The Role of Efficiency as an Explanation of International Income Differences

Richard Kneller[†] *and Philip Andrew Stevens*[‡]

Abstract

Why are some countries richer than others? If, as some recent work has suggested, the answer lies not in differences in physical and human capital accumulation but in differences in productivity, this merely shifts the question to: why are some countries more productive than others? This paper investigates differences in productive efficiency as an explanation of international income difference using stochastic frontier analysis. We find that human capital and geography are important in explaining differences in productive inefficiency in a panel of 82 countries over the period 1960-87. We also investigate the effects of government policy, as measured by its fiscal stance, on a subset of OECD countries over a shorter period. We find that increases in the budget surplus are associated with lower levels of productive efficiency in the economy as a whole.

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[†] *Leverhulme Centre for Research on Globalisation and Economic Policy, School of Economics, University of Nottingham, Nottingham, NG7 2RD.*

[‡] *National Institute of Economic and Social Research 2, Dean Trench Street, Smith Square, London, SW1 3HE.*

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1 Introduction

Why are some countries richer than others? Recent work by Prescott (1998), Hall and Jones (1999), McGrattan and Schmitz (1998) and others suggest that the answer lies not in differences in physical and human capital accumulation but in differences in productivity. But this – as Prescott (1998) notes – simply transfers the question to: why are some countries more productive than others? A number of recent empirical papers provide evidence on this question (for example Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997; Senhadji, 2000; Miller and Upadhyay, 2000). The general approach adopted in these papers has been to generate cross-country productivity estimates as the residuals from a production function and then perform a regression of these residuals on a set of variables thought to affect productivity. This method is rather *ad hoc* in nature. Stochastic frontier analysis allows one to investigate these issues in a more formal setting (e.g. Koop, Osiewalski, and Steel, 1999, 2000).

In this paper we adopt the stochastic frontier framework advocated in Koop, Osiewalski, and Steel (1999) for a similarly broad set of countries but investigate the influence of a broader set of determinants of inefficiency, namely a set of policy, political and geographic variables. Our results are based on a panel of between 75 and 82 countries over a 28 year period. In the next section we provide the background for this paper. Section 3 describes our empirical model and data. In section 4 we present and discuss our results. Section 5 concludes.

2 Background

In modern growth theory, technical change – the engine for growth – results from investment in knowledge-generating activities such as R&D. If this knowledge is assumed to be non-rivalrous, partially-excludable and infinitely expandable in character then knowledge disperses via some dissemination process – such as international trade or foreign direct investment (Keller, 1997) – and in the long-run all countries will grow at an identical rate. Differences in the rate of productivity growth at a point in time will depend upon transitional factors only (Hall and Jones, 1999). This has led to a burgeoning literature studying the relationship between productivity growth and the determinants of the knowledge dispersion process.[1]

This view of productivity is inconsistent with the persistent differences in the *level* of productivity between countries present in the data, although more recent models by Howitt (2000) and Howitt and Mayer-Foulkes (2002) have started to introduce such effects. There is a large body of evidence from the micro-empirical literature, using frontier methods such as data envelopment analysis (DEA) and stochastic frontier analysis (SFA), that differences in economic efficiency are qualitatively important and persistent[2]. Recent studies by Prescott (1998) and Hall and Jones (1999) have argued in favour of similar effects at the macro level. Theoretical models of this sort can be found in Cohen and Levinthal (1989) and Neary and Leahy (1999). Four sets of explanations have been put forward in the literature to account for persistent cross-country productivity differences: resistance to new technologies because of institutional design (Prescott, 1998; Parante and Prescott, 2000); appropriate technology (Acemocoglu and Zibilioti, 1999); physical distance or geography (Keller, 2000, 2001a, 2001b); and finally absorptive capacity (Eaton and Kortum, 1999; Griffiths, Redding and Van Reenan, 2000; Xu, 2000).

The approach adopted in most papers that seek to explain cross-country differences in productivity is a two-stage approach. Cross-country estimates of productivity are generated as the residuals from a production function, where the parameters of the function are either estimated (Senhadji, 2000; Miller and Upadhyay, 2000) or imposed (Griffith, Redding and Van Reenan, 2000). These productivity estimates are then regressed on a different set of variables in a second stage regression. An exception to this is the work conducted in Koop, Osiewalski, and Steel (1999, 2000) and Koop (2001), who have shown that using stochastic frontier analysis provides the additional insight that one would expect from a methodology that more closely matches the underlying theoretical model.

