UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 00/25

TESTING THE ENDOGENOUS GROWTH MODEL: PUBLIC EXPENDITURE, TAXATION AND GROWTH OVER THE LONG-RUN

by Michael Bleaney, Norman Gemmell and Richard Kneller

November 2000

DP 00/25

ISSN 1360-2438

UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 00/25

TESTING THE ENDOGENOUS GROWTH MODEL: PUBLIC EXPENDITURE, TAXATION AND GROWTH OVER THE LONG-RUN

By Michael Bleaney, Norman Gemmell and Richard Kneller

Michael Bleaney is Professor, Norman Gemmell is Emeritus Professor, both in the School of Economics, University of Nottingham, and Richard Kneller is Research Officer, National Institute of Economic and Social Research

November 2000

Testing the Endogenous Growth Model:
Public Expenditure, Taxation and Growth over the Long-Run+

by

Michael Bleaney*, Norman Gemmell* and Richard Kneller**

*School of Economics, University of Nottingham
**National Institute of Economic and Social Research

e-mail: norman.gemmell@nottingham.ac.uk

Abstract

Endogenous growth models, such as Barro (1990), predict that government expenditure and taxation will have both temporary and permanent effects on growth. We test this prediction using panels of annual and period-averaged data for OECD countries during 1970-95, isolating long-run from short-run fiscal effects. Our results strongly support the endogenous growth model and suggest that long-run fiscal effects are not fully captured by period averaging and static panel methods. Unlike previous investigations, our estimates are free from biases associated with incomplete specification of the government budget constraint, and do not appear to result from endogeneity of fiscal or investment variables.

JEL Nos: H30, O40
Keywords: endogenous growth, government, taxation, fiscal policy

1. Introduction

In the neoclassical growth model of Solow (1956), together with its many subsequent extensions, the long-run growth rate is driven by population growth and the rate of technical progress. Distortionary taxation or productive government expenditures may affect the incentive to invest in human or physical capital, but in the long run this affects only the equilibrium factor ratios and not the growth rate, although there will in general be transitional growth effects. Endogenous growth models such as those of Barro (1990) and King and Rebelo (1990), on the other hand, predict that distortionary taxation and productive expenditures *will* affect the long-run growth rate. The implications of endogenous growth models for fiscal policy have been particularly examined by Barro (1990), Jones *et al*. (1993), Stokey and Rebelo (1995) and Mendoza *et al*. (1997).

In testing whether the historical evidence supports the neoclassical or the endogenous growth model, several major difficulties arise. One is that there may be only limited data on government expenditures and revenues, particularly at the required level of disaggregation, and the definition of particular expenditures as productive or unproductive, or particular taxes as distortionary or non-distortionary, may be open to debate.[1] Much empirical 'government and growth' research predates the new generation of theoretical models and therefore fails to address these issues. Even recent contributions however have given limited attention to the measurement of fiscal variables.

A second – and often overlooked – problem is that, because of the linear relationship between fiscal variables implied by the government budget constraint, biases can easily be introduced into regression equations if the researcher neglects the implicit financing assumptions built into the specification. This is not simply a point of interpretation of regression results, since it also has implications for the appropriate testing strategy, as we indicate below.

A third problem is that the usefulness of fiscal policy data in testing the endogenous growth model rests on the ability of the empirical methodology employed to separate

[1] See Evans and Karras (1994) for evidence on 'productive' government expenditures across US states.

the effects of policy on the transition from those on the steady state. Much existing evidence is based on single cross-sections or panels of five-year averages (and allows only for contemporaneous effects within each five-year period), relying on the period-averaging process to capture the long-run. Whether this is an adequate procedure or whether longer lags are required remains an under-researched issue. It is, however, an important one, since neoclassical and endogenous growth models differ only in their *long-run* predictions. If existing evidence captures short-run behaviour only it cannot discriminate between alternative theories.[2]

A fourth, and related, problem concerns the endogeneity of regressors in growth equations. In this case, does faster growth induce larger government expenditures and taxes (*e.g.* via Wagner's Law), or *vice versa*, or both? Clearly if fiscal variables are not strictly exogenous, evidence based on cross-section or static panel approaches may be misleading.

In Kneller *et al*. (1999) we sought to deal with the first two of the above problems. In the context of static panel regressions, we showed that complete specification of the government budget constraint and careful attention to fiscal classifications produces dramatically different results for the growth effects of fiscal policy compared with previous investigations. Our results offered strong support for the endogenous growth models of Barro (1990) and others. However, to facilitate comparisons with earlier evidence, Kneller *et al*. (1999) used static panel regression techniques on five-yearly averaged data and provided only limited testing for endogeneity of fiscal regressors. Dealing with these latter two problems is the primary focus of this paper – do five-year averages capture long-run behaviour or are longer lags required? And are 'static' results undermined when we allow for dynamic responses and the endogeneity of fiscal policy?

In this paper we investigate these questions using data from a panel of 22 OECD countries during 1970-95. We allow for alternative classifications of fiscal variables

---

[2] Since Jones (1995a) a number of papers have begun to use time-series or dynamic panel methods to distinguish short- from long-run growth effects for investment or convergence variables (see, for example, Caselli *et al.* (1996), Evans (1998)). Karras (1999) appears to be the first paper to apply Jones's (1995a) methodology to examine the growth effects of taxes. We discuss his evidence further below.

and consider various methods of estimating the long-run impact, in each case taking care to avoid the afore-mentioned biases to the parameter estimates. Despite numerous sensitivity tests, our results continue to provide strong support for the endogenous growth model. Compared with previously published work, our findings demonstrate greater consistency between theory and empirics. We attribute this to the inclusion of disaggregated revenues *and* expenditures in the model combined with careful attention to the implicit financing assumptions that would otherwise bias the results sufficiently to make a dramatic difference to the investigator's conclusions. We find that the long-run effects of fiscal policy take longer than five years to come through, and that these effects are *not* due to 'fiscal endogeneity'. In line with Jones's (1995a) finding, investment does however appear to be endogenous and its effects on growth will be exaggerated if fiscal policy is ignored.

The remainder of the paper is organised as follows. In Section 2 we summarise the key predictions of recent public policy endogenous growth models and reiterate the implications of the government budget constraint for empirical testing. Section 3 then discusses our empirical methodology; section 4 present the results for our OECD sample, subjecting these to several endogeneity and specification tests. Section 5 draws some conclusions.

