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Foreign aid, economic growth and efficiency development

A Data Envelopment Analysis approach

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Preface

The Swedish Agency for Development Evaluation (SADEV) is a government-funded institute that conducts and disseminates evaluations of international development cooperation. SADEV's overall objective is to increase the efficiency of Swedish development cooperation.

SADEV has two main areas of work. The first is the organization of international development cooperation focusing on issues such as management and monitoring of executive organisations, donor coordination, and the internal efficiency of donor organisations. The second area is concerned with the short- and long-term impact of development assistance on the well being of partner country populations. SADEV evaluations are published as reports and studies. Interim or pre-studies are circulated as working papers.

This SADEV Report is part of the wider project theme: *Foreign aid, economic growth and efficiency development*, and is the first of a series of studies investigating aid effectiveness in a production theory context. One purpose of the report is to investigate whether foreign aid improves the efficiency of resource use in a country in the short term. Another is to investigate the feasibility of using the specific production theory context when examining aid effectiveness. This should be seen as the first step towards finding a method for policy makers to assess the overall impact of aid on development in a partner country. Such methods are of increasing importance in an era of increased ownership according to the Paris Declaration and increased use of budget support.

October, 2007

Lennart Wohlgemuth

Acting Director General

Abstract

This study attempts to add a piece to the aid effectiveness puzzle by evaluating aid effectiveness in a production theory context. The first step is to establish how well a country is using its resources. This is measured by means of an efficiency index which reflects the production ability of a country. The second step is to examine whether we can find any systematic correlation between the efficiency of a country and resource inflow in the form of aid.

The study covers the performance of 60 countries between 1995 and 2000. China, followed by Nigeria, displays the highest relative efficiency values over the period of study. The lowest efficiency, between 14 and 15 per cent each year between 1995 and 2000, is found in India, Indonesia and Pakistan. We also find that labour and energy intensive countries generally display lower efficiency scores in relation to less labour and energy intensive countries while we find indications of a positive relation between capital intensity and country efficiency.

When linking country efficiency development to aid, there is no clear pattern to be found. This fact clearly points to the value of a continued study covering a substantially longer period of time, a more extensive data set and perhaps also the inclusion of different aid measures.

Contents

1 Executive summary

The question whether or not foreign aid enhances economic growth and efficiency in resource use has long been debated, but still no consensus is found among researchers and policy makers. In spite of numerous studies, there is little evidence of a significant positive effect of aid on the long-term growth of poor countries. Politically important results showing that aid works better when policy environment is conducive to growth have proven not to hold when data is expanded and/or new variables added.

This study attempts to add a piece to the aid effectiveness puzzle by evaluating aid effectiveness in a production theory context. The first step is then to establish how well a country is using its resources. This is measured by means of an efficiency index which reflects the production ability of a country. The second step is to examine whether we can find any systematic correlation between the efficiency of a country and resource inflow in the form of aid.

Energy, labour and capital are the resources (inputs) traditionally considered in production models, while GDP may be regarded as the output produced in the production process of a country. Increased GDP growth is considered to be the objective of the 60 countries included in this study. The countries belong to five different geographical categories: Sub-Saharan Africa, East Africa and the Pacific, Latin America and the Caribbean, Middle East and North Africa and South Asia. Input and output data were obtained for each country each year between 1995 and 2000.

The efficiency concept used (obtained through the Data Envelopment Analysis, DEA, method), tells us how successful different countries are when “producing” GDP. This is a relative measure of efficiency, and the efficiency of a country is thus measured relative to the efficiency of all the other countries. The DEA method creates a best practice, or efficiency frontier which then serves as a benchmark against which the efficiency of the 60 different countries is measured for each of the six years.

Given the amount and combination of resources used, the estimated efficiency values thus indicate how much GDP a country “produced” as a portion of the GDP that would have been possible to produce had the country in question employed the resources in a more efficient way.

China, followed by Nigeria, displays the highest relative efficiency values over the period of study. The lowest efficiency, between 14 and 15 per cent each year between 1995 and 2000, is found in India, Indonesia and Pakistan.

We also find that that labour and energy intensive countries generally display lower efficiency scores in relation to less labour and energy intensive countries while we find indications of a positive relation between capital intensity and country efficiency.

The finding that capital intensive countries have had a more positive efficiency development compared to less capital intensive countries may come as no surprise. Does this then mean that we can conclude that aid, as a component adding to the size of the capital stock of a country, contributes to an increased efficiency development of that country? Is there in fact a positive correlation between aid and GDP growth?

When linking country efficiency development to aid we do, however, get a somewhat ambiguous picture. Although some of the more efficient countries seem to have a relatively low aid share, we also see that countries with a relatively small aid share are found among the more as well as among the less efficient ones. Most large aid recipients seem to be found in the middle of the “efficiency spectrum”.

Consequently, when it comes to the relation between aid and efficiency our findings must be regarded as inconclusive. There is no clear pattern to be found. This fact clearly points to the value of a continued study covering a substantially longer period of time, a more extensive data set and perhaps also the inclusion of different aid measures.

Finally, it should be noted that the efficiency comparisons of this study are based on resource use and that the results do not explicitly reflect political or other background variables. The results may, however, reflect potential problems of a country in the way that it is found that the country in question is not able to put its resources to good use and hence is found to be inefficient. An analysis of such relationships is data demanding and would require far-reaching analysis and investigation that is beyond the scope of this study.

2 Introduction

This study attempts to add a piece to the aid effectiveness puzzle by using an alternative economic growth measure. Most aid effectiveness studies exploit the GDP per capita measure when capturing economic growth. The GDP per capita measure is, however, similar in nature to the labour productivity measure and consequently subjected to the drawbacks of such partial measures. To remedy the shortcomings of a partial measure of performance, we suggest evaluating aid effectiveness in a production theory context, applying the Data Envelopment Analysis (DEA) method. This approach considers all factors of production, and hence also includes the capital and energy components of production, implying that we will evaluate the economic performance considering achieved production in relation to *all* resources used in the production process.

DEA has several attractive characteristics. Since the technology is non-parametric, there is no need to specify a specific functional form, nor do we need to place any restrictions on the scale properties of the underlying production technology. Furthermore, no assumptions regarding economic behaviour in terms of profit maximization or cost minimization need to be made and we do not need information on input prices. The DEA approach is thus particularly suitable in a context like the present, where price information is weak and where little is known about production technologies and economic behaviour.

