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On and Off the Frontier: the Impact of Taxes on Growth*

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Abstract: In the context of explaining inter-country growth rates, empirical work to date finds a negligible role for the parameters of a country's taxation system. In our opinion, part of the explanation for this result is that the wrong dependent variable is used in the analyses. We decompose the growth rate for OECD countries into movements *along* and movements *towards* the frontier. The inter-temporal change in our index of movement *towards* the frontier is used as the dependent variable in an analysis of the role in growth of non-input country characteristics, especially the taxation regime. We find a very strong negative relationship between movement towards the frontier and changes in the rate of labour taxation.

I INTRODUCTION

Puzzles in the data have been the impetus to the interest in growth theory in this century. As Solow (1994) notes the theoretical prediction of instability arising from Harrod-Domar growth theory derived from the requirement that the theory replicate two stylised facts — the constancy of the output/capital ratio and the realised saving (investment)/output (income) ratio. His own contribution (Solow, 1956) was to make the former ratio endogenous and not a datum in the theory. In this way, through diminishing returns, he was able to reverse the instability conclusion and thereby provide a theory more in accord with the record of capitalist economies. Solow's (1957) subsequent empirical work found that a large portion of observed output

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growth could not be attributed to growth in conventional inputs. This residual needed to be accounted for by theory. This was easily achieved by multiplying the aggregate production function by a time related scale factor. With this addition per capita output grew in steady-state at a rate equal to the rate of technical progress. Given that this latter element is a datum this can be called an exogenous growth model.

The theory does not say that the rate of technical progress is constant nor as Solow (1994) notes was it ever suggested that it was not at least partially endogenous. However, it was not clear that economists had "anything useful to say about the process, in a form that can be made part of an aggregative growth model" (Solow, 1994, p. 48). Modern growth theory will be useful to the extent that it models "the endogenous component of technological progress as an integral part of the theory of economic growth" (Solow, 1994, p. 51).

The impetus for our paper is not so much to address "data facts" in the growth debate but rather to focus on certain "facts" in the sense of Romer (1994). Stern (1991, p.128), for example, noting that standard growth theory has concentrated on the augmentation of inputs, suggests that some emphasis should be given to the management of such inputs. This element may not be easily transferable across countries and so it may go some way towards explaining the persistence of inter-country growth gaps. More generally country-specific determinants of growth can arise from a host of institutional and cultural factors such as a country's political system, the competence and credibility of its system of government, its taxation regime, its structure of trade barriers, the independence of its central bank, the work ethic of its labour force, its unique network of business organisations etc. There are indeed now a large number of papers exploring the effect of country characteristics on growth (see Easterly *et al.*, 1993, footnote 1, for an extensive list). Not all of these characteristics are readily amenable to measurement and thus their importance to growth must remain speculative. Of the remainder, what is perhaps a substantial puzzle is why, in the context of explaining inter-country growth rates, the parameters of a country's taxation system are either difficult to isolate (Easterly and Rebelo, 1993 and 1993a) or appear to be of very small magnitude (Mendoza *et al.*, 1995). Our paper addresses this puzzle.

A starting point for our consideration of this issue is to suggest that it is useful to decompose a country's growth performance into movements *along* its production frontier and movements *towards* its frontier. The extent to which a country is off its frontier we term its degree of X-inefficiency. We believe that many of the country characteristics suggested above, and especially the taxation regime, can contribute to X-inefficiency. Thus, in our

opinion, part of the explanation for the failure of existing empirical work to establish an important role for taxation and possibly other factors in growth performance, is that the wrong dependent variable is used in the analyses. The appropriate dependent variable, in our view, is an index which can capture over time the extent to which a country moves towards or away from its frontier.

The plan of our paper is as follows. Section II presents a methodology which decomposes the growth rate for OECD countries for the period 1967 to 1985 into movements *along* and movements *towards* the frontier. Section III takes the inter-temporal change in our index of X-inefficiency developed in Section II and uses it as the dependent variable in an analysis of the role in growth of non-input country characteristics, especially the taxation regime. Finally, Section IV provides a few concluding comments and indicates some avenues for further research.

