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OVERCOMING BARRIERS TO COMPETITIVENESS

by

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PREFACE

As part of its 2003-2004 work programme on *Market Access, Capacity Building and Competitiveness*, the Development Centre has a deep interest in uncovering the determinants of productivity differences among countries, because such differences govern growth and development performance. The work aims to guide policy makers in developing countries to diagnose their national economic situations and, given their limited resources, to make choices that can have the greatest possible positive impact on development performance.

This Working Paper develops the analysis and presents the methodological tools for a forthcoming Development Centre Study, to tackle this problem. It focuses on the manufacturing sectors of a sample of 53 developed and developing countries and develops a reliable technique for identifying the domestic origins of differences in their international competitiveness. This technique decomposes the sources of productivity in a way that can reveal the key bottlenecks a country faces and how they interact to influence competitiveness. A variant of the macroeconomic, growth-accounting approach, pioneered by Denison in 1967, is used to focus on and identify the roles of five factors that could be influenced by policy action: private capital, infrastructure, education, trade integration and net efficiency. The relevance of the rankings should be clear: they differentiate between countries suffering from a variety of shortcomings, each of which hamper productivity growth and development and require different forms of policy action.

The decomposition technique chosen also permits the development of new sets of country competitiveness rankings for the 53 countries in the paper's sample. With further refinement, these rankings — which are cardinal rather than ordinal and thus allow judgement of how far apart individual countries stand from each other — may represent an advance over the currently most heavily used "league tables", such as the popular annual rankings published by the World Economic Forum. The analysis thus also provides valuable information to private investors and government officials.

If the same methodology as that described in this paper is applied to other countries beyond the 53 covered here, a "competitiveness map" of the world could be established. On the basis of this, different strategies in different regions applied to similar deficits in each of the five factors can be compared with the objective of identifying those which have been more successful. This comparative policy agenda is one of the hallmarks of the Development Centre approach.

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RÉSUMÉ

L'accroissement de la productivité manufacturière est une priorité essentielle des pays en voie de développement. *Vers une meilleure productivité industrielle des pays pauvres* se donne pour objectif de fournir une analyse de la productivité manufacturière qui soit susceptible d'aider les décideurs politiques de ces pays à fixer leurs priorités. L'article démontre que la productivité repose sur cinq facteurs: les infrastructures, le capital, le commerce, l'éducation, et l'efficacité globale. Il permet ce faisant de classer les pays relativement les uns aux autres eu égard leur dotation en chacun de ces facteurs. Plus qu'une simple comparaison, ce système de classement permet d'identifier les éléments qui, à un niveau régional ou national, requièrent une attention particulière. L'une des thèses centrales de l'article est que les pays pauvres doivent le plus souvent s'atteler à la résolution de ces cinq handicaps à la fois, l'idée sous-jacente est en effet d'éviter que l'un d'entre eux puisse impacter négativement sur l'autre. Cette approche peut être comprise comme une manière alternative de comprendre le « problème de compétitivité » des pays pauvres en soulignant le ou les facteurs qui pèsent plus lourds que d'autres. Le défi majeur auquel sont confrontés les pays pauvres est d'accroître les gains de productivité, seuls susceptibles de contribuer à l'éradication de la pauvreté et à la réalisation des objectifs du millénaire.

SUMMARY

Raising manufacturing productivity is of central importance to the developing world and an essential element of policy making. *Overcoming Barriers to Competitiveness* is about establishing the most reliable analysis of manufacturing productivity possible and helping policy makers set their priorities. The paper demonstrates that productivity rests on five elements of the economy: infrastructure, capital, trade, education and aggregate efficiency. These factors, when multiplied together, give a true picture of a country's situation on the productivity "league table". More than a simple comparison, this ranking system allows the identification of which elements in each particular national or regional case require most attention. This approach can be viewed as another way of addressing the so-called "competitiveness problem" of poor countries. It does not say, however, that other areas can be totally neglected; one of the main points of the paper is that all five elements have to be dealt with if they are not to impact negatively on each other and, thus, hamper productivity gains that could contribute to the reduction of poverty and attainment of several of the Millennium Development Goals (MDGs).

I. INTRODUCTION

Macroeconomic theory uses a single index to portray a country's "competitiveness": the productivity of its workers. Low labour productivity may result either from a lack of inputs, such as physical capital or education, or from inadequate efficiency, which measures workers' ability to combine inputs into outputs. From a country's perspective only the net result really matters, because overall productivity ultimately determines income. From an investor's perspective, however, the causes of high or low productivity do not all have the same implications. A poorly educated country does not offer the same potential as one with a low investment rate, for which the private firm can much more easily supply a good substitute with foreign direct investment (FDI). Competitiveness indices have flourished because they give foreign investors direct information on the economic environments that they will find, information that raw productivity indices do not appropriately reveal.

