# STRATHCLYDE

# DISCUSSION PAPERS IN ECONOMICS

The Impact of the Barnett Formula on the Scottish
Economy: A General Equilibrium Analysis

BY

Linda Ferguson, David Learmonth, Peter G McGregor, J
Kim Swales and Karen Turner

No. 03-04

DEPARTMENT OF ECONOMICS
UNIVERSITY OF STRATHCLYDE
GLASGOW

# The Impact of the Barnett Formula on the Scottish Economy:

# A General Equilibrium Analysis*

**21st March 2003**

by

Linda Ferguson**

David Learmonth**

Peter G McGregor+

J Kim Swales**

and

Karen Turner**

** Fraser of Allander Institute, Department of Economics, University of Strathclyde

+ Department of Economics, University of Strathclyde

# 1. Introduction

The Barnett formula is the official basis upon which public funds are allocated to the UK devolved territories - Northern Ireland, Scotland and Wales - for those parts of the budget that are administered locally. In the past, actual allocations have differed markedly from the Barnett benchmarks. However, the recent moves towards devolution in the UK have both significantly increased the level of interest in the formula and further fuelled the controversy surrounding its implications for the regions of the UK.

The existing literature on the Barnett formula has improves our understanding of its operation. However, this literature is extremely circumscribed, focusing primarily on the equity implications of the spatial changes to government expenditure per head that would accompany the strict imposition of the Barnett formula under various scenarios. There has been no corresponding analysis of the likely spatial impact on wider economic and demographic variables. This is despite the fact that the Barnett formula effectively determines the geographic distribution of a significant element of exogenous demand in the devolved territories. In this paper we begin to redress this imbalance.

In this paper we attempt to provide theoretical and empirical analyses of the system-wide effects of the operation of the Barnett formula in one of the devolved regions of the UK, Scotland. We use a sectorally disaggregated version of the Layard *et al* (1991) regional model. The empirical results are derived through numerical simulation with an appropriately parameterised version of our Scottish computable general equilibrium (CGE) model, AMOS. Further we employ this analysis to explore the importance of the recent switch to the regular up-dating of the population weights in the Barnett formula.

Section 2 presents a schematic account of how the Barnett formula allocates the devolved budgets and Section 3 briefly describes the way in which the operation of the formula has changed over time. Section 4 defines the notion of a Barnett equilibrium. This is a distribution of public expenditure which, if reached, would be

subsequently replicated through the action of the Barnett mechanism. In this section we focus particularly on the interaction between population and public expenditure implied by the action of the Barnett formula together with a flow-equilibrium migration process. In Section 5 we outline the Scottish Computable General Equilibrium model, AMOS, which is used to simulate Barnett equilibria over a number of conceptual time periods. Section 6 reports the simulation results and Section 7 is a short conclusion.

## 2. Devolved Budgets under Barnett

For our purposes, it is sufficient to know that the Barnett formula is used to determine any increase (or decrease) to the assigned budgets of the devolved authorities. These cover those elements of UK Department Expenditure Limits (DEL) for which there is equivalent expenditure in the devolved authorities. DEL covers spending under headings such as Health, Social Work, and Education in the devolved authorities. It does not finance spending on departmental programmes whose provision is included in the vote of the UK Parliament, such as, for example, the Common Agricultural Policy or spending on teachers' pensions.[1]

In modelling the implications for aggregate economic activity in Scotland of the strict implementation of the Barnett formula, we focus on the consequences for the level of government final demand in Scotland and the subsequent product and labour market impacts. In these simulation exercises we take 1999 as our base year.[2] In that year, 77% of the government final demand identified in the Scottish Input-Output accounts is funded from the assigned budget, that is DEL expenditures. The remainder consists of final demands attributable to programmes reserved to the UK government or financed by local authority expenditures.

The Barnett formula allocates a population-based share of any increase (or decrease) in comparable English DEL expenditure to the devolved authorities of the UK. At

---

[1] More detail of the different public spending aggregates that apply to the devolved authorities is given in Appendix 1.
[2] 1999 is the last year for which Scottish Input-Output accounts are available. These accounts are required to parameterise our model.

present the formula operates in nominal terms. Therefore, in so far as the Barnett formula is scrupulously adhered to, marginal changes in DEL in Scotland are determined by the difference equation:

$$\Delta G_{S,t} = \alpha_t \Delta G_{E,t} \tag{1}$$

where: $G_{S,t}$ ($G_{E,t}$) is the nominal level of DEL expenditure in Scotland (England) in period t, $\Delta$ is the first difference operator, and $\alpha_t$ is a parameter based upon the ratio of Scottish to English population.

A factor central to the debate concerning the operation of the Barnett formula in Scotland is that at present the proportion of UK DEL expenditure that is allocated to Scotland is much greater than Scotland's population share.[3] Therefore under strict adherence to the Barnett formula, the marginal allocation of UK DEL expenditure to Scotland is lower than its average allocation. Much of the Scottish literature surrounding the Barnett formula therefore focuses on the fact that with increasing nominal public expenditure in England, the proportionate public expenditure advantage at present enjoyed by Scots will decline. This is the so-called Barnett squeeze (see, for example, Bell *et al* 1996; Cuthbert, 2001; Heald, 1996; Heald and McLeod, 2002; Kay, 1998; McCrone, 1999; Midwinter, 2000, 2002; Twigger 1998.)

## 3. A History of the Barnett Formula

The account so far gives the principles underlying the operation of the Barnett formula. However, the details have changed over time. This particularly applies to the population weights used in the formula, that is the population numbers that determine the value of the parameter $\alpha_t$ in equation (1).

In the 1960s and early 1970s, public expenditure plans for Scotland, Wales and Northern Ireland were determined by the same departmental bargaining that characterises the rest of spending allocations among Whitehall departments  (HM

---

[3] For example, in the mid 1970s HM Treasury (1979) estimated Scotland's *per capita* public expenditure to be 22% higher than the corresponding English figure.

Treasury, 1997a). The Barnett formula - named after the then Chief Secretary of the Treasury - was used for the first time in 1978 in Scotland and two years later for Northern Ireland and Wales, and has been in continuous use ever since.[4] The population proportions used at the time of the formula's initial implementation were estimates for 1976. Under the Barnett formula Scotland then received 10/85[ths] of any increase or decrease in comparable English programmes (HM Treasury, 1999).

There have been a number of subsequent changes to the Barnett allocation mechanism. First, up until 1985 the formula was applied in real terms with figures rolling forward from one year to another with an in-built allowance for inflation. However, post-1985 expenditure changes have been allocated in nominal terms only (UK Treasury, 1999). Second, in 1992, Michael Portillo, as Chief Secretary to the Treasury, revised the formula to reflect the population figures given in the 1991 Census. Scotland's share in the UK population had fallen, so that marginal change in Scottish nominal DEL for any change in marginal English DEL - the value of $\alpha_t$ in equation 1 - was reduced from 11.76% to 10.66% (McCrone, 1999). Finally in 1997 a rather more fundamental modification was introduced. Chief Secretary to the Treasury, Alastair Darling, committed the government to an annual revision of the Barnett population weights, based on the latest population estimates for England, Scotland and Wales, published each year by National Statistics (HM Treasury, 1997b). This was to take effect from 1999.[5]

It is important to say that during much of the period since 1979, bypass and adjustment of non-formula-driven expenditures have meant that actual DEL expenditures in Scotland have differed, to Scotland's advantage, from those which would have emerged from the strict application of the Barnett formula (Midwinter, 2002). However, the formula has been accepted as the basis for determining the DEL of the Scottish Parliament (and the budgets of other devolved territories). Further, the

---

[4] The formulaic approach to allocating public expenditure between the countries of the UK goes back to Chancellor Goschen in 1891. He introduced a formula to allocate probate duties between countries in support of local government expenditure, based on each country's overall proportionate contribution to the Exchequer. This formula was also used as a basis for allocating some elements of public expenditure (e.g. education grants).

recent concern with adjusting the formula population weights, together with the greater transparency produced by devolution, has led to a belief that the Barnett formula will play a more central role in the actual allocation in the future (Goudie, 2003).

However, the Barnett formula takes no account of the relative need between Scotland and England, apart from their relative population sizes. Alternative methods of allocating expenditure between regions have been investigated using the needs assessment approach (Christie, 2002). This takes the view that the budget to the Scottish Executive should reflect the differing expenditure needs of the Scottish people as against their English counterparts. Scotland's higher morbidity rates, sparse populations in remote areas and greater poverty are thought to warrant higher expenditure (Midwinter, 2000).

In the mid 1970s, the Treasury led an interdepartmental study to assess the level of *per capita* spending in Scotland and Wales that would be required in order to provide a level of services comparable to that in England (HM Treasury, 1979). It estimated a required level of Scottish expenditure per head of 16% above the corresponding English level. This compared with the actual figure that showed Scottish expenditure per head 22% higher than the corresponding English figure. It is thought that the Barnett mechanism was introduced in order to affect a short-run adjustment towards these needs based figures.

## 4. Barnett Equilibria

In the analysis in this section we focus on the impact of the operation of the Barnett formula within a single devolved territory. We take the case of Scotland but the analysis can be replicated for any other region. Existing work on the Barnett formula is organised around the following relationship:

---

[5] The population proportions used in the 1998 Comprehensive Spending Review related to 1996 mid-year population estimates that reported Scotland's population as 10.45% of the English value.

$$\frac{G_{S,t} / P_{S,t}}{G_{E,t} / P_{E,t}} = B(\overline{G}_{S,0}, \overline{G}_{E,0}, ..., \overline{G}_{E,t}, \overline{P}_{E,0}, ..., \overline{P}_{E,t}, \overline{P}_{S,0}, ..., \overline{P}_{S,t}) \qquad (2)$$

where P is population. This work attempts to reveal the evolution of Scottish DEL *per capita* expenditure under a strict Barnett regime and alternative scenarios concerning the exogenous growth in nominal English DEL and exogenous population changes.

As such, this analysis simply charts the public finance implications of the operation of the Barnett allocation formula and requires no additional information. In particular, where the relevant explanatory variables are taken to be exogenous, the results are wholly independent of other economic variables, such as the level of activity, output or employment. The analysis is therefore rather restricted. Perhaps more importantly, it is also conceptually flawed if the changes in devolved public expenditure have direct demographic implications. Such a link operates most straightforwardly through migration. If changes in aggregate economic activity brought about through changes in government expenditure influence migration flows, then population becomes endogenous.

In this paper we wish to model the effect of the strict application of variants of the Barnett formula on economic activity through its impact on devolved government expenditure. We limit our analysis to the impact on a single region and adopt the small-region assumption. This takes the region to be so small relative to the rest of the economy that changes in the region's activity, fiscal arrangements and population do not have impacts on the rest of the nation large enough for there to be perceptible positive or negative feedback to the region itself.

Further, we do not track the period by period changes. Rather we focus on the economic implications of achieving Barnett equilibria. We designate a Barnett equilibrium to be a spatial allocation pattern of devolved DEL expenditure which, once reached, would be replicated by the subsequent operation of the Barnett formula.