II DECOMPOSING OUTPUT GROWTH IN OECD COUNTRIES

Our discussion in the introduction suggested that useful insights into the processes underlying any given growth rate can be provided by the decomposition of the growth rate in actual output into movements *along* the production frontier and movements *towards* the frontier, that is:

$$\begin{aligned} Y^a_{it} &= Y^f_{it} * (XE_{it}) \\ \Delta \log(Y^a_{it}) &= \Delta \log(Y^f_{it}) + \Delta \log(XE_{it}) \end{aligned} \tag{1}$$

where,

Y^a = actual GDP;

Y^f = frontier GDP;

XE = proportionate deviation from the frontier or the degree of X-inefficiency. This index ranges in value from 1 to 0.

An expansion or contraction in actual output can thus occur because of differential trend performances in a country's movement along the frontier or towards the frontier. Indeed it is possible for countries to experience a negative relationship between these two components.

The proposed decomposition in Equation (1) is straightforward but the difficulty arises in operationalising the idea. The central problem involves the estimation of the X-inefficiency term for each country over time. If this can be estimated, then the frontier can also be generated for each country.

A number of parametric and non-parametric approaches can be adopted to estimate XE_{it} (e.g., Farrell, 1957; Mundlak, 1961; Fare *et al.*, 1985; Aigner *et al.*, 1977). The most appealing in our view is the composite-error frontier model of Aigner *et al.*, which provides an econometric approach to estimation of the frontier and hence of XE_{it}. Their model is given by:

$$\begin{aligned} y &= f(x_1, x_2, \ldots, x_n)e^{\varepsilon} \\ \varepsilon &= v - |u|; \; v \sim N\left[0, \sigma_v^2\right] \end{aligned} \tag{2}$$

The model is a standard production function except for the error term (e) which is made up of a random part (v) and a systematic part (u) which is assumed to have a one-sided distribution and to be independent of the random and normally distributed part. The moments of the assumed distribution of u provide information on the degree of X-inefficiency in the set of observations.

Individual observation X-inefficiency values can also be computed, following Jondrow *et al.* (1982), as $E[u_{it}|e_{it}]$. The moments and individual observation X-inefficiency measures uniquely depend on the assumed distribution of the one-sided error term. The literature on the measurement of X-inefficiency has tended to focus on three distributions, namely, the *Half Normal*, the *Exponential* and the *Truncated Normal*.

We have estimated Equation (2) using the maximum likelihood estimators provided by Greene (1991) by assuming a Cobb-Douglas technology and employing as independent variables the labour force, capital stock, average years of schooling and a time trend to capture time-related shifts in the frontier.[1] We also experimented with the three one-sided distributions just mentioned. The panel of data available for the regression analysis consisted of 18 of the 24 OECD countries for the period 1967 to 1985 owing to lack of complete variable coverage.

Table 1 presents OLS estimates of Equation (2) for three time periods. The aggregate production function exhibits marginally increasing returns for the full data set. It is of note that including the schooling variable adds significantly to the explanatory power of the regression and boosts the share of broadly defined capital by a factor of 0.07. The coefficients are fairly stable

1. All of the data bar the schooling variable were based on the Summers and Heston (1991) (SH) PENN5 dataset. The real GDP series used is the chain index computed at 1985 international prices. The schooling variable used was that developed by Barro and Lee (1993) and employed also by O'Neill (1995). The SH capital stock data only run from 1980 to 1988 so estimates for earlier years were as used by O'Neill (1995) who employed the methodology proposed by Benhabib and Spiegel (1994) to generate estimates of stock figures for earlier years.

Table 1: *OLS Estimates of Equation (2) for Selected Periods*[a]

Regressors	*1967-1985 (n=342)*	*1967-1975 (n=162)*	*1976-1985 (n=180)*
Constant	3.503	3.141	3.640
	(0.241)	(0.315)	(0.439)
Capital stock	0.551	0.588	0.536
	(0.027)	(0.035)	(0.047)
Labour	0.514	0.477	0.529
	(0.028)	(0.036)	(0.049)
Schooling	0.072	0.088	0.041
	(0.034)	(0.048)	(0.049)
Trend	–0.010	–0.020	–0.004
	(0.002)	(0.009)	(0.003)
R^2	0.99	0.99	0.99
DW	2.04	2.01	2.11
Parameter stability (Chow) = 2.37			

(a) Standard errors are in parentheses beneath coefficient estimates.

as a whole over the two time periods. In the final period, however, the schooling variable and the trend term shrink substantially in magnitude and are not statistically significant.