This report is to be regarded as a pilot study, a first step to investigate the possibilities of launching a more substantial study of the effects of aid on country performance. We begin by studying the productive efficiency development in 60 countries over a five year period. The study presents efficiency results for each of the included countries for the period between 1995 and 2000. The focus is on output increasing efficiency, i.e. the relationship between the actual production volume and the production volume that could be obtained if the resources were employed in an efficient way.

Labour and energy intensive countries seem to be among the less efficient countries, although we find high labour and energy utilisation in both extremes of the efficiency distribution. Relatively capital intensive countries are, to a large extent, found to use resources more efficiently and to have a more positive efficiency development.

When linking country efficiency development to aid, we get a somewhat ambiguous picture. This finding clearly points to the value of a continued study covering a substantially longer period of time, a more extensive data set and perhaps also the inclusion of different aid measures. Although such a study would certainly be warranted, as well as methodologically feasible, to shed further light on the relationship between aid and growth, limited data availability is a serious concern.

The report is organized as follows. We begin with a brief summary of some of the recent work in the field of aid effectiveness and point to the value of trying a different approach to the issue. This is followed by Section IV, a discussion of the efficiency concept. Section V is a presentation of data and model specification, while empirical results are found in Section VI. Section VII concludes.

3 Aid Effectiveness

Aid issues have received renewed political interest during the first years of the 21st century. At the Millennium Summit of 2000, the international community agreed on certain Millennium Development Goals (MDG) to be reached by 2015: Halving extreme poverty, providing universal primary education, promoting gender equality, reducing child mortality, improving maternal health, halting the spread of HIV/AIDS, ensuring environmental sustainability and developing a global partnership for development. World leaders have acknowledged that objective attainment depends on increased resource transfers as well as improved aid effectiveness through donor co-ordination. Aid increase has been suggested in the Monterrey Consensus (UN 2004) and (UN 2005). Furthermore, the multilateral debt relief initiative (MDRI) has been introduced to reduce the debt burden of developing countries.

The renewed political interest together with increased resource transfers have resulted in numerous studies on the impact of aid on growth. There is, however, little evidence of a significant positive effect of aid on the long-term growth of poor countries. The link between aid and growth goes via investment and there is no doubt that aid sometimes finances investment. Dalgaard, Hansen and Tarp (2004) have shown that aid transfers improve steady state productivity in partner countries through raising the capital stock per person. Roodman, (2004) finds that the aid-growth link is influenced by factors such as domestic policies, governance, external conditions and historical circumstances.

Looking at recent developments in the aid and growth literature, Hansen and Tarp (2001) divide the studies into three generations. The first generation, being influenced by the Harrod-Domar model, mainly focused on the aid-savings link. Saving was assumed to lead to investment and growth. Second generation studies investigated the aid-investment-growth link more directly without focusing on savings. Third generation studies entail a number of contributions, such as improved country coverage, use of regressors representing the policy environment, acceptance of non-linearity in the aid-growth relationship.

A key study of the third generation is Burnside and Dollar (2000), where the authors find support for the basic idea that an increase in aid flows strengthens economic growth in poor countries when the policy environment is conducive. In the presence of poor policies, aid was not found to have any positive effect on growth. The Burnside and Dollar result was supported by a number of follow-up studies. Collier and Dollar (2002), using a different data set and another specification, validated the significance of the policy environment. Collier and Dehn (2001) find that well-timed aid alleviates effects of negative export shocks, while Collier and Hoeffler (2004) find that aid works particularly well in good policy environments a few years after a conflict has ended.

Subsequent studies have, however, suggested that the Burnside and Dollar results were not robust. Dalgaard and Hansen (2001) argue that the Burnside and Dollar results are sensitive to the treatment of outliers and when removing outliers they found that aid had no effect on growth. Easterly, Levine and Roodman (2004) discovered that the results were sensitive to data expansion, both in years and countries. Hansen and Tarp (2001), adding a squared aid variable to the regressions, show that aid is effective on average, but with diminishing returns. This finding holds regardless of partner country policy. The hypothesis of Guillaumont and Chauvet (2001) is that economic vulnerability influences aid effectiveness. Aid stabilizes countries with terms of trade difficulties. The authors introduce a "vulnerability variable" resulting in the Burnside and Dollar (2000) policy variable becoming insignificant. Dalgaard, Hansen and Tarp (2004) introduce a geographical variable into the aid-growth perspective to find that, on average, aid seems to work for areas outside the tropics.

Roodman (2004) studied the robustness of the findings in Burnside and Dollar (2000), Hansen and Tarp (2001), Guillaumont and Chauvet (2001), Collier and Dollar (2002), Collier and Dehn (2001), Collier and Hoeffler (2002) and Dalgaard, Hansen and Tarp (2004). The study indicates that non-robustness is a common feature of the cross-country aid effectiveness literature. Most sensitive were the results of Burnside and Dollar (2000), Collier and Dollar (2002) and Collier and Dehn (2001), while Dalgaard, Hansen and Tarp (2004) and Hansen and Tarp (2001) proved more stable. Thus, the conclusion seems to be that aid, on average, seems to work outside the tropics.

Aid heterogeneity is an inherent problem when studying the aid-growth relationship. Growth and poverty reduction have not always been the main motives for providing aid. Berthélemy (2006) shows that strategic motives and self-interest by donors to a large extent explain aid allocation. Clemens, Radelet and Bhavnani (2004) divide aid into three categories to discover that the effects on growth differ considerably. Emergency and humanitarian aid has no effect on growth. The same is true for aid aiming at a long term growth effect, such as aid in support of democracy, the environment, education and health[1]. Aid with possible short term growth effects, such as aid as budget support and support to productive sectors, is found to have a strong effect on growth.

The aid effectiveness literature also discusses two other possible outcomes of aid flows. Rajan and Subramanian (2005) argue that aid flows reduce partner country competitiveness through exchange rate appreciations. This could prove particularly harmful if results by Hausmann, Pritchett and Rodrik (2005) are proven to be correct. The authors studied turning points in growth to discover that growth acceleration tends to correlate with increases in investment and exports, and with real exchange depreciation.

Our study takes a different approach to the issue. By exploiting properties of the traditional micro economic theory of production, we study how the efficiency with which individual countries produce GDP may be linked to the relative size of aid received by the country.

[1] The authors emphasise though that the standard growth regression analysis based on a four year panel data is an inappropriate tool for examining the effects of these two types of aid.

4 Measuring Efficiency

The efficiency of a production unit is defined as the ratio between the output(s) produced by the unit and the amount of resources used in the production process. To be meaningful, the individual efficiency measure must be compared to equivalent efficiency measures of other production units, over time or at the same point of time. Consequently, efficiency is a *relative* measure.