2. Theory

As is well known, in the neoclassical growth model, if the incentives to save or to invest in new capital are affected by fiscal policy, this alters the equilibrium capital-output ratio, and therefore the level of the output path, but not its slope (with transitional effects on growth as the economy moves onto its new path). The novel feature of the public-policy endogenous growth models of Barro (1990), Barro and Sala-i-Martin (1992, 1995) and Mendoza *et al*. (1997) is that fiscal policy can determine both the level of the output path and the steady-state growth rate.[3] This is easily seen in the following model from Barro and Sala-i-Martin (1992). There are n producers each producing output (y) according to the production function:

---

[3] Of course, not all endogenous growth models predict long-run growth effects from fiscal policy. The 'semi-endogenous', R&D-based model of Jones (1995b), for example, yields endogenous growth via R&D activities, but the long-run growth rate depends only on the exogenous rate of population growth.

$$y = Ak^{1-\alpha}g^{\alpha} \tag{1}$$

where k represents private capital and g is a publicly provided input. The government balances its budget in each period by raising a proportional tax on output at rate τ and lump-sum taxes of L. The government budget constraint is therefore

$$ng + C = L + \tau ny \tag{2}$$

where C represents government-provided consumption ('non-productive') goods[4]. The lump-sum (or non-distortionary) taxes do not affect the private sector's incentive to invest in the input good, whereas the taxes on output do. With an isoelastic utility function, Barro and Sala-i-Martin (1992) show that the long-run growth rate in this model (ϕ) can be expressed as

$$\phi = \lambda(1-\tau)(1-\alpha)A^{1/(1-\alpha)}(g/y)^{\alpha/(1-\alpha)} - \mu \tag{3}$$

where λ and μ are constants that reflect parameters in the utility function. Equation (3) shows that the growth rate is decreasing in the rate of distortionary taxes (τ) and increasing in government productive expenditure (g), but is unaffected by non-distortionary taxes (L) or non-productive expenditure (C).

This is the model which we seek to test. In practice, we need to take account of the fact that the government budget is not balanced in every period, so the constraint becomes

$$ng + C + b = L + \tau ny \tag{4}$$

where b is the budget surplus. The predicted signs of these components in a growth regression would be: g – positive; τ – negative; C and L – zero; b – zero provided that Ricardian equivalence holds *and* that the composition of expenditure and taxation remains unchanged.

To see the implications of this for empirical testing, suppose that growth, ϕ_t, at time t is a function of conditioning (non-fiscal) variables, Y_{it} , and the fiscal variables from equation (4), X_{jt}.

$$\phi_t = \alpha + \sum_{i=1}^{k} \beta_i Y_{it} + \sum_{j=1}^{m} \gamma_j X_{jt} + u_t \tag{5}$$

Because of the linear constraint represented by equation (4), we have

[4] Government consumption goods are defined as those which enter consumers' utility functions but do not enter the production function in (1).

$$X_{mt} = -\sum_{j=1}^{m-1} X_{jt} \qquad (6)$$

so one element of *X* must be omitted in the estimation of equation (5) in order to avoid perfect collinearity. The omitted variable is effectively the assumed compensating element within the government's budget constraint. Thus for estimation equation (5) must be rearranged to give:

$$\phi_t = \alpha + \sum_{i=1}^{k} \beta_i Y_{it} + \sum_{j=1}^{m-1} (\gamma_j - \gamma_m) X_{jt} + u_t \qquad (7)$$

This shows that the coefficient of X_{jt} should be interpreted as $(\gamma_j - \gamma_m)$ rather than γ_j. In other words, the correct interpretation of the coefficient on each element of the government budget is as the effect of a unit change in the relevant variable *offset by a unit change in the element omitted from the regression* (or some mix of the omitted elements, if there is more than one). To give an example, the coefficient on productive expenditure will tend to be higher if it is financed by non-distortionary taxation rather than by distortionary taxation or by some mixture of the two. The problem is not solved by omitting many elements of the government budget constraint from the regression instead of just one. This is a straightforward point, but one which has frequently been ignored.

The implications for the regression specification are as follows. At the first stage, omit from the regression one of those budget elements for which theory suggests that $\gamma = 0$ (*e.g.* *L*), and test whether the hypothesis of a zero coefficient for any other "neutral" budget elements can be rejected (in this case, *C*). If the theory passes this test (*i.e.* the hypothesis is not rejected), then estimate a second regression with both *L* and *C* omitted. This should yield the most precise estimates of the fiscal parameters, and ensures that the assumed financing is innocuous. If the hypothesis of a zero coefficient for *C* is rejected at the first stage, this is of course evidence against the model under test. It should be noted that, if this procedure is followed, the budget surplus would be expected to have a positive coefficient even under Ricardian equivalence, because the constraint of neutral financing applies to the current period only (this point is elaborated below).

As we have demonstrated in detail in an earlier study (Kneller *et al*., 1998), much previous research has ignored the effect of the implicit financing assumptions on the coefficients of fiscal variables in growth regressions. Only Helms (1985), Mofidi and Stone (1990) and Miller and Russek (1993) have addressed the issue explicitly, although Kocherlakota and Yi (1997) refer to it in interpreting their results.

3 Data and Empirical Methodology

The theoretical model requires the classification of expenditures into productive and non-productive, and taxation into distortionary and non-distortionary. Appendix Table 1 shows how we do this, using data from the IMF *Government Finance Statistics Yearbook* (GFSY)); Kneller *et al*. (1998) provides more detail. On the expenditure side, the most important component of the non-productive category is social security. We treat most other expenditure (*e.g.* transport and communication, education, health) as productive, and later test the validity of this aggregation. We classify consumption taxes as non-distortionary, which is valid if the utility function does not contain leisure as an argument (as in Barro (1990)). With leisure as an argument in the utility function, consumption taxes will have some impact by distorting the labour-leisure choice. This would leave the category of non-distortionary taxation as an empty set. Since consumption taxes do not distort the choice between consumption at different dates, it seems valid to argue that they should still appear as a separate category on the grounds that they are less distortionary than income taxes.[5] Whether they are non-distortionary or merely less distortionary than other taxes is a question which can be answered in the empirical estimation. Finally there are some revenues and expenditures whose classification is ambiguous (we label these “other revenues” and “other expenditures”). Since these are small in magnitude, we discuss them only briefly in what follows.[6]

---

[5] In addition, since the income and substitution effects operate in opposite directions in the choice between labour and leisure, the impact of consumption taxation on labour input may in practice be small.

[6] In Kneller et al. (1999) we examine alternative classifications and disaggregations of taxes and expenditures and find that results are not sensitive to productive/non-productive or distortionary/non-distortionary definitions. Note also that ‘other revenues’ includes taxes on international trade which, though these are very small in the OECD and do not tax investment directly, can be expected to distort some investment decisions.