Given the reasonable level of parameter stability suggested by the OLS estimates, we focus in Table 2 on the maximum likelihood results for three assumed one-sided error distributions for the full time period. It is evident that the coefficient estimates are very similar to the OLS results and also there is very little difference in the parameter values across the different distributions. Two factors are, however, noticeably different as between the *Half Normal* and the other two models. The *Half Normal* specification produces the highest log-likelihood and relative standard deviation of the one-sided errors. Thus estimation of XE_{it} will be sensitive to the assumed one-sided distribution. Preliminary analysis has indicated that there is very little difference in the measures of X-inefficiency between the *Exponential* and *Truncated Normal* models but the *Half Normal* distribution generates values which are significantly higher, but of the same trend, than these two models. In the results which follow we use the *Half Normal* estimates but the choice of the distribution of u requires further investigation.

In Table 3 we document the estimates of $(XE_{it})^2$ for selected years for the

2. We actually estimate this expression as $EXP(-E[u_{it} | e_{it}])$.

Table 2: *Maximum Likelihood Results, 1967-1985, for Various Distributional Assumptions of* $u^{(a)}$

Regressors	*Half Normal*	*Exponential*	*Truncated Normal*
Constant	3.290	3.292	3.387
	(0.312)	(0.262)	(0.304)
Capital stock	0.576	0.567	0.563
	(0.034)	(0.029)	(0.033)
Labour	0.500	0.509	0.510
	(0.033)	(0.029)	(0.033)
Schooling	0.089	0.111	0.098
	(0.035)	(0.033)	(0.039)
Trend	–0.014	–0.012	–0.012
	(0.002)	(0.002)	(0.002)
Log L	241.81	237.17	239.04
s_u/s_v	4.61	1.70	2.82

(a) Standard errors are in parentheses beneath coefficient estimates.

18 countries in our analysis. Values close to unity suggest that a country is close to its frontier. Most countries were within 10 per cent of their frontiers on average for the period. However, actual GDP per worker in Denmark and Germany was over 20 per cent short of their respective frontier levels. The outstanding outlier is Japan which is estimated to be in excess of 30 per cent below its frontier over the full period of the analysis.

It is we believe important to appreciate the extent to which a country's actual growth record is determined by changes in its efficiency or changes in its position on the frontier. It is also of interest to establish whether these processes reinforce each other or act as countervailing forces. In Table 4 we present our estimates of Equation (1) for individual countries for two time periods 1968-76 and 1977-85.

The two periods are quite different in important respects. The actual growth rate for all countries in the second period is well under half the rate of the first. In addition the relative importance of movements along the frontier on average is much more significant in explaining actual growth performance in the second time period than in the first. In fact on average the growth in XE is identical to the growth in Y^f. Looking at the first period we observe that the growth in movements towards the frontier in the majority of countries is negative and of the opposite sign to movements along the frontier.

The experience of individual countries is quite interesting. Japan, for

Table 3: *X-inefficiency Estimates, OECD Countries, Selected Years*

	1967	*1970*	*1975*	*1980*	*1985*	*MEAN*
Australia	0.96	0.92	0.87	0.87	0.92	0.91
Austria	0.82	0.87	0.90	0.94	0.95	0.90
Belgium	0.97	0.97	0.95	0.96	0.96	0.96
Canada	0.98	0.96	0.90	0.91	0.96	0.94
Denmark	0.65	0.68	0.67	0.73	0.87	0.72
Finland	0.85	0.79	0.72	0.78	0.85	0.80
France	0.81	0.83	0.80	0.84	0.84	0.82
Germany, W.	0.72	0.74	0.70	0.76	0.78	0.74
Greece	0.89	0.83	0.75	0.79	0.83	0.82
Ireland	0.92	0.94	0.92	0.91	0.81	0.90
Italy	0.85	0.87	0.87	0.98	0.98	0.91
Japan	0.76	0.68	0.61	0.64	0.66	0.67
The Netherlands	0.98	0.96	0.93	0.95	0.97	0.96
Norway	0.87	0.82	0.79	0.88	0.95	0.86
Spain	0.78	0.83	0.93	0.92	0.91	0.87
Sweden	0.84	0.85	0.86	0.87	0.97	0.88
UK	0.86	0.84	0.83	0.89	0.96	0.87
USA	0.98	0.96	0.88	0.89	0.95	0.93