Whilst the results from Koop, Osiewalski, and Steel (1999) might be considered robust for a large sample of countries, the information that can be drawn from the variables included in the efficiency matrix is limited compared to that from other studies. Koop, Osiewalski, and Steel (1999) explain efficiency by the inclusion of an index of economic freedom. This index contains information on the trade policy, fiscal policy, monetary policy, financial institutions, social institutions and the protection of property rights within each country of the sample. While a useful summary of the general policy climate it assumes that the effect of each of these variables on efficiency is identical. In addition it is not possible to determine the relative importance of

[1]See Coe and Helpman (1995), Keller (1997), Griffith *et al* (2000) for the effects of foreign and domestic R&D and Barrell and Pain (1997) for foreign direct investment (FDI).
[2] See Coelli, Rao and Battesse (1999) for references to this literature.

these policy variables and also ignores many variables, such as the geographic variables and human capital variables that have been used previously and found to be important.

The variables that have been included in the second-stage regressions of productivity determinants in the previous literature can be broadly grouped into three types:

1) *Geographic*
2) *Historical, Political and Cultural*
3) *Policy Dependent*

The geographic variables included in productivity regressions have included variables such as the longitude and latitude of the country, as well as climate measures such as whether a country is tropical and the level of rainfall. These variables might be best thought of as capturing appropriate technology, the idea that the technical frontier does not move out evenly across its surface but is biased towards certain factors of production (Acemoglu and Zibilioti, 2000). The returns to technology may therefore differ when the choice of input mix of countries differs. To argue that technological improvements are country-specific is a rather extreme view; instead Basu and Weil (1998) suggest rather that there are certain groups of countries that share the same technology.

Evidence of the importance of geographic variables is, compared to may other variables considered, robust. Hall and Jones (1999) find that the latitude of a country helps to predict differences in the level of productivity, while the findings of Bloom, Canning and Sevilla (2002) are somewhat more complex. In that paper the aim is to test whether differences in the level of income are due to fundamental forces, geography, climate or culture, or poverty traps/multiple equilibria. The paper is interesting as it allows for convergence through technical adoption rather than simply out of steady state capital accumulation, as has been typical in the convergence literature. They find two equilibria: one that depends on geographic factors and one that does not. From this they conclude that there exists a low level steady state – possibly based on agriculture – in which incomes rise with latitude, and a higher level steady state – perhaps based on industry or services – that does not. They also find that the probability of jumping to the higher equilibrium increases with latitude.

The historic, political and cultural variables that have been investigated include whether the country had been part of a colonial power in the 19^{th} and 20^{th} century (Hall and Jones, 1999), measures of ethnic homogeneity (Bloom, Canning and Sevilla, 2002), political stability (Senhadji, 2000) and indicators of the strength of domestic institutions (Koop, Osiewalski, and Steel, 2000, Bloom, Canning and Sevilla, 2002). Whilst not always made clear, these variables capture the effect of absorptive capacity and institutional resistance on productivity. Prescott (1998) and Parente and Prescott (2000) argue that the level of productivity is lower in some countries because social institutions are of such a design they are able to resist the adoption of new technologies. A related concept is the idea of absorptive capacity. Countries may differ in their effort and ability to adopt new technologies even in knowledge is global (Fagerberg, 1998; Verspagen, 1991; Eaton and Kortum, 1996; Griffith, Redding and Van Reenan, 2000; Papageorgiou, 2000; Xu, 2000). The results for these variables are somewhat dependent on the measures used. Bloom, Canning and Sevilla (2000) find no significant effect from ethnic homogeneity on the level of productivity. This is interesting as it contrasts strongly with the robust findings for this variable in the growth literature (see for example Rodrik, 1998; Easterly, 2000). Koop, Osiewalski, and Steel (2000) and Bloom, Canning and Sevilla (2002) find evidence to suggest that the strength of domestic institutions is important and Senhadji (2000) finds that political stability also matters.