Our annual dataset covers 22 developed countries for various periods during 1970-95, from two sources[7]. Government budget data come from the GFSY; remaining data are from the World Bank Tables. Summary descriptive statistics are given in Appendix Table 2.[8] An important issue is how to extract the long-run information from this annual data. One method is to estimate the model in (7) with annual data, but use many lags of the independent variables to pick up long-run effects (as is done by Kocherlakota and Yi (1997) for a century of UK and US data). The more commonly chosen alternative is to take averages of five years or more of data in order to iron out cyclical fluctuations, but at the expense of losing degrees of freedom (*e.g.* Grier and Tullock, 1989; Cashin, 1995; Devarajan et al., 1996; Mendoza *et al*., 1997; Kneller *et al.,* 1999). In section 4 we start by taking five-year averages and allowing for current-period effects only, as most previous authors have done. We then show that this is inadequate, since there is evidence of lagged effects (*i.e.* fiscal variables in one five-year period have a significant effect in the subsequent as well as in the current five-year period), and we estimate a dynamic (five-year) panel that incorporates these effects. Thirdly, we allow the data to determine the appropriate number of lags in an annual dynamic model. The results of this exercise suggest that long-run effects take more than five years to come through.

In each case our regression equations follow the form of equation (7) above, using the two-way fixed-effects model (Least Squares Dummy Variables (LSDV), with time and country-specific intercepts)[9]. Dynamic fixed-effects models are however known to generate biased and/or inefficient coefficient estimates arising mainly from the presence of the lagged dependent variable and omitted variable bias associated with

---

[7] For details of country coverage and time periods, see Tables 1 and 2.

[8] Based on five-yearly averages, our sample countries grew, on average, around 2.8 per cent per capita per annum, with investment ratios in excess of 20% and labour force growth around 1% p.a. Among the fiscal variables, distortionary taxation yields about twice as much revenue as nondistortionary taxes (18.8% of GDP compared with 9.2%), while the two main expenditure categories each account for about 15% of GDP (see Appendix Table 2).

[9] We experimented with alternative random and fixed-effects estimators and found that the two-way fixed-effects model gave the best fit to the data.

the country-specific effects.[10] These biases typically depend on the characteristics of the panel (*e.g.* its time and cross-section dimensions, the exogeneity of the regressors), which also influences the optimal solution. Following Nickell (1981) and Anderson and Hsiao (1981), a number of instrumental variable (IV) solutions have been proposed to overcome these problems (*e.g.* Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1997). Recent applications of these methods to a number of empirical growth models have demonstrated that they can overturn or substantially modify established results from cross-section or static panel methods.[11] In section 4.2 we therefore adopt these IV methods to investigate the robustness of our fiscal policy results.

An important issue which these methods attempt to deal with is the endogeneity of the regressors, essentially by exploiting the panel's time-series information to use predetermined variables as instruments. An alternative approach to overcome the paucity of instruments in growth regressions has been suggested by Jones (1995a). He argues that the OLS estimate of the contemporaneous effect of the suspected endogenous variable (investment, in his case) on growth is likely to be the upper bound of its 'true' value, under the assumption that the contemporaneous correlation of investment with growth is positive and therefore likely to bias the coefficient upwards. The lower bound is set to zero where theory provides unambiguous sign predictions. In our case the potentially endogenous variables are investment and the set of fiscal variables. As we noted above, in each case theory provides unambiguous predictions regarding the direction of growth effects, allowing us to treat zero as the lower bound for contemporaneous effects, and measuring the long-run growth effects from the sum of the remaining $t-j$ coefficients ($j = 1 \ldots T$).[12] For fiscal variables, however, OLS estimates may not represent the upper bound (in absolute value); in

[10] Growth regressions typically contain an implicit lagged dependent variable (even if an 'initial income' term is omitted) since they can be re-written in terms of income *levels* with lagged income as a right-hand-side variable.

[11] See, for example, Caselli *et al.* (1996) on country growth convergence rates; Forbes (1998) on the relationship between inequality and growth; and Levine *et al.* (1999) on financial intermediation and growth.

[12] In fact Jones (1995a, Appendix A) experiments with setting the contemporaneous coefficient to alternative values between the upper and lower bounds. For such intermediate values however it is not possible to obtain relevant standard errors on the long-run parameters since these are a mixture of imposed and estimated effects.

particular, the use of expenditure policy and budget surpluses as automatic stabilisers will likely result in a negative bias to these coefficients. For (distortionary) taxes, since these are generally non-proportional, any bias to the tax coefficient can be expected to be positive.

4. Empirical Results

Table 1 (columns 1-3) presents the results when the data are arranged as five-year averages with only current-period effects (*i.e.* estimated as a static panel). The regression includes the ratio of investment to GDP and labour force growth as conditioning variables, although neither is in fact significant in this case. (Below we investigate the sensitivity of our results to the conditioning set[13]). Following the procedure proposed in section 2, the first column of the table uses only non-distortionary taxation as the implicit financing element, and the second column uses non-productive expenditure. Each of these items should have a zero coefficient according to the Barro (1990) model, and the results confirm that each has a coefficient close to zero when the other is omitted, implying that they do indeed have very similar coefficients.[14] The third column therefore omits both non-distortionary taxation and non-productive expenditures, which is equivalent to imposing a common coefficient (which we presume to be zero, according to the theory). Omission of both reduces the standard errors associated with the other fiscal variables, and the coefficients are intermediate between the column 1 and column 2 results, as would be expected.

The signs of the fiscal variables in Table 1 are consistent with theory. Productive expenditures have a significant positive coefficient; the point estimate suggests that an increase by one percentage point of GDP raises the growth rate by 0.30 percentage points. Other (unclassified) expenditures also have a significant positive coefficient,

---

[13] Kneller *et al.*(1999) show, using period averaged data, that regressions are not sensitive to the inclusion/exclusion of initial GDP. In annual panel regressions below we use lagged growth to capture ‘convergence’ effects.

[14] Because of the linear constraint amongst the fiscal variables, the coefficients of the non-fiscal variables and the residuals are the same for these two columns.

which is slightly larger than that of productive expenditure (0.33).[15] Distortionary taxation, on the other hand, significantly reduces growth: its estimated coefficient is –0.46, while other revenues also have a negative (but much smaller and statistically insignificant) effect. The budget surplus has a surprisingly large positive coefficient of 0.39. A positive coefficient is to be expected, since we are constraining the current surplus to finance neutral elements of the budget, which have no growth effects, whereas the compensating future deficits anticipated under Ricardian equivalence may partially finance productive expenditure or cuts in distortionary taxation, raising the anticipated returns to investment and hence growth. This argument would however tend to suggest a somewhat smaller positive coefficient than our estimates yield.

These results appear to give strong support to the Barro (1990) model; indeed, fiscal effects are surprisingly strong. Could they however be the result of short-run effects persisting in the five-yearly averaged data and/or endogeneity of our investment and fiscal variables? We consider these issues in turn below.

4.1 Long-run Effects?

To address the issue of whether five years is long enough to capture long-run effects we start by allowing for lagged effects of fiscal variables from the previous five-year period. The results are shown in the final column of Table 1 (regression coefficients are for the sum of current and lagged effects).[16] The numbers are similar (though point estimates are generally smaller for the fiscal variables), but the lagged effects are collectively significant, with a Wald χ^2 test statistic of 25.4 against a 5% critical value of 16.9, implying that a static panel of five-yearly averaged data is not the right specification and is likely to result in the contamination of the long-run effects by short-run responses.