instance, had the highest growth rate in GDP per worker over the period 1968-76 and this growth rate was accomplished despite it displaying the largest movement away from the frontier among our sample of countries. This adverse development in its level of X-inefficiency should also be set against our finding in Table 3 that Japan had the lowest absolute level of X-inefficiency for all years in our sample. Finland and Greece also stand out as having somewhat similar experiences to Japan. On the other hand for some countries (most notably Spain and Austria) we find that movements towards the frontier reinforce movements along the frontier. In the case of Ireland our results suggest that Ireland's growth performance was predominantly caused by movements along the frontier.

Turning to the second period we observe a qualitatively different set of findings. This period was one in which all countries experienced a significant slowdown in GDP growth. What is, however, striking about this period is that, with the notable exception of Ireland, all countries improved performance relative to the frontier. Exceptional performances are indicated for the Scandinavian countries, especially Denmark and Finland. As most countries approached the frontier at an annual rate of around 1 per cent, it makes Ireland's annual rate of deviation from the frontier of over 1 per cent all the more glaring. Japan's performance again stands out, not so much for its

actual growth performance, which was matched by Finland and almost Norway, but because of the exceptional growth in its frontier output. Also Japan managed to turn an annual rate of decline in its X-inefficiency in the period 1967-76 to an annual rate of improvement of about 1 per cent in the second period.

Table 4: *Decomposition of Annual (log) Change in GDP Per Worker into Movements Along the Production Frontier and Movements Towards the Frontier*

	1967-76			*1977-85*		
	Y^a	Y^f	*XE*	Y^a	Y^f	*XE*
Australia	0.022	0.031	–0.010	0.007	0.002	0.006
Austria	0.042	0.034	0.011	0.013	0.009	0.005
Belgium	0.035	0.036	–0.001	0.002	0.002	0.000
Canada	0.010	0.017	–0.008	0.010	0.004	0.007
Denmark	0.017	0.014	0.007	0.016	0.000	0.025
Finland	0.034	0.048	–0.021	0.027	0.014	0.021
France	0.035	0.035	0.000	0.009	0.007	0.003
Germany, W.	0.034	0.033	0.001	0.011	0.007	0.007
Greece	0.056	0.068	–0.016	0.018	0.012	0.008
Ireland	0.037	0.038	–0.002	0.006	0.014	–0.011
Italy	0.039	0.033	0.008	0.023	0.016	0.008
Japan	0.057	0.069	–0.024	0.030	0.027	0.007
The Netherlands	0.031	0.035	–0.004	0.002	0.000	0.002
Norway	0.023	0.030	–0.009	0.024	0.010	0.018
Spain	0.044	0.029	0.020	–0.004	–0.002	–0.002
Sweden	0.016	0.017	–0.001	0.016	0.002	0.016
UK	0.019	0.020	–0.002	0.015	0.003	0.014
USA	0.004	0.013	–0.010	0.012	0.007	0.006

III TAXATION AND X-INEFFICIENCY

We have seen that countries differ in the extent of their movement towards the production frontier. In this section we seek to determine if changes in tax rates are powerful in explaining off frontier behaviour. As we noted in the first section previous work (Easterly and Rebelo, 1993 and 1993a and Mendoza *et al.*, 1995) has either found the growth impact of taxation difficult to isolate or of a small magnitude. Our contention is that empirical investigation should follow from basic public finance principles. Factor taxes result in off frontier behaviour to the extent that the net of tax factor price ratio is not equalised across sectors of the economy. We would, therefore, expect to find a negative relationship between increases in distortionary

factor taxes and movements towards the frontier. Two issues must be addressed before we can investigate our hypothesis: the calculation of tax rates, and the tax incidence concept being employed.