The policy dependent variables that have been used include human capital as well as various measures of trade policy, openness to international trade and macroeconomic stability. Again the results from these variables are mixed. Miller and Upadhyay (2000) do not find a significant effect from human capital on productivity at the cross-country level but do find evidence that trade distortions reduce productivity. These authors also find a significant effect from an interaction term between openness and human capital. The authors interpret this combination of results as suggesting that the effect of openness is leveraged by the stock of human capital and that human capital investment without trade liberalisation may lead to the under-utilisation of human capital. Senhadji (2000) in contrast finds a robust significant positive effect for human capital but finds more mixed results for trade policy. Griffith, Redding and Van Reenan (2000), Kneller (2002) and Kneller and Stevens (2002) have all found a significant positive relationship between human capital and productivity at the industry level, the latter paper using SFA.

Of other papers that have looked at the role of international trade Koop, Osiewalski, and Steel (2000) find no significant effect of openness to trade, whereas Hall and Jones (1999) does. In this latter paper the authors also concern themselves with the combined effect of human capital and trade openness on the level of economic development. Trade variables are found to significantly affect the level of TFP whereas human capital does not, unless the level of openness exceeds a particular threshold. Coe and Helpman (1995) and Coe, Helpman and Hoffmaister(1997) consider a somewhat different role of trade. They regress measures of foreign R&D weighted by trade flows against the level of productivity in a sample of OECD and developing countries respectively. The results from those papers suggest that international trade acts as a channel for the international transfer of technology.

The final set of factors studied in the literature is the macroeconomic stability variables. Miller and Upadhyay (2000) find significant effects from the terms of trade, inflation and the standard deviation of these variables. In contrast both, Koop, Osiewalski, and Steel (2000) and Senhadji (2000) find no evidence for an effect from the inflation rate and external shocks on productivity.

The main general conclusion one can draw from a review of the previous literature on the determinants of variation in TFP is that outside of those for the geographic variables, the results are not robust. The explanation for this non-robustness is not altogether clear. Whilst there are differences in the sample frame across studies in general the data used is from one of either two sources (Penn World Tables or the World Bank) and almost all are estimated using similarly broad samples of countries. A more plausible explanation may lie in the known sensitivity of the productivity estimates from the first stage of the methodology (McGrattan and Schmitz, 1998); and the restrictive nature of functional form for the production function typically imposed (Barrell and Pain, 1997; Duffy and Papageorgiou, 2000; Kneller and Stevens, 2002).

3 Empirical Model

We assume that output, *Y*, is a function of the production technology set out in equation (1), where *i* indexes the country and *t* time.

$$Y_{it} = f\left(K_{it}, L_{it}\right)\exp(\eta_{it})\exp(\varepsilon_{it}) \tag{1}$$

where *K* is the capital stock, *L* is the effective labour supply (number of workers adjusted for average hours per week), $\varepsilon \sim N\left(0, \sigma_{\varepsilon}^{2}\right)$ reflects the random character of the frontier, due to measurement error or other effects not captured by the model and η represents economic efficiency $\left(0 < \eta \leq 1\right)$.

Equation (1) recognises that countries may differ in their level of productivity through the term η. If a country is 100% efficient (η = 1), it can utilise all frontier knowledge, otherwise impediments to absorption will cause the country to produce within the industry frontier.

Following Battese and Coelli (1995), the inefficiency effect is obtained by a truncation of the normal distribution $N(\mu_{it},\sigma^2)$. The mean level of inefficiency is defined by

$$\mu_{ijt} = \delta_0 + \sum_{k=1}^{K} \delta_k z_{k,it} \tag{2}$$

where $z_{k,it}$ is a set of economic, geographic and social factors which influence the technical efficiency of a country, which we discuss below.

The realisations of η_{it} are not directly observable – we only observe $\upsilon_{it} = \eta_{it} + \varepsilon_{it}$. We may however define the efficiency predictor using the conditional expectation of $\exp(\eta_{it})$, given the random variable ε_{it}:[3]

$$\begin{aligned} EE_{it} &= E\left[\exp(-\eta_{it})\middle|\upsilon_{it}\right] \\ &= \left[\exp\left(-\theta_{it} + \tfrac{1}{2}\tilde{\sigma}^2\right)\right] \times \left[\Phi\left(\frac{\theta_{it}}{\tilde{\sigma}} - \tilde{\sigma}\right) \Big/ \Phi\left(\frac{\theta_{it}}{\tilde{\sigma}}\right)\right] \end{aligned} \tag{3}$$

where $\Phi(.)$ denotes the distribution function of the standard normal variable,

$$\theta_{it} = (1-\gamma)\left[\delta_0 + \sum_{m=1}^{M} \delta_m E_m\right] - \gamma\upsilon_{it}, \qquad \tilde{\sigma}^2 = \gamma(1-\gamma)\sigma^2, \quad \text{and} \quad \gamma = \frac{\sigma^2}{\sigma_\varepsilon^2 + \sigma^2}.$$

We can obtain an operational predictor for the efficiency of country *i* at time *t* by replacing the unknown parameters in equation (4) with the maximum likelihood predictors. Note that in what follows we will be discussing *inefficiency*, that is 1/*EE*. This is intended to clarify discussion, since anything that increases inefficiency also increases costs.