Efficiency may be calculated in different ways. A common method is to calculate partial efficiency measures, often called key performance indicators or productivity measures. A partial measure is often regarded as easier to interpret. As can be seen by the following simple example this is, however, generally not the case. Assume that we are studying a unit that is producing more than one product (good or service) using more than one type of production resources. In this case, several partial efficiency measures need to be calculated – one measure for each combination of products and production resources. The fact that the different partial efficiency measures of an individual production unit generally yield different results, imply serious interpretation problems. Furthermore, since all resources and achievements are inter dependent, there is a substantial risk of partial measures being misleading.

The calculation of a performance indicator that allows for the multiple input – multiple output structure of most production processes should naturally be based on solid economic theory. This study is based on a well established method in the field of production theory, the so called Data Envelopment Analysis (DEA) method.

DEA is a non-parametric representation of the production process. In the same way as the production function, DEA has its origin in micro economics, and in the same way as the production function traditionally has been (see e.g. Solow (1957)), and still is, used in macro modelling it is natural to employ the DEA concept in a similar manner; see e.g. Färe et. al. (1994).

A central feature of this method is that no assumption regarding the functional form of the underlying production needs to be made. DEA is a linear programming technique for the construction of a non-parametric, piecewise linear convex hull to the observed set of output and input data; see e.g. Charnes and Cooper (1985) for a detailed discussion of the methodology. The DEA approach defines a non-parametric frontier (hull) which may serve as a benchmark for efficiency measures. The most efficient units constitute the efficiency (best practice or production) frontier, i.e. the production possibility set, which is solely based on the actual observations of the different production units[2].

Farrell (1957) presented a method by which technical efficiency could be measured against an efficiency frontier, assuming constant returns to scale. The DEA method is closely related to Farrell's original approach and should be regarded as an extension

[2] It should be noted that the production unit in this study is a country and that the output of the country is GDP while inputs (resources used to produce GDP) are labour, capital and energy.

of that approach initiated by Charnes et. al. (1978) and related work by Färe et. al. (1983 and 1985) and Banker et. al. (1984).

This study applies Farrell-type ray measures as generalized into input-saving and output – increasing efficiency measures by Førsund and Hjalmarsson (1974, 1979 and 1987). For a more detailed presentation of different Farrell-type efficiency measures and their application to Data Envelopment Analysis, see, for example, Hjalmarsson and Veiderpass (1992).

Increased GDP growth is considered to be the objective of the 60 countries included in this study. Consequently, we focus on the output oriented (output increasing) efficiency measure. The output oriented efficiency measure in our study indicates potential output, i.e. GDP growth, of each country relative to observed GDP growth, given that the country's resources had been used efficiently. Productive efficiency may also be calculated as an input oriented measure, measuring the input (resource) saving potential of each production unit. See Figure 1 for a graphic illustration and Appendix 1 for a mathematical presentation of the output increasing efficiency measure used in this study.

Figure 1 illustrates output oriented efficiency measures, for one input x and one output y, given variable and constant returns to scale technologies. A, B, C and D represent different production units (countries). The variable returns to scale, VRS, frontier consists of the lines between x^o_A, A, B, C and the line to the right of Unit C. Units A, B and C are the most efficient countries, i.e. no other unit (country) uses less resources in relation to output produced, and the efficiency scores of these countries equal one. Unit D, which is dominated by units B and C, has a lower efficiency and its efficiency score is measured by the ratio between the observed quantity produced y^o_D and the quantity produced on the frontier, y^v_D, $y^o_D / y^v_D < 1$. The constant returns to scale, CRS, frontier consists of the line from the origin through unit B. In this case, Unit B is the only efficient unit and the corresponding efficiency score equals one. Unit A, which produces under increasing returns to scale, has an efficiency score equal to $y^o_A / y^c_A < 1$.

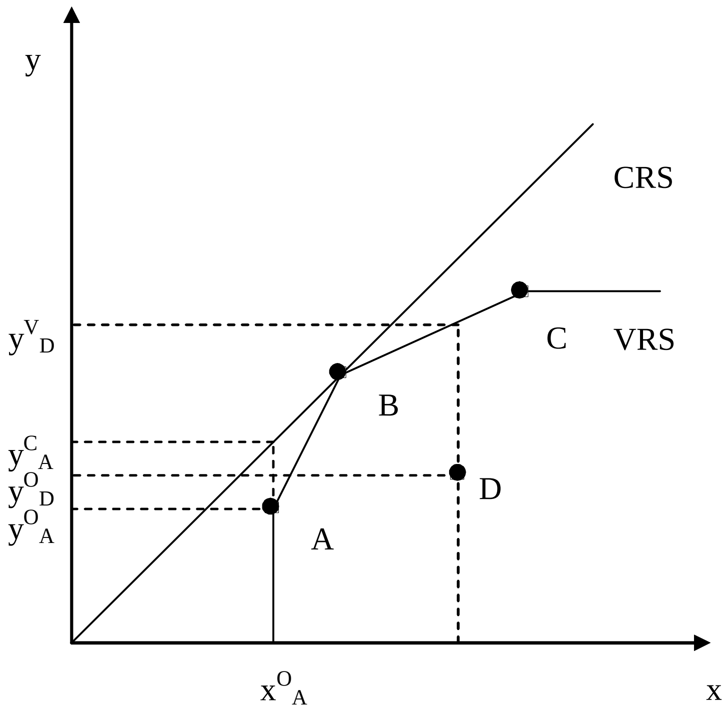

Figure 1 Output Oriented Efficiency Measures

In the DEA context efficiency is measured in relative terms, i.e. the efficiency of a production unit (in this case, a country) is measured relative to the efficiency of all other observed production units (countries). The distance from an observation to the frontier (the hull) constitutes the measure of the individual country's technical (productive) efficiency. For a fully efficient unit, the estimated efficiency equals 1.

5 Data and model specification

The data used in this study comprise information on 60 different countries for which we were able to collect consistent data for the period between 1995 and 2000. The countries belong to five different geographical categories: Sub-Saharan Africa (SSA), East Africa and the Pacific (EAP), Latin America and the Caribbean (LAC), Middle East and North Africa (MNA) and South Asia (SAS).

An intertemporal frontier approach[3] is used, enabling comparison between all countries and all years of study. Assuming the reference production set to be invariant over time, we are thus able to follow and compare the efficiency development of each country each year between 1995 and 2000 without further calculations of productivity measures or concern about changing production sets.

The study employs the following multiple input – single output production model:

3 INPUTS

Energy Use

Refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Unit of measurement: Kt of oil equivalent.

