total population (000's)	-1.41	0.46	-1.18	0.44
Price of value added:				
Manufacturing	1.45	0.00	1.34	0.03
Non-Manu traded	1.34	0.00	1.24	0.03
Sheltered	1.55	0.00	1.43	0.03
Capital rental rates:				
Manufacturing	0.49	0.00	0.46	0.01
Non-Manu traded	0.49	0.00	0.45	0.01
Sheltered	0.49	0.00	0.45	0.01
Consumer price index	0.57	0.00	0.53	0.01
Value-added:				
Manufacturing	-1.70	0.02	-1.56	-0.02
Non-Manu Traded	-2.08	-0.07	-1.92	-0.11
Sheltered	-0.37	1.22	-0.24	1.19
Capital stocks:				
Manufacturing	-1.41	0.02	-1.30	-0.01
Non-Manu Traded	-1.83	-0.07	-1.69	-0.11
Sheltered	-0.05	1.22	0.05	1.19
Exports:				
Manufacturing	-1.29	0.00	-1.19	-0.03
Non-Manu Traded	-1.93	0.00	-1.78	-0.04
Sheltered	-2.77	0.00	-2.55	-0.06
Real income (CPI deflator):				
Households disposable	-1.65	-0.71	-1.57	-0.73
Firms disposable	-1.34	0.03	-1.23	0.00

Figure 2 Long-run % change in population after the introduction of a tartan tax

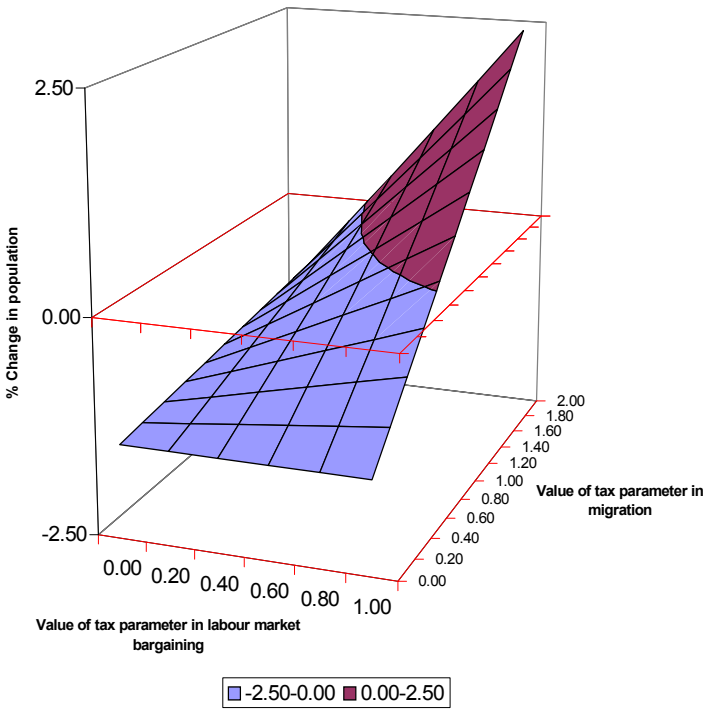


Figure 3 Long-run %changes in sectorally disaggregated employment and population following the imposition of the "Tartan Tax"