Where the Barnett population weights, taken at time period 0, are fixed, then the Barnett equilibrium is very straightforward to determine. In the two-region case, in time period t the Barnett equilibrium ratio of DEL government expenditure in the two regions, $B^F$, where the F superscript stands for fixed population weights, is given as:

$$B^F = \frac{G_{S,t}}{G_{E,t}} = \frac{P_{S,0}}{P_{E,0}} \tag{3}$$

Further, this equilibrium is stable in the sense that in periods of increasing nominal government expenditure, the operation of the Barnett formula will drive the distribution towards the Barnett equilibrium, independently of the initial distribution. That is to say:

$$\frac{G_{S,t}}{G_{E,t}} \rightarrow B^F \ as \ G_{E,t} \rightarrow \infty$$

Our concern is to quantify the implications of achieving the Barnett equilibrium on the level and composition of activity in Scotland, $A_S$. In order to isolate the impact of the adjustment in government expenditure required to achieve the Barnett equilibrium, we keep all other exogenous variables fixed. Essentially we impose the *ceteris paribus* assumption. As noted above, we are also operating with a stand-alone regional model that ignores inter-regional feedback effects. These combined exogeneity assumptions mean that the analysis simply focuses on the impact of change in public expenditure in Scotland in a straightforward comparative static manner.

Under these circumstances, economic activity in Scotland is derived as:

$$A_S = A_S(\overline{A}_E, \overline{R}_E, \overline{p}_E, \overline{z}_S, B^F) \tag{4}$$

In this analysis, we hold constant: English economic activity ($A_E$), real government expenditure ($R_E$) and prices ($p_E$); and Scottish exogenous demands ($z_S$) - primarily

export demands. But Scottish nominal public expenditure is determined by the Barnett equilibrium ($B^F$).

Whilst the exogeneity assumptions imposed in equation (4) give an appropriate focus to the simulations, how can they be justified? In particular, we know that nominal government expenditure in England (and also Scotland) must rise for a Barnett equilibrium to be reached with existing population weights. Will these increases not automatically violate the *ceteris paribus* assumptions that we have imposed?

The approach we adopt can be motivated in two ways. First, equation (4) could be thought of as resulting from purely nominal changes in the UK economy, with no changes in real variables aside from Scottish public expenditure. As long as the two economies are homogeneous of degree zero in prices this interpretation is valid. A second interpretation for equation (4) is that it shows the proportionate deviations from the counterfactual that would occur in the Scottish economy if the Barnett equilibrium were imposed in a UK economy experiencing linear expansion, with all real exogenous variables increasing at the same rate. In this case, provided that the economies are linear homogeneous in the real exogenous variables, this is a reasonable interpretation.

Up to now we have been considering the application of the Barnett formula with fixed population weights. However, as explained in the previous section, under the 1997 Darling amendment, the population weights used to calculate marginal nominal changes in DEL public expenditure are, if required, updated to reflect any changes in the population levels. Under this formulation a necessary condition for the economy to be in a Barnett equilibrium in time period t would be that:

$$B^V = \frac{G_{S,t}}{G_{E,t}} = \frac{P_{S,t}}{P_{E,t}} \qquad (5)$$

where $B^V$ represents the Barnett equilibrium ratio where the formula has variable population weights (that is, with the full updating of those weights). Equation (5)

indicates that in this case, Barnett equilibrium implies that DEL nominal public expenditure per head will be equalised among devolved territories.

In the single-region analysis, with English nominal government expenditure, prices and population held constant, equation (5) implies:

$$G_S = \beta P_S \tag{6}$$

where $\beta = \dfrac{G_E}{P_E}$. Equation (6) captures the equilibrium operation of the Barnett mechanism in the allocation of expenditure. It is shown as the Barnett distribution line $B^V$ in Figure 1.

But with population endogenous, there will be a second relationship between Scottish population and DEL nominal expenditure that operates through the requirement for zero net migration in Barnett equilibrium. That is to say, for a given Scottish DEL nominal expenditure, there will be an equilibrium population level needed so as to generate no desire for net out- or in-migration. This can be expressed as:

$$P_S = P_S(G_S, \overline{A}_E, \overline{P}_E, \overline{p}_E, \overline{z}_S) \tag{7}$$

Expression (7) identifies the stable Scottish population level supported by a given level of nominal DEL nominal expenditure with English activity, prices and population fixed and with other elements of Scottish final demand constant at their initial values. For equation (7) we expect $P_S(0) > 0$ and $\dfrac{dP_S}{dG_S} > 0$. This is represented as the equilibrium population line, $P_S$, in Figure 1. Simultaneously solving equations (6) and (7) generates the variable-weight Barnett equilibrium population and nominal Government expenditures. This is shown diagrammatically as the intersection, E, between the lines $B^V$ and M in Figure 1. We then determine the level of Scottish activity, given the variable-weight Barnett equilibrium DEL expenditure.

$$A_S = A_S(\overline{A}_E, \overline{P}_E, \overline{p}_E, \overline{z}_S, \overline{\beta}) \tag{8}$$

In considering the stability of the variable-weight Barnett equilibrium, Figure 1 suggests that if there is one or more equilibria, then at least one will be stable in terms of the equilibrium relationships identified here. The Barnett distribution curve, $B^V$ must cut the equilibrium population curve M from below. If the initial government allocation is above $G^{V^*}{}_S$, then the subsequent population adjustment is insufficient to maintain that nominal government expenditure. Similarly, if the initial population is above $P^*{}_S$, subsequent changes in the allocation of nominal expenditures are not large enough to maintain this population. The variable weight Barnett equilibrium is therefore stable, subject to exogenous shocks.

The Barnett distribution and stable population curves illustrated in Figure 1 can be used to identify the implications for nominal DEL expenditure and population of imposing Barnett equilibria. Figure 2 is again drawn in nominal DEL expenditure (G) and population (P) space. The initial equilibrium – that is before the introduction of the Barnett formula - is at A, with population and DEL expenditure $P_0$, $G_0$.

There are two stable population curves, $M^L$ and $M^M$ that pass through point A. These curves represent the long- and medium-run relationships between population and nominal DEL imposed via the zero net migration constraint. We expect population will be more sensitive to changes in DEL expenditures in the long run, when capital stocks are allowed to fully adjust, than in the medium run, when they are assumed fixed. Capital fixity, together with price flexibility, cushions the impact on population. As DEL expenditure falls, prices fall as the capital rental rates decline. This means that the real expenditure reduction is less than the nominal reduction. Also the unchanged real wage required by the zero net migration constraint implies a fall in the nominal wage and therefore increased competitiveness and potential crowding in for some sectors. $M^L$ is therefore steeper than $M^S$.

11

*Barnett equilibria with fixed population weights*

Imposing the Barnett equilibrium implies for Scotland a reduction in DEL expenditure. Begin with the Barnett equilibrium with fixed weights. The new nominal DEL expenditure would be the initial population times the English per capita nominal DEL, β. With fixed population weights, this gives a new Scottish nominal DEL expenditure that is independent of subsequent changes in population. It is represented in Figure 2 by the vertical line at $B^F$.

In the short run, when population and capital stocks are fixed, the equilibrium is at B. Population is at its original value $P_0$ and the nominal DEL expenditure falls to $G^F$. The reduction in nominal government expenditure with population and capital stocks fixed implies that the unemployment rate will rise. With the regional bargaining function adopted in this variant of the AMOS model (Layard *et al*, 1991), Scottish real wage will fall. Capital rental rates will also tend to fall as commodity demand falls. However, these price reductions will cushion the decline in Scottish GDP because they generate crowding in of activity as a consequence of increased Scottish price competitiveness.

In the medium run, where population is allowed to fully adjust but capital stocks held fixed, the new equilibrium is identified by point C in Figure 2. Given the flow-equilibrium regional net migration function we use here (Layard *et al*, 1991), together with the regional bargaining function, out-migration will reduce the Scottish population up to the point where the original unemployment rate and real wage are reinstated (McGregor *et al.*, 1995). The population adjustment limits the fall in the nominal wage generated by the fall in government expenditure, reducing crowding in. The negative impact on GDP is therefore larger in this case.

In the long run, with full capital adjustment, the population decline is even greater. In this case the Barnett equilibrium is at D with population $P^F_L$. This represents the Input-Output adjustment to the reduced government expenditure (McGregor *et al*,

1996).[6] Output in all sectors will fall with a corresponding proportionate reduction in employment. Because the zero net migration condition implies no change in the unemployment rate, the proportionate fall in population will equal the proportionate fall in total employment.

*Barnett equilibria with variable (constantly up-dated) population weights*

In Figure 2, at point B the Scottish *per capita* DEL expenditure equals the initial English figure. If there is to be constant updating of the Barnett weights, the equilibria must lie on the straight line from the origin through B. This is simply a representation of equation (6) and the slope of the line is $\frac{1}{\beta}$.

In the short run there is no population change, therefore the issue of updating the weights in the Barnett formula simply does not arise. However, in the medium and long run, the adjustment of the stable population level to changes in nominal DEL expenditure will mean that unless the weights are amended, Barnett equilibrium DEL expenditure *per capita* will continue to vary across space. In the medium run without corrections to the weights the equilibrium is at C, with population and DEL nominal expenditure $P^F_M$ and $G^F$ respectively. Adjusting the weights leads to lower DEL expenditure but also further falls in population and DEL expenditure as part of a downward multiplier process. The new equilibrium is at E, where population and DEL expenditure stands at $P^V_M$ and $G^V_M$.

A similar relationship is apparent in the long-run adjustment. With a full adjustment of the population weights, the Barnett equilibrium shifts from D to F. From inspection of Figure 2, it is clear that the expected adjustment to population as a result of updating the Barnett weights will be larger in the long run than the medium run. Population is more responsive to changes in DEL expenditure in the long run, so that the multiplier effects will be larger.

---

[6] The analytical characteristics of the medium- and long-run results are discussed in greater detail in Section 5.

*Needs assessment*

We represent the impact of an allocation formula based upon a needs assessment in the following way. Under a needs assessment we take real Scottish DEL expenditure to be:

$$G_S^N = \beta \phi P_S \quad \text{(9)}$$

where $\beta$ is defined as for equation (6) as the English DEL expenditure *per capita* and $\phi$ is the needs index which reflects differences in needs *per capita* and initial differences in the cost of providing the comparable services in Scotland and England. If $\phi > 1$, then Scotland has a greater *per capita* need for DEL expenditure than England. In the case of the needs assessment, we are assuming another change in the public expenditure allocation process. This is that expenditure will be determined in real terms, rather than nominal terms as with the Barnett formula.

The analysis of the impact of a needs assessment allocation is very similar to that of the population-up-dated Barnett formula. Equation (9) will be represented as a straight line through the origin in the same way as the updated Barnett formula allocation is captured in Figures 1 and 2, except that real, rather than nominal, DEL expenditure will be on the vertical axis. The equilibrium will be where the stable population line cuts this needs assessment line. The multiplier impacts running from a change in DEL expenditure to a change in population to further changes in DEL expenditure operates here too. However, because Scotland would be expected to have a value of $\phi > 1$, the needs assessment line will be less steeply sloped than the population up-dated Barnett equilibrium line.