The log-likelihood function for this model is presented in Battese and Coelli (1993), as are the first partial derivatives of the log-likelihood function with respect to the different parameters of the model[4]. One of the parameters of particular interest, and included with the tables of results below is the estimated the variance of the efficiency term relative to the variance of the total

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[3] See Battese and Coelli (1993) and Coelli, Perelman and Romano (1999).

[4] This parameterisation originates in Battese and Corra (1977).

error, γ.[5] The value of the parameter provides a useful test of the relative size of the inefficiency effects and lies between zero and one. If $\gamma = 0$, this indicates that deviations from the frontier are due entirely to noise, previous studies that use a standard (i.e. non-stochastic frontier) econometric methodology are entirely correct in their implicit assumption of economic efficiency. If $\gamma = 1$, however, this would indicate that all deviations are entirely due to economic inefficiency and hence the stochastic frontier model is not significantly different from the deterministic frontier model with no random error. The generalised likelihood-ratio test for the null hypothesis that the γ parameter and the δ parameters are jointly equal to zero is calculated by using the values of the log-likelihood function for estimating the full frontier model and that obtained from an OLS regression of the production function. This statistic has a mixed chi-square distribution.[6]

Our empirical model is a translog stochastic production frontier of the form:

$$y_{it} = \beta_0 + \beta_1 k + \beta_2 l + \beta_3 k_{it}^2 + \beta_4 l_{it}^2 + \beta_5 k_{it} l_{it} + \lambda_1 t_1 + \lambda_1 t_2 + \sum_j \phi_j C_j + \eta_{it} + \varepsilon_{it} \qquad (4)$$

where lower cases indicate logarithms, the *C* terms are *j* country group dummies, t1 and t2 a broken time trend for the period before and after 1973 (Duffy and Papageorgiou, 2000), and η and ε are as defined above. We discuss the efficiency determinants (the *z*s) in the data and results sections below.

4 Data

The main source of data for our analysis is the World Bank STARS dataset. The geographic variables included in our analysis include the latitude and longitude of the country (*LAT* and *LONG*, respectively), whether or not it is tropical (*TROP*) or landlocked (*LAND*) and finally the urban population as a percentage of total population (*URBAN*). This data is taken from the World Bank.

Benhabib and Spiegel (1994), Pritchett (1996), Islam (1995) and Kneller and Stevens (2002) all found that human capital affects TFP or efficiency. In order to capture the capacity of an

[5] Note that γ is not the proportion of the total error term explained (except at values of $\gamma = 0$ and $\gamma = 1$) (see footnote 7, page 188 of Coelli, Rao and Battese, 1999; Coelli, 1995).

[6] See Coelli and Battese (1996).

economy to absorb new technology, we include the level of human capital (*H*), as measured by the average years of schooling. This data comes from Barro and Lee (2000).

In order to investigate the effect of the openness of the economy, we include the Sachs and Warner (1995) indicator of openness to international trade (*SWOPEN*). There are advantages and disadvantages to this measure. We prefer it over alternatives such as the ratio of export plus imports to GDP as it is more likely to capture the trade stance of the country as opposed to simply the effect of country size and wealth. Also, as Greenaway *et al* (2002) note, such measures are able capture the multi-faceted nature of trade reform, but have the disadvantage that they are often subjective in nature. Rodrik and Rodriguez (2000) object to one of the variables used in the construction of the Sachs and Warner measure, the black market premium. Bearing these objections in mind, we feel that it is perhaps more appropriate to interpret *SWOPEN* as also picking up the effects of macroeconomic instability as well as trade reform.[7]

In order to assess the quality of institutions, we include the inter-country risk guide from Knack and Keefer (1995) (*ICRGE*). In preliminary analysis, we also included measures of the level of corruption and an index of property protection, but the effect of these variables over and above *ICRGE* was insignificant.