In a thorough review of competitiveness indices, Lall (2001) carefully distinguishes two dimensions of what one should think of them. The first is scientific integrity. Most often, they are simple arithmetic averages of quite heterogeneous items. Some of them build on hard facts; others build on subjective judgements extracted from questionnaires sent to market participants. Both are of course interesting, but it is hard to understand the nature of an index obtained from a simple average of the two. As an illustration, Gregoir and Maurel (2003) have analysed the robustness of the World Economic Forum (WEF) classification. They show that a totally different ranking could emerge among countries only by weighting the data used by the WEF differently on the basis of econometric results.

Second, competitiveness indices can reveal countries' structural problems, at least from the point of view of foreign investors and policy makers seeking to attract them. In a report on Latin American competitiveness, for instance, the Inter-American Development Bank (IADB, 2001) concludes that Latin America suffers from credit-market inefficiency, which translates "into lower-sized firms [and] correspondingly low productivity" and is evidenced by "an usually large bid/ask spread on loans". The IADB study implicitly suggests that a critical bottleneck may shackle a country's potential. The "O-Ring Theory of Economic Development" (Kremer, 1993) provides a good starting point for better understanding what such bottlenecks mean. Kremer draws an analogy with the explosion of the shuttle Challenger, which occurred because a small O-Ring was not adapted to the high temperature to which it was exposed. One poor-quality item destroyed the entire shuttle. In the fascinating theory that proceeds from this observation, one should expect paired inputs of equal quality. It usually does not make sense to match a highly paid lawyer with a bad secretary, for example. The theory (built on matching models originally developed by Gary Becker) suggests looking for the weak link(s) in the chain as one avenue to study economic development. Given two countries with equal labour productivity, one can be regarded as less competitive than the other if even one such weak link exists. One thus can rank countries not just by productivity levels but also by the extent to which major bottlenecks hamper their performance.

This report builds upon these intuitions and attempts to decompose the sources of productivity to reveal the key bottlenecks that countries face. It takes productivity in the manufacturing sector as the key building block of the analysis. It analyses how manufacturing productivity is determined by focusing on the role of private capital, infrastructure, education, trade integration, and a residual of net efficiency. It shows that many countries fit the O-Ring model. They are all subject to the "tyranny of numbers" (*cf.* Young, 1995). Several relatively small handicaps, combined multiplicatively, can reveal why a country may end up poor or very poor. The least productive country in the sample, Bangladesh, has a productivity level about one-fiftieth of that of the richest nations. This discomforting figure is the product of five terms that each stand at about 45 per cent of their values in high-income countries, but 0.45 to the power of five is 2 per cent. Poverty hits many countries evenly, but some suffer from major bottlenecks. Egypt and India, both among the least productive countries in the sample, owe most of their problems to one factor, low labour efficiency. Too little infrastructure appears as the critical factor in Africa. The analysis points out the most relevant diagnoses on a country-by-country basis.

The sections that follow first return briefly to the subject of competitiveness indices and the need for improved measures to better guide investors in their choices of where to put their resources and governments in their decisions on priorities for policy action. The paper then presents the approach that it takes to search for better measures, reviews the key results obtained at a continental level and offers a new battery of country rankings that could help decision makers to focus more accurately on real opportunities and policy priorities. A concluding section discusses policy implications and policy questions that need more examination based on the paper's findings.

II. COMPETITIVENESS INDICES

The WEF index has gained pre-eminence over other indices of competitiveness. For 2002, the WEF released a table ranking countries according to two indices: the Growth Competitiveness Index (GCI) and the Current Competitiveness Index (CCI). The GCI aims to measuring the growth potential of countries. The CCI measures their current status. The difference between the two is thin, however. Both take averages of indicators that all point to the same concept, namely the ability of countries to make the best use of new technologies. Finland and the United States, for instance, rank first and second in each of the two. China, on the other hand, ranks 39th in the GCI and 47th in the CCI, well behind France at 20th for the growth index and 12th for the current index. Few observers would doubt, however, that China's growth potential well exceeds France's.

The indices weight a number of items that all clearly have great importance. They range from the macroeconomic environment through innovation, technological diffusion and general infrastructures to indices of corruption and good governance. The indices combine hard data and responses to qualitative questions scaled from one to seven. Altogether, the GCI index weights 34 indices, 14 of them using hard data and 20 based on qualitative information. Only qualitative data measure the rule of law and the extent of corruption. Hard data predominate in the analysis of macroeconomic activity.

Gregoir and Maurel (2003) show how delicate the construction of rankings based on aggregating such heterogeneous information can be. All