The most common way of classifying a country's tax system is to express categories of taxation as a share of GDP. An immediate problem with this approach is that the categorisation of taxes respects administrative rather than economic criteria. Taxes get classified according to whether they are direct or indirect and not according to the economic function on which they are levied. A second problem is that this approach combines two features of the tax system — the base and rate — and is therefore less informative in assessing changes over time. A proper indicator must therefore re-classify taxes and separate the base and rate.

Once it has been decided to re-classify according to economic function it is then necessary to decide on the level of disaggregation. There is no global principle to be followed in making this decision. The best that can be done is to tailor the disaggregation to the purpose for which the measures are being used. There exists a vast literature on effective marginal tax rates at the microeconomic level.[3] Wedges between consumer and producer prices are calculated for labour and capital by *type* of labour and capital. Average and marginal tax rates on labour can be calculated by assessing the impact of the tax system on some notional worker. The OECD use the income of the *Average Production Worker* (APW) as the basis for making such calculations. Standard tax allowances are deducted and the statutory tax schedule is applied in order to arrive at the marginal income tax rate. The full marginal rate is obtained by combining this with social security, payroll taxes and consumption taxes. This exercise can be performed for a variety of typical workers by scaling the APW income up and down. Such exercises are reported in OECD (1994). In the case of capital, tax rates are calculated by type of asset, industry, instrument and source of finance. An extensive study of capital taxes along these lines is contained in OECD (1991). The main purpose of this work is in identifying areas in which the tax system favours certain activities over others. Much of this work was undertaken in the early 1980s when *neutrality* of the tax system was the main policy concern. We believe that this level of disaggregation is not necessary or appropriate for our purpose. It would certainly be required if we were concerned to know whether the tax system favoured certain categories of labour over others. However, what is needed is a measure of the extent to which the tax system impacts on factors in general and how this varies over time.

Another approach involves reporting effective tax rates for the economic

3. Useful references are McKee *et al.* (1986) and OECD (1991).

functions in general. In the case of the USA Barro and Sahasakul (1983 and 1986) and Joines (1981) have reported a long series of tax rates on labour and capital. More recently an internationally comparable methodology for calculating implicit tax rates on economic functions at the aggregate level has been outlined by Mendoza, Razin and Tesar (1995). The basis of their method is simple and can be explained in the following way. Imagine that a specific (per-unit) tax is levied on a certain commodity. This can be expressed as a tax rate by dividing the difference between the consumer and producer price, at the post-tax equilibrium, by either of these prices. A similar approach can be used in calculating tax rates on labour and capital. At the aggregate level, however, we will not have data on prices since National Accounts and revenue statistics provide only revenue data. This, of course, presents no problem as the quantity index above and below the line will just cancel.

We employ the Mendoza *et al.*, methodology to estimate implicit tax rates.[4] They assume that all sources of income are taxed at the same rate. They calculate this rate by dividing all taxes on income, profits and capital gains of individuals (OECD tax revenue category 1100) by the sum of the operating surplus of private unincorporated enterprises (OSPUE), households' property and entrepreneurial income (PEI) and wages and salaries gross of employers' social security contributions (W). The rate is then multiplied by W to allocate income taxes to labour and by the sum of OSPUE and PEI to allocate income taxes to capital.

The tax rate on labour is calculated by summing labour's share of income tax, social security taxes and payroll taxes and dividing by the wage bill, gross of employer's social security. The capital tax rate is calculated by summing capital's share of income tax, corporation tax, property tax and taxes on financial transactions and dividing by the operating surplus of the economy. Finally, the rate of consumption tax is the sum of general goods taxes and excise divided by public and private consumption less government employee remuneration and consumption taxes (the latter in order to calculate the tax rate at producer prices as with the factor tax rates).

We used OECD Revenue Statistics and OECD National Account Data (Volume 2: Detailed Tables) in order to implement the Mendoza *et al.*, methodology. Table 5 contains summary statistics on the results.