[15] This surprisingly strong effect is weakened considerably in the annual panel.

[16] Omitting each of non-distortionary taxation and non-productive expenditures in turn from the regression again supports the omission of both variables.

To explore the appropriate lag length more precisely we use the annual observations instead of five-year averages and investigate how many lags are significant. Testing alternative lag structures (again with a Wald χ^2 test) is made on the null of the joint significance of the last lag of the explanatory variables within the regression.[17] We find that eight lags are required: the Wald values for 7, 8, and 9 lags respectively are 30.8, 12.7 and 3.4 against critical values (with six degrees of freedom) of 10.6 (10%) or 12.6 (5%).[18] Table 2 presents the results using eight lags (together with results for five-yearly averaged data for a comparable sample).[19] Once again, we cannot reject the hypothesis that non-productive expenditures and non-distortionary taxation have identical coefficients, equal to zero. The main fiscal variables of interest – distortionary taxation, productive expenditures and the budget surplus - are all significant at the 1% level, with the point estimate for the budget surplus now around 0.1, somewhat lower than the estimated effects for taxes and expenditures. At around 0.4 (in absolute value) both productive expenditures and distortionary taxes continue to exhibit strong growth effects. (Other revenues and expenditures appear to have no discernible growth effects). Investment now appears to have a larger, and statistically significant, estimated effect on growth, compared with those obtained using five-yearly averaged data. As can be seen from column 3, these changes are not due to the smaller sample of countries used in the annual panel regressions – both the 17- and 22-country, period-averaged panels yield similar results.

We noted above however that the LSDV technique applied to a dynamic panel may bias coefficient estimates due to endogeneity from the presence of the lagged dependent variable and/or endogenous regressors. The relatively large parameter estimates on investment and lagged growth in Table 2 are suggestive that this may be the case. We proceed to test for this in the following section.

---

[17]The maximum number of lags that it was felt could reasonably be used was nine. Only countries with eighteen or more annual observations were included. (Excluded countries are: Greece (10 years), Ireland (11), Italy (11), Portugal(11), and Switzerland (15)).

[18] These results are obtained using the six fiscal variables in the regression. Similar results are obtained if all variables are included in the lag structure test. Interestingly, both Kocherlakota and Yi (1997) and Jones (1995a) find eight lags are required to capture long-run behaviour in their empirical growth models.

[19] All annual dynamic panel regression results are obtained using DPD98 – see Arellano and Bond (1998). 'Robust' *t*-statistics, (that is, those consistent in the presence of heteroskedasticity) are reported for the annual panel regressions in Table 2.

4.2 Endogeneity

Perhaps the problem most often discussed when referring to growth regressions is the potential endogeneity between the right-hand-side variables and the growth rate. Obvious candidates in this case are investment and the fiscal variables. As we noted earlier this problem is compounded in dynamic regressions involving a lagged growth rate. In this section we consider possible IV estimators to deal with these problems, together with the Jones (1995a) approach which attempts to identify 'bounds' for the true value of the suspected endogenous parameter.

Recent developments in dynamic panel data models (*e.g.* Arellano and Bond, 1991; Arellano and Bover, 1995; Kiviet, 1995) have focussed mainly on those applicable to micro data sets which generally have a large cross-section dimension but a limited time-series dimension (large N, small T). These properties also typically match well the dimensions of growth data sets based on five-year averages: T around 5, N up to around 100 and, as we noted earlier, their application has led to important challenges to existing growth empirics.[20] For our annual panel however, $T > N$ ($N = 17$; $T = 18$ to 24), - a characteristic more common among macro data sets - and, as Judson and Owen (1999) have shown, the appropriate method for correcting endogeneity bias differs with the time dimension of the panel. For panels with a time dimension similar to that here ($T = 20$) they find (i) OLS and LSDV estimators lead to average biases to the parameter on the lagged dependent variable around 13% and up to 3% on the (presumed) exogenous regressors; and (ii) the Anderson-Hsiao (AH) estimator consistently performs best (minimum bias) for panels with a larger time dimension.[21] We therefore use the AH IV-estimator in this section. This involves first differencing

[20] Kneller *et al.* (1999) have also applied a variant of the Arellano and Bond (1991) approach to their five-yearly averaged data for fiscal variables. Though standard errors increased, parameter estimates for distortionary taxation and productive expenditures were not much affected.

[21] Judson and Owen (1999) compare five panel data estimators: the LSDV; the LSDV 'correction' (LSDVc) proposed by Kiviet (1995); the Anderson-Hsiao estimator (AH); and two Arellano-Bond generalised method of moment estimators (GMM1, GMM2). Their results suggest LSDVc performs best for T small and AH performs best for larger T. Both consistently outperform LSDV and GMM1 or 2.

the growth regression in (7) and instrumenting the first difference of the lagged dependent variable with lagged levels.[22] Results for the variables of interest – investment, the six fiscal variables, and lagged growth – are shown in Table 3 which also reports results using the Jones (1995a) method of constraining the contemporaneous parameters on the variables suspected of endogeneity. Two constrained values are selected in applying this method: (i) half the LSDV estimate in Table 2; and (ii) zero; (the LSDV result is repeated for comparison).

The AH result in column 1 confirms the upward bias on the lagged growth parameter using LSDV, but importantly this does not substantially affect the long-run estimates of the main fiscal variables: strong negative, statistically significant, effects of distortionary taxation and similar positive effects of productive expenditures are confirmed.[23] Similar conclusions emerge from the Jones methodology in columns 2 and 3. Indeed, allowing *no* contemporaneous correlation (column 3) reveals larger and more robust effects from distortionary taxes and productive expenditures compared with LSDV results. Estimates of the growth effects of budget surpluses are also similar to (or larger than) those obtained using LSDV, though the AH standard errors appear somewhat larger. Evidence on the endogeneity of investment is less clear-cut: parameter estimates are only slightly reduced when IV techniques are used, except in the case where a zero contemporaneous effect is imposed. However standard errors are again larger so that positive growth effects of investment cannot be confirmed. It is clear however, that the major impact on the long-run investment parameter is *contemporaneous* (the long-run parameter falls to 0.02 in column 3), casting doubt on the exogeneity of investment, and in line with Jones' (1995a) results.

4.3 Specification Testing

The lack of robustness of fiscal effects on growth in previous studies is apparent from the wide range of estimates. Easterly and Rebelo (1993), for example, found their

[22] As Judson and Owen (1999) note, AH is effectively a special case of the Arellano and Bond GMM estimators, where the latter use all possible lagged values (of the dependent variable and exogenous regressors) as instruments. For panels with $T > N$ however this can lead to over-identification of the system.