Source: International Energy Agency.

Labour force

Comprises people who meet the International Labour Organization definition of economically active population: All people who supply labour for the production of goods and services during a specified period.

Unit of measurement: Number of people.

Source: International Labour Organization, using World Bank population estimates.

Capital

Capital Stock based on Nehru and Dhareshwar (1993), mid-year value (two-period average).

The Capital Stock is based on a geometric depreciation rate of 0.05.

Unit of measurement: Billions of USD and the prices of 1995.

[3] The concept of intertemporal efficiency estimation was first defined and labelled by Tulkens and Vanden Eeckaut 1991. For non-parametric applications of intertemporal frontiers in a developing economy context, see e.g. Cabezas Vega and Veiderapss (1994), Veiderpass (1997) or Isgut, Tello and Veiderpass (1999).

1 OUTPUT

GDP

Real Gross Domestic Product based on World Bank data.

Unit of measurement: Billions of USD and the prices of 1995.

Table 1 presents the full data set which includes 359 observations. Data are divided into five different geographical categories.

Table 1 Summary statistics on inputs and outputs

	Energy	Labour	Capital	GDP
SSA				
Max	109478	42545604	375731	151113
Min	2371	482351	3	2
Median	8859	5799325	4427	2245
Mean	23454	9759570	19468	9089
EAP				
Max	1140446	738929024	1426804	588063
Min	21468	1764813	25	12
Median	71718	29335333	224573	73601
Mean	227103	129436669	426248	166217
LAC				
Max	185061	83444192	1907893	704304
Min	1717	287658	19	9
Median	6329	3128259	10633	5124
Mean	27577	9832295	152659	57845
MNA				
Max	118646	24409360	216534	90548
Min	2007	349718	10494	3359
Median	17619	9254000	30229	12619
Mean	31367	9791016	58754	24743

SAS				
Max	516891	396216480	81153	39935
Min	5950	7220793	234	123
Median	36513	48932936	3186	1527
Mean	140491	120880133	21611	10702
TOTAL DATA				
Max	1140446	738929024	1907893	704304
Min	1717	287658	3	2
Median	11793	6226845	8591	3935
Mean	62826	31160106	119486	46910

It is apparent from Table 1 that the sizes of all four variables included in the study vary considerably within all geographical categories. The lowest energy and labour input values are found in 1995, in (LAC) Haiti and Guyana respectively, while the lowest capital input value as well as the lowest output value are found in Ghana in 2000. Mainly due to extensive exchange rate adjustments, capital inputs, as well as GDP, are declining in Ghana every year during the period of study. The corresponding maximum energy and labour input values are found in (in the year 2000), while Brazil presents the highest capital input and GDP.

6 Empirical Results

This section reports the efficiency development, as measured by the output increasing efficiency measure, of the different countries. The section illustrates the results of the efficiency analysis together with the relative aid proportions of the different countries. All individual efficiency values are listed in Appendix 2.

In this study we do not place any restrictions on the scale properties of the underlying production technology. If, in a DEA context, the underlying production technology is specified in a way flexible enough to allow variable returns to scale, the resulting efficiency measures would nevertheless display constant returns to scale characteristics if the actual technology is characterized by constant returns to scale. Furthermore, as outlined above, this study measures output increasing efficiency, i.e. the relationship between actual production volume (output i.e. GDP) and the production volume that could have been obtained if the resources were employed in the most efficient way possible. Given the amount and combination of inputs used, the estimated efficiency values thus indicate how much GDP a country “produces” as a portion of the GDP that would have been possible to produce had the country in question been on the best practice frontier, i.e. had it been efficient.

For an efficient production unit (country), the estimated efficiency equals 1. An efficiency value of, for example, 0.73 means that this country is only producing 73 % of the GDP that would have been possible to produce with the observed amount of resources (inputs) used.

China, followed by Nigeria, displays the highest relative efficiency values over the period of study. The lowest efficiency, between 14 and 15 per cent each year between 1995 and 2000, is found in India, Indonesia and Pakistan.

Substantial and steady efficiency decline is found in Colombia (from an efficiency score of 0.965 in 1995 to an efficiency score of 0.774 in 2000; i.e. from 96.5 % to 77.4 %), Turkey (from an efficiency score of 0.85 in 1995 to an efficiency score of 0.341 in 2000), Zimbabwe (from an efficiency score of 0.533 in 1995 to an efficiency score of 0.251 in 2000) and Venezuela (from an efficiency score of 0.384 in 1995 to an efficiency score of 0.149 in 2000).

Since it has not been possible to obtain data on energy use for 8 of the 60 countries, an auxiliary model has been used to test the importance of these missing values and to ensure the reliability of our results. The auxiliary model consists of the same output measure while labour and capital are the only inputs. This model covers all 60 countries. With the exception of Ecuador, Guatemala and Haiti, the result of the auxiliary model provides a virtually identical ranking of the performance of the observed countries. The same countries are found to be the most/least efficient and the sharp efficiency decline of Colombia, Turkey, Zimbabwe and Venezuela is confirmed. In addition, Malawi, one of the 8 countries not included in our main model is found to be highly inefficient displaying falling efficiency scores between 0.179 and 0.088.

Consequently, this result may be regarded as an indication of the robustness of our main model findings.

By means of Figure 2, the efficiency analysis is taken a step further, as we examine whether there are any systematic correlations between input size and efficiency. Figure 2 shows the efficiency distribution in three different efficiency diagrams, often called Salter-Diagrams[4]. The efficiency of each country is shown by the height of the corresponding bar, while the width of the bar shows the size of the (input) variable in question. Consequently, the distance from the top of each bar to the 1.0 mark is a measure of the country's inefficiency. Countries are sorted from left to right by increasing efficiency scores.

For example, the height of the first bar indicates that that country has an efficiency value of approximately 0.12 and, consequently, the inefficiency is the difference between 1.00 and 0.12 (i.e. approximately 88 per cent). The width of the bar shows that the country's share of total labour input is approximately 0.03, i.e. 3 per cent.

It is obvious from the figure that countries with substantial labour input are found among the most as well as among the least efficient ones. The same circumstance seems to apply when studying efficiency distribution and energy use. These findings are also confirmed in Appendix 4. When focusing on the energy labour ratio, the least efficient units are clearly among the least energy intensive, while high as well as low energy labour ratios are found among the most efficient countries (see Appendix 4, third diagram).