Rodrik (1998) argued that the effect of economic shocks is likely to be greater when the country is divided along ethnic lines. Divisions between different social groups lead to distributional conflicts and poor management of the consequences of shocks, which in turn magnify their effect on the economy. This variable is provided by the World Bank.

5 Results

The results of our stochastic frontier analysis are presented in Table 1. Since some of our variables are only available for a subset of countries, in column (1) we present results using variables that are available for all 82 of the countries in our sample. The set of countries is reduced successively as additional variables are added.

[7] See Rodrik and Rodriguez (2000) for further details.

Table 1 Results

	(1)		(2)		(3)		(4)	
Production frontier								
Constant	8.348	(10.3)	9.961	(16.8)	9.604	(16.2)	9.893	(17.2)
k	-0.359	(4.8)	-0.268	(4.5)	-0.268	(4.8)	-0.288	(5.0)
l	1.131	(14.6)	0.802	(13.0)	0.796	(13.2)	0.792	(12.9)
k^2	0.035	(12.3)	0.03	(13.2)	0.037	(16.7)	0.038	(15.5)
l^2	-0.002	(0.4)	0.001	(0.6)	0.018	(6.0)	0.018	(5.6)
kl	-0.037	(5.9)	-0.028	(6.1)	-0.048	(10.2)	-0.049	(9.4)
$T_{60\text{-}73}$	-0.001	(0.8)	-0.001	(0.6)	0	(0.3)	0	(0.4)
$T_{74\text{-}87}$	-0.022	(12.6)	-0.017	(14.2)	-0.017	(12.6)	-0.017	(11.6)
C_1	0.033	(1.1)	0.032	(1.4)	0.171	(7.2)	0.173	(7.7)
C_2	0.275	(8.6)	-0.036	(1.5)	-0.033	(1.6)	-0.033	(1.6)
C_3	-0.235	(6.4)	-0.292	(10.3)	-0.255	(10.1)	-0.256	(10.2)
C_4	-0.007	(0.2)	-0.12	(4.4)	0.008	(0.3)	0.018	(0.9)
C_5	-0.07	(2.6)	-0.115	(5.4)	-0.006	(0.3)	-0.001	(0.1)
Efficiency Effects								
Constant	0.189	(1.7)	-0.354	(1.2)	-1.556	(12.8)	-1.317	(6.4)
H	-0.217	(10.9)	-0.203	(5.0)	-0.025	(3.6)	-0.045	(4.1)
SWOPEN	0.039	(0.8)	-0.064	(0.8)	-0.17	(4.3)	-0.236	(1.4)
LAND	0.51	(9.1)	0.76	(5.2)	0.361	(9.8)	0.343	(9.8)
LAT	-0.014	(7.8)	-0.012	(4.0)	-0.018	(16.7)	-0.019	(7.8)
TROP	0.227	(3.8)	0.513	(3.9)	1.176	(18.1)	1.086	(8.2)
ICRGE			-0.029	(1.3)	-0.007	(0.5)	-0.022	(2.2)
ETHNIC					0.009	(12.9)	0.008	(8.3)
*SWOPEN*H*							0.014	(0.4)
σ^2	0.278	(11.3)	0.363	(5.2)	0.166	(11.7)	0.173	(23.9)
γ	0.876	(55.3)	0.96	(117.4)	0.863	(51.7)	0.871	(65.2)
Countries	82		77		75		75	
Obs.	2168		2043		1999		1999	

t-stats in parenthesis

Of the determinants of efficiency a number of robust results are established. First, geography is found to be an important explanation of cross-country differences in efficiency. The level of efficiency is found to depend significantly on whether the country is landlocked, is in the tropics, as well as its latitude. These mirror earlier findings by Bloom, Canning and Sevilla (2002) and Hall and Jones (1999) of the importance of geography in determining the level of productivity. Efficiency is found to depend weakly on social institutional variables. In model (2), (3) and (4) inefficiency is found to decrease with increases in institutional quality, as measured by ICRGE, but this effect is significant only in model (4). Inefficiency is found to depend robustly by ethnic diversity however. Increases in ethnic diversity increase inefficiency. Rodrik (1998) argues that ethnic cleavages generate a lack of co-operation and rent-seeking behaviour between groups resulting in sub-optimum payoffs from the investments. Bloom, Canning and Sevilla (2002) and Koop, Osiewalski, and Steel (2000) have found social institutional variables to be important.

