UNITED NATIONS UNIVERSITY
UNU-WIDER
World Institute for Development Economics Research

Research Paper No. 2007/46

Public Sector Efficiency and Small Island Developing States

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August 2007

Abstract

This paper examines the efficiency of public sector expenditures at achieving social sector outcomes in small island developing states (SIDS). Public sector efficiency is estimated using a stochastic production function (SPF) approach and panel data since 1990. A second stage of the analysis examines the determinants of efficiency. Results indicate that the efficiency of public sectors at improving life expectancy has deteriorated during the 1990s but efficiency at improving school enrolments has increased. Higher levels of governance are associated with higher public sector efficiency. There is also evidence to suggest that efficiency is lower in SIDS, as well as in Sub-Saharan Africa.

Keywords: public sector expenditures, efficiency, life expectancy, school enrolments

JEL classification: H11, H51, H52

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This study has been prepared within the UNU-WIDER project on Fragility and Development, directed by Mark McGillivray and Amelia Santos-Paulino.

UNU-WIDER gratefully acknowledges the financial contribution to the project by the Australian Agency for International Development (AusAID), the Finnish Ministry for Foreign Affairs, and the UK Department for International Development (DFID).

UNU-WIDER also acknowledges the financial contributions to the research programme by the governments of Denmark (Royal Ministry of Foreign Affairs), Norway (Royal Ministry of Foreign Affairs), and Sweden (Swedish International Development Cooperation Agency—Sida).

ISSN 1810-2611 ISBN 92-9190-989-0 ISBN 13 978-92-9190-989-6

Acknowledgements

The authors are grateful to Mark McGillivray for helpful comments and suggestions.

Acronyms

CPI consumer price index

DEA data envelopment analysis

FDH free disposable hull method

HDI human development index

MDGs Millennium Development Goals

RICE relative income conversion efficiency

SIDS small island developing states

SPF stochastic production function

WDI *World Development Indicators*, World Bank

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Typescript prepared by Liisa Roponen at UNU-WIDER

1 Introduction

Increasing expenditures devoted to health and education is likely to be important in assisting with the achievement of the Millennium Development Goals (MDGs) by the year 2015. However, increasing the level of these expenditures does not always lead to better health and education outcomes. Improving their efficiency is also crucial in improving levels of human wellbeing. This paper has two main objectives. The first is to examine which countries have the most efficient public sector expenditures using stochastic production frontier (SPF) analysis. The second objective is to identify the factors that are most important in explaining the variation in efficiency. The paper focuses on small island developing states (SIDS) and Pacific SIDS in particular.

Although no official definition of SIDS exists, the list of 37 countries categorized as SIDS by the United Nations indicates they are a heterogeneous group of countries, including both low- and middle-income countries with populations ranging from a few thousand to over nine million. They are constrained by small domestic markets with limited opportunities to experience economies of scale, volatile economic growth rates, a heavy dependence on imports, high levels of export concentration, vulnerability to external shocks and, often, a lack of natural resources. Some, but not all, are remote and isolated, being a long distance from major international markets. Many receive the highest levels of aid in the world relative to the size of their populations and economies. Given their characteristics, there are often calls for special treatment of SIDS in international fora. Indeed, the eighth MDG includes a target to addresses the special needs of SIDS.

Although there is a literature examining whether economic growth is different in SIDS (see for example, Milner and Westaway 1993; Armstrong et al. 1998, Easterly and Kraay 2000) the efficiency of expenditures at improving human wellbeing in these countries has not been examined. Given the small size of SIDS, health and educational outcomes might be easier to achieve in these countries for a given level of resources. However, the revenue base of SIDS is usually small and volatile which could hamper the delivery of basic services. The social sectors might also suffer from a relatively small pool of skilled workers.

Pacific countries provide an interesting sub-sample of SIDS. There are a number of important reasons to focus on these countries. Pacific countries have, in general, fared less well than other SIDS during recent decades. Although these countries have had health and education expenditures at levels similar to other countries, health and education outcomes have shown little improvement during the last decade and some have even deteriorated.

The UN Millennium Project (2005) classifies the SIDS of the Pacific as Oceania and notes the poor progress these countries are making towards the achievement of the MDGs:

> The region is off track for nearly every Goal, and falling back in some areas. The share of undernourished people increased from 25 per cent to 27 per cent in between 1990-92 and 1999-2001. Net primary enrolment rates remain below 80 per cent. Measles immunization coverage dropped from 70 per cent to 57 per cent between 1990 and 2003. HIV and TB infection rates are rising, and maternal mortality remains high. Even where there is progress, it is too slow to

> achieve the Goals … Only Sub-Saharan Africa is off track on more indicators than Oceania (UN Millennium Project 2005: 21).

This paper examines which public sectors are the most efficient at achieving social outcomes. It does so by estimating SPFs for life expectancy and school enrolments. Panel data for developing countries covering the period 1990 to 2004 are employed. The public sector efficiencies derived from the SPF estimations are used as dependent variables in second stage regressions to examine the factors which explain the variation in efficiencies. At the outset, it is important to realise that such techniques should be used to gain insight into complex situations and cannot, in themselves, provide definitive answers. The results indicate that governance is important for public sector efficiency and that public sectors in SIDS and Sub-Saharan Africa are less efficient than other developing countries at improving life expectancy and school enrolments.

The remainder of this paper is organized as follows. Section 2 provides a brief overview of the empirical literature examining the impact and efficiency of public expenditures. Section 3 discusses the data and econometric procedure. Section 3 presents and interprets the results; finally section 5 concludes with some policy recommendations while recognizing the limitations of the research.

2 Previous literature

There are two strands of the existing academic literature that are related to the analysis of this paper. The first strand investigates whether there is a relationship between social outcomes, typically health and education outcomes and the expenditures directed towards these sectors. Some studies have found that the relationship between health expenditures and outcomes (usually measured by mortality rates) is tenuous (see, for example, Filmer, Hammer and Pritchett 1998; Filmer and Pritchett 1999; Jayasuriya and Wodon 2003). They find that other factors such as income per capita, income inequality, female education and ethnic fragmentation are more important in explaining rates of child and infant mortality. Other studies have found positive associations (Anand and Ravallion 1993; Bidani and Ravallion 1997; Gupta, Verhoeven and Tiongson 1999; Evans et al. 2001). The evidence of relationship between education spending and educational attainment also appears to be mixed. Hanushek (1995) and Mingat and Tan (1998) and Jayasuriya and Wodon (2003) find little evidence of a relationship between the two, although a positive relationship is identified by Gupta, Verhoeven and Tiongson (1999). Rajkumar and Swaroop (2002) find the impact of health and education expenditures on outcomes is dependent upon the quality of governance.