It is thought likely that a needs assessment would identify a real DEL *per capita* expenditure for Scotland above the average for England, but less than the present actual level. If this is so, we would expect the impact of the downward adjustment on Scotland's population and economic activity to be less than for the variable-weights Barnett equilibrium. This is unambiguously so for the long-run equilibrium where

prices do not change so that there is no distinction between real and nominal expenditure changes.

## 5. AMOS: the numerical version of the regional Layard, Nickell and Jackman model

We here outline the numerical, multi-sectoral, variant of the Layard *et al.* (1991) regional general equilibrium model employed in producing the simulation results reported in this paper. This model is captured by a particular configuration of the AMOS model, a computable general equilibrium (CGE) modelling framework that is parameterised on data from a UK region, Scotland.[7] A very brief description is presented in this section: more detail is available in Appendix 2 and a full listing of an earlier vintage of the AMOS model is provided in Harrigan *et al* (1991).

The current version of AMOS has 3 transactor groups, namely households, corporations, and government;[8] 25 commodities and activities and two exogenous external transactor groups (RUK and ROW). Throughout this paper commodity markets are taken to be competitive.[9] We do not explicitly model financial flows, our assumption being that Scotland is a price-taker in competitive UK financial markets and, under the small open economy assumption, the Bank of England's Monetary Policy Committee's interest-rate-setting decisions are taken to be exogenous to Scotland.

Production is determined through cost minimisation with multi-level production functions. These are generally of a CES form but with Leontief and Cobb-Douglas available as special cases. For simplicity, all domestic intermediate transactions are assumed to be Leontief in this paper. Otherwise we assume CES technology (notably

---

[7] AMOS is an acronym for *A M*acro-micro model *Of S*cotland. For reviews of CGE modelling see Greenaway *et al*, (1993) and Partridge and Rickman (1998).
[8] At present, AMOS treats Scotland as a self-governing economy, in the sense that there is only one consolidated government sector. Central government activity is partitioned to Scotland and combined with local government activity. This is adequate for the present paper but a more sophisticated treatment of the public sector is part of the work plan under the ESRC Devolution project.
[9] This assumption is also made for the regional model in Layard *et al.* (1991).

for the production of value-added from capital and labour services) with "best guess" elasticities of substitution of 0.3 (Harris, 1989).

There are four major components of final demand: consumption, investment, exports and government expenditure. Of these, consumption is a linear homogeneous function of real disposable income. Exports (and imports) are generally determined via an Armington link (Armington, 1969) and are therefore relative-price sensitive with trade substitution elasticities of 2.0 (Gibson, 1990). Nominal government expenditure in Scotland is taken to be exogenous and the policy shocks involve changes to this variable. Of course when we have full updating of the Barnett formula there is a degree of endogeneity in that we link DEL government nominal expenditure to the population level. Investment is initially set equal to depreciation although, as explained later in this section, in some closures capital stock is endogenous.

In all of the simulations reported in this paper we impose a single Scottish labour market characterised by perfect sectoral mobility. In general we explore the consequences of wages being subject to a bargaining function in which the regional real consumption wage is directly related to workers' bargaining power, and therefore inversely to the regional unemployment rate (Minford *et al*, 1994). This hypothesis has received considerable support in the recent past from a number of authors. Here, however, we take the bargaining function from the regional econometric work reported by Layard *et al.* (1991):

$$w_{s,t} = a - 0.068u_{s,t} + 0.40w_{s,t-1} \tag{10}$$

where $w_s$ and $u_s$ are the natural logarithms of the Scottish real consumption wage and the unemployment rate respectively, t is the time subscript and **a** is a calibrated parameter.[10] Empirical support for this "wage curve" specification is now widespread, even in a regional context (Blanchflower and Oswald 1994).

---

[10] The calibration is made so that the model, together with the set of exogenous variables, will recreate the base year data set. This calibrated parameter does not influence simulation outputs, but the assumption of initial equilibrium is, of course, important.

The only exception to this treatment of the labour market occurs in the sensitivity analysis reported in Section 6. Here we explore the consequences of a national bargaining system under which small open regions face a nationally determined wage. Essentially this implies that the region is characterised by a fixed nominal wage rate, a labour-market closure that has been very widely applied in traditional regional macroeconomic modelling.

We report the results of simulations under three conceptual time intervals: the short, medium and long runs. In the short run, population and all sectoral capital stocks are fixed. In the medium run, all sectoral capital stocks remain constant, but population is allowed to adjust fully. In the long run, adjustments of both capital and population stocks are complete.

The population adjustment is driven by a relationship whereby Scottish net migration is positively related to the real wage differential, and negatively to the unemployment rate differential, with the rest of the UK (RUK). This variant of the Harris and Todaro (1970) model is commonly employed in studies of US migration (e.g. Greenwood *et al*, 1991; Treyz *et al*, 1993). It is parameterised here from the econometrically estimated model reported in Layard *et al.* (1991):

$$m = b - 0.08(u_s - u_r) + 0.06(w_s - w_r) \tag{11}$$

where: m is the net in-migration rate (as a proportion of the indigenous population); $w_r$ and $u_r$ are the natural logarithms of the RUK real consumption wage and unemployment rates and b is a calibrated parameter.[11]

Full population adjustment implies a change in the population, with the attendant changes in the unemployment rate and consequently the real wage rate, to the point where net migration falls to zero. Therefore setting m = 0 in equation (11) generates the following zero-net-migration relationship between the wage and unemployment rate:

$$w_s = w_r + 0.75(u_s - u_r) + \frac{b}{0.06} \qquad (12)$$

The Scottish population is initially assumed to be in equilibrium. Combining equations (10) and (12) means that with unchanged values for the RUK real wage and unemployment rate, population equilibrium will reinstate the Scottish initial real wage and unemployment rate (McGregor *et al*, 1995).

In the long run, both population and capital stocks are optimally adjusted. In the case of capital, this means that the actual and desired capital stocks are equated, so that the risk-adjusted capital rental rate in each sector equals the user cost of capital. Again we assume the Scottish economy to be initially in long-run equilibrium. With all the labour market closures adopted in this paper, reinstating long-run equilibrium in the face a demand disturbance produces no change in prices, the real wage or the unemployment rate. The economy acts as a population-endogenous Input-Output system (McGregor *et al*, 1996). Therefore the equilibrium population relationship - identified in the previous section - between nominal government expenditure and the population level is represented, in this case, by a straight line.

## 6. Simulating Barnett equilibria

*Simulation strategy*

Both our theoretical analysis and empirical model focus on the impacts on the economy of Scotland of the imposition of a Barnett equilibrium in the determination of Scottish public expenditure. As discussed in the Section 4, the simulations are performed whilst holding all other exogenous variables constant, so that the economic impacts are measured relative to the *status quo*. Against this background we perform a number of numerical simulations.

---

[11] Again, the calibrated parameter is to ensure population equilibrium (zero net migration) in the base year.

First we undertake core simulations where economic impacts are determined over alternative time periods. In these simulations, all parameter values are set to their best-guess values, wages are determined through the real-wage bargaining mechanism and where migration is allowed it has a flow equilibrium form, driven by inter-regional variations in the unemployment rate and the real wage. We calculate the effects of the Barnett formula being applied with both fixed (base-period) or variable (constantly updated) population weights. At present the Barnett formula operates in nominal terms. In the AMOS model, Scottish prices can diverge from RUK prices and they will, in general, vary across different time periods. These price changes are incorporated into the Scottish government real-expenditure adjustments implied by the Barnett equilibria.

As we note in Section 3, some contributors to the debate have argued that the Barnett mechanism should be replaced by a needs-based allocative system. We therefore have carried out a set of simulations where Scottish DEL expenditure is determined by the last available official needs assessment for Scotland. Finally, we perform a limited amount of sensitivity analysis. In particular we consider the effect of replacing the regional with a national wage bargaining mechanism and the impact allowing full capital adjustment but no population adjustment.

*Core simulations*

We consider the fixed- and variable-population-weight cases in turn.

*Barnett equilibria with fixed population weights*

Imposing the Barnett equilibrium implies for Scotland a reduction in DEL expenditure. We begin with the Barnett equilibrium with fixed weights. In this case the new nominal DEL expenditure would be the Scottish initial population times the English *per capita* nominal DEL. This gives a new Scottish nominal DEL expenditure that is entirely independent of subsequent changes in population. Recall from Figure 2 in Section 4 that in the short run this produces a Barnett equilibrium at B: population is fixed at $P_0$ and the nominal DEL expenditure falls to $G^F$. The simulation results

reported in the first column of Table 1 give the accompanying changes in GDP, employment, the unemployment rate, cpi and real and nominal wage. The simulation results report the real-resource squeeze that accompanies the expenditure squeeze.

For each simulation, our first step is to identify the appropriate real government expenditure contraction that corresponds to the required change in nominal Scottish DEL. For this, two calculations must be made. First, changes in the Scottish consumer price index (cpi) need to be incorporated, so as to convert the nominal DEL expenditure changes into real terms. The adjustments take full account of the endogeneity of the cpi changes. Second, the real change in DEL expenditure must be expressed as a proportion of total public sector expenditure in Scotland. This is the way the model accepts a shock to government expenditure and the way in which the public expenditure shocks are reported in this section. Note that this means that any marginal changes to government DEL expenditure are assumed to have the sectoral composition of average public expenditure.

The short-run fixed-population-weights simulation results are given in the first column of Table 1. Note first that the 17% reduction in nominal DEL translates to a 10.65% reduction in real Scottish government expenditure. This contraction in government expenditures, implied by continued rigorous application of the Barnett formula, would have significant negative effects on the relative prosperity of Scotland. Scottish GDP falls by 1.27% and employment by 1.49%. There is an accompanying large fall in the real wage as the unemployment rate rises.

Figure 3 illustrates the corresponding sectoral employment, value added and output impacts. Note that in this case, the overall contraction in activity is focussed on the sectors in which government expenditure is concentrated – Public Administration, Education Health and Social Work, and Sewage and Refuse Disposal. In all other sectors the reduction in the nominal wage improves Scottish competitiveness and crowds in activity thereby stimulating activity and employment. For all sectors the proportionate change in employment, either positively or negatively, is greater than the change in value added reflecting the short-run capital fixity.

In the medium run, the new fixed-population-weight Barnett equilibrium is identified by point C in Figure 2 indicating a negative population adjustment. The simulation results are reported in the second column of Table 1. As noted in Section 4, the medium-run equilibrium with the regional bargaining labour-market closure leads to the reinstatement of the original unemployment rate and real wage (McGregor *et al.*, 1995). The population adjustment limits the fall in the nominal wage so that the extent of crowding in is reduced. Scottish GDP now falls by 1.75% and employment by 2.27%.

Figure 4 presents the sectorally disaggregated results for the medium-run Barnett equilibrium with the fixed population weights. In this case the reduction in activity is no longer limited to sectors dominated by public sector demand. The much smaller reduction in the nominal wage in this case leads to a much reduced positive competitiveness effect. Therefore the fall in intermediate and consumption demand now generates small reductions in activity in a number of service and utility sectors such as Energy and Water, Wholesale and Retail, and Hotels, Restaurants and Catering.