When studying efficiency and capital utilisation, we find a somewhat different picture as indicated by the third diagram in Figure 2. Large units, where large is defined in terms of capital utilization, are now found to dominate the higher and "medium" efficiency intervals. Very few small units are found among the fully efficient ones, and only small units are found at the lowest efficiency values. As confirmed by the first two diagrams of Appendix 4, capital intensive countries thus generally seem to have had a more positive efficiency development during the period of study.

[4] This type of diagram, based on the input coefficient in Salter (1960), was first introduced in Førsund and Hjalmarsson (1979).

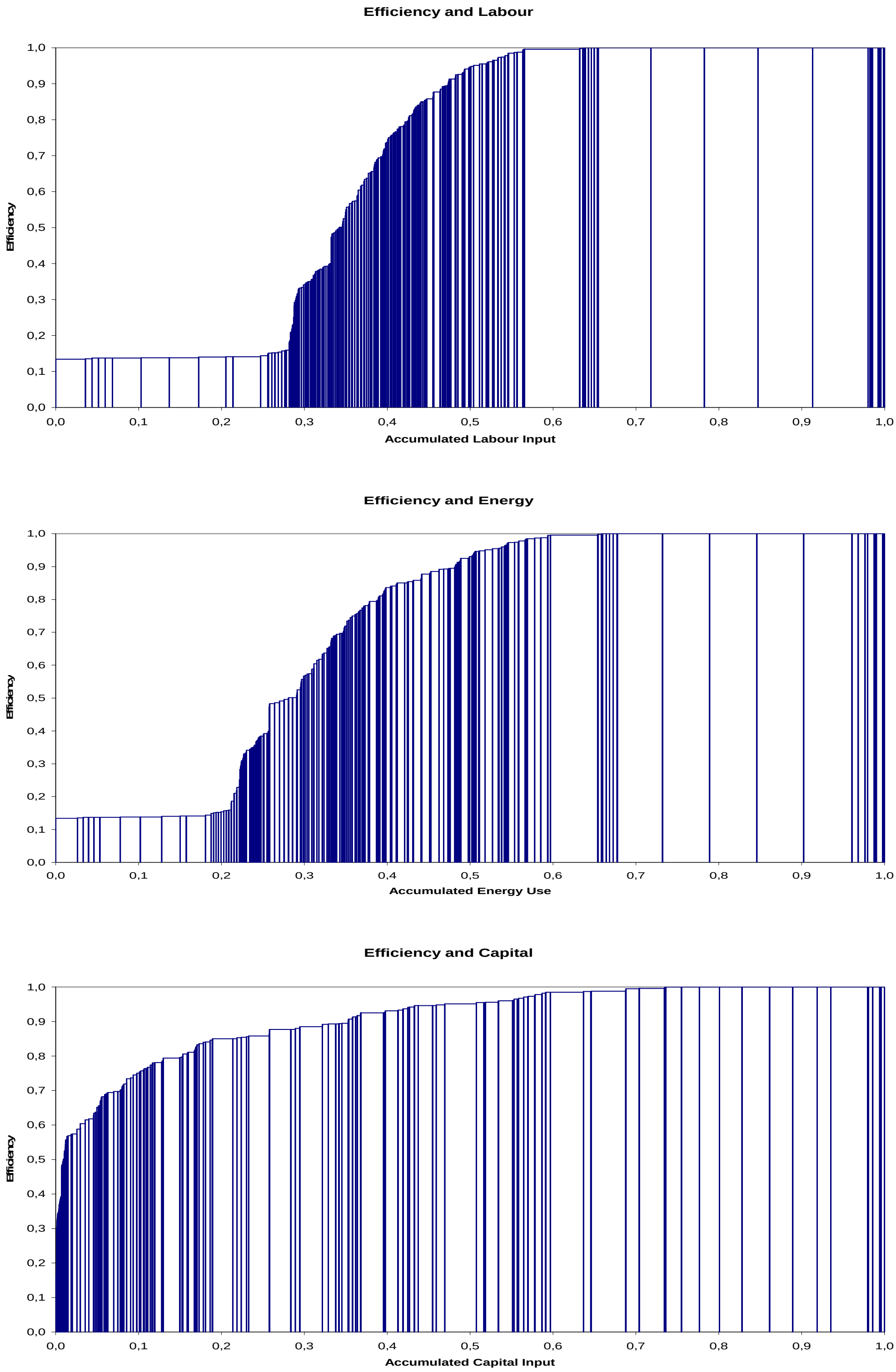

Figure 2 Efficiency distribution 1995 – 2000

The finding that capital intensive countries have had a more positive efficiency development compared to less capital intensive countries may come as no surprise. Does this then mean that we can conclude that aid, as a component adding to the size of the capital stock of a country, contributes to an increased efficiency development of that country? Is there in fact a positive correlation between aid and GDP growth?

We conclude this analysis by presenting Figure 3, showing the efficiency distribution and the extent of aid in the countries of study in an efficiency diagram of the same type as was presented in Figure 2 and Appendix 4. Due to data considerations, i.e. to be able to include as many countries as possible in the analysis, the figure is based on the auxiliary two input model specification. Aid is measured in per cent of government expenditures[5] and includes both official development assistance and official aid.