The second strand of the literature examines the efficiency of countries at achieving social outcomes in addition to examining their determinants. There is a fairly large literature which has examined efficiency of public sectors. Efficiency has been measured using both parametric and non-parametric methods. Non-parametric methods, or deterministic techniques, include the free disposable hull (FDH) method and data envelopment analysis (DEA). These methods examine the relationship between a social outcome and input variables. No functional form is imposed on the data within these approaches. A frontier is derived such that all outputs lie below it with deviations from the frontier being attributed to inefficiency. Deterministic methods do not allow for any stochastic error and can therefore be sensitive to outliers.

Parametric or stochastic techniques estimate a model in which social outcome variables are regressed on public sector expenditures and other control variables. The main advantage of stochastic techniques is that they allow for random factors or shocks that are likely to impact on outcomes. Some studies simply use the residuals from estimating the model as a measure of efficiency. A residual is said to capture the difference in a country's actual social outcome with the outcome that is predicted given its level of income and other characteristics. The country with the highest residual is deemed the most efficient. If panel data are collected, a fixed effects model can be specified and efficiency can be calculated using the intercept terms of countries relative to that of a best performer. Other studies follow Aigner, Lovell and Schmidt (1977) in assuming that the error term of the model used to estimate the frontier has two components. The first component captures random errors while the second is a non-negative term capturing technical inefficiency. Battese and Coelli (1995) develop this approach further by specifying a model in which technical inefficiencies are allowed to vary through time.

Part of this literature extends the analysis further by seeking to explain the determinants of efficiency in a second stage regression. This sparse strand of the literature includes Moore et al. (1999) and Jayasuriya and Wodon (2003). This paper builds on these studies. Moore et al. (1999) calculate the efficiency with which countries convert their wealth or resources (measured by GDP per capita) into human development (measured by life expectancy and educational attainment). They term this the relative income conversion efficiency (RICE). In the second stage they use a number of variables to explain variations in RICE. The study finds that the most important variables are population density, geographic location, quality of institutions, and state-society relations. State-society relations measure the extent that governing elites are financially independent of their own citizens and is negatively correlated with RICE. However, counter-intuitively, institutional quality is negatively associated with RICE.

Jayasuriya and Wodon (2003) examine the most efficient countries at achieving life expectancy and net primary school enrolments. They use a panel of 76 countries covering the period 1990 to 1998. In the first stage they estimate a SPF using per capita expenditures on health and education, the level of GDP per capita, the adult literacy rate, a time trend and region dummies as explanatory variables. In the second stage they explain the variation in efficiency using measures of corruption, bureaucratic quality and urbanization. Results indicate that bureaucratic quality and urbanization are the most important determinants of efficiency in determining health and education outcomes but with diminishing returns. These variables explain up to half of the variation in efficiency measures between countries.

3 Methodology and data

This paper employs a SPF approach to measuring public sector efficiency. SPF techniques were initially proposed by Aigner, Lovell and Schmidt (1977). The model employs panel data and is estimated using maximum likelihood. The strength of the approach is that the country specific technical efficiencies are allowed to vary through time. In a second stage regression the estimated efficiencies are regressed on a number of other variables to identify the most important determinants of social efficiency.

The SPF estimated in the first stage is specified as follows:

$$\ln y_{it} = \alpha + \beta \ln x_{it} + (v_{it} - u_{it}) \qquad (1)$$
$$i = 1,.....,N, \qquad t = 1,.....,T$$

where y_{it} represents a health or education outcome for country i at time period t. x_{it} is a vector of country-specific control variables, and β is a vector of unknown parameters. The v_{it}s are assumed to be random errors ~ $N(0,\delta^2_v)$. The u_{it}s are non-negative random variables referred to as the inefficiency term.

This paper follows the Battese and Coelli (1992, 1995), parameterization of the time effects, known as the time-varying decay model. In this model the inefficiency term is modelled as a truncated-normal random variable multiplied by a specific function of time: $u_{it}=u_i\{\exp[-\eta(t\text{-}T)]\}$, where T corresponds to the last period in each panel and η is the decay parameter to be estimated. Technical efficiency can either be increasing (η>0), decreasing (η<0) or remain constant (η=0).

The model estimated in the second stage is specified as follows:

$$u_i = \alpha_0 + \gamma z_i + e_i$$
$$i = 1,.....,N$$

where u_i is the time averaged country-specific technical efficiency term estimated from the first stage regression.[1] z_i is a vector of averaged country-specific variables believed to impact on public sector efficiency, and γ is a vector of unknown parameters.

This paper examines the efficiency of public sector expenditures on both health and educational outcomes. It therefore estimates two SPFs and examines the determinants of efficiency in two subsequent OLS regressions. There are various options regarding the choice of dependent variables for the estimates of the SPFs. Following Moore et al. (1999), this paper uses (i) life expectancy as an outcome for health and (ii) combined gross primary and secondary and school enrolments (with an equal weighting) are used as the measure for educational achievement.[2] These are widely accepted measures of wellbeing and represent components of the UNDP's human development index (HDI). Data for these measures of wellbeing are more widely available than for other measures. Moreover, these two outcomes are directly affected by public sector expenditures. Life expectancy is defined as the number of years a newborn infant would live if prevailing patterns of age-specific mortality rates at the time of birth were to stay the same throughout the child's life.[3] Gross enrolments relate to the number of students enrolled

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1 The model can include the same variables as those included in the SPF, provided the inefficiency effects are stochastic (Battese and Coelli 1995).

2 Note Moore et al. (1999) also include gross tertiary enrolments in the calculation of their dependent variable. Infant, child and maternal mortality rates are other commonly used measures of health. Years of schooling, school retention rates and literacy rates are commonly used measures of educational outcomes. Given the focus of the current paper on SIDS, data availability prevented an analysis of public sector expenditures on these outcomes.