The results for human capital and openness to international trade are interesting. Human capital appears to significantly help to explain cross-country differences in income levels when using a SFA methodology. This supports claims in Benhabib and Speigal (1994) and Pritchett (1995) that human capital affects productivity. However unlike those authors we find that this result is robust to the inclusion of human capital in the frontier in model (5). Human capital appears to have a dual effect on the economy it affects output through its use as an input and its effect on productivity. The coefficient on human capital is sensitive to the choice of conditioning variables. The effects of an increase in human capital predicted by model (3) are much lower than those for model (1). It would appear that much of the variation in efficiency levels being captured in model (1) by human capital in fact reflect differences in institutional quality and ethnic diversity. It is not surprising that countries with better quality institutions have higher average levels of human capital. Controlling for institutions in regressions that include human capital is clearly important.

Openness to international trade does not appear to be important for explaining differences in efficiency once variations in the data generated by differences in ethnic diversity have been controlled for. This result might be used to suggest that trade liberalisation in countries that are ethnically diverse does not yield an identical payoff to countries without such ethnic diversity. This might be because the likelihood that conflict over the nature of trade reforms and concessions to some social groups are more likely in ethnically diverse countries. Unlike Miller and Upadhyay (2000) in model (4) we uncover no indirect role of trade openness through human capital, an interaction term is insignificant. The benefits to human capital do not appear to be greater in countries that are more open to international trade.

Table 2 Results 2

	(5)		(6)	
Production frontier				
Constant	12.070	(16.5)	-6.546	(5.58)
k	0.323	(4.42)	1.727	(9.62)
l			-0.340	(2.00)
k^2	0.006	(2.66)	0.000	(0.02)
l^2			0.073	(7.77)
kl			-0.064	(3.90)
hl	-1.721	(9.24)		
hl^2	-0.025	(2.70)		
hlk	0.077	(7.84)		
$t_{60\text{-}73}$	-0.001	(0.55)	0.001	(1.15)
$t_{74\text{-}87}$	-0.019	(11.2)	-0.008	(5.76)
C_1	0.569	(22.2)		
C_2	0.076	(3.03		
C_3	0.217	(7.47)		
C_4	0.305	(9.44)		
C_5	0.144	(7.09)		
Efficiency Effects				
Constant	-3.126	(16.3)	1.405	(16.5)
H	-0.025	(3.15)	-0.072	(11.4)
SWOPEN	-0.064	(1.61)	-0.090	(2.48)
LAND	0.703	(9.67)	-0.673	(2.17)
LAT	-0.011	(9.10)	0.000	(1.11)
TROP	2.008	(16.8)		
ICRGE	0.126	(7.15)	-0.066	(8.97)
ETHNIC	0.010	(13.4)	-0.003	(5.68)
σ^2	0.180	(12.7)	0.014	(12.7)
γ	0.783	(35.7)	0.485	(7.8)
Countries	75		24	
Obs.	1999		776	

t-stats in parenthesis

6 OECD Countries and Fiscal Variables

In this section we will consider the effect of a number of variables intended to account for governments' fiscal stance. However, since this will reduce considerably the number of countries that we can analyse, it is useful to consider the effects of this on our reduced sample size before we consider the effects of the fiscal variables.

Before we continue, it is appropriate to consider the effects of reducing the sample size before we consider those of our additional variables. The results of this estimation are shown in column

(6) of Table 2. Many of the variables found to affect the broader sample of countries also effect inefficiency in OECD countries, although some of these have unexpected signs. For example, ethnically diverse countries are found to have higher efficiency levels than ethnical homogeneous countries. This may reflect the quality of institutional structures in OECD countries that stops the effect of ethnic diversity negatively affecting productivity or the fact that the issues surrounding ethnic diversity are very different in OECD countries than in Africa, for example. Landlocked countries also have higher efficiency rather than lower efficiency. This variable picks up the effect of Switzerland, which has high efficiency. It is no surprise to learn that efficiency is not found to be affected by the latitude of the country, since there is very little variation in this variable within OECD countries. This result supports findings in Bloom, Canning and Sevilla (2002) for the growth rate of productivity. Finally it is also worth noting that the effect of human capital and trade openness is higher in OECD countries than in the broader sample of countries.