[23] Note that, *ceteris paribus*, any upward bias in the lagged growth parameter using LSDV methods will impart a *downward* bias to the long-run parameter estimates of the exogenous variables in the regression. This could mitigate or enhance any biases associated with tax or expenditure variables due to the 'non-proportionality' or automatic stabiliser effects mentioned earlier.

fiscal estimates were sensitive to the exclusion of an initial income term from their growth regressions.[24] In this section we examine the robustness of our earlier results to three changes: (i) the set of conditioning variables; (ii) the countries in the sample; and (iii) the classification of productive expenditures. In all cases, though fiscal parameters change somewhat, our main results are robust, with consistent evidence of long-run adverse effects on growth from distortionary taxation but growth-enhancing effects from productive expenditures.

Alternative Conditioning Variables and Samples

Table 4 (columns 1-3) reports results omitting investment, labour force growth, and lagged growth[25] and it is clear that the inclusion of these variables is not responsible for the strong fiscal effects we identified earlier. Indeed parameter estimates for distortionary taxation and productive expenditures are larger (in absolute value), and more significant, when conditioning variables are omitted compared to the counterpart regression in Table 3 (column 4). The inclusion of a terms of trade index in column 5 (which Mendoza *et al.* (1997) found to be a significant growth determinant), similarly has minimal impact on fiscal-growth estimates.

Table 4 also includes results for the case where fiscal variables are omitted. As might be expected, investment now appears to have strong positive effects on growth. Together with our earlier results this suggests a simultaneous relationship between investment and fiscal policy, which causes erroneously strong growth effects to be attributed to investment when fiscal policy variables are omitted.[26]

Though the OECD is usually regarded as a fairly homogeneous country grouping, it nevertheless includes some relatively under-developed countries (*e.g.* Turkey) and Appendix Table 2 reveals a fairly wide cross-country dispersion in the values of some

---

[24] In Kneller *et al.* (1999) we tested for this using a comparable dataset and found our results were *not* sensitive to the inclusion or otherwise of initial income.

[25] Note that the inclusion of lagged growth in the annual panel regressions is analogous (but not identical) to the inclusion of initial income in cross-section or static panel regressions. Our conclusions are also unaffected by adding initial income to the regressions in Tables 1 (and lagged initial income in column 4).

[26] Applying Jones' (1995a) method to this regression, with contemporaneous effects set to zero, again leads to a long-run investment parameter which is both small and insignificantly different from zero, further suggesting that investment is endogenous.

fiscal and other variables. However, as we showed in Tables 1 and 2, reducing the sample to 17 countries (omitting Greece, Ireland, Italy, Portugal and Switzerland) had no substantive effect on our results. Examining our remaining sample for outliers, using the regression residuals from column 2 in Table 2, revealed only 8 residuals (out of 237) outside a two standard error confidence interval and none larger than 2.5 times the standard error. Germany and the UK each have two such residuals and no country has more than two 'outlying' residuals.[27] In Table 5 we omit, in turn, Germany, the UK, Turkey (the poorest country in the sample), the US and Sweden (which have among the smallest and largest public sectors respectively).[28] It is clear that inclusion/exclusion of these countries does not substantively affect the fiscal results. For example, the parameter on distortionary taxation is always significantly negative and falls in the range –0.41 to –0.45 (except when Turkey is excluded, when the parameter becomes –0.54); and productive expenditure is always significantly positive, in the range 0.34 to 0.40.

Classification of Expenditures

Finally, certain types of expenditure that we have classified as productive might be considered to include elements of consumption. Health and education are obvious candidates. Accordingly, we investigated the effect of separating health and education expenditures from other productive expenditures. The coefficient on health expenditures is found to be virtually identical to that for other productive expenditures (at 0.33), while the coefficient of education expenditures is about 50% greater (at 0.48, although the *difference* is not significant), suggesting that all three forms of expenditure have similarly productive effects on growth.

4.4 Comparisons with Previous Results

The robustness of these results contrasts quite markedly with those in the published literature. Comparable recent studies, using static panel techniques are Mendoza *et*

---

[27] A number of alternative 'outlier tests' are available to test individual parameters or the regression as a whole (see Belsley *et al*., 1980).

[28] To conserve space we focus on the fiscal parameters; parameters on other variables are not substantively affected.

al. (1997) and Devarajan *et al.* (1996).[29] Mendoza *et al*., using data from eleven OECD countries over the period 1965-91, found estimated effective tax rates on capital, consumption and labour all to be insignificant in a growth regression using five-yearly averaged data, but significant (although not robustly so) in some regressions using annual data. They conclude from this that taxation has short-run effects on the growth rate but no long-run effect - consistent with the neoclassical rather than the endogenous growth model. Devarajan *et al*. (1996, table 2) use data from 21 developed countries from 1970 to 1990 to study the growth effects of the expenditure mix. They find consistently positive (but not always statistically significant) effects of total government expenditure on growth.[30] In each of these cases, however, the estimation procedure incorporates a bias towards a statistically insignificant result, either because the taxes are implicitly part-financing productive expenditures that will offset the negative growth impact of distortionary taxation (Mendoza *et al*., 1997), or because the expenditures are partly financed by distortionary taxation (Devarajan *et al*., 1996). We have shown elsewhere that these biases to estimation results are substantial (Kneller *et al*., 1999), and this is the most likely explanation for the difference between our results and theirs. From the evidence in this paper, differences do not appear to be due to the use of annual versus period-averaged data.

Two studies using essentially time-series methods also find contradictory results. Kocherlakota and Yi (1997), using long time-series for the US and UK, find insignificant tax effects when public capital expenditures are excluded from the regression, but significant tax effects when they are included (in which case the tax parameter no longer reflects implicit financing of growth-enhancing expenditures). In other words their evidence is consistent with ours when they come close to specifying the government budget constraint fully. An alternative approach is followed by Karras (1999) who adopts the Jones (1995a) method discussed above, but where taxes are the proposed source of endogenous growth rather than investment. For a sample of 11 OECD countries over 1960-92, Karras finds that GDP growth rates are stationary while (total) tax rates appear to be non-stationary (and increasing over the

[29] Devarajan *et al.* (1996) however use a five-year forward moving average for their dependent variable to help deal with endogeneity issues.

long-run), and therefore incapable of explaining the long-run behaviour of GDP. As Karras (1999) notes however, this evidence *would* be consistent with a model where taxes are the source of endogenous growth, *if* there was some countervailing, non-stationary influence on growth. Given the government budget constraint, our evidence is suggestive that such a factor may be productive public expenditure. As public expenditure ratios rise in OECD countries, financed by rising tax ratios (especially for distorting taxes such as income tax), our evidence suggests that these can be expected to exert similar, but opposite, effects on GDP growth. Thus, time-series models which include an overall tax rate as the only fiscal variable are also likely to be mis-specified.