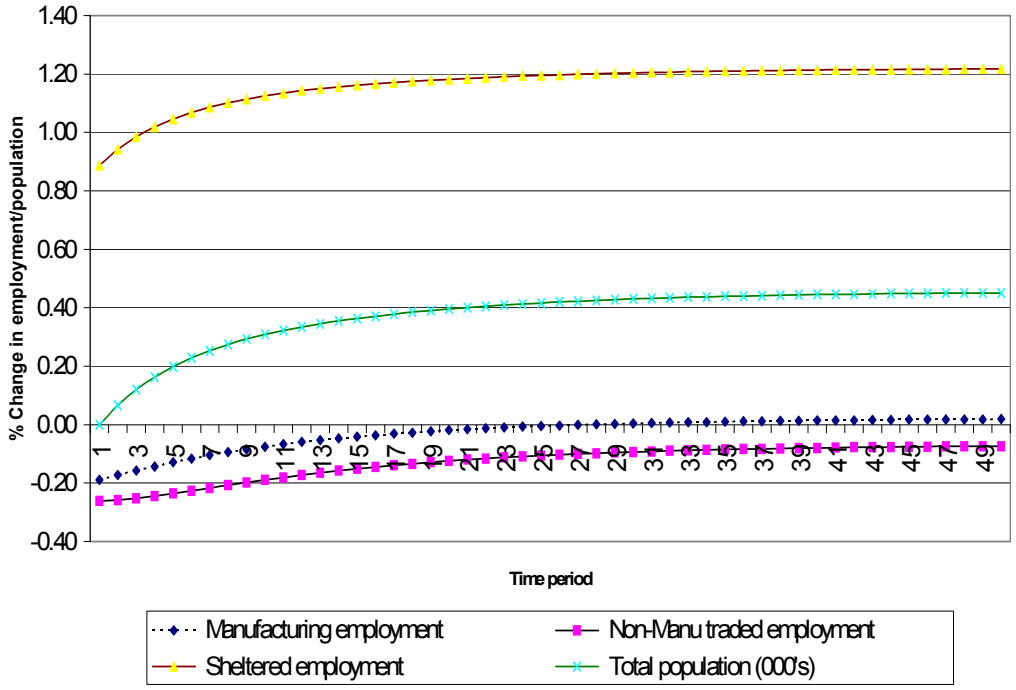


Figure 4. The sensitivity of total employment to parameter variability (for $\alpha = \beta = 1$)

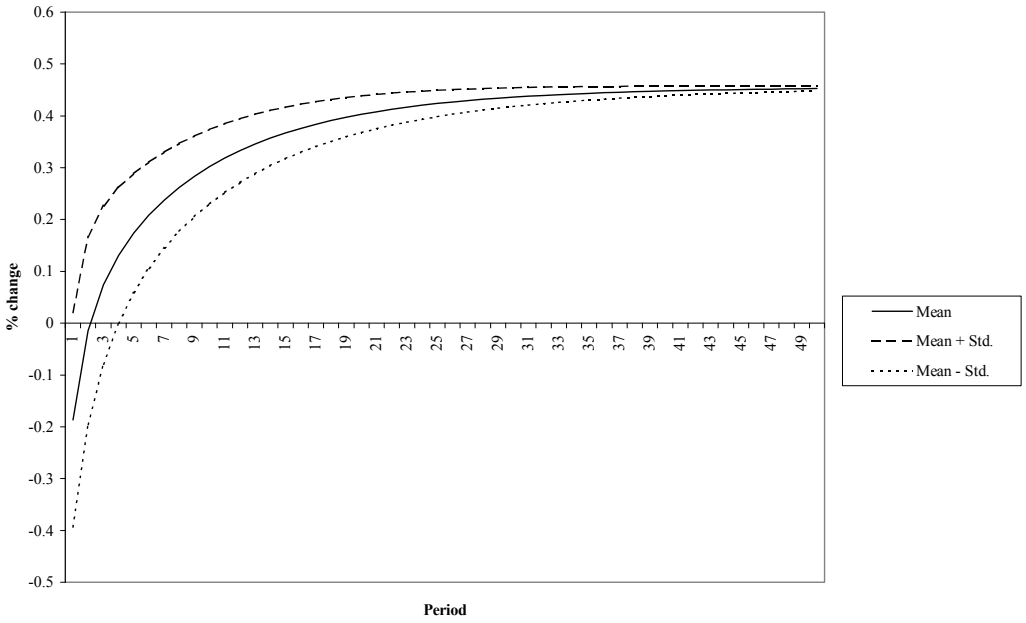


Figure 5. The sensitivity of total employment to parameter variability (for $\alpha = 0.8$ and $\beta = 1$)