A second issue concerns the nature of the tax incidence. There exists two paths to assessing the incidence of taxation: the balanced budget and differential approaches. In the former, revenue from increased taxes is used to fund increased public expenditure. To the extent that the marginal cost of public funds exceeds unity this results in extraction from the economy — the

4. The Mendoza *et al.*, approach cannot be implemented for Ireland. Instead we allocate taxes on a line by line (Eurostat "Taxes and Social Contributions" codes) basis to labour and capital.

Table 5: *Means of Implicit Tax Rates and Rates of Change 1967-85*

	Mean of Labour Tax	*Mean of Consumption Tax*	*Mean of Rate of Change of Labour Tax*	*Mean of Rate of Change of Consumption Tax*
Australia	18.12	8.14	1.30	0.43
Austria	41.86	22.53	0.35	0.08
Belgium	40.72	17.68	0.80	–0.39
Canada	21.56	11.46	1.52	2.10
Denmark	40.94	32.95	0.23	0.39
Finland	29.34	22.11	1.05	2.83
France	50.04	5.08	0.80	–0.05
Germany, W.	35.85	14.49	0.63	1.75
Ireland[a]	27.03	24.07	2.22	1.85
Italy	37.01	11.93	1.00	–4.83
Japan	20.78	4.89	1.11	–1.13
The Netherlands	52.40	17.50	–0.30	0.50
Norway	38.62	35.43	0.20	0.30
Spain	34.72	9.30	1.08	3.50
Sweden	51.06	21.94	0.55	0.88
UK	27.40	14.31	–0.22	0.15
USA	24.14	5.68	0.92	0.21
MEAN	34.80	16.44	0.78	0.50

(a) See footnote 4.

post-tax production frontier lies below the pre-tax frontier. With the differential approach, revenue raised by taxes is held constant and one tax is partially substituted for another.

Both concepts of incidence underlie our empirical analysis. We will assume that additional tax revenue is raised by consumption taxes.[5] Alterations in the tax system are of a differential nature involving a trade off between taxes on labour and capital.

Our empirical specification begins with Equation (1). Easterly and Rebelo (1993a) and Mendoza, Milesi-Ferretti and Asea (1995) use the left hand side of Equation (1) as the dependent variable. This includes frontier and off-frontier movements. It is our contention that this corruption of the dependent variable lies at the heart of their inability to isolate a quantitatively significant impact of taxation on growth. We use Dlog (XE_{it}) as the dependent variable and control for changes in the frontier arising from extractive taxes in the form of consumption taxes.

To the extent that increases in consumption taxes (CHGCONS) reduce the

5. Given the equivalence of general consumption taxes and general factor taxes this is a reasonable approximation.

post-tax frontier the efficiency gap should move closer to unity and so we expect to find a positive coefficient on this variable. We also include the level of the consumption tax (LEVCONS) in order to take account of the possibility that the marginal cost of public funds is increasing in the level of taxation.

Our main interest is in the change in the rate of taxation of labour (CHGLAB). As we noted above the idea here is that we are holding the revenue raised from factor taxation constant, raising labour taxes and reducing capital taxes. There is some empirical warrant for this — as is evidenced in an analysis of trends in taxation in the European Union and by Mendoza, Razin and Tesar (1995) for the G7 countries. A negative coefficient on CHGLAB would indicate that changes in the structure of taxation retarded movement to the frontier thereby promoting X-inefficiency.

Our empirical analysis is contained in Table 6.[6] For the independent variables we pool cross-section and time series information. Five year averages for the tax rates and the rate of change of tax rates are calculated for each of the countries indicated in Table 3, excluding Greece, for the period 1967-85. Where observations are missing we use means of the observations for other countries.

The results suggest a very strong relationship between movement towards the frontier and changes in the rate of taxation of labour (CHGLAB). Contrast this with the conclusion of Easterly and Rebelo (1993, p.442):

> The evidence that tax rates matter for growth is disturbingly fragile. This empirical fragility contrasts sharply with the robustness of the theoretical predictions: most growth models predict that income and investment taxes are detrimental to growth. Our results on the dependence of both growth and tax policy on initial income help explain why it is difficult to isolate the effects of tax policy on growth. One avenue for further empirical research is to search for natural experiments in which there are large changes in tax policy, where the covariation with income does not constitute a problem.