5. Conclusions

Endogenous growth theory predicts that the impact of fiscal policy on growth depends on the structure as well as the level of taxation and expenditure. Any empirical test of this theory needs to address the implications of the linear relationship between the elements of the government budget. This constraint implies that the coefficient of any budget element must be interpreted as the impact of a unit increase in that element financed by a unit change in the element or elements omitted from the regression. Using an OECD data set, we have found that, when financed by a mixture of non-productive expenditures and non-distortionary taxation, productive expenditures raise the growth rate and distortionary taxes reduce it, in accordance with the predictions of the Barro (1990) model. A budget surplus financed in this way also raises the growth rate, which is consistent with the assumption of Ricardian equivalence because the anticipated compensating future deficits may partially finance growth-enhancing productive expenditures or cuts in distortionary taxation. Our results also suggest that consumption taxation can realistically be regarded as non-distortionary, rather than as merely less distortionary than income taxation. When education and health were separated out, we could find no evidence that they have any smaller impact on growth than other productive expenditures.

[30] Their results for different components of expenditure suggest that health should be classified as productive expenditure and education as unproductive.

A primary objective of this paper has been to test the robustness of these results to alternative methods of isolating long-run effects, either by taking five-year averages (with current-period effects only, or with current and lagged effects), or by estimating the model on the original annual data but with long lags. We found that period averaging, the most common method employed in previous studies, does not appear to capture long-run responses fully, but both approaches produce consistent evidence in favour of fiscal effects on growth.

We have also investigated the robustness of our results to potential endogeneity of the fiscal regressors, to sample selection, and to regression specification. Again, in all cases we continue to find evidence in favour of the predictions of the endogenous growth model. The high degree of theory-consistency of the empirical results contrasts sharply with the more ambiguous findings that characterise much of the previous literature. At least some of this ambiguity must be attributed to misinterpretation of regression results by authors who ignore the implicit financing assumptions imposed, or who omit 'non-neutral' financing elements from their specifications.

REFERENCES

Anderson, Theodore W. and Cheng Hsiao (1981) 'Estimation of dynamic models with error components,' *Journal of the American Statistical Association* 76, 589-606

Arellano, Manuel and Stephen Bond (1991) 'Some specification tests for panel data: Monte Carlo evidence and an application to employment equations,' *Review of Economic Studies* 58, 277-297

Arellano, Manuel and Stephen Bond (1998) 'Dynamic panel data estimation using DPD98 for GAUSS,' mimeo, Oxford University

Arellano, Manuel and Olympia Bover (1995) 'Another look at the instrumental variable estimation of error-components models,' *Journal of Econometrics* 68, 29-52

Barro, Robert, (1990) 'Government spending in a simple model of endogenous growth,' *Journal of Political Economy* 98, s103-s117

Barro, Robert, and Xavier Sala-i-Martin (1992) 'Public finance in models of economic growth,' *Review of Economic Studies* 59, 645-61.

Barro, Robert, and Xavier Sala-i-Martin (1995) *Economic Growth* (New York: McGraw-Hill

Belsley, David A., Edwin Kuh and Roy E. Welsch (1980) *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity* (New York: Wiley)

Blundell, Richard, W., and Stephen Bond (1997) 'Initial conditions and moment restrictions in dynamic panel data models,' Discussion Paper No. 97-07, University College, London

Caselli, Francesco, Gerardo Esquivel and Fernando Lefort (1996) 'Reopening the convergence debate: a new look at cross-country growth empirics,' *Journal of Economic Growth* 1, 363-389

Cashin, Paul (1995) 'Government spending, taxes and economic growth,' *IMF Staff Papers* 42, 237-69

Devarajan, Shantayanan, Vinaya Swaroop, and Heng-fu Zou (1996) 'The composition of public expenditure and economic growth,' *Journal of Monetary Economics* 37, 313-44

Easterly, William, and Sergio Rebelo (1993) 'Fiscal policy and economic growth,' *Journal of Monetary Economics* 32, 417-458

Evans, Paul, (1998) 'Using panel data to evaluate growth theories,' *International Economic Review* 39, 295-306

Evans, Paul, and Georgios Karras (1994) ‘Are government activities productive? Evidence from a panel of US states,’ *Review of Economics and Statistics* 76, 1-11

Forbes, Kristin J. (1998) ‘A reassessment of the relationship between inequality and growth,’ mimeo, MIT (forthcoming *American Economic Review*)

Grier, Kevin, and Gordon Tullock (1989) ‘An empirical analysis of cross-national economic growth, 1951-80,’ *Journal of Monetary Economic,* 24, 259-76.

Helms, L. Jay, (1985) ‘The effect of state and local taxes on economic growth: A time series-cross section approach,’ *The Review of Economics and Statistics* 67, 574-82

Jones, Charles, (1995a) ‘Time series tests of endogenous growth models,’ *Quarterly Journal of Economics* 110, 495-525.

Jones, Charles, (1995b) ‘R&D-based models of economic growth,’ *Journal of Political Economy* 103, 759-784

Jones, Larry E., Rodolfo E. Manuelli, and Peter E. Rossi (1993) ‘Optimal taxation in models of endogenous growth,’ *Journal of Political Economy* 101, 485-519

Judson, Ruth A. and Ann L. Owen (1999) ‘Estimating dynamic panel data models: a guide for macroeconomists,’ *Economics Letters* 65, 9-15

Karras, Georgios, (1999) ‘Taxes and growth: testing the neoclassical and endogenous growth models,’ mimeo, University of Illinois at Chicago

King, Robert, and Sergio Rebelo (1990) ‘Public policy and economic growth: Developing neoclassical implications,’ *Journal of Political Economy* 98, s126-s151

Kiviet, Jan F. (1995) ‘On bias, inconsistency and efficiency of various estimators in dynamic panel data models,’ *Journal of Econometrics* 68, 53-78

Kneller, Richard, Michael, F. Bleaney and Norman Gemmell (1998) ‘Growth, public policy and the government budget constraint: evidence from OECD countries,’ Discussion Paper no. 98/14, School of Economics, University of Nottingham

Kneller, Richard, Michael, F. Bleaney and Norman Gemmell N. (1999) ‘Fiscal policy and growth: evidence from OECD countries,’ *Journal of Public Economics* 74, 171-190

Kocherlakota, Narayana R., and Kei M. Yi, (1997) ‘Is there endogenous long-run growth? Evidence from the United States and the United Kingdom,’ *Journal of Money Credit and Banking* 29, 235-62

Levine, Ross, Norman Loayza, and Thorsten Beck (1999) 'Financial intermediation and growth: causality and causes,' mimeo, World Bank

Mendoza, Enrique G., Gian Maria Milesi-Ferretti and Patrick Asea (1997) 'On the effectiveness of tax policy in altering long-run growth: Harberger's superneutrality conjecture,' *Journal of Public Economics* 66, 99-126