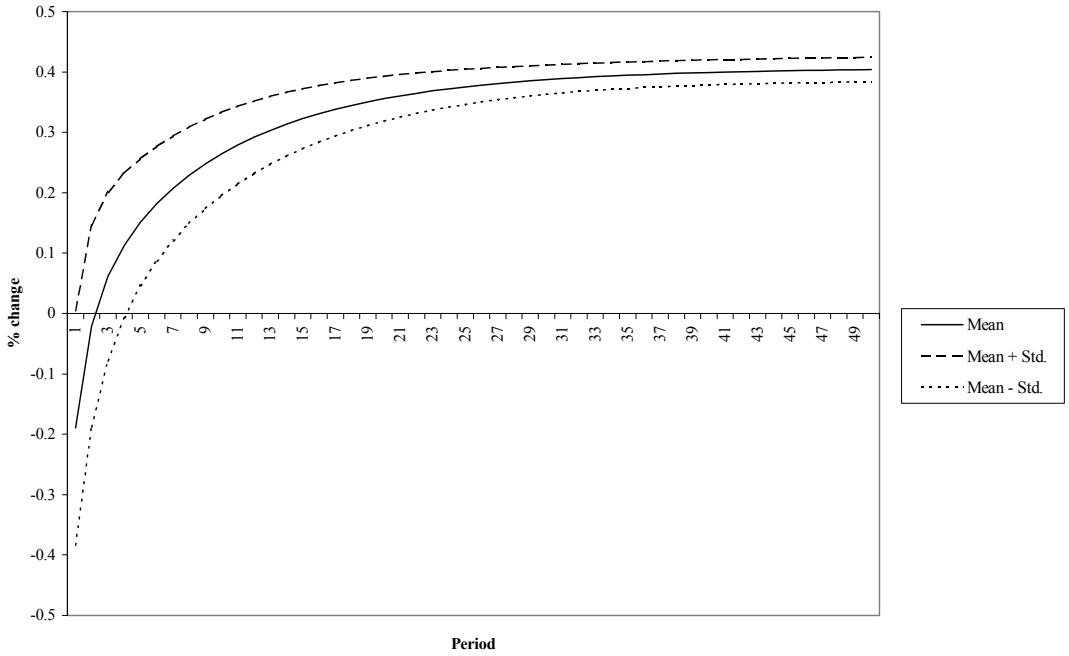


Table 1: The Basic Analytical Model: Level Form Equations

Zero Net Migration

$$\frac{w}{(1-t)^{\beta}} = w(e) \qquad \beta \geq 0,\ w_e < 0 \tag{1}$$

Employment Rate

$$e = \frac{n}{N} \tag{2}$$

Pre-Tax Nominal Wage

$$W = \frac{w \,.\, cpi}{1-t} \tag{3}$$

Consumer Price Index

$$cpi = cpi(W) \qquad 0 < cpi_W < 1 \tag{4}$$

Labour Demand

$$n = n(W,\ t,\ U) \qquad n_t,\ n_U > 0,\ n_W < 0 \tag{5}$$

Unemployment

$$U = (1-e)N \tag{6}$$

Wage Bargaining

$$\frac{w}{(1-t)^{\alpha\beta}} = b(e) \qquad b_e > 0,\ 1 \geq \alpha \geq 0 \tag{7}$$

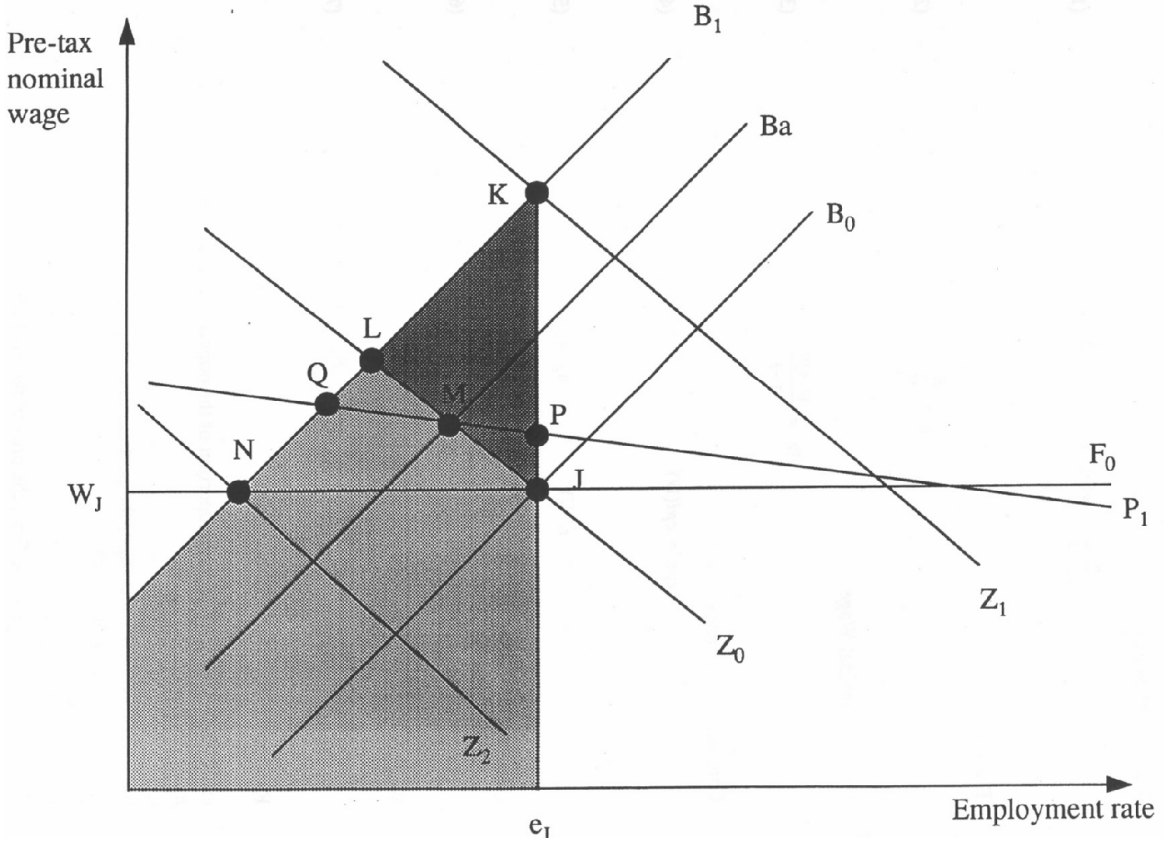
Endogenous Variables

e: employment rate, the proportion of the population employed
n: total employment
t: income tax rate
w: real consumption wage, the post-tax real wage
cpi: consumer price index
N: population
U: unemployment
W: nominal wage to the firm, the pre-tax nominal wage