In this section we also test whether the level of efficiency is associated with fiscal policy. At the simplest level this might be tested by including a measure of government size (such as government expenditures or taxation) into the estimated production function. However the developments within the endogenous growth literature by the likes of Barro (1990), Devarajan *et al* (1996) and Mendoza *et al* (1997) lead us to conclude that the composition of fiscal policy may also be important.[8] In the Barro (1990) model the growth effects of various government tax and expenditure policies depend on their classification as one of four types. Decreases in distortionary taxes and increases in productive expenditures raise the steady state rate of growth, whereas non-distortionary and non-productive expenditures have no direct effect. One important policy conclusion that can be drawn from the Barro model is that the growth effect of any particular change in fiscal policy on growth can only be properly identified with reference to the government budget constraint, the chosen method of financing.

Drawing on the earlier work of Mofidi and Stone (1989) and Miller and Russek (1997), Kneller, Bleaney and Gemmell (1999) and Bleaney, Gemmell and Kneller (2001) test the empirical counterpart of the Barro model. Kneller *et al* (1999) stress the importance of accounting for the government budget constraint when estimating the growth effects of fiscal policy. The authors show that the interpretation of the coefficients from a regression that includes fiscal policy variables depends in part upon which fiscal variables have been omitted from the estimated

[8] While all of these models are endogenous growth models fiscal policy would affect the level of income in a similar manner in neo-classical models.

equation. For example, were welfare spending alone to be included in the estimated equation then the coefficient on this variable would provide information as to its effect on GDP growth conditional on changes in the omitted elements of the budget constraint (which include the budget surplus, productive expenditures and distortionary taxation). Kneller *et al* (1999) follow the predictions of the Barro (1990) model and omit instead those fiscal categories predicted by the theory to have no effect on growth. Once the government budget constraint is properly specified in the estimated regression the predictions of the Barro (1990) contain empirical support.

We follow this same methodology in the paper, but here we test for the effect of fiscal policy on the level of inefficiency. In so doing we aggregate the functional classification of the fiscal data in the IMF Government Financial Statistics into one of 7 groups. A key issue is the allocation of taxes and expenditures respectively to distortionary/non-distortionary and productive/non-productive categories. Whilst all major taxes are distortionary and in some respect discretionary, in testing endogenous growth models the relevant distortion is that on growth. Following Barro (1990), we treat income and property taxes as ‘distortionary’ and consumption (expenditure-based) taxes as ‘non-distortionary’. This is done on the grounds that the latter do not reduce the returns to investment, even though they may affect the labour/leisure choice. Of course, in more sophisticated models consumption taxes do distort the decision to invest (indirectly) to the extent that they affect the labour-education-leisure choices of agents. In allocating expenditures to productive/non-productive categories we generally follow Barro and Sala-i-Martin (1995) and Devarajan *et al* (1996) and treat expenditures with a substantial (physical or human) capital component as ‘productive’. Fiscal variables that we are unsure how to classify we aggregate into residual categories labelled other expenditures and other revenues. Finally we also include a measure of the budget surplus/deficit. Full details as to how the data are classified can be found in the Appendix. Restriction on the availability of the data combined with a desire that the fiscal policies included in these aggregate categories were comparable across countries meant this analysis is conduced on a sub-sample of OECD countries only.

We begin however by reporting the results for total revenues and total expenditures in model (7). While both have the expected sign neither are significant. This implies that the larger size of governments in European countries is not necessarily associated with lower efficiency. The results from the remaining two models do imply however that the structure of fiscal policy is important.

In the final two sets of results we report the results from the inclusion and exclusion of non-productive expenditures and non-distortionary taxation. Some sensitivity of the parameters to the choice of excluded fiscal category suggests caution in the interpretation of the parameters and also the importance of accounting for the government budget constraint in analysis of this sort. Of the fiscal variables included in the models only the budget surplus (*B.SURP*) and other expenditures (*EOTH*) is robust in all of the models. The results from these variables imply that increases in the budget surplus (reductions in the deficit) or increases in other expenditures financed by increases in non-distortionary taxation or reductions in non-productive expenditure reduce inefficiencies.