In long-run equilibrium - that is where there is full capital adjustment - the population change associated with achieving the fixed-population-weight Barnett equilibrium is even greater. This is shown as point D in Figure 2, and the simulation results associated with this equilibrium are summarised in Column 4 of Table 1. The real contractionary impact on the Scottish economy generated by the reduction in government demand is now reinforced by reduced capacity, with Scottish GDP and employment falling by 3.56% and 3.88% respectively. Note that there are no changes in commodity prices or the nominal wage. We therefore obtain, as expected, extended Input-Output results. However, because population is fully endogenous, the unemployment rate returns to its original level (McGregor *et al*, 1995, 1996).

 The Input-Output character of the results is immediately apparent from the sectorally disaggregated results presented in Figure 5. In the long run all sectors contract. The explanation is that in this case neither the nominal wage nor the capital rental rates are ultimately affected by changes in exogenous demand, so neither are any value added

or commodity prices. Therefore the entire impact of the government expenditure fall is on quantities and no incentive from the relative cost side leads sectors to change production techniques. This implies that all inputs adjust equi-proportionately within individual sectors so that employment, value added and output all change by the same proportionate amount.

*Barnett equilibria with variable (constantly up-dated) population weights*

Over time periods within which the population is allowed to vary, the contractionary impact on Scotland of the imposition of the Barnett equilibria is increased if the population weights are constantly updated. In Figure 2, the adoption of variable population weights leads to the medium-run Barnett equilibrium moving from points C to E and the long-run equilibrium from D to F. In columns 3 and 5 of Table 1, we report the results from the simulations that replicate these equilibria. The corresponding sectorally disaggregated results are given in Figures 6 and 7. In each case the decline in real government expenditure in Scotland is higher than for the corresponding fixed-weight equilibrium. Similarly the GDP, employment and population decline is greater. However, for simulations over comparable time intervals, the qualitative impacts are similar.

These simulations serve to emphasise the importance of population up-dating in the operation of the Barnett formula. Where regions are relative losers from Barnett, population, up-dating will further reinforce that loss. With population up-dating, the Scottish long-run Barnett equilibrium implies a level of GDP 4.61% below what it otherwise would have been, as compared to 3.56% with fixed population weights. Potentially the Darling amendment has an important impact on the distribution of demand among the regions of the UK. In our long-run model closure it produces a contractionary effect that is nearly 30% greater than in the fixed-population-weights case.

*Needs Assessment*

There has been much interest in the idea that the DEL devolved expenditures should be determined through some needs-based formula (Christie, 2002). It is therefore of value to compare the real impact of such a scheme as against the Barnett equilibrium. However, one problem is in determining the precise form that a needs assessment would have. Here we take the last official needs assessment, made for 1977 (HM Treasury, 1979) that estimated the required Scottish DEL *per capita* expenditure to be 16% higher than the English level. We have therefore adjusted the real Scottish DEL *per capita* expenditure to this level and in Table 2 present the corresponding simulation results for the short-, medium- and long-run closures as described for Table 1.

The key result here is that the 1999 Scottish *per capita* DEL expenditure is only slightly higher than the estimated needs-assessment level. This means that whilst the qualitative characteristics of the adjustments in Table 2 are similar to those in Table 1, the absolute scale is much lower. Therefore even in the long run, with full capital and population adjustment the reduction in GDP is only 0.29% and in employment and population 0.32%.

*Sensitivity analyses*

Assumptions about the nature of both the wage bargaining and migration behaviour can have a significant impact on the nature of the response to a Barnett-induced contraction. We have seen in the results presented in Table 1 that the fall in the nominal wage that accompanies the short- and medium-run Barnett equilibria increases competitiveness and has, in itself, a stimulating impact on the regional economy. But with alternative wage closures, where there is a degree of wage rigidity, such flexibility would be curtailed or non-existent.

In Table 3 we therefore explore the impact of imposing Barnett fixed- and variable-weight equilibria, but in this case assuming national, rather than regional, bargaining which as discussed in Section 5 implies a fixed (exogenously determined) nominal wage. This alternative assumption about wage bargaining has a major impact in the short-run, causing GDP to contract by 1.99% as compared with 1.27% in the regional

bargaining case. This differential impact is less marked in the medium-run results. This is because regional bargaining combined with full population adjustment implies that the real wage returns to its original level, implying a much smaller (0.87%) fall in the nominal wage. Over the long run, for the Barnett equilibria, the structure of bargaining makes no difference. In both regional and national bargaining regimes Input-Output results prevail over this interval and there are no price, wage or unemployment rate changes. The regional and national bargaining simulation results therefore converge.

Population change, generated in the AMOS model through migration, has two main effects on the Barnett equilibria impacts. The first is that the population level directly affects the change in DEL expenditure since the Darling amendment and the subsequent continuous updating of the population weights. Second, population change affects the unemployment rate that is associated with any change in DEL expenditure. Where there is regional bargaining this affects the real and nominal wage and therefore competitiveness. Where there is national bargaining, the unemployment level has an impact on benefit-funded consumption.

In the simulations reported in Table 1, comparing the short- and medium-run results identifies the additional impact of allowing migration but holding capital fixed for the regional bargaining closure. Table 3 presents the same results for the national bargaining closure. With the results from the simulations reported in Table 4, we can identify the impact of allowing migration in both the regional and national bargaining closures where capital is allowed to adjust fully.

The first column in Table 4 gives the proportionate impacts on key variables in the Scottish economy of the Barnett equilibrium where there is regional bargaining, full adjustment to the capital stock but no population change. First, because population has not changed there is no possible updating of the population weights. Second, comparing these changes with those reported in column 1 of Table 1 isolates the impact of the capital stock adjustment. The adjustment to the capital stock in itself produces a very small additional fall in GDP and employment over those reported in the short-run simulation.

Again, comparing the figures in column 1 of Table 4 with those in column 4 of Table 1 gives the additional impact of allowing a full population adjustment once we have allowed for a full capital stock adjustment. In this case the additional fall in activity is large. The change in GDP and employment are both reduced by over two percentage points. As observed already, the loss of competitiveness in the economy as the real wage is regained has a large negative impact on local economic activity.

Similar comparisons can be made for the results in column 2 of Table 4, which are for the national bargaining simulations with full capital adjustment, and those in columns 1 and 4 of Table 3. Note that in these simulations the assumption of national bargaining removes the link between Scottish population and the nominal wage. The initial short-run adjustment here shows a much bigger reduction in activity and the additional effect of allowing a full capital adjustment is rather large. For example, with national bargaining GDP falls by 1.99% in the short run and by 3.30% if full capital adjustment is incorporated. In fact this result is very similar to the long-run Barnett equilibrium with fixed population weights, where the GDP change fall is 3.56%. The only difference between these two simulations is that in long-run equilibrium the unemployment rate returns to its initial level so that consumption funded by benefits is lower.

Figure 8 summarises this information for GDP. It shows the full range of alternative decompositions of the long-run variable-population-weight Barnett equilibria adjustments to Scottish GDP that can be made using the information in Tables 1, 3 and 4.

## 6. Conclusions

While previous analyses of the operation of the Barnett formula have been instructive, the system-wide economic consequences of its strict imposition have been neglected, despite the fact that the Barnett formula drives the regional distribution of an important element of aggregate demand. The present paper attempts to fill this gap. We use a multi-sectoral general equilibrium regional Layard *et al.* (1991) model to quantify the real-resource Barnett squeeze on the Scottish economy. This is the likely

contractionary impact of Barnett equilibria in Scotland. The importance of the wage bargaining and migration processes in governing the likely scale of the effects is determined through sensitivity analysis. Furthermore, we are able to show the even greater contractionary impact of the recent change to regular up-dating of the population weights in the Barnett formula, once the endogeneity of population in a small regional economy like Scotland is accommodated through the migration process.

While our analysis represents a significant generalisation of past work, there remain four important areas for further research. First, while we concentrate here on the implications of Barnett (and other) equilibria, we know that these are only attained after a substantial lag. In practice, the impact of adherence to the Barnett formula over a period of a few years is unlikely to be very significant, although this is an issue that clearly merits further investigation.

Second, our assumption that the expenditure changes analysed here constitute a pure demand disturbance considerably simplifies our analysis. It allows us to focus on this critical but, up to now, entirely neglected aspect of the formula. In reality, however, adverse supply-side impacts may well accompany the relative expenditure contractions, so that the estimates we present here cannot be regarded as providing a "worst case" scenario. While these supply impacts will undoubtedly prove difficult to quantify, they merit further investigation.

Third, our analysis explores the impact of Barnett on economic activity in Scotland alone. The extensive use of the small-region assumption means that inter-regional spill-overs and national macro-economic constraints are ignored. However, future work will relax these restrictions and provide an explicitly interregional approach.

A fourth area is investigation of a wider range of alternative schemes for distributing public expenditures among the regions of the UK. There are many forms and degrees of fiscal federalism and we aim to exploit the power of general equilibrium models to investigate the possible impact of alternative fiscal systems in a UK context.

The neglected system-wide effects of the Barnett formula are important in practice. Yet alternatives to Barnett are often framed essentially in terms of microeconomic "needs". If the macroeconomic consequences of Barnett really matter, as our analysis suggests, they should feature more heavily in decisions concerning the regional distribution of government expenditures.

**REFERENCES**

Armington, P. (1969), "A Theory of Demand for Products Distinguished by Place of Production", *IMF Staff Papers*, Vol.16, pp. 157-178.

Bell, D., Dow, S., King, D., and Massie. N. (1996), "Financing Devolution." *Hume Papers on Public Policy,* Edinburgh University Press, Vol. 4, No.2.

Blanchflower, D., and Oswald, A. (1994), *The Wage Curve,* MIT Press: Cambridge, MA.

Christie, A. (2002), "The 1979 Needs Assessment: Lessons from Australia and Canada", *Fraser of Allander Quarterly Economic Commentary,* July 2002, pp. 30-35.

Cuthbert, J. (2001), "The Effect of Relative Population Growth on the Barnett Squeeze", *Fraser of Allander Quarterly Economic Commentary*, May 2001, pp. 34-37.

Gibson, H. (1990), "Export Competitiveness and UK Sales of Scottish Manufacturers", *Working Paper,* Scottish Enterprise, Glasgow.

Goudie, A. (2003), "GERS and Fiscal Autonomy", *Scottish Affairs,* No. 41, pp. 56-85.

Greenaway, D., S.J. Leyborne, G.V. Reed and Whalley J. (1993), *Applied General Equilibrium Modelling: Applications, Limitations and Future Developments,* HMSO, London.

Greenwood, M.J., Hunt, G., Richman, D., and Treyz, G. (1991), "Migration, Regional Equilibrium, and the Estimation of Compensating Differentials", *American Economic Review*, Vol. 81, pp. 1382-90.

Harrigan, F., McGregor, P., Perman, R., Swales, K. and Yin, Y.P. (1991), "AMOS: A Macro-Micro Model of Scotland", *Economic Modelling*, Vol. 8, pp. 424-479.

Harris, J. R. and Todaro, M. P. (1970), "Migration, Unemployment, and Development: A Two-Sector Analysis", *American Economic Review*, Vol. 60, pp. 126-142.