We agree with Easterly and Rebelo that the relation between growth and initial income is at the heart of the difficulty in isolating tax effects on growth. A failure to abstract from this also explains Mendoza *et al*'s. (1995) finding that the magnitude of the tax impact on growth is small. We disagree with Easterly and Rebelo that some natural experiment is required in order to rectify the problem. Rather the solution lies in following basic public finance principles and seeking to isolate the impact of taxes on growth

6. We also experimented with measures of X-inefficiency using the *Truncated Normal* and *Exponential* distributions as outlined in Section 2 but the robustness of our conclusions were not affected.

through their impact on changes in X-inefficiency.

We are not suggesting that all changes in X-inefficiency can be attributed to factor taxes. In order to establish other likely candidates we investigated a number of hypotheses current in the literature. One suggestion, due to Mendoza (1994), is that variability in the terms of trade will have a negative impact on growth. Including a variable for this in our regressions did not yield statistically significant results. We also examined the possibility that inflation in an environment in which personal and business taxes are not fully integrated would not be neutral. Again we could not find a statistically significant effect.

A further line of enquiry relates to the link between good government and growth. Grilli *et al.* (1991) investigate this issue in the context of *Economic and Monetary Union*. They find that electoral processes and political traditions affect the ability of governments to deal with deficits. We take the change in the deficit/GDP ratio (DEF) as a reduced form for political tradition and ask whether this will impact on X-inefficiency. The deficit measure is government savings. Hence our results indicate a positive relationship between deficit reduction and movements towards the frontier. To the extent that deficit reduction is a measure of good government this indicates that "the way in which things are done" can be important for growth. However, this is an issue that needs further analysis.

Table 6: *Explaining Changes in X-inefficiency in OECD Countries*[a]
Dependent Variable: $log(XE_{it}/XE_{it-1})$[b]
Estimation Method: OLS

Independent Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Constant	.003	.003					.003
	(.001)	(.001)					(.001)
CHGLAB	−.144	−.255	−.117	−.204	−.209	−.153	−.258
	(.064)	(.069)	(.055)	(.057)	(.055)	(.053)	(.066)
CHGCONS		.252	.226	.216	.226	.236	.255
		(.079)	(.083)	(.077)	(.075)	(.078)	(.075)
LEVCONS				.019	.014		
				(.005)	(.006)		
DEF					.009	.012	.010
					(.004)	(.004)	(.004)
R^2	.071	.198	.146	.226	.282	.244	.281
Observations	68	68	68	68	68	68	68

(a) Standard errors appear in parentheses beneath coefficient estimates. (b) The mean of the dependent variable is .001.

V CONCLUDING REMARKS

As indicated in the introduction we believe that the task of identifying the empirics of growth can benefit from following Solow's (1957) approach and applying some simple techniques from microeconomic production theory. Our contribution was first to focus on the path of X-inefficiency by applying techniques which are fairly widely used in the microeconomic theory of production to the modelling of aggregate data. For the OECD countries our findings show that movements in X-inefficiency have been an important factor in the growth record from 1967 to 1985. We followed up this analysis by testing some hypotheses to explain changes in the off-frontier location of countries over the same period. In this way we were able to identify a significant impact of taxation on growth. As Easterly and Rebelo (1993) note such an impact arises in most theoretical models of growth. Public policy takes it as a matter of faith that such effects exist. Previous empirical work yielded results which were disturbing to this consensus. Our results therefore give empirical support to received wisdom.

We would like to highlight an issue for further research which is suggested by our analysis. Our empirical approach affords, we believe, a potentially richer perspective on the issue of convergence. Two aspects of convergence now come into focus, namely, convergence in terms of movements along the frontier and convergence in terms of progression towards the frontier. While we might expect convergence in movements along the frontier there is no reason to expect convergence in movements in the X-inefficiency term. This is likely to be especially true if X-inefficiency arises because of non-transitory country-specific factors. Of their nature good practice in terms of such characteristics cannot be readily transmitted across national frontiers. This is a hypothesis which would appear to be worth testing using perhaps the techniques we have proposed in another paper (Boyle and McCarthy, 1997).

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