3 This paper notes that these outcomes can be the result of public sector expenditures in years prior to the current. For example since current mortality rates reflect health care in previous years, life

in a level of education, regardless of age, as a percentage of the population of official school age for that level.[4]

Careful consideration was given to the explanatory variables included in the first stage regression versus the second stage, since this has been a criticism of the approach used in the existing literature.[5] The efficiency of public sectors is the primary focus of the paper. In the first stage it is therefore important to include the resource inputs which are at the disposal of the public sector. These include health and education expenditures and also foreign aid since international donors provide additional resources for public sector spending.[6] Expenditures are expressed as a ratio to GDP for the current year. Jayasuriya and Wodon (2003) argue that there is a low risk of endogeneity bias using cross-country expenditure data since fiscal constraints tend to limit opportunities to increase expenditures quickly when outcomes are deficient.[7] However, in some specifications, the expenditures are lagged to examine whether results are sensitive to these changes.

To interpret the u_{it}s as measures of efficiency, we argue that it is also important to control for other factors which impact on the social outcomes but which are outside the direct control of the recipient government in the first stage regression. Variables include the level of per capita income, urbanization, population density, the level of ethnic fractionalization, the fraction of land located in the tropics, and a time trend to capture technological improvements.[8] These fundamental control variables are very difficult or impossible for governments to alter in the short run.[9] Unless we control for these variables in the first stage, a public sector could be deemed inefficient even though its

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expectancy is to some extent historically determined. The issue of how to appropriately incorporate lags of expenditures into such an analysis is problematic and remains an important area for future research (for example, see Gupta, Honjo and Verhoeven 1997: 19).

4 The gross enrolment ratio can be greater than 100 per cent as a result of grade repetition and entry at ages younger or older than the typical age at that grade level (see UNDP 2005).

5 For example, Ravallion (2003) argues that it is unclear which variables should be applied in the first stage of the regression analysis and which should be employed in the second. He also notes that misspecification in the first stage will contaminate the second stage results.

6 Ideally, primary health expenditures and primary and secondary school expenditures would be employed in the model since it is these specific categories of expenditures which should impact on the dependent variables in the SPFs. Unfortunately, disaggregated expenditure data are not available for most SIDS.

7 Few studies control for the potential joint causality between social outcomes and social spending. Exceptions include Filmer and Pritchett (1999) who instrument health expenditures using average public sector health spending as a share of GDP and average defence spending as a share of GDP of a country's geographic neighbours. Rajkumar and Swaroop (2002) instrument for health expenditures using health expenditures of a neighbouring country and their own population. However, results from 2SLS estimation reported by these studies are similar to those from OLS.

8 Provided the technical inefficiency effects are stochastic, the model permits the estimation of both technical change and time-varying inefficiencies (Battese and Coelli 1995).

9 Unlike Jayasuriya and Wodon (2002) we do not include a full list of regional dummy variables. Including these dummies implies that the SPF is allowed to vary by region and that the predicted efficiencies are regional rather than global. We see no reason a priori to believe that region should have an impact on the level social outcomes and they are therefore not included in the first stage regressions. However, the impact of region on public sector efficiency is examined in the second stage regressions.

predicted efficiency is a result of low levels of urbanization or high levels of ethnic fractionalization, for example.

Income is included since those with higher incomes are likely to experience better health outcomes through better nutrition, housing and sanitation (Filmer and Pritchett 1999). The relative cost of sending children to school is also lower for those on higher incomes (Gupta, Verhoeven and Tiongson 1999). Population density and urbanization are included since higher levels of these variables are likely to imply that access and delivery of health and education services are cheaper and easier. Ethnic fractionalization is included since minority groups often have lower health and education indicators; it is also postulated that countries with high ethnic tensions can create greater political fractionalization leading to inferior social outcomes (Filmer and Pritchett 1999). Tropical area is included since it is well established that countries located in this region suffer from a large number of epidemics and diseases.

In the second stage regression analyses, potential determinants of public sector efficiency are included as explanatory variables. These variables relate to factors not directly related to health and education outcomes but which might have an impact on the relationship between inputs and outputs in these sectors. They are loosely termed 'policy variables' and relate to macroeconomic and institutional environment. They are all at least partially under the control of recipient public sectors.

A macroeconomic policy index is employed as an explanatory variable. Following Burnside and Dollar (2000) the index consists of two equally weighted components: inflation and trade (measured as the ratio of imports plus exports to GDP).[10] Governance is measured using indicators from Kaufman, Kraay and Mastruzzi (2006). These indicators include measures of (i) voice and accountability, (ii) political stability, (iii) government effectiveness, (iv) regulatory quality, (v) government effectiveness and, (vi) control of corruption. These governance indicators are equally weighted in the construction of a governance index.

A donor fragmentation index is also included to capture the presence of donors with a small share of total aid provided to the recipient. High values of the index are associated with greater donor fragmentation. It is postulated that a large number of donors in a country might reduce the effectiveness of aid at increasing social outcomes by placing a large administrative burden on recipients (Knack and Rahman 2004). Public sectors face negotiation, management and reporting requirements for all aid projects. A population variable is included to examine whether the size of a country impacts on public sector efficiency. Explanatory variables also include illiteracy (as a measure of human capital), and dummy variables for Sub-Saharan Africa and SIDS.

In the regressions explaining life expectancy, panel data for 111 countries over the period 1990 to 1998 are used.[11] Data availability permits the first stage regression that

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[10] Burnside and Dollar (2000) also include a country's budget balance (expressed as a ratio to GDP) in their policy index. The components of their index are weighted using parameter estimates on these variables from an economic growth regression. Our view is that the inflation variable will capture serious budgetary imbalances.