Harris, R.I.D. (1989) *The Growth and Structure of the UK Regional Economy, 1963-1985*, Avesbury, Aldershot.

Heald, D. A. (1996), "Formula-Controlled Territorial Public Expenditure in the United Kingdom", *Public Finances/Finances Publiques*, Vol. 8, pp. 23-52.

Heald, D.A. and McLeod, A. (2002), " Beyond Barnett: Financing Devolution", in J. Adams and P. Robinson (eds.) *Devolution in Practice: Public Policy Differences within the UK,* IPPR, *London*

HM Treasury (1979), *Needs Assessment Study: Report*, Stationery Office, London.

HM Treasury (1997a), *Select Committee's Second Report on the Barnett Formula,* House of Commons, December 1997.

HM Treasury (1997b), *Principles to Govern Determination of the Block Budgets for the Scottish Parliament and National Assembly for Wales*, December 1997.

HM Treasury (1999), *Funding the Scottish Parliament National Assembly for Wales and Northern Ireland Assembly,* 2nd edition, Stationary Office, London.

Kay, N. (1998), "The Scottish Parliament and the Barnett Formula." *Fraser of Allander Quarterly Economic Commentary*, Vol. 24, No 1, pp. 32-48.

Layard, R., Nickell, S., and Jackman, R. (1991), *Unemployment: Macroeconomic Performance and the Labour Market*, Oxford University Press, Oxford.

McCrone, G. (1999), "Scotland's Public Finances from Goshen to Barnett", *Fraser of Allander Institute Quarterly Economic Commentary*, Vol. 24, No. 2, pp. 30-46.

McGregor, P. Stevens, J. Swales, J.K. and Yin, Y. (1997), "The Economics of the 'Tartan Tax'." *Fraser of Allander Quarterly Economic Commentary*, Vol. 22, No. 3, pp. 72-86

McGregor, P.G., Swales, J.K., Yin, Y.P. (1995), "Migration Equilibria /Disequilibria and the Natural Rate of Unemployment in a Regional Context", *International Journal of Manpower*, Vol. 16, pp. 66-72.

McGregor, P. Swales, J.K. and Yin, Y. (1996), "A Long-run Interpretation of Regional Input-Output Analysis", *Journal of Regional Science*, Vol. 36, pp. 479-501.

Midwinter, A. (2000), "Devolution and Public Spending: Arguments and Evidence", *Fraser of Allander Quarterly Economic Commentary*, Vol. 25, No. 4, pp. 38-48.

Midwinter, A. (2002), "The Limits to Full Fiscal Autonomy: A Critique of the Scottish National Party's Agenda for Devolution Finance", *Scottish Affairs,* No. 41, pp. 121.

Minford, P., Stoney, P., Riley, J., and Wedd, B. (1994), "An Econometric Model of Merseyside: Validation and Policy Simulations", *Regional Studies*, Vol. 28, pp. 563-575.

Partridge, M.D. and Rickman, D.S. (1998), 'Regional Computable General Equilibrium Modelling: A Survey and Critical Appraisal', *International Regional Science Review,* Vol.21, pp. 205-248.

Treyz, G.I., Rickman, D.S., Hunt G.L., and Greenwood, M.J. (1993), "The Dynamics of Internal Migration in the U.S.", *Review of Economics and Statistics*, Vol. 75, pp. 209-214.

Twigger, R. (1998), "The Barnett Formula." House of Commons Library: Economic Policy and Statistics Section, Research Paper, No. 98/8.

**Appendix 1: Public Expenditure Aggregates in Scotland**

In June 1998, the UK government introduced a new key spending aggregate, Total Managed Expenditure (TME), which covers current and capital expenditure of the public sector, including expenditure on central and local government and public corporations. TME is an aggregate drawn from UK National Accounts, and is technically defined as public sector current expenditure plans plus net investment plus depreciation. In other words, TME is the expenditure side of Public Sector Net Borrowing (PSNB) (PESA, 2000). TME is comprised of Annually Managed Expenditures (AME) and Departmental Expenditure Limits (DEL).

AME covers expenditure items that are reviewed and set for the coming year, and include some self-financed expenditures. AME is classified in terms of main departmental programmes such as policy-specific, ring-fenced items where provision is included within the vote from the UK Parliament. Other AME spending includes locally financed items, including expenditure financed by the Scottish Variable Rate of Income Tax.

The relevant spending aggregates used to estimate the expenditures affected by the Barnett formula are those included in the Assigned Budget, equal to DEL (subject to minor adjustments). DEL expenditure is split between those items within the assigned budget and those within the non-assigned budget, i.e. current and capital budgets. By definition DEL expenditure includes current and capital expenditure. Total government expenditure (GGFC) identified by the 1998 CGE model does not include capital expenditure by the Government. However, we are concerned with the long run results of the simulations, where capital consumption will not be affected. Changes in assigned budget items to the Devolved administrations are determined through the Barnett formula. Non-assigned budget elements of DEL are those which are ring-fenced and specific to spending priorities.

It is difficult to identify public expenditure aggregates by country or region. For this reason, Identifiable Total Managed Expenditure (TME) is used to allocate expenditure to specific countries and reflects the relative benefits incurred by the respective populations. Identifiable Total Managed Expenditure in Scotland is equal to those expenditures which can be identified from official records as having been incurred on behalf of the population of Scotland, based on the 'who benefits' principal. By definition DEL expenditure includes current and capital expenditure. Total government expenditure (GGFC) identified by the 1998 CGE model does not include capital expenditure by the Government. However, we are concerned with the long run results of the simulations, where capital consumption will not be affected.

The main expenditure aggregates used for the simulation are summarised below:

- Departmental Expenditure Limits (DEL) in Scotland ($G_S$), is equal to Barnett-formula determined expenditure only;

- Departmental Expenditure Limits (DEL) in England ($G_E$), is equal to the sum of comparable expenditures by non-territorial departments;

- Gross Government Final Consumption (GGFC) in Scotland is equal to total government expenditure identified by the Scottish Input-Output Tables.

- Identifiable Total Managed Expenditure (TME) in Scotland is equal to those expenditures which can be identified using the 'who benefits' principal.

**Derivation of English DEL for 1998 and Reduction in Government Expenditure**

The first stage in estimating the required reduction in Scottish expenditure is to estimate the sum of DEL expenditures in England using official data published by HM Treasury for 1998. A detailed breakdown of public expenditure figures are available in the annual *Public Expenditure Statistical Analysis* (HM Treasury). DEL figures are available at the UK and devolved administration level, but no DEL aggregates are separately identified for England. Therefore, a DEL aggregate for England needs to be estimated.

The Scottish DEL figure represents Barnett formula determined DEL only. This excludes non-Barnett determined elements such as 'Welfare to Work' and HLCAs (Table 1.1).

**Table 1.1: Composition of Public Expenditure in Scotland**

| Scottish Executive Public Expenditure Regime | | |
|---|---|---|
| **1999-2000 onwards** | | |
| **Assigned Budget** | **Non-assigned Budget** | |
| **Departmental Expenditure Limit (DEL):** | | **Annually Managed Expenditure (AME):** |
| **Barnett Formula Determined[1]** | **Non-Barnett determined** | **Main Programme spending:** |
| Secretary of State's/Advocate General's Office | | |
| Education and arts,<br>Health and social work<br>Industry, enterprise and training | HLCAs | Common Agricultural Policy (CAP) [4] |
| Transport and<br>Roads<br>Housing, Scottish Homes external finance | Welfare to Work | Housing support grant [4] |
| Law and order<br>Crown Office | | NHS and teachers' pensions [4,6] |
| Domestic agriculture<br>Environmental services,<br>Forestry<br>CalMac and HIAL's External Finance<br>Requirements<br>Student Loans: implied subsidies and<br>provision for bad debts | | **Other AME:**<br>Certain accrual items such as capital charges and depreciation charges |
| Capital Receipts Initiative<br>Trust Debt Remuneration [3]<br>Scottish Renewables Obligation | | Local Authority Self Financed Expenditure (LASFE) [5] |
| Bus Fuel Duty Rebates | | Scottish Non-Domestic Rates |
| | | Scottish Variable rate of Income Tax |
| Other expenditure outside DEL: Police Loans Charges | | |

Notes:
[1] Undifferentiated expenditures linked to changes in the provision of United Kingdom
Government departments;
[2] Secretary of State's and Advocate General's Offices remain part of the United
Kingdom Government;
[3] Trust Debt Remuneration is both payments and receipts (both interest and
dividends);
[4] Items of expenditure determined or forecast annually;
[5] Post-devolution, determined by local authorities within framework set by National
Assembly for Wales;
[6] Forecast by the Scottish Executive, approved by the Secretary of State for Scotland
and the Treasury and voted by the United Kingdom Parliament

Given the above, the equivalent expenditures for England can be estimated by taking
the total value of all comparable expenditures in England (Table 1.2).

**Table 1.2: Scottish, English and UK Departmental Expenditure Limits**

| Departmental Expenditure Limits [1] | Expenditure for 1998-99 (£ millions) | Comparable Expenditure with Scotland [2] |
|---|---|---|
| **Defence** <br> *Ministry of Defence* | 22,475 | No |
| **Foreign and Common Wealth Office** <br> *Foreign and Common Wealth Office* | 1,094 | No |
| **Agriculture, Fisheries and Food (MAFF)** [3] <br> *Ministry of Agriculture, fisheries and Food* <br> *Intervention Board;* <br> *Forestry Commission* | 1,362 | No |
| **Social Security** <br> *Department of Social Security* | 2,944 | No |
| **Chancellor's Departments** <br> *HM Treasury;* <br> *Scottish Executive and its Department's* <br> *Crown Office* <br> *General Register Office for Scotland;* <br> *National Archives of Scotland* | 3,141 | No |
| **Trade and Industry** <br> *Department of Trade and Industry;* <br> *British Trade International;* <br> *Office of Fare Trading;* <br> *Office of Gas and Electricity Markets;* <br> *Office of Telecommunications;* <br> *Postal Service Commission;* <br> *Export Credits Guarantee Department* <br> *(Capital Expenditure only)* | **2,916** | Yes |

| | | |
|---|---|---|
| **DETR – Main Programmes** <br> *Department for Environment, Transport and the Regions (except local government and regional policy);* <br> *Office of Passenger Rail Franchising;* <br> *Office of Rail regulator;* <br> *Office of Water Services* | **8,998** | Yes |
| **DETR - Local Government and Regional Policy** <br> *Department for Environment, Transport and the Regions - mainly block and transitional grants to English local authorities, the Greater London Authority, and Regional Development Agencies* | **32,737** | Yes |
| **Home Office** <br> *Home Office* | **7,104** | Yes |
| **Legal Departments** <br> *Lord Chancellor' Department's* <br> *Crown Prosecution Service;* <br> *Northern Ireland Court Service;* <br> *Public Records Office;* <br> *Serious Fraud Office;* <br> *Treasury Solicitor's Department* | **2,680** | Yes |
| **Education and Employment** <br> *Department For Education and Employment;* <br> *Office for Standards in Education* | **14,326** | Yes |
| **Culture, Media and Sport** <br> *Department of Culture, Media and Sport* | **917** | Yes |
| **Health** <br> *Department of Health;* <br> *Food Standards Agency* | **37,376** | Yes |
| **Cabinet Office** <br> *Cabinet Office;* <br> *Central Office of Information;* <br> *House of Commons;* <br> *House of Lords;* <br> *National Audit Office;* <br> *Electoral Commission;* <br> *Privy Council Office;* <br> *Security and Intelligence Services* <br> *Office of the Parliamentary Commissioner for Administration and Health Service Commissioners for England* | 1,248 | Yes |
| **Of which:** *Cabinet Office and Parliament* [4] | 1,047 | No |
| **Of which:** *Cabinet Office: Office of Public Services*[5] | **201** | Yes |
| **TOTAL DEL FOR ENGLAND** | **107,255** (sum of all figures in bold) | |