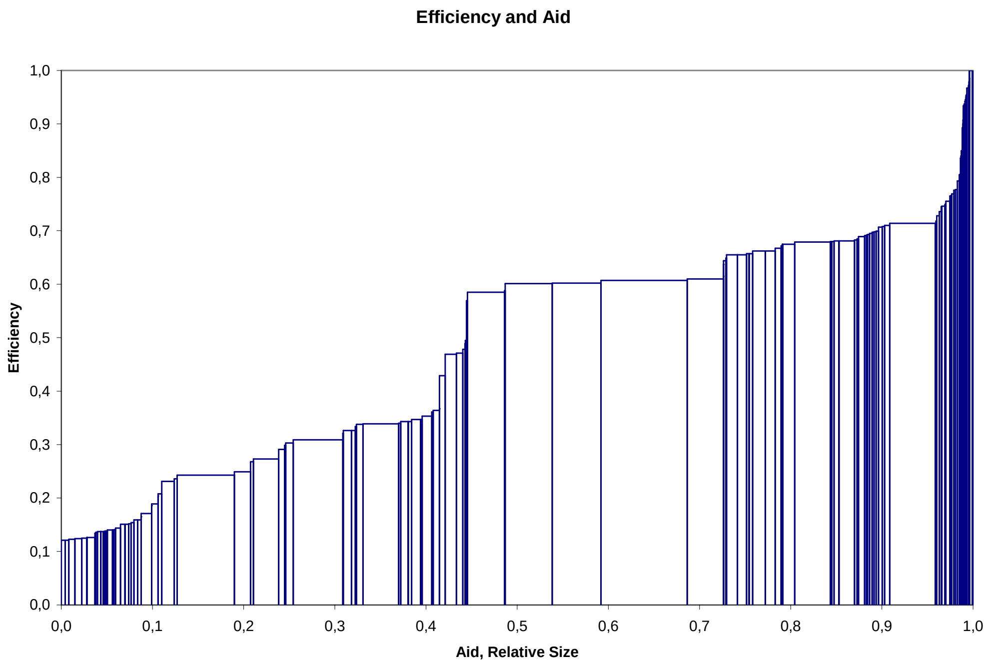

Figure 3 Efficiency and Aid

Figure 3 provides no definite answer to our questions. When linking country efficiency development to aid, we get a somewhat ambiguous picture. Although some of the more efficient countries seem to have a relatively low percentage of government expenditures consisting of aid, we also see that units with a relatively small aid share are found among the more as well as among the less efficient units. Generally, we find the large units in the centre of the diagram.

[5] Source: Development Assistance Committee of the Organisation for Economic co-operation and Development, and IMF government expenditures estimates.

7 Concluding Comments

As might have been expected, we find that labour and energy intensive countries display lower efficiency scores in relation to less labour and energy intensive countries. We also find indications of a positive relation between capital intensity and country efficiency. When it comes to the relation between aid and efficiency, however, our findings are inconclusive. There is no clear pattern to be found. It should be kept in mind that the relation between aid and efficiency is based on our auxiliary two input model specification. Although the efficiency results of the main and auxiliary models generate similar rankings, it would naturally have been preferable to have been able to base Figure 3 on the main model. An extended study, where data on energy use are collected for more countries and during an extended period of time is thus a natural next step to further clarify the issue of the relationship between aid and efficiency.

This study is based on data for the period between 1995 and 2000. A longer period of study, together with the possibility of including technical change in terms of frontier shifts (a total factor productivity approach) might prove helpful in several aspects. It might, for instance, provide the possibility to study whether aid would enable a specific country to “catch-up” and reduce the distance to other countries and to the moving best practice frontier over a longer period of time.

A most natural, non-parametric, continuation of the current efficiency development study would then be an application of the, equally non-parametric, Malmquist productivity index. The calculation of the Malmquist index would then be based on the efficiency measures derived from the DEA-model; see e.g. Färe et. al. (1994) for an application of the Malmquist productivity index to the measurement of country productivity growth.

In this context, it would also be natural to use a common so called two stage approach to try to further explain the obtained efficiency or productivity scores. The variables used in stage two would be different environmental variables, i.e. explanatory variables that influence the production process in a different way compared to traditional inputs in the sense that substitutability may not be assumed.

Apart from a total factor productivity study, there are at least four other evident paths open to future studies:

1 **More recent developments**: Several important developments in the beginning of the 21st century provide interesting research topics. The most important is of course the rapid growth in China and India, affecting raw material prices. Aluminium, gold and oil have all seen a doubling of their price during the last five years, while the copper price has tripled. As a result, countries in Sub-Saharan Africa have experienced positive growth after seeing negative growth during the two last decades of the 20th century. Updating the analysis to the period 2001-2006 will of course imply a comprehensive work with data.

2 **Separate aid**: Another possibility to examine is to follow the path of Clemens et al (2004) who divided aid into three categories: (1) emergency and humanitarian aid; (2) aid that affects growth over a long period of time; and (3) aid that affects growth over a short period of time. The second category includes aid to health and education as well as to support democracy and the environment, while the third category includes budget support, infrastructure investments and aid for productive sectors. The authors found that the third aid category had a significant effect on growth over a four-year period, while the other categories had no significant effect. Furthermore, the impact was larger than found in similar studies where gross aid had been examined. This path will include a considerable amount of data work. Clemens et al. (op.cit.) used data from the Creditor Reporting System (CRS) and the Donor Assistance Committee of the OECD.

3 **Industry level**: There is also a possibility to investigate whether aid has an impact on efficiency and/or productivity at industry level. The experiences from East Asia suggest that labour intensive manufacturing enterprise (LIME) growth has had large pro-poor growth components and an investigation into the aid effect on LIMEs could provide important policy lessons. Rajan and Subramanian (2005) studied the aid effect on country competitiveness. They claim that aid inflow leads to exchange rate overvaluation which, in turn, results in lower growth in labour intensive industries. Kraay (2006) criticizes Rajan and Subramanian mainly from two points of view. First, there is no convincing link between aid and overvaluation of currency. Second, the sample is small and Kraay would have preferred a study of the effects on the tradable sector. We could contribute to the discussion through a DEA study on industry level. Data on labour and to some extent capital are available from the UNIDO. Energy use data are, however, missing.

4 **Country studies**: This last alternative is different from the above in the sense that we ignore cross-country comparisons and concentrate on country in-depth studies, preferably on countries being important as recipients of Swedish aid. These studies would comprise updated efficiency and productivity aspects on both country level and industry level with aid being separated. By following this path, we leave the empirical approach of growth regression for the other main approach, namely growth accounting.

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Appendix 1

Output Increasing Efficiency

To calculate the output increasing efficiency measure for unit A operating in a variable returns to scale production technology, the following linear programming problem is solved:

$$\min \mu = \sum_{i=1}^{m} v_i x_i^A + v_0 \qquad 1\text{ (a)}$$

$$\sum_{r=1}^{s} u_r y_r^A = 1 \qquad 1\text{ (b)}$$

$$-\sum_{r=1}^{s} u_r y_r^j + \sum_{i=1}^{m} v_i x_i^j + v_0 \geq 0, \qquad j = 1,\dots,N \qquad 1\text{ (c)}$$

$$v_i \geq 0, \quad u_r \geq 0\,, \quad v_0 \overset{<}{\underset{>}{=}} 0 \qquad 1\text{ (d)}$$

The output efficiency measure is calculated as μ^{-1}. For Country A, we obtain the solution by minimizing the weighted sum of inputs for this unit (1 (a)), given that the weighted sum of outputs for the unit in question equals one (1 (b)). Furthermore, the weighted sum of inputs minus the weighted sum of outputs for all units included is greater than or equal to zero (1 (c)). To calculate the corresponding measure under the assumption of constant returns to scale, the weight v_0 is excluded from the LP-problems.

Appendix 2

Efficiency development 1995-2000, full model (3 inputs 1 output).