[11] Data relating to public health expenditures as a percentage of GDP were obtained from the World Bank's *World Development Indicators* database and the Asian Development Banks, *Key Indicators of Developing Asian and Pacific Countries*. Data for the years after 1998 could not be used due to a

explains gross primary and secondary school enrolments (combined) to include 115 countries over the period 1990 to 2002. Data on life expectancy, health expenditures, urbanization, population density, population, trade, inflation, budget balances and illiteracy came from the World Bank (various) and the ADB (various). Data on school enrolments and education expenditures came from UNESCO (2006). Aid data were obtained form the OECD (2006), ethnic fractionalization data from Grimes (2000), and tropical area data from Gallup and Sachs (1999). Further details of the data are available in Tables A1 to A4 of the Appendix.

4 Results and interpretation

Results from the estimation of the SPF using maximum likelihood for life expectancy are provided in Table 1. Results are provided for five different model specifications. The first model assumes that the country-specific technical inefficiency effects are time invariant. The second model uses the Battese and Coelli (1992) parameterization of the time effects to examine whether technical efficiency has changed during the sample period. Minor specification changes are applied in the remaining three models to examine the sensitivity of results.

Results from Model 1, provided in the second column indicate that GDP per capita, urbanization and population density are positively associated with life expectancy. Following Jayasuriya and Wodon (2003), an urbanization squared term is included to pick up diminishing returns from this variable with respect to life expectancy. The coefficients attached to the urbanization variables confirm the existence of such a relationship.[12] Tropical area and the level of ethnic fractionalization are negatively associated with life expectancy, and the coefficients attached to these variables are statistically significant. The coefficient on the year variable is not statistically significant indicating that technological change has not been important in improving life expectancy during the sample period.

There is no evidence that health expenditures or foreign aid is associated with levels of life expectancy. The former result is consistent with a number of previous studies and suggests that the quality of expenditures is likely to be more important for changes in life expectancy rather than the level of expenditures (Filmer, Hammer and Pritchett 1998; Filmer and Pritchett 1999; Jayasuriya and Wodon 2003). Since foreign aid constitutes an important component of public sector expenditures, its inclusion in the regression equation might lead to double counting and biased results (Gomanee et al. 2005). However, the coefficient on the aid variable remains statistically insignificant when the health expenditures variable is omitted from the model (and vice versa). Results also remain the same if health expenditures are expressed on a per capita basis.

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change in the classification of these expenditures in the World Bank database. Ideally private health expenditures would also be included in the first stage regressions. However, there are concerns over the accuracy over these data and they are not readily available for Pacific and other SIDS.

12 Results from other specifications (not reported here for parsimony) found no evidence of diminishing returns for life expectancy in the cases of population density and foreign aid.

Table 1
SPF estimation results (maximum likelihood)—life expectancy

Log(Life expectancy)	(1)	(2)	(3)	(4)	(5)
Constant	6.887 (3.85)***	0.388 (0.17)	1.816 (0.73)	2.608 (0.64)	1.653 (0.65)
GDP per capita ($US)	0.079 (6.28)***	0.070 (6.01)***	0.079 (6.67)***	0.095 (6.50)***	0.079 (6.50)***
Health expenditures (% GDP)	0.001 (0.20)	0.003 (0.45)	0.002 (0.29)		0.002 (0.30)
Health expenditures (% GDP)_1				-0.001 (0.13)	
Urbanization	0.548 (6.79)***	0.595 (6.97)***	0.619 (7.35)***	1.116 (7.92)***	0.622 (7.33)***
Urbanization^2	-0.081 (6.11)***	-0.088 (6.33)***	-0.092 (6.66)***	-0.167 (7.46)***	-0.092 (6.64)***
Population density	0.015 (2.19)**	0.008 (1.18)	0.011 (1.65)*	-0.001 (0.10)	0.010 (1.46)
Tropical area	-0.901 (3.58)***	-0.690 (3.01)***	-0.848 (3.60)***	-1.861 (5.85)***	-0.831 (3.42)***
Ethnic fractionalization	-0.781 (2.38)**	-0.645 (2.46)**	-0.654 (2.48)**	-0.684 (2.01)**	-0.644 (2.38)**
Net ODA (% GDP)	0.003 (0.29)	0.000 (0.05)			
Social ODA commitments (% GDP)			0.003 (1.86)*		0.003 (1.88)*
Social ODA commitments (% GDP)_1				-0.001 (0.35)	
SIDS					-0.005 (0.25)
Year	-0.000 (0.13)	0.003 (2.61)***	0.002 (1.90)*	0.003 (1.41)	0.002 (1.94)*
η	- -	-0.018 (3.32) ***	-0.018 (2.90) **	-0.013 (1.68) *	-0.018 (2.92) **
Observations	420	420	407	314	407
Number of countries	111	111	111	104	111

Note: *t*-statistics in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

Results from the estimation of Model 2, the time varying decay model, are similar to those from Model 1. The coefficients attached to the GDP per capita, urbanization, tropical area and ethnic fractionalization variables remain statistically significant. However, the coefficient on the population density variable loses its significance while the statistically significant coefficient on the year variable indicates that technological change has assisted in improving life expectancy. Importantly, the parameter η is negative and statistically significant, indicating that the degree of country inefficiency is increasing over time. The coefficient continues to be negative and significant in subsequent specifications. A potential explanation for this finding is the increase in HIV/AIDS and other diseases during the 1990s has led to a fall in countries efficiencies at improving the duration of life.

A potential explanation for the finding of no impact of foreign aid on life expectancy is that foreign aid consists of heterogeneous flows, many of which should not be expected to have an impact on life expectancy.[13] In Model 3, an alternative foreign aid variable is employed. This variable represents the volume of aid directed towards the social sectors. It is this component of foreign aid which should impact directly on health outcomes. Results from this model confirm a positive association between this variable and life expectancy which is statistically significant at the 10 per cent level.