Parameters

α, β: the incorporation of amenity effects in the bargaining function, and the zero ne migration function respectively

Figure 1: Long-run equilibrium following the introduction of a balanced budget fiscal expansion



FOOTNOTES

1. For a general review of CGEs see Shoven and Whalley (1992). Rickman and Partridge (1998) provides a critical review of the literature on regional CGEs.

2. Layard, Nickell and Jackman (1991, chpt. 6) also assume competitive commodity markets in their exposition of disaggregated labour markets.

3. This function has its roots in Harris and Todaro (1970) and has been widely employed elsewhere. See e.g. Greenwood *et al* (1991) and Treyz *et al* (1993) for applications in a U.S. context, and Bradley *et al* (1995) and Ermisch (1995) for Irish studies.

4. For simplicity, we abstract from changes in the participation rate in the theoretical analysis. We do allow for this, however, in our subsequent simulations.

5. Conventional regional policy wisdom in the U.K. is predicated upon a judgement of very immobile labour in which case equation (1) would be non-binding. We consider the implications of modifying our migration assumptions in Section 6 of the paper.

6. No nominal inertia is implied by this formulation, which is a re-parameterised version of a specification in which labour demand is a declining function of the real product wage.

7. Silvestre (e.g. 1990), describes this general equilibrium labour demand curve as the "full" demand curve for labour.

8. The labour supply decision could, of course, be influenced by the amenity if, for example, the amenity were complementary to leisure.

9. The normalisation adopted is to set the initial values of w, W, N and cpi to unity and the initial value of t to zero.

10. Where $\beta > 1$, so that the ZNM function falls, either the BRW function actually rises or it falls by a smaller amount than the ZNM function.

11. For extreme values of n_U and n_1, the coefficient on dn will be positive. However, this implies a perverse system in which total employment falls with an expansion in exogenous employment. This requires that, as unemployment declines, the negative employment effects of lower welfare payments dominate the original employment expansion.

12. The ZEC function would also pass through the point P but would slope less steeply.

13. AMOS is an acronym for a macro-micro model of Scotland. The model is calibrated using a Social Accounting Matrix based around the latest available complete Input-Output Table for Scotland which is for 1989.

14. Manufacturing comprises sectors 12-89; non-manufacturing traded, sectors 1-10, 91-97, 99-102 and 109-111; and the sheltered, sectors 11, 90, 98, 103-108 and 112-114 in the 1989 Scottish

Input-Output Tables. (Scottish Office, 1994)

15. Our treatment of long-run equilibria is identical to that employed in Harrison et al (1997) EJ paper.

16. The speed of adjustment parameter is 0.5. This process of capital accumulation is compatible with a simple theory of firm's optimal behaviour given the assumption of quadratic adjustment costs. This method of investment determination is also equivalent to capital stock adjustment motivated by the desire to equilibrate the user costs of capital and capital rental rates.

17. The compact form of AMOS abstracts from the complexities of distributional considerations and the detailed production structure. Details are available in Harrigan et al (1991).

18. The scale of AMOS relative to the analytical model of Sections 2 and 3 reflects its sectoral disaggregation and its complete specification of commodity demands and supplies and income transfer system that underly the general equilibrium demand curve for labour.

19. Earlier versions of this paper used the £390m figure (at 1995prices) for the yield of the tartan tax that was given in response to a parliamentary question from Peter Brook, *Hansard*, 1st May, 1996, column 1149.

20. The proportionate employment change figures are very close to those for population change and the cells which mark the boundary between positive and negative values are the same for the two variables.

21. In AMOS with national bargaining the pre-tax nominal wage is fixed at its initial level.

23.The formula, named after Joel Barnett, then Labour's Chief Secretary to the Treasury, was based on 1976 population figures. It originally allocated Scotland £10 and Wales £5 for every £85 change in expenditure on comparable English programmes.(See e.g. Bell *et al,* 1997.) This meant that Scotland received 11.6% and Wales 5.88% of any *change* in English expenditure. Michael Portillo, who was Chief Secretary to the Treasury in 1992, cut Scotland's share to 10.66% of changes in comparable English programmes and 10.06% of changes in combined English and Welsh programmes such as Law and Order.

24. In McGregor *et al* (1995), we begin to explore the consequences of moving from the current "soft" regional budget constraints to the hard constraints that would bind under independence. In McGregor and Swales (2005) we provide a non-technical overview of the economics of devolution/ decentralisation in a UK context.