Output Increasing Efficiency. VRS: Variable Returns to Scale

Id		VRS Output Increasing Efficiency
Cote d'Ivoire 1995		0.894
	1996	0.925
	1997	0.936
	1998	0.975
	1999	0.929
	2000	0.876
Cameroon 1995		0.628
	1996	0.653
	1997	0.653
	1998	0.676
	1999	0.688
	2000	0.666
Ethiopia 1995		0.378
	1996	0.393
	1997	0.384
	1998	0.35
	1999	0.334
	2000	0.332
Ghana 1995		1
	1996	1
	1997	1
	1998	0.655
	1999	0.473
	2000	1
Kenya 1995		0.393
	1996	0.381
	1997	0.367
	1998	0.351
	1999	0.316
	2000	0.292
Mozambique 1995		0.5
	1996	0.481
	1997	0.517
	1998	0.558
	1999	0.55
	2000	0.495
Nigeria 1995		1
	1996	1
	1997	0.998

	1998	1
	1999	0.974
	2000	1
Senegal 1995		1
	1996	1
	1997	0.994
	1998	1
	1999	0.999
	2000	0.996
Tanzania 1995		0.389
	1996	0.4
	1997	0.398
	1998	0.382
	1999	0.356
	2000	0.347
South Africa 1995		0.893
	1996	0.895
	1997	0.892
	1998	0.854
	1999	0.841
	2000	0.836
Zambia 1995		0.376
	1996	0.379
	1997	0.385
	1998	0.346
	1999	0.325
	2000	0.304
Zimbabwe 1995		0.533
	1996	0.543
	1997	0.509
	1998	0.368
	1999	0.283
	2000	0.251
China 1995		1
	1996	1
	1997	1
	1998	1
	1999	0.996
	2000	1
Indonesia 1995		0.137
	1996	0.137
	1997	0.135
	1998	0.144
	1999	0.141
	2000	0.137
Korea, Rep. 1995		1
	1996	1
	1997	0.925
	1998	0.794
	1999	0.85
	2000	0.885

Malaysia 1995		0.745
	1996	0.734
	1997	0.697
	1998	0.569
	1999	0.588
	2000	0.615
Philippines 1995		0.651
	1996	0.656
	1997	0.634
	1998	0.567
	1999	0.573
	2000	0.557
Singapore 1995		0.946
	1996	0.971
	1997	0.985
	1998	0.853
	1999	0.88
	2000	0.933
Thailand 1995		0.811
	1996	0.781
	1997	0.694
	1998	0.574
	1999	0.604
	2000	0.618
Argentina 1995		0.931
	1996	0.956
	1997	0.995
	1998	1
	1999	0.96
	2000	0.946
Bolivia 1995		0.917
	1996	0.908
	1997	0.888
	1998	0.865
	1999	0.814
	2000	0.786
Brazil 1995		1
	1996	0.988
	1997	0.985
	1998	0.951
	1999	0.858
	2000	0.877
Chile 1995		0.825
	1996	0.81
	1997	0.798
	1998	0.754
	1999	0.69
	2000	0.689

Colombia 1995		0.965
	1996	0.913
	1997	0.894
	1998	0.84
	1999	0.78
	2000	0.774
Costa Rica 1995		1
	1996	0.974
	1997	0.979
	1998	0.991
	1999	1
	2000	0.963
Dominican Republic 1995		0.721
	1996	0.747
	1997	0.775
	1998	0.786
	1999	0.795
	2000	0.805
Ecuador 1995		1
	1996	0.945
	1997	1
	1998	0.591
	1999	1
	2000	1
Guatemala 1995		0.925
	1996	0.9
	1997	0.848
	1998	0.817
	1999	0.819
	2000	0.767
Honduras 1995		1
	1996	1
	1997	0.974
	1998	0.83
	1999	0.763
	2000	0.715
Haiti 1995		1
	1996	0.913
	1997	0.884
	1998	0.814
	1999	0.794
	2000	1
Jamaica 1995		1
	1996	0.937
	1997	0.967
	1998	0.942
	1999	0.877
	2000	0.806

Mexico 1995		0.948
	1996	0.955
	1997	0.987
	1998	0.978
	1999	0.973
	2000	1
Nicaragua 1996		0.778
	1997	0.792
	1998	0.806
	1999	0.807
	2000	0.775
Panama 1995		1
	1996	0.94
	1997	0.911
	1998	0.848
	1999	0.82
	2000	0.78
Peru 1995		0.856
	1996	0.833
	1997	0.846
	1998	0.796
	1999	0.763
	2000	0.764
Paraguay 1995		1
	1996	0.913
	1997	0.863
	1998	0.971
	1999	1
	2000	1
El Salvador 1995		0.997
	1996	0.968
	1997	0.959
	1998	0.944
	1999	0.931
	2000	0.907
Trinidad and Tobago 1995		1
	1996	0.983
	1997	0.936
	1998	0.903
	1999	0.899
	2000	0.905
Venezuela. RB 1995		0.384
	1996	0.228
	1997	0.21
	1998	0.186
	1999	0.158
	2000	0.149

Cyprus 1995		1
	1996	0.983
	1997	1
	1998	0.987
	1999	0.997
	2000	1
Algeria 1995		0.371
	1996	0.357
	1997	0.344
	1998	0.349
	1999	0.33
	2000	0.309
Egypt, Arab Rep. 1995		0.682
	1996	0.697
	1997	0.719
	1998	0.737
	1999	0.757
	2000	0.767
Iran, Islamic Rep. 1995		0.496
	1996	0.501
	1997	0.501
	1998	0.491
	1999	0.483
	2000	0.486
Israel 1995		1
	1996	0.982
	1997	0.946
	1998	0.917
	1999	0.893
	2000	0.907
Jordan 1995		0.713
	1996	0.691
	1997	0.682
	1998	0.681
	1999	0.688
	2000	0.701
Morocco 1995		0.76
	1996	0.828
	1997	0.782
	1998	0.816
	1999	0.785
	2000	0.754
Tunisia 1995		0.67
	1996	0.693
	1997	0.701
	1998	0.704
	1999	0.716
	2000	0.711

Turkey 1995		0.85
	1996	0.75
	1997	0.637
	1998	0.525
	1999	0.392
	2000	0.341
Bangladesh 1995		0.965
	1996	0.961
	1997	0.955
	1998	0.941
	1999	0.926
	2000	0.913
India 1995		0.14
	1996	0.141
	1997	0.138
	1998	0.137
	1999	0.138
	2000	0.134
Sri Lanka 1995		0.298
	1996	0.231
	1997	0.218
	1998	0.209
	1999	0.181
	2000	0.159
Pakistan 1995		0.159
	1996	0.157
	1997	0.152
	1998	0.151
	1999	0.152
	2000	0,154

Results from Ghana must be regarded as outliers.