Given concerns regarding the endogeneity of public sector expenditures and foreign aid, both of these variables are lagged in Model 4. Results from this model relating to public health expenditures remain unchanged. There is still no evidence that the level of these expenditures is associated with life expectancy. There is also no evidence of foreign aid impacting on life expectancy in this particular model specification.[14]

Table 2
Public sector efficiency of SIDS—life expectancy SPF

SIDS	Efficiency
Suriname	0.98
Belize	0.98
Dominica	0.98
Trinidad and Tobago	0.94
Vanuatu	0.94
Cape Verde	0.93
Tonga	0.92
Samoa	0.91
Fiji	0.91
Jamaica	0.90
Mauritius	0.89
Dominican Republic	0.88
St Vincent and the Grenadines	0.88
Grenada	0.87
Antigua and Barbuda	0.87
St Lucia	0.86
Guyana	0.86
Comoros	0.85
Papua New Guinea	0.85
Kiribati	0.83
St Kitts and Nevis	0.82
Maldives	0.79
Haiti	0.68

13 See for example, Clemens, Radelet and Bhavnani (2004) on the importance of foreign aid disaggregation.

14 Concerns regarding the endogeneity of variables should not be overplayed in this context. This paper is primarily concerned with deriving and explaining the efficiency of public sectors. It is important to control for factors which might be important in explaining social outcomes in the first stage regressions even though the coefficients attached to some variables might suffer from endogeneity bias.

In the final model we include a SIDS dummy variable to examine whether the level of life expectancy is different in this group of countries. The coefficient on the variable is not statistically significant. This is not surprising since the important factors which impact on life expectancy should be picked up by the other explanatory variables in the model. However, the efficiency of the SIDS at achieving life expectancy can be different, which is the issue examined in the second stage regressions.

Table 2 lists the (averaged) predicted technical efficiencies for SIDS using the results from Model 3. Note that the rankings of the countries would change very little if results from other model specifications were used. As Appendix Table A5 shows, correlation coefficients of the predicted technical inefficiency effects from the different models are very high. Table 2 shows that Surinam, Belize and Dominica have the highest technical efficiencies with respect to life expectancy and Haiti and the Maldives have the lowest. Vanuatu, Tonga, Samoa and Fiji have the highest efficiencies for Pacific countries while Papua New Guinea and Kiribati the lowest.

Table 3
SPF estimation results (maximum likelihood)—school enrolments

Log (Gross primary and secondary school enrolments combined)	(1)	(2)	(3)	(4)	(5)
Constant	-11.855 (5.03)***	-2.430 (0.89)	-2.350 (0.87)	-3.786 (1.49)	-2.556 (0.95)
GDP per capita ($US)	0.080 (3.50)***	0.054 (3.37)***	0.053 (3.44)***	0.035 (2.65)***	0.055 (3.67)***
Education expenditures (% GDP)	0.275 (5.88)***	0.280 (6.32)***	0.281 (6.39)***		0.287 (6.47)***
Education expenditures (% GDP)_1				0.281 (6.58)***	
Urbanization	0.489 (2.74)***	0.182 (0.71)	0.111 (3.78)***	0.097 (3.55)***	0.103 (3.24)***
Urbanization^2	-0.050 (1.92)*	-0.010 (0.28)			
Population density	0.039 (4.13)***	0.027 (3.45)***	0.027 (3.48)***	0.023 (3.45)***	0.026 (3.50)***
Tropical area	-1.162 (3.13)***	-0.534 (1.90)*	-0.530 (1.91)*	-0.284 (1.16)	-0.452 (1.61)
Ethnic fractionalization	-1.443 (3.12)***	-1.202 (2.95)***	-1.180 (2.98)***	-1.009 (2.73)***	-1.350 (3.19)***
Net ODA (% GDP)	0.027 (1.29)	0.036 (1.76)*	0.036 (1.78)*		0.039 (1.94)*
Net ODA (% GDP)_1				0.011 (0.56)	
SIDS					-0.036 (0.99)
Year	0.010 (12.17)***	0.005 (3.99)***	0.005 (3.99)***	0.005 (4.52)***	0.005 (4.15)***
η	- -	0.022 (7.62)***	0.022 (7.81)***	0.025 (8.76)***	0.021 (7.80)***
Observations	815	815	815	774	815
Number of group(country)	115	115	115	117	115

Note: *t*-statistics in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4
Public sector efficiency of SIDS—school enrolments SPF

SIDS	Efficiency
Guyana	0.96
Tonga	0.96
St Kitts and Nevis	0.93
Fiji	0.91
Suriname	0.89
Samoa	0.89
Seychelles	0.88
Belize	0.88
Kiribati	0.87
Grenada	0.86
Mauritius	0.83
Dominica	0.81
Trinidad and Tobago	0.80
Maldives	0.77
St Lucia	0.76
Dominican Republic	0.76
Jamaica	0.76
Cape Verde	0.74
Marshall Islands	0.73
Vanuatu	0.73
Solomon Islands	0.71
St Vincent and the Grenadines	0.65
Papua New Guinea	0.65
Comoros	0.59
Haiti	0.39

Results from the estimation of the SPF using maximum likelihood for school enrolments are provided in Table 3. Again, results are provided for five different model specifications. The first model assumes that the country specific technical inefficiency effects are time invariant. With the exception of the foreign aid variable all coefficients attached to the explanatory variables have their expected signs and are statistically significant. Results suggest that school enrolments are positively associated with GDP per capita the level of public sector education expenditures, urbanization, population density and year and negatively associated with tropical area and ethnic fractionalization. Interestingly, the level of education expenditures appears important for school enrolments even though the level of health expenditures does not appear to matter for life expectancy.