Table 3 Results, reduced sample

	(7)		(8)		(9)	
Production frontier						
Constant	-0.162	(0.0)	5.092	(3.8)	2.516	(1.6)
k	0.822	(2.1)	0.365	(1.6)	0.541	(2.7)
l	0.355	(1.5)	0.476	(2.3)	0.503	(2.8)
k^2	0.033	(3.5)	0.042	(5.0)	0.04	(5.3)
l^2	0.092	(8.0)	0.09	(7.5)	0.091	(7.7)
kl	-0.114	(7.5)	-0.116	(6.8)	-0.118	(7.0)
$t_{74\text{-}87}$	-0.007	(5.6)	-0.009	(6.1)	-0.009	(5.5)
Efficiency Effects						
Constant	1.385	(10.8)	1.261	(11.2)	1.358	(12.9)
H	-0.053	(3.8)	0	(0.2)	-0.061	(5.6)
SWOPEN	-0.386	(8.6)	-0.01	(3.0)	-0.387	(8.3)
LAND	-0.053	(1.4)	-0.002	(0.4)	-0.015	(0.5)
LAT	-0.001	(1.9)	0.009	(2.8)	-0.002	(3.0)
ICRGE	-0.041	(3.4)	0.007	(1.8)	-0.038	(2.9)
ETHNIC	-0.004	(6.0)	-0.004	(1.7)	-0.003	(5.0)
RTOT	0.002	(1.1)				
ETOT	-0.001	(1.0)				
B.SURP			-0.059	(6.8)	-0.008	(2.5)
RDIS			-0.337	(10.7)	0.002	(0.7)
RNDIS					0.022	(4.3)
EPRD			-0.068	(2.7)	0.005	(0.8)
ENPRD			-0.001	(2.0)		
ROTH			-0.028	(2.6)	-0.005	(0.3)
EOTH			-0.003	(5.8)	-0.017	(3.8)
σ^2	0.008	(7.7)	0.007	(8.9)	0.007	(6.0)
γ	0.379	(1.5)	0.143	(1.0)	0.293	(1.5)
Countries						
Obs.						

t-stats in parenthesis

The coefficients on the distortionary taxation (*RDIS*) and productive expenditure (*EPRD*) are significant only when non-distortionary taxation is used as the implicit financing variable (model 8) and the coefficient on *RDIS* has an unexpected sign. We might draw a number of conclusions from this result. First, the level of productive expenditures in many OECD countries is not beyond their optimum level, such that the marginal benefit of any further increase in expenditures of this type is positive. Second, the government expenditures and revenues included in these categories should not all be considered to be productive or distortionary. Some caution on this conclusion is warranted and while the results in Table 3 are suggestive further research on the issue of fiscal policy and efficiency may yield some interesting results.

7 Conclusion

In this paper we have investigated the influences of a variety of geographic, social and economic factors on differences in economic efficiency in a diverse panel of countries using stochastic frontier analysis. The advantage of this methodology is that it closely mirrors the economic theory underlying it and allows us to investigate the production technology and the determinants of deviations from best practice production in a single model.

We find that geography is important in explaining differences in productivity. Landlocked countries are less efficient, as are those nearer the equator and tropical countries in particular. These geographic variables are robust to the specification of the efficiency determinants. Our results support the thesis that human capital is important for enabling a country to absorb frontier technology and as such provides support for the results of work such as Benhabib and Spiegel (1994). This result is robust to the inclusion of human capital in the frontier. Therefore, unlike Benhabib and Spiegel (1994) we cannot conclude that the effect of human capital on output is solely through its effect on productivity.

The results for other variables are less robust. In some of our specifications openness to international trade does appear to increase inefficiency, but this result is not significantly significant in the majority of specifications. In our analysis of the larger sample of countries, ethnic diversity appears to reduce efficiency. This result supports the argument of Rodrik (1998) that ethnic cleavages lead to conflict over the division of output that are inefficient. This result does not hold in the reduced sample of OECD countries, where the effect is in fact positive.

However, it is unlikely that ethnic diversity in these countries represents the same type of ‘ethnic cleavage’ as it does in non-OECD countries.

We also investigate the effects government policy, as measured by a set of fiscal variables, on a sub set of OECD countries over a shorter time-span. We find that it is not necessarily the overall size of government, but rather the structure of fiscal policy that is the important factor in explaining differences in economic efficiency. Although some of the parameters are sensitive to the choice of variables, one result that is robust is the effect of the budget surplice and the ubiquitous ‘other’ expenditures. We find that increases in the budget surplus (or reductions in the deficit), or increases in other expenditures are associated with lower levels of productive efficiency in the economy as a whole.

Table A: Theoretical Aggregation of Functional Classifications

Theoretical Classification	Functional Classification
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
productive expenditures	general public services expenditure defence expenditure educational expenditure health expenditure housing expenditure transport and communication expenditure

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