Notes:
**1** These figures represent the main departmental groupings within UK DEL. Figures for sub-programme expenditures for 1998-99 are not available. Individual departments' expenditures have been grouped together broadly on the basis of Ministerial responsibilities. Provisional sub-programme expenditures for 1998-99 are available in Appendix C of '*Funding the Scottish Parliament, National Assembly for Wales and Northern Ireland Assembly: A Statement of Funding Policy'*. However, the DEL aggregates used in this table have been taken from '*Public Expenditure Statistical Analysis (PESA) 2000-01'*.
**2** Comparability figures for 1998-99 are published in Appendix C of '*Funding the Scottish Parliament, National Assembly for Wales and Northern Ireland Assembly: A Statement of Funding Policy'*, HM Treasury, (March 1999). The comparability percentages have been used as an indication of comparable departmental spending in Scotland.
**3** MAFF sub-programmes were on a Great Britain basis for the relative Comprehensive Spending Review (CSR) for that year. United Kingdom domestic Agriculture for Scotland was therefore determined by allocating population share of changes in domestic spending in England. MAFF's sub-programmes will be re-aligned to reflect spending within England for future reviews.
**4** Assuming 'Office of Public Service' element represents approximately 16 per cent of the Cabinet Office total.
**5** Assuming 'Cabinet Office and Parliament ' element represents approximately 84 per cent of the Cabinet Office total.

The English DEL figure (£107,255 million) represents the sum of all comparable expenditures in England, excluding all other departmental and sub-programme expenditures distributed at the UK level. Any change in the level of English DEL ($G_E$) will therefore imply a change to Scotland's DEL ($G_S$), as determined by the Barnett formula. Under the Barnett formula Scotland will receive a population-based proportion of any change in planned departmental spending on comparable UK government services in England.

The comparability percentages published in '*Funding the Scottish Parliament, National Assembly for Wales and Northern Ireland Assembly: A Statement of Funding Policy' 2000,* have been used to indicate what departmental expenditures in England are comparable with Scotland. Where there is zero comparability, it has been inferred that these departmental expenditures are distributed at the UK level and have been excluded from the English DEL figure ($G_E$). Similarly, the Scottish DEL figure ($G_S$) excludes any proportion of expenditures distributed at the UK level and represents Barnett determined DEL only.

The English and Scottish DEL figures used to calculate the government expenditure shocks have been taken from *PESA* 2000-01, and are consistent with Government Expenditure figures in the CGE model database for 1998.

## Appendix 2

## Table 1: A Condensed Version of the AMOS CGE Model

| | |
|---|---|
| (1) Commodity Price | $p_i = p_i(w_n, w_{ki})$ |
| (2) Consumer Price Index | $cpi = \sum_i \theta_i p_i + \sum_i \theta_i^{UK} \bar{p}_i^{UK} + \sum_i \theta_i^{ROW} \bar{p}_i^{ROW}$ |
| (3) Capital Price Index | $kpi = \sum_i \gamma_i p_i + \sum_i \gamma_i^{UK} \bar{p}_i^{UK} + \sum_i \gamma_i^{ROW} \bar{p}_i^{ROW}$ |
| (4) User Cost of Capital | $uck = uck(kpi)$ |
| (5) Wage setting<br>    Regional Bargaining<br>    National Bargaining | $w_n = w_n\left(\dfrac{N}{L}, cpi\right)$<br><br>$w_n = \bar{w}_n$ |
| (6) Labour Force:<br>    Short-Run<br><br>    Full Adjustment | $L = \bar{L}$<br><br>$L = L\left(\dfrac{w_n}{cpi}, N\right)$ |
| (7) Labour Demand | $N_i^D = N_i^D(Q_i, w_n, w_{k,i})$ |
| (8) Labour Market Clearing | $\sum_i N_i^D = N$ |
| (9) Capital Demand | $K_i = K_i^D = K_i^D(Q_i, w_n, w_{k,i})$ |
| (10) Capital Rental Rate<br>    Short-Run<br><br>    Full Adjustment | $w_{k,i} = w_{k,i}^s\left(K_i^d, \bar{K}_i^s\right)$<br><br>$w_{k,i} = w_{k,i}^l(uck)$ |
| (11) Household Income | $Y = \Psi_n N w_n + \Psi_k \sum_i K_i w_{k,i}$ |
| (12) Commodity Demand | $Q_i = C_i + I_i + G_i + X_i$ |
| (13) Consumption Demand | $C_i = C_i(p_i, \bar{p}_i^{UK}, \bar{p}_i^{ROW}, Y, cpi)$ |

| (14) Capital Stock Adjustment | $\Delta K_i = d_i K_i$ |
|---|---|
| (15) Investment Demand | $I_i = I_i(p_i, \bar{p}_i^{UK}, \bar{p}_i^{ROW}, \sum_i b_{i,j} \Delta K_j)$ |
| (16) Government Demand<br><br>    No Population Updating<br><br>    Full Population Updating | <br><br>$G_i = G_i^s(\bar{G}^n, cpi)$<br><br>$G_i = G_i^l(L, cpi)$ |
| (17) Export Demand | $X_i = X_i(p_i, \bar{p}_i^{UK}, \bar{p}_i^{ROW}, \bar{D}^{UK}, \bar{D}^{ROW})$ |

## NOTATION

### Activity-Commodities

i, j are activity/commodity subscripts.

### Transactors

UK = United Kingdom, ROW = Rest of World

*Time Periods*
s = short run, l = full adjustment

*Nominal/Real*
Allvariables are expressed in real terms apart from where the superscript n is used.

### Functions

| | |
|---|---|
| p (.) | cost function |
| uck(.) | user cost of capital formulation |
| $w_n(.)$, $w_k(.)$ | factor price setting functions |
| C(.), I(.), X(.) | Armington consumption, investment and export demand functions, |
| | Homogenous of degree zero in prices and one in quantities |
| $K^D(.)$, $N^D(.)$ | factor demand functions |
| L | zero net migration condition |
| G | Barnett pulic sector expenditure formula |

### Variables

| | |
|---|---|
| C | consumption |
| D | exogenous export demand |
| G | government demand for local goods |

| I | investment demand for local goods |
|---|---|
| $\Delta K$ | investment demand by activity |
| $K^D, K^S, K$ | capital demand, capital supply and actual capital stock |
| L | labour force |
| $N^D, N^S, N$ | labour demand and total employment |
| Q | commodity/activity output |
| X | exports |
| Y | household nominal income |
| b | elements of capital matrix |
| cpi, kpi | consumer and capital price indices |
| d | physical depreciation |
| p | price of commodity/activity output |
| uck | user cost of capital |
| $w_n, w_k$ | wage, capital rental |
| $\Psi$ | share of factor income retained in region |
| $\theta$ | consumption weights |
| $\gamma$ | capital weights |

*Note* (*): A number of simplifications are made in this condensed version of JEMENVI

1. Intermediate demand is suppressed throughout (e.g. only primary factor demands are noted in price determination in equation (1) and final demands in the determination of commodity demand in equation (12).
2. Income transfers are generally suppressed.
3. Taxes are ignored.
4. The participation rate is ignored.

**Figure 1:** The equilibrium population and government expenditure with Barnett equilibrium (variable weights)
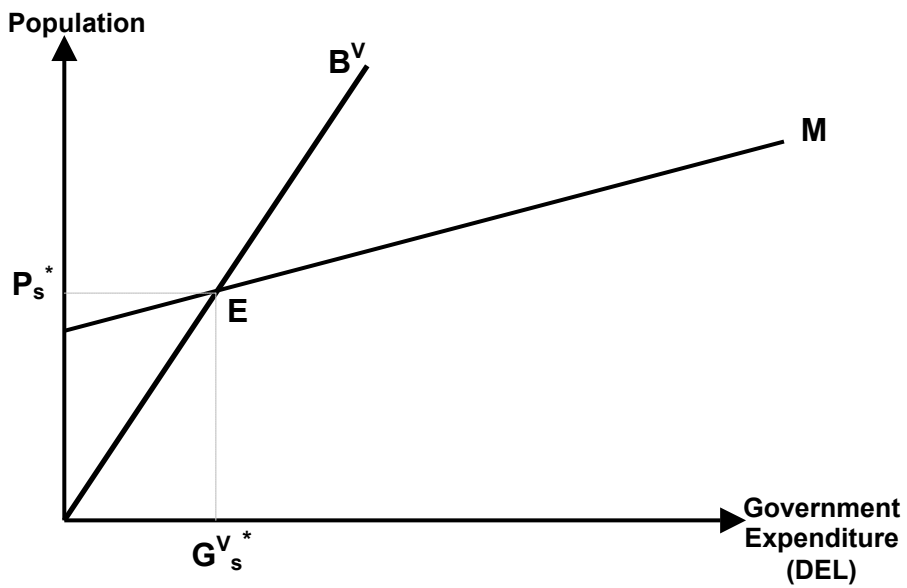


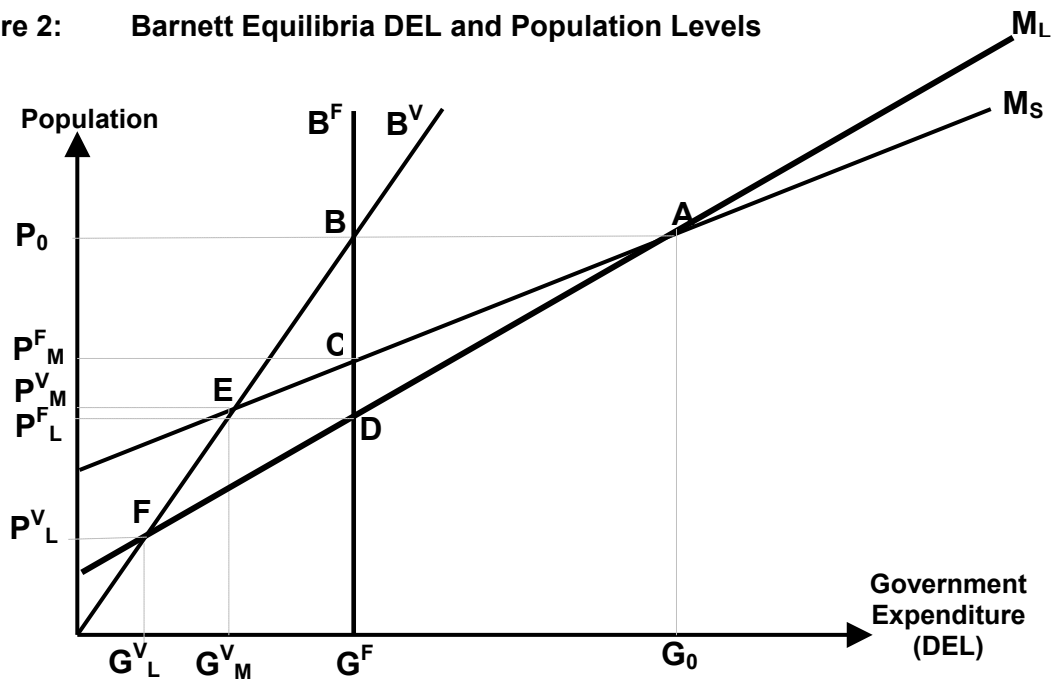**Figure 2:** Barnett Equilibria DEL and Population Levels