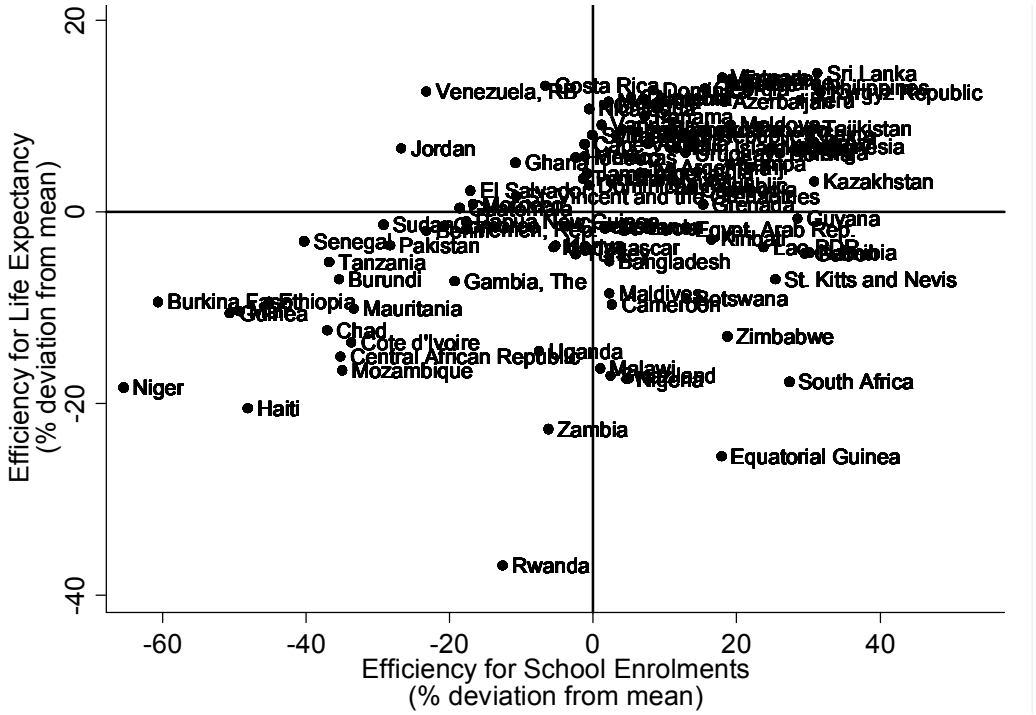
The coefficient on the foreign aid variable becomes statistically significant at the 10 per cent level in Model 2, the time varying decay model. However, the coefficients attached to the urbanization variables lose their statistical significance in this specification. The parameter η is positive and statistically significant in this model, indicating that public sector efficiency has improved during the sample period. Due to concerns of multicollinearity between the urbanization variables, the squared term of this variable is dropped in Model 3. There is a positive and significant coefficient on the urbanization variable in this model and all other results remain unchanged. In Model 4 the education and expenditure and aid variables are lagged one period. Although the coefficient on the

aid variable loses it statistical significance, the coefficient on the education expenditure remains virtually unchanged. Finally, in Model 5, the SIDS dummy variable is employed as an explanatory variable. The coefficient is not statistically significant. This suggests that the level of school enrolments in SIDS is not statistically different to other developing countries.[15]

Table 4 provides the predicted technical efficiencies from Model 4. Again, correlations between predicted efficiencies across the different models are very high (see Table A6 in the Appendix). Guyana and the Pacific nation of Tonga have the highest technical efficiencies while Haiti has the lowest. Fiji and Samoa are other Pacific countries with high technical efficiencies while Papua New Guinea's are relatively low.

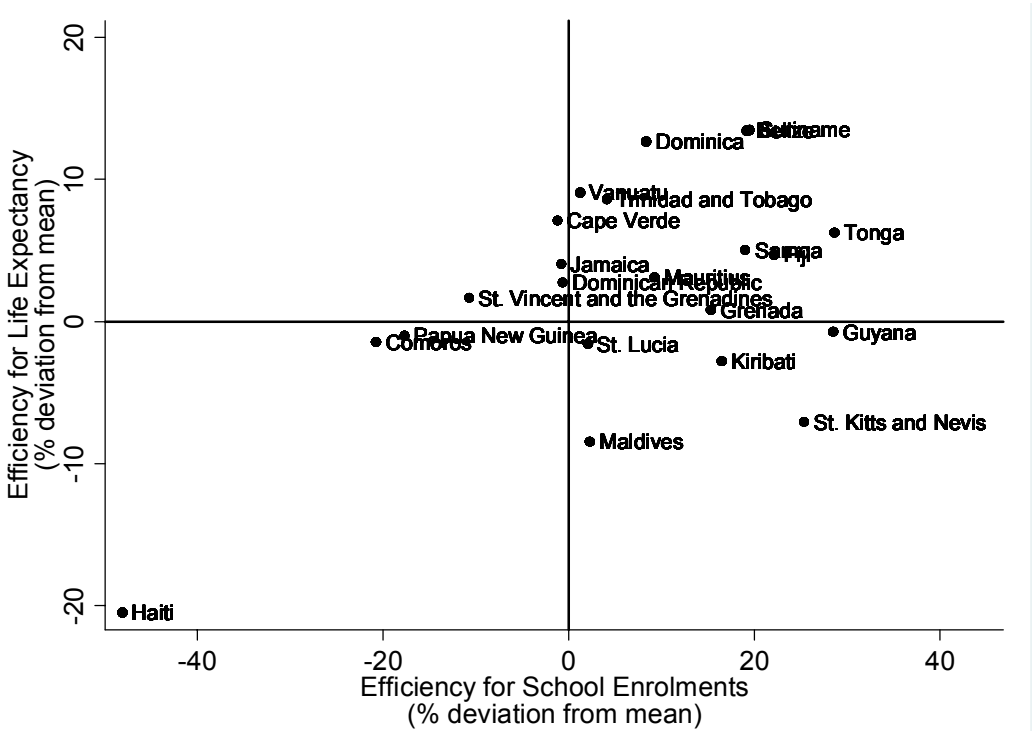
The correlation between the predicted technical efficiencies for life expectancy and school enrolments is fairly high (0.46). However, Figure 1 demonstrates that some countries have a relatively high technical efficiency with respect to life expectancy but a relatively low technical efficiency with respect to school enrolments (and vice versa). Some countries such as Niger and Haiti have low technical efficiencies for both social outcomes. The correlation between relative efficiencies for SIDS only is provided in Figure 2.

Figure 1
Public sector efficiency—full sample



15 UNESCO suggests caution should be exercised when using enrolment and expenditure data pre- and post-1998. A dummy variable controlling for this was included in the first stage regressions which was not statistically significant in any of the specifications. The coefficients attached to the other variables remained largely unchanged. Moreover, models for the periods 1990 to 1998 and 1999 to 2004 were run separately and results were in broad agreement with those presented in the paper.