Miller, Stephen M., and Frank S. Russek (1993) 'Fiscal structures and economic growth: International evidence,' mimeo, University of Connecticut

Mofidi, Alaeddin and Joe A. Stone (1990) 'Do state and local taxes affect economic growth?' *Review of Economics and Statistics* 72, 686-91

Nickel, Stephen, (1981) 'Biases in dynamic models with fixed effects,' *Econometrica* 49, 1417-426

Solow, Robert M., (1956) 'A contribution to the theory of economic growth,' *Quarterly Journal of Economics* 71, 65-94

Stokey, Nancy, and Sergio Rebelo (1995) 'Growth effects of flat-rate taxes,' *Journal of Political Economy* 103, 510-50

APPENDIX: Data Sources and Characteristics

Data are available for 22 OECD countries from 1970. This time span is not consistent across countries; for example, data for Switzerland exits only for 1970-84. The fiscal data used in this paper are collated from IMF, *Government Financial Statistics Yearbook*. The used in the study refer to expenditure by function (Table B) and the breakdown of revenues and grants (Table A). All fiscal variables are expressed as percentages of GDP. In accordance with usual practice the growth rate is taken as the log difference between annual per capita GDP figures taken from the World Bank CD ROM. The investment rate and the labour force growth rates were taken from the same source.

Table 1 Static and Dynamic Panels with Five-Year-Averaged Data

Estimation Technique	LSDV: 2 way FE; 5-year averages;			
Dependent variable: per capita GDP growth				
	1: Static	2: Static	3: Static	4: Dynamic
Omitted Fiscal Variable(s):	Non-distortionary taxation	Non-productive expenditure	Non-dis. Taxation Non-prod. Exp.	Non-dis. Taxation Non-prod. Exp.
Investment ratio	0.020 (0.32)	0.020 (0.32)	0.021 (0.35)	0.052 (0.75)
Labour force growth	-0.015 (-0.05)	-0.015 (-0.05)	0.001 (0.00)	0.124 (0.55)
Other revenues	-0.101 (-0.51)	-0.140 (-1.27)	-0.140 (1.28)	-0.095 (-0.69)
Other expenditures	0.301 (1.82)	0.340 (2.86)	0.329 (3.01)	0.305 (2.57)
Budget surplus	0.357 (2.17)	0.400 (4.23)	0.389 (4.41)	0.368 (3.15)
Distortionary taxation	-0.427 (-2.36)	-0.467 (-4.66)	-0.463 (-4.72)	-0.449 (-3.55)
Non-dist. taxation	-	-0.039 (-0.23)	-	-
Productive expenditure	0.273 (1.77)	0.312 (2.31)	0.296 (2.56)	0.233 (1.69)
Non-prod. expenditure	-0.039 (-0.23)	-	-	-
Net lending	0.314 (1.32)	0.353 (1.89)	0.349 (1.89)	0.587 (3.65)
Lagged Growth	-	-	-	-0.504 (-2.96)
No. of obs.	98	98	98	76
Adj-R^2	**0.574**	**0.574**	**0.581**	**0.660**

Notes:

Regressions are based on five-year averages for 1970-95 (Australia, Austria, Canada, Denmark, Finland, Germany, Iceland, Luxembourg, Netherlands, Norway, Spain, Sweden, Turkey, UK, USA); 1975-95 (France); 1970-90 (Belgium); 1970-85 (Greece, Switzerland); 1975-90 (Italy, Portugal); and 1980-95 (Ireland). Figures in parentheses are *t*-statistics. Country and time intercepts are included in all regressions. Coefficients shown in column 4 are total effects (calculated from current, lagged, and lagged growth parameters). For definitions of fiscal variables see Appendix Table 1. Time dummies, which were collectively insignificant are omitted from the dynamic regression in column 4.

Table 2 Dynamic Panel with Eight Lags of Annual Data

Estimation Technique:	*Columns 1 & 2:* LSDV: 2 way FE; annual data. *Column 3:* five-yearly averaged data; restricted sample.		
Dependent variable: per capita GDP growth			
	Omitted Fiscal Variable(s):		
	1. Non-distortionary taxation	2. Non-distort. taxation, Non-prod. expenditure	*3. Non-distort. taxation, Non-prod. expenditure*
Investment ratio	0.120 (4.21)	0.126 (3.99)	0.079 (1.05)
Labour force growth	-0.350 (-2.67)	-0.226 (-1.51)	0.128 (0.56)
Other revenues	-0.041 (0.32)	0.040 (0.63)	0.029 (0.18)
Other expenditures	0.013 (0.10)	0.040 (0.59)	0.283 (2.10)
Budget surplus	0.109 (1.12)	0.105 (2.07)	0.368 (3.15)
Distortionary taxation	-0.393 (-2.92)	-0.411 (-6.18)	-0.478 (-3.49)
Productive expenditure	0.337 (3.67)	0.387 (4.88)	0.316 (2.20)
Non-prod. Expenditure	0.045 (0.49)	-	-
Net lending	-3.865 (-4.03)	-3.44 (-2.58)	0.612 (3.63)
Lagged growth	-2.062 (-9.11)	-1.336 (-6.40)	-0.472 (-2.51)
No. of obs.	237	237	66
Adj-R^2	**0.758**	**0.723**	**0.626**

Notes:
Regressions are based on annual data for 17 of the 22 countries used in Table 3. (Greece, Ireland, Italy, Portugal and Switzerland are omitted due to short time-series). Column 3 of the table shows results for five-yearly averaged data for the comparable data set of 17 countries. Heteroskedasticity-robust *t*-statistics are shown in parentheses. Coefficients are total effects (current plus lagged, adjusted for lagged growth). Country and time intercepts are included. For definitions of fiscal variables see Appendix Table 1.