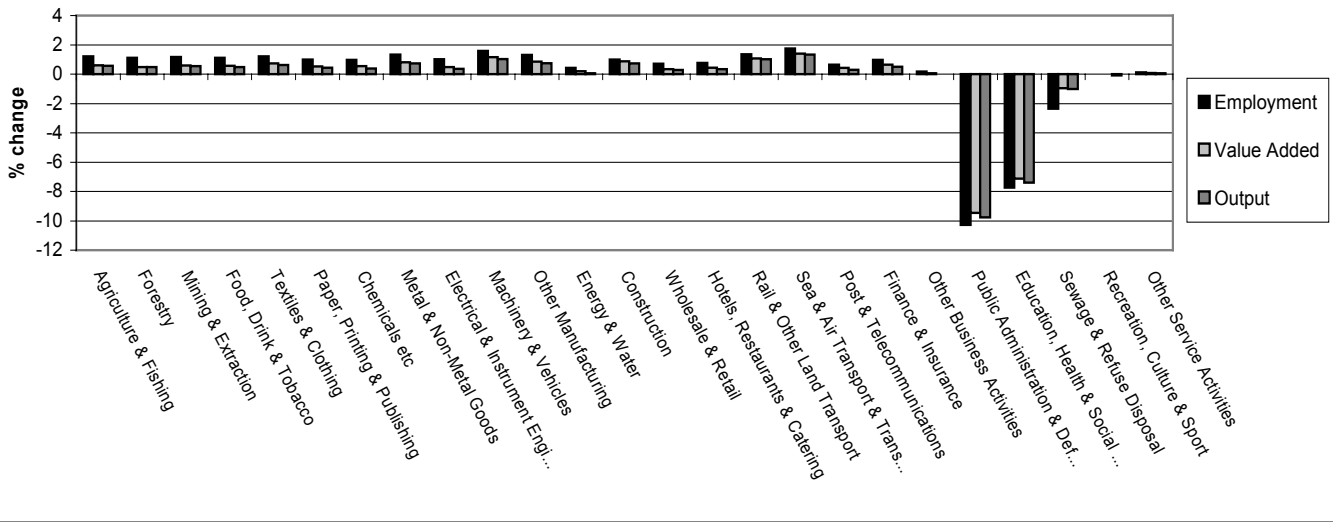Figure 3 - Short-run sectorally-disaggregated changes in employment, value added and output with Barnett equilibrium
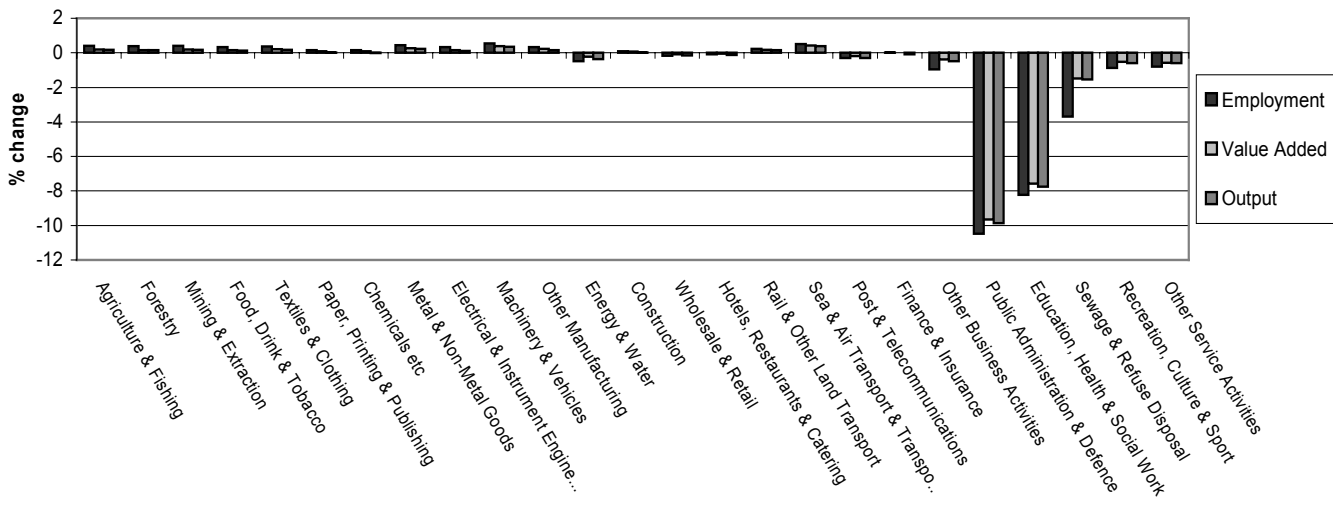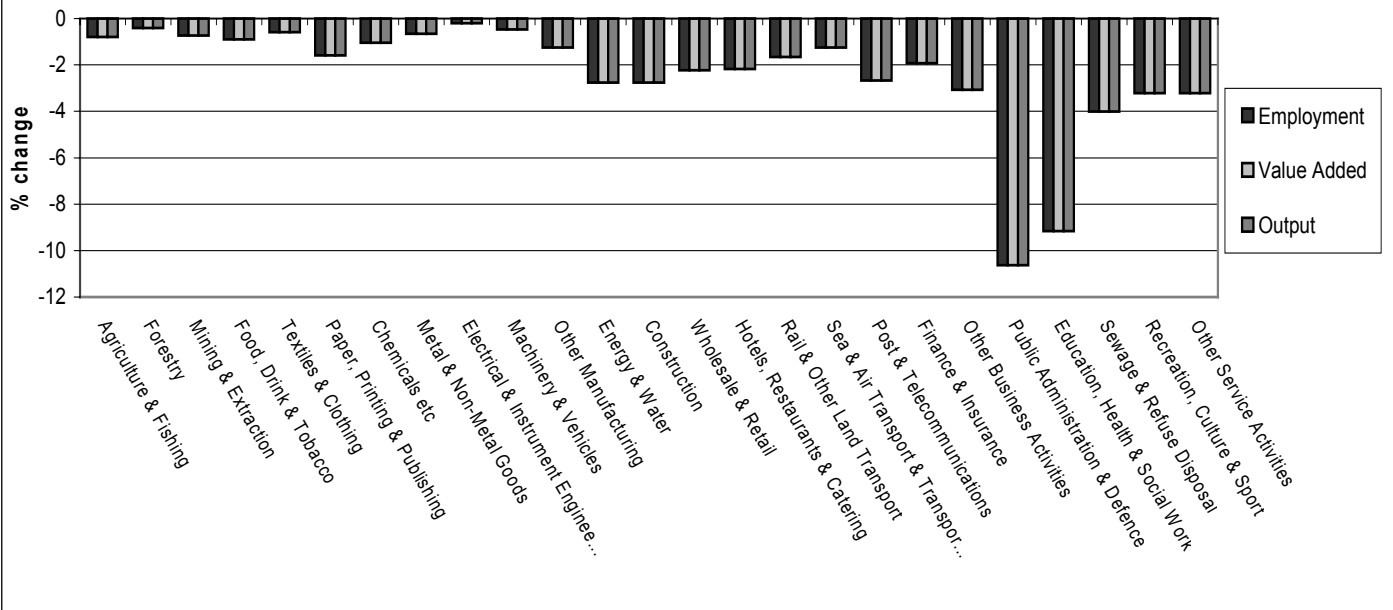


Figure 4 - Medium-run sectorally-disaggregated changes in employment, value added and output with Barnett fixed population weights equilibrium

**Figure 5 - Long-run sectorally-disaggregated changes in employment, value added and output with Barnett fixed population weights equilibrium**



**Figure 6 - Medium-run sectorally-disaggregated changes in employment, value added and output with Barnett variable population weights equilibrium**