Figure 2
Public sector efficiency—SIDS



The predicted technical efficiencies are now used as dependent variables in second stage regression to examine the potential determinants of public sector efficiency. Results using the technical efficiencies from the life expectancy regression are provided in Table 5. Five models are estimated. Results from Column (1) indicate that macroeconomic policies (proxied by trade and inflation) are not associated with public sector efficiency but that the level of governance is positively associated with efficiency. These two variables explain 13 per cent of the variation in efficiencies of public sectors at improving life expectancy. In Model 2, population is included as a variable to examine whether the size of a country might explain efficiency. The square of population is also included to capture a non-linear relationship. However, the coefficients attached to these variables are not statistically significant and the R^2 remains unchanged. In Model 3 dummy variables for SIDS and Sub-Saharan Africa are included together with an aid donor fragmentation index. Only the coefficient attached to the Sub-Saharan Africa dummy is statistically significant. The coefficient is negative and the R^2 from this model is much higher (0.53). There is, therefore, strong evidence to suggest that public sector efficiency is far lower in these countries, although results cannot reveal why.

In Model 4 the governance index is disaggregated into its various components. Interestingly it is the voice and accountability component which is statistically significant. The variable is defined as the extent to which citizens of a country are able to participate in the selection of governments, as well as freedom of expression, association and in the media. A high level of voice and accountability is associated with higher levels of public sector efficiency and this variable appears more important than corruption, regulatory quality and government effectiveness.[16] Moreover, the

[16] The various components of the governance index are fairly highly correlated but the result remains unchanged when the components are employed individually in the regression models.

coefficient attached to the SIDS dummy variable in this model is negative and statistically significant providing some evidence that public sector efficiency is lower in these countries. This finding is confirmed in Model 5 which includes illiteracy as an explanatory variable. The coefficient on this variable is negative and statistically significant although the R^2 increase only slightly.

The same models are estimated for the predicted efficiencies from the school enrolment regressions. Results are presented in Table 6. Results from Model 1 provide evidence that the level of governance but not macroeconomic policy is positively associated with public sector efficiency. However, the R^2 from this regression is a very low (0.05). Results from Model 2 indicate that the size of a country helps explain more of the variation in public sector efficiency. The coefficients attached to the population variables suggest a U-shaped relationship between size and efficiency. The level of efficiency is negatively associated with population size up to a certain threshold and then efficiency increases with size. Results indicate that this threshold is where population is 8.9 million.

Table 5
Determinants of public sector efficiency—life expectancy

	(1)	(2)	(3)	(4)	(5)
Constant	0.879 (46.87)***	1.166 (4.09)***	0.992 (10.80)***	1.003 (8.81)***	0.986 (8.26)***
Macroeconomic policy index	0.000 (0.54)	0.001 (0.99)	-0.000 (0.10)	0.000 (0.28)	-0.000 (0.01)
Governance index	0.066 (3.37)***	0.064 (3.26)***	0.038 (2.30)**		
Population		-0.045 (1.28)	-0.002 (0.40)	-0.001 (0.21)	-0.000 (0.04)
Population^2		0.002 (1.48)			
SIDS			-0.034 (1.27)	-0.058 (1.93)*	-0.051 (1.84)*
Donor fragmentation			-0.051 (1.16)	-0.082 (1.57)	-0.057 (1.00)
Sub-Saharan Africa			-0.123 (7.36)***	-0.123 (6.81)***	-0.101 (5.28)***
Voice and accountability				0.036 (2.07)**	0.038 (2.04)**
Political stability				0.007 (0.44)	-0.005 (0.35)
Government effectiveness				0.027 (0.83)	0.044 (1.60)
Regulatory quality				-0.018 (1.05)	-0.028 (1.54)
Rule of law				-0.001 (0.04)	0.020 (0.80)
Control of corruption				-0.015 (0.46)	-0.050 (1.66)
Illiteracy					-0.001 (1.94)*
Observations	102	102	102	96	86
R-squared	0.13	0.15	0.53	0.58	0.60

Note: Robust *t*-statistics in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Results from Model 3 suggest that public sector efficiency is lower in SIDS and Sub-Saharan African countries. Since the model controls for population, results indicate that SIDS might have characteristics other than their size which have a negative impact on public sector efficiency. Results from disaggregating the governance index into its various components provided in Model 4 fail to reveal any further insights into the variation of efficiencies. However, results from Model (5) reveal that the level of illiteracy is important in explaining efficiency. The coefficient attached to this variable is negative and statistically significant and the R^2 is for this model is 0.53. While it might be viewed as circular to argue that lower illiteracy in adult population will improve the efficiency of schooling provision, the finding does indicate the wide potential benefits of adult literacy programmes.

Table 6
Determinants of public sector efficiency—school enrolments

	(1)	(2)	(3)	(4)	(5)
Constant	0.720 (18.13)***	3.131 (4.62)***	3.693 (4.73)***	4.373 (4.37)***	3.500 (5.11)***
Policy index	0.001 (1.41)	0.001 (1.62)	0.001 (1.27)	0.001 (1.60)	0.001 (1.11)
Governance index	0.055 (1.79)*	0.051 (1.76)*	0.027 (0.88)		
Population		-0.320 (3.82)***	-0.354 (3.87)***	-0.435 (3.65)***	-0.340 (4.15)***
Population^2		0.010 (4.02)***	0.011 (4.00)***	0.013 (3.77)***	0.011 (4.30)***
SIDS			-0.115 (2.08)**	-0.137 (2.24)**	-0.103 (1.97)*
Donor fragmentation			-0.133 (1.19)	-0.170 (1.32)	0.159 (1.24)
Sub-Saharan Africa			-0.119 (2.77)***	-0.120 (2.62)**	-0.071 (1.48)
Voice and accountability				0.038 (1.16)	0.016 (0.60)
Political stability				-0.006 (0.18)	-0.027 (0.95)
Government effectiveness				-0.043 (0.68)	-0.007 (0.12)
Regulatory quality				0.017 (0.43)	-0.058 (1.44)
Rule of law				-0.015 (0.26)	-0.002 (0.04)
Control of corruption				0.031 (0.44)	0.053 (0.94)
Illiteracy					-0.005 (5.24)***
Observations	93	93	93	91	84
R-squared	0.05	0.15	0.29	0.33	0.53

Note: Robust *t*-statistics in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

5 Conclusion and policy recommendations

This paper uses SPF analysis to measure public sector efficiency in developing countries. Separate frontiers are estimated for public sector achievements in life expectancy and school enrolments. Factors important in explaining the variation in public sector efficiencies are explored in the second stage regressions. Results suggest that public sector efficiency at improving life expectancy has deteriorated during the 1990s (at a rate of around 1.8 per cent per year). However, efficiency at increasing school enrolments has increased (at a rate of around 2.2 per cent per year). Further, governance and literacy appear important for public sector efficiency and there is also evidence that efficiency is lower in SIDS and Sub-Saharan African countries.