Appendix 3

Geographical Categories, in accordance with World Development Indicators,

World Bank. 2006.

Category Sub-Saharan Africa (SSA)

IVORY COAST, CAMEROON, ETHIOPIA, GHANA, KENYA, MADAGASCAR, MALI, MOZAMBIQUE, MAURITIUS, MALAWI, NIGERIA, RWANDA, SENEGAL, SIERRA LEONE, TANZANIA, UGANDA, SOUTH AFRICA, ZAMBIA, ZIMBABWE

Category East Asia and Pacific (EAP)

CHINA, INDONESIA, KOREA REP., MALAYSIA, PHILIPPINES, SINGAPORE, THAILAND

Category Latin America and Caribbean (LAC)

ARGENTINA, BOLIVIA, BRAZIL, CHILE, COLOMBIA, COSTA RICA, DOMINICAN REP. ECUADOR, GUATEMALA, GUYANA, HONDURAS, HAITI, JAMAICA, MEXICO, NICARAGUA, PANAMA, PERU, PARAGUAY, EL SALVADOR, TRINIDAD and TOBAGO, VENEZUELA

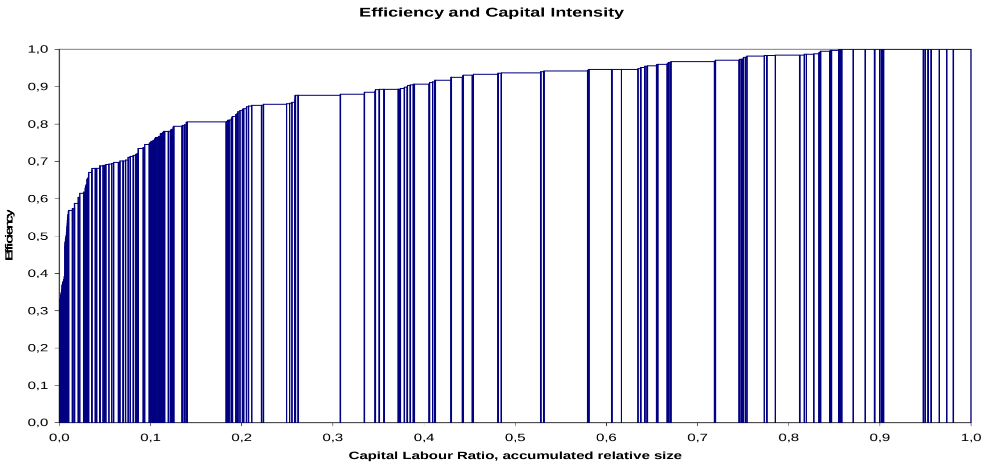
Category Middle East and North Africa (MNA)

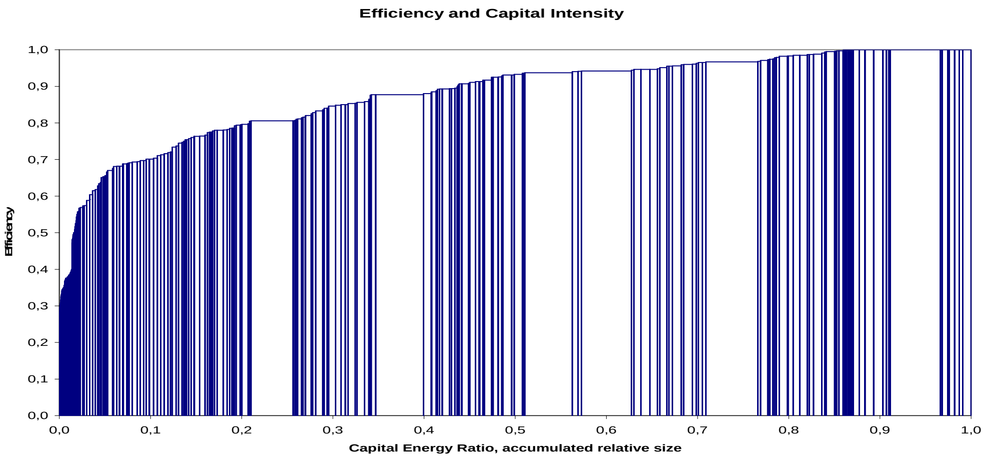
CYPRUS, ALGERIA, EGYPT, IRAN, ISRAEL, JORDAN, MOROCCO, TUNISIA, TURKEY

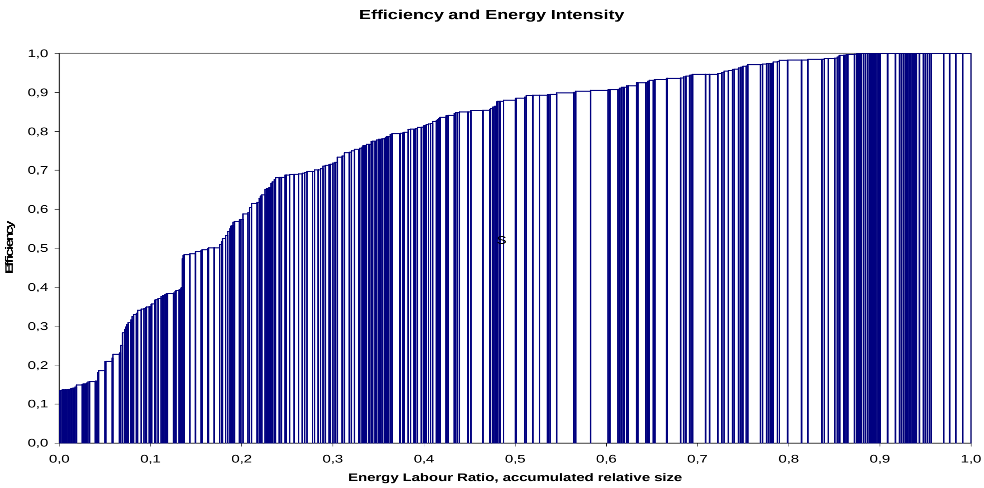
Category South Asia (SAS)

BANGLADESH, INDIA, SRI LANKA, PAKISTAN

Appendix 4


Efficiency and Capital Intensity
Efficiency
Capital Labour Ratio, accumulated relative size


Efficiency and Capital Intensity
Efficiency
Capital Energy Ratio, accumulated relative size


Efficiency and Energy Intensity
Efficiency
Energy Labour Ratio, accumulated relative size