Table 3 Annual Dynamic Panels: Instrumental Variables

Dependent variable: per capita GDP growth				
Estimation Technique:	1: AH	2: Jones (γ_t = LSDV/2)	3: Jones (γ_t = 0)	*4: LSDV*
Investment ratio	0.105 (1.09)	0.094 [-0.37]	0.020 (1.31)	0.126 (3.99)
Labour force growth	0.069 (0.34)	-0.032 [-1.60]	0.083 (0.05)	-0.226 (-1.51)
Other revenues	0.096 (0.86)	0.044 [2.61]	0.051 (3.35)	0.040 (0.63)
Other expenditures	-0.119 (-1.20)	0.108 [1.58]	0.191 (0.39)	0.040 (0.59)
Budget surplus	0.103 (0.99)	0.173 [0.30]	0.143 (7.15)	0.105 (2.07)
Distortionary taxation	-0.408 (-4.64)	-0.426 [-3.21]	-0.442 (-6.63)	-0.411 (-6.18)
Productive expenditure	0.300 (2.94)	0.418 [4.70]	0.467 (5.50)	0.387 (4.88)
Net lending	-1.745 (-0.91)	-3.13 [2.58]	-2.64 (-0.71)	-3.44 (-2.58)
Lagged Growth	-0.644 (-1.74)	-1.417 [-4.67]	-1.15 (-5.40)	-1.336 (-6.40)
No. of obs.	237	237	237	237
Adj-R^2	**0.657**	**0.887**	**0.385**	**0.723**

Notes:
AH = Anderson-Hsiao IV estimator; 'Jones' = Jones (1995a, Appendix A) approach. *t*-statistics are in parentheses. γ_t = LSDV/2 (γ_t = 0): the values of the parameters on the current lag (γ_t) for all fiscal variables and investment are set to half their LSDV estimated values (zero). Parameter values shown are the long-run values (*i.e.* the sum of γ_t and the estimates for the *t-j* lags (*j* = 1 – 8), adjusted by the lagged growth parameters. Standard errors/*t*-statistics cannot be calculated for the (γ_t = LSDV/2) case because of the imposed component within the long-run parameters. The [*t*-statistics] shown in column 2 refer to the test of the significance of the long run coefficient for lags 1 to 8, *i.e.* it does not include any contemporaneous effect.

Table 4 Altering the Conditioning Set

Estimation Technique: LSDV: 2 way FE; annual data.					
Dependent variable: per capita GDP growth					
Omitted Variables:	1: investment	2: investment, lab. force growth	3: investment, lab. force growth, lagged growth	4: all fiscal variables	5. *including* terms of trade
Investment ratio	-	-	-	0.257 (3.52)	0.074 (1.14)
Labour force growth	0.064 (0.37)	-	-	-0.067 (-0.20)	-0.062 (-0.23)
Terms of Trade inverse	-	-	-	-	-18.54 (-1.72)
Other revenues	-0.019 (-0.23)	-0.058 (-0.58)	-0.370 (-1.83)	-	0.145 (1.31)
Other expenditures	0.105 (1.56)	0.189 (2.26)	0.528 (2.85)	-	0.121 (1.15)
Budget surplus	0.269 (5.00)	0.283 (4.35)	0.485 (3.30)	-	0.203 (2.45)
Distortionary taxation	-0.522 (-7.91)	-0.539 (-7.65)	-0.854 (-6.17)	-	-0.455 (-6.25)
Productive expenditure	0.405 (5.89)	0.341 (4.55)	0.598 (3.50)	-	-0.302 (3.64)
Net lending	-3.700 (-3.31)	-1.333 (-1.09)	-0.010 (0.003)	-	-3.237 (-2.00)
Lagged Growth	-1.696 (-5.55)	-1.254 (-4.69)	-	-0.487 (-2.92)	-1.179 (-3.65)
No. of obs.	237	237	237	237	226
Adj-R^2	**0.656**	**0.616**	**0.588**	**0.403**	**0.702**

Notes: *t*-statistics are shown in parentheses. Non-productive expenditures and non-distortionary taxes are also omitted from all regressions. The terms of trade variable is obtained from the Penn World Table 5.6 and is defined such that an increase in the index represents a *worsening* of the terms of trade. Limited coverage for this variable reduces the sample size in column 5.

Table 5 Alternative Samples

Estimation Technique: LSDV: 2 way FE; annual data					
Dependent variable: per capita GDP growth					
	1: Germany omitted	2: UK omitted	3: Turkey omitted	4: US omitted	5: Sweden omitted
Investment ratio	0.156 (3.28)	0.152 (3.15)	0.078 (1.61)	0.175 (3.37)	0.155 (2.90)
Labour force growth	-0.544 (-2.15)	-0.050 (-0.27)	-0.074 (-0.36)	-0.302 (-1.54)	-0.068 (-0.35)
Other revenues	0.083 (1.03)	0.058 (0.68)	-0.017 (-0.21)	0.036 (0.44)	0.010 (0.10)
Other expenditures	-0.025 (-0.37)	0.052 (0.74)	0.077 (0.88)	0.052 (0.78)	0.024 (0.29)
Budget surplus	0.244 (4.05)	0.199 (3.59)	0.200 (3.63)	0.169 (3.03)	0.165 (2.43)
Distortionary taxation	-0.413 (-6.61)	-0.421 (-6.33)	-0.542 (-5.19)	-0.449 (-5.93)	-0.425 (-5.83)
Productive expenditure	0.342 (5.21)	0.404 (5.42)	0.339 (4.72)	0.406 (5.20)	0.373 (4.46)
Net lending	-3.575 (-3.68)	-3.663 (-3.22)	-3.726 (-2.44)	-3.516 (-3.03)	-3.300 (-2.75)
Lagged Growth	-2.170 (-5.31)	-1.694 (-4.99)	-1.930 (-5.59)	-1.765 (-5.12)	-1.678 (-5.15)
No. of obs.	237	237	237	237	237
Adj-R^2	**0.722**	**0.701**	**0.668**	**0.693**	**0.689**

Notes: see Table 4.

Appendix Table 1 Functional/Theoretical Classifications

Theoretical Classification	Functional Classification
budget surplus	budget surplus
distortionary taxation	taxation on income and profit
	social security contributions
	taxation on payroll and manpower
	taxation on property
non-distortionary taxation	taxation on domestic goods and services
other revenues	taxation on international trade
	non-tax revenues
	other tax revenues
productive expenditures	general public services expenditure
	defence expenditure
	educational expenditure
	health expenditure
	housing expenditure
	transport and communication expenditure
unproductive expenditures	social security and welfare expenditure
	expenditure on recreation
	expenditure on economic services
other expenditure	other expenditure (unclassified)

Appendix Table 2 Summary Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum (country)	Maximum (country)
GDP p.c. growth (% p.a.)	2.79	1.66	1.54 - Switzerland	5.09 - Turkey
Investment	22.06	3.61	18.11 - UK	29.43 - Portugal
labour force growth (% p.a.)	1.06	0.80	-0.06 - Germany	2.06 - Iceland
Budget surplus	-3.08	3.39	-11.76 - Portugal	1.65 - Luxembourg
Net lending	1.22	1.39	0.11 - Ireland	4.49 - Norway
Distortionary taxation	18.76	7.25	7.10 - Iceland	33.47 - Netherlands
Non-distortionary taxation	9.15	4.22	0.96 - US	16.77 - Norway
Other revenues	4.56	2.96	1.51 - Germany	16.72 - Ireland
Productive expenditure	14.69	4.57	7.35 - Canada	23.74 - Italy
Non-productive expenditure	15.24	6.05	4.96 - Turkey	24.31 - Luxembourg
Other expenditures	4.44	3.07	0.98 - Finland	9.16 - Ireland

Notes:

All variables are percentages of GDP except where stated and are based on five-year averages of data.