Results from the estimation of the SPF for life expectancy indicate that the level of public sector health expenditures does not matter. This is consistent with a number of other studies. Improving public sector efficiency is therefore likely to be very important for the achievement of the MDGs by 2015. The international community should seek to address issues of efficiency in addition to providing additional resources for social sector spending. Results from this paper suggest that assisting with reforms in developing countries to improve governance and the level of human capital might be ways to achieve this aim.

The issue is particular pertinent for the SIDS since these countries appear to have lower public sector efficiencies relative to most other developing-country public sectors. A potential explanation is that the revenue base of SIDS is small and volatile thus hampering the delivery of basic services. The social sectors might also suffer from a relatively small pool of skilled workers.

However, this paper has identified some SIDS that are relatively efficient at achieving improvements in social outcomes. Additional resources from the international community are more likely to translate into improvements in wellbeing in these countries. To varying extents, donors provide aid to countries in which it has the greatest impact. Emphasis has been placed on favouring countries with good macroeconomic policy environments. Judging countries on the efficiencies of their expenditures is a better way of identifying countries in which aid is likely to lead to better social outcomes. Rather then neglect countries with low levels of efficiency, this paper argues that international donors should also use aid to support programmes which help improve the effectiveness of public sectors.

A limitation of the analysis conducted in the paper is that SPFs are only estimated for two social outcomes. Lack of data prevented an analysis of the impact of public sector expenditures on a number of other measures of human wellbeing. Further, the analysis was only carried out at a national level. Many developing countries are characterized by large regional inequalities in health and education outcomes and inequalities across gender, income and ethnic groupings. Efficiency at a provincial level can provide other important insights for policymakers.

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Appendix

Table A1
Variable definitions and sources (first stage)

Variable	Definition	Source
Life	The number of years a newborn infant would live if prevailing patterns of age-specific mortality rates at the time of birth were to stay the same throughout the child's life.	World Bank, WDI (2006)
School	Gross (number of students enrolled in a level of education, regardless of age, as a percentage of the population of official school age for that level) primary and secondary school enrolments combined (equally weighted).	UNESCO (2006)
Health	Ratio of total public sector health expenditures to GDP	World Bank, WDI (2006)
Education	Ratio of total public sector education expenditures to GDP	UNESCO (2006)
Per capita income	Real GDP per capita (2000)	World Bank, WDI (2006)
Ethnic fractionalization	Chance that two people drawn at random from the population will speak the same language	Grimes (2000)
Urbanization	Urban population as a % of total population	World Bank, WDI (2006)
Population density	Population per square kilometre	World Bank, WDI (2006)
Tropical area	The fraction of a countries land lying between the Tropic of Cancer and the Tropic of Capricorn	Gallup and Sachs (1999)
Foreign aid	Net official development assistance (ODA)	OECD (2006)

Table A2
Variable definitions and sources (second stage)

Variable	Definition	Source
Policy	Equally weighted index of trade (ratio of the sum of imports and exports to GDP) and inflation (annual percentage change in the consumer price index (CPI)).	Authors' calculation using data from World Bank, WDI (2006)
Governance index	Equally weighed index of the following dimensions of governance: - Voice and accountability - Political stability and absence of violence—government effectiveness - Regulatory quality - Rule of law - Control of corruption	Kaufman, Kraay and Mastruzzi (2006)
Population	Natural log of population	World Bank, WDI (2006)
Donor fragmentation	Inverse of an index calculated by summing the squares each donors share of aid in a recipient. A high value represents a high degree of donor fragmentation.	Authors' calculation using data from OECD (2006)
Illiteracy	Percentage of people ages 15 and above who cannot, read and write a short, simple statement on their everyday life.	World Bank, WDI (2006)

Table A3
Summary statistics—life expectancy SPF

Variable	Obs	Mean	Std dev.	Minimum	Maximum
Life expectancy	407	62.0	10.3	23.7	77.0
GDP per capita (US$) (2004)	407	1700.2	1729.8	90.2	8308.7
Public health expenditure (% GDP)	407	2.5	1.7	0.3	14.1
Urbanization	407	43.1	20.1	5.3	91.4
Urbanization squared	407	2257.6	1958.4	28.4	8346.6
Population density	407	99.5	139.2	1.7	932.8
Tropical area	407	0.7	0.4	0.0	1.0
Ethnic fractionalization	407	0.4	0.3	0.0	1.0
Social sector ODA commitments (% GDP)	407	1.2	1.8	0.0	19.1

Table A4
Summary statistics—school enrolments SPF

Variable	Obs	Mean	Std dev	Minimum	Maximum
Gross primary and secondary school enrolments (combined) (%)	815	76.4	20.8	17.2	127.5
GDP Per capita (US$) (2004)	815	1768.1	1793.1	87.1	8720.5
Public health expenditure (% GDP)	815	4.4	2.1	0.5	11.8
Urbanization	815	45.1	20.7	6.3	92.5
Population density	815	96.5	142.7	1.4	1070.7
Tropical area	815	0.7	0.4	0.0	1.0
Ethnic fractionalization	815	0.5	0.3	0.0	1.0
Net ODA (% GDP)	815	7.5	9.4	-2.8	59.4

Table A5
Technical efficiency correlation coefficients—life expectancy models

	Model 1	Model 2	Model 3	Model 4	Model 5
Model 1	1.000				
Model 2	0.839	1.000			
Model 3	0.802	0.894	1.000		
Model 4	0.855	0.996	0.909	1.000	
Model 5	0.854	0.997	0.909	1.000	1.000

Table A6
Technical efficiency correlation coefficients—school enrolments models

	Model 1	Model 2	Model 3	Model 4	Model 5
Model 1	1.000				
Model 2	0.613	1.000			
Model 3	0.612	1.000	1.000		
Model 4	0.573	0.990	0.991	1.000	
Model 5	0.615	0.998	0.999	0.991	1.000