Figure 7 - Long-run sectorally-disaggregated changes in employment, value added and output with Barnett variable population weight equilibrium
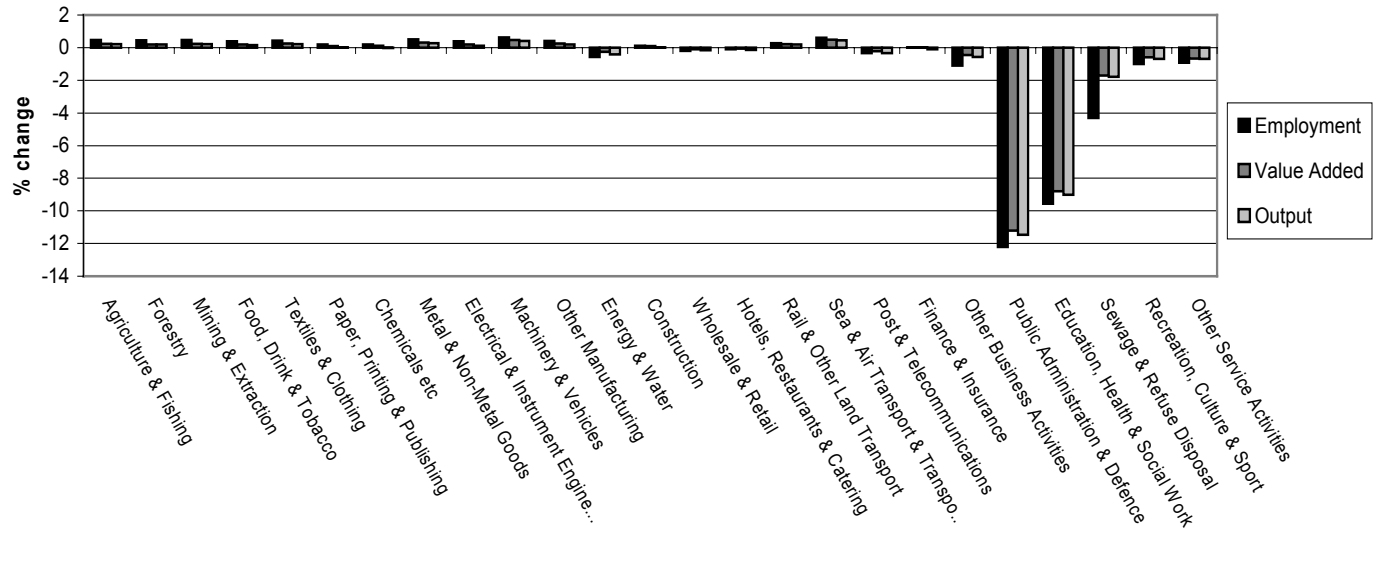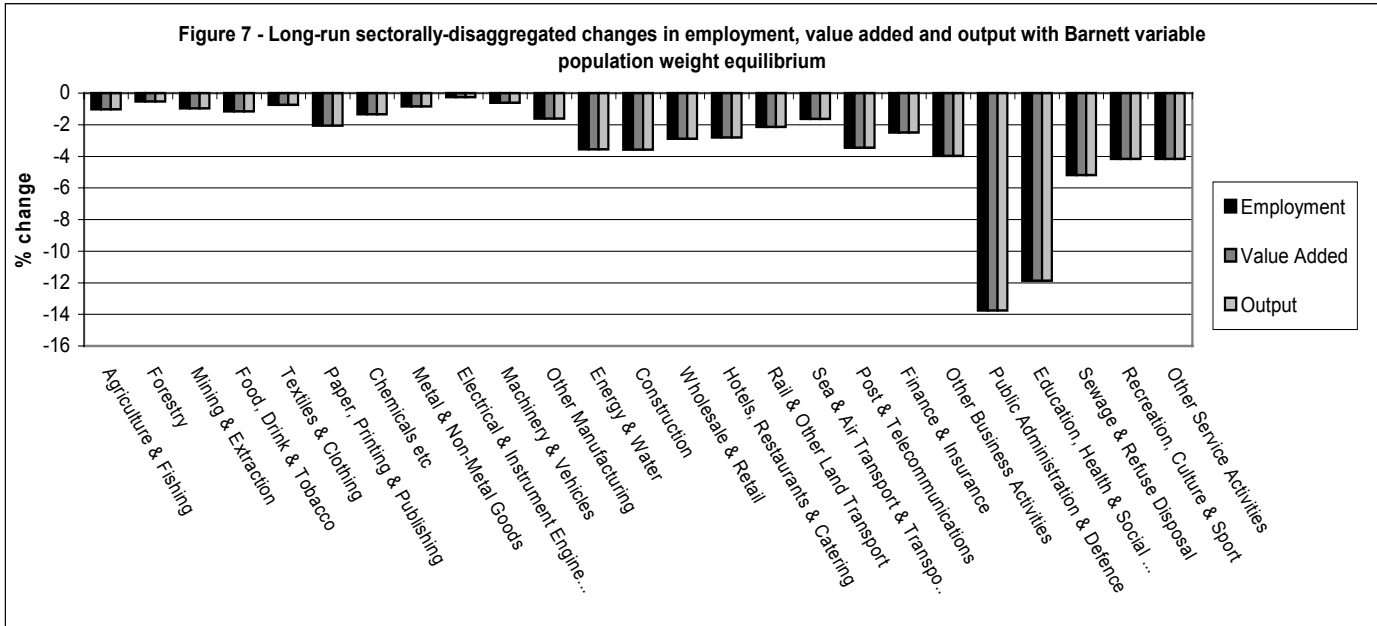
**Figure 8: Alternative decompositions of the long-run variable-population weight Barnett equilibrium adjustments to GDP (percentage changes from base)**



**Short run impact**
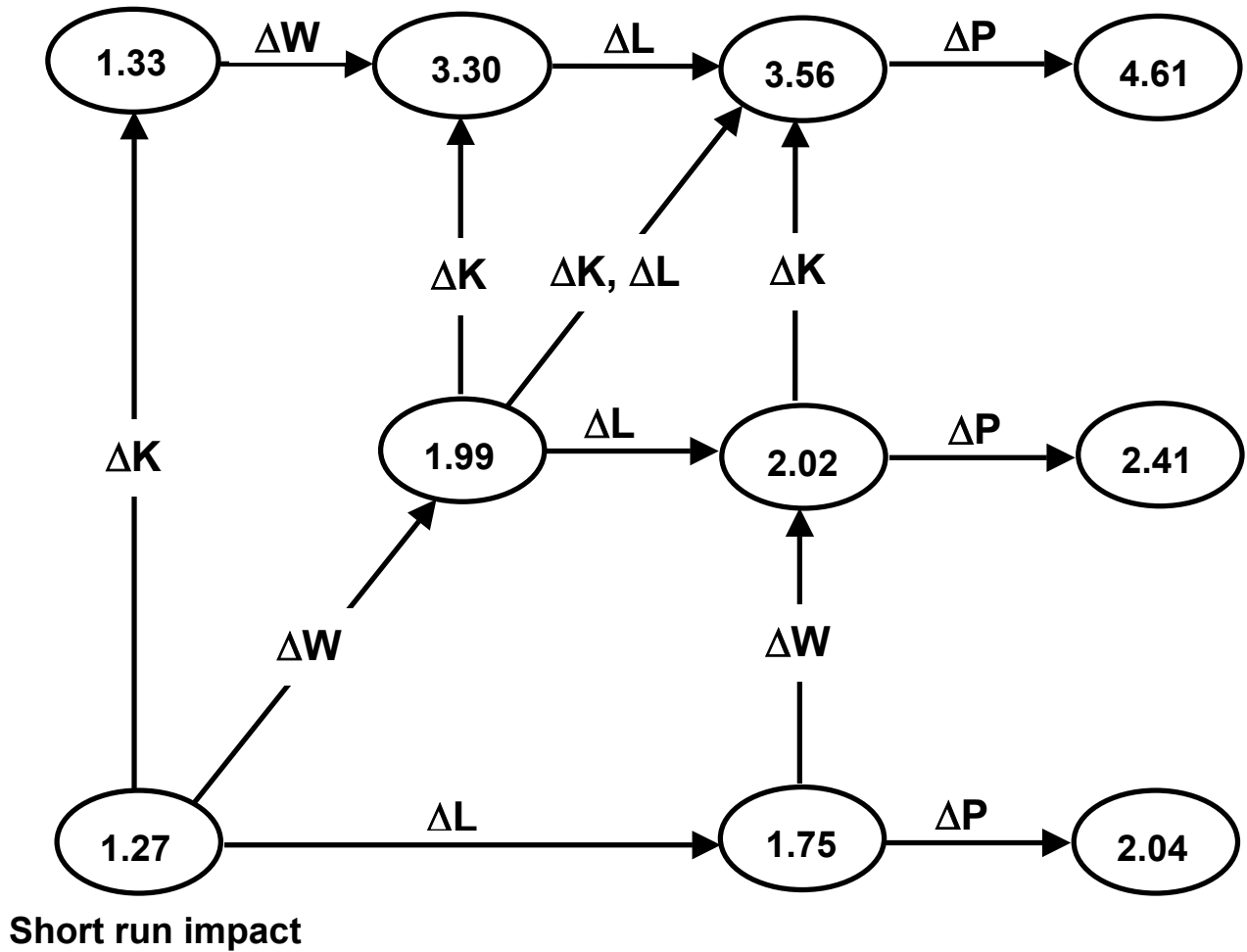
**Table 1: The percentage change in the value of key economic variables as a result of imposing Barnett equilibria with regional wage bargaining**

| | Short run[1] | Medium run[2] | | Long run[3] | |
|---|---|---|---|---|---|
| | | **Fixed Weights** | **Variable Weights** | **Fixed Weights** | **Variable Weights** |
| GDP | -1.27 | -1.75 | -2.04 | -3.56 | -4.61 |
| Population | 0.00 | -2.27 | -2.64 | -3.88 | -5.03 |
| Employment | -1.46 | -2.27 | -2.64 | -3.88 | -5.03 |
| CPI | -0.92 | -0.87 | -1.01 | 0.00 | 0.00 |
| Wages: | | | | | |
|   Real Before Tax | -1.49 | 0.00 | 0.00 | 0.00 | 0.00 |
|   Nominal Before Tax | -2.42 | -0.87 | -1.01 | 0.00 | 0.00 |
| Unemployment | 12.29 | 0.00 | 0.00 | 0.00 | 0.00 |
| % change in Government Expenditure | -10.65[4] | -10.69[4] | -12.43[5] | -11.26 | -14.58[6] |

[1]Fixed population and fixed sectoral capital stocks
[2]Fixed sectoral capital stocks, but full population adjustment
[3] Full capital and population adjustment
[4] CPI adjustment in short-run and medium-run
[5] Population and CPI adjustment in medium-run
[6] Population adjustment

**Table 2: The percentage change in the value of key economic variables as a result of imposing the Treasury 1976/7 needs assessment DEL expenditure**

|  | Short run[1] | Medium run[2] | Long run[3] |
|---|---|---|---|
| GDP | -0.08 | -0.13 | -0.29 |
| Population | 0.00 | -0.17 | -0.32 |
| Employment | -0.10 | -0.17 | -0.32 |
| CPI | -0.06 | -0.07 | 0.00 |
| Wages: | | | |
|   Real Before Tax | -0.09 | 0.00 | 0.00 |
|   Nominal Before Tax | -0.15 | -0.07 | 0.00 |
| Unemployment | 0.80 | 0.00 | 0.00 |
| % change in Government Expenditure | -0.68 | -0.81[4] | -0.92[4] |

[1]Fixed population and fixed sectoral capital stocks
[2]Fixed sectoral capital stocks, but full population adjustment
[3]Full capital and population adjustment
[4]Population adjustment

**Table 3: The percentage change in the value of key economic variables as a result of imposing Barnett equilibria with national wage bargaining**

| | Short run[1] | Medium run[2] | | Long run[3] | |
| --- | --- | --- | --- | --- | --- |
| | | **Fixed Weights** | **Variable Weights** | **Fixed Weights** | **Variable Weights** |
| GDP | -1.99 | -2.02 | -2.41 | -3.56 | -4.61 |
| Population | 0.00 | -2.64 | -3.16 | -3.88 | -5.03 |
| Employment | -2.64 | -2.70 | -3.23 | -5.44 | -5.03 |
| CPI | -0.73 | -0.81 | -0.97 | 0.00 | 0.00 |
| Wages: | | | | | |
|   Real Before Tax | 0.72 | 0.80 | 0.96 | 0.00 | 0.00 |
|   Nominal Before Tax | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Unemployment | 22.17 | 0.60 | 0.72 | 0.00 | 0.00 |
| % change in Government Expenditure | -10.78[4] | -10.72[4] | -12.81[5] | -11.26 | -14.58[6] |

[1]Fixed population and fixed sectoral capital stocks
[2]Fixed sectoral capital stocks, but full population adjustment
[3] Full capital and population adjustment
[4] CPI adjustment
[5] Population and CPI adjustment
[6] Population adjustment

**Table 4: The percentage change in the value of key economic variables with full capital adjustment but no population adjustment**

|  | REGIONAL BARGAINING<br>Long run | NATIONAL BARGAINING<br>Long run |
|---|---|---|
| GDP | -1.33 | -3.30 |
| Population | 0.00 | 0.00 |
| Employment | -1.52 | -3.61 |
| CPI | -0.72 | 0.00 |
| Wages:<br>　Real Before Tax<br>　Nominal Before Tax | <br>-1.56<br>-2.29 | <br>0.00<br>0.00 |
| Unemployment | 12.80 | 30.27 |
| % change in Government Expenditure | -11.74 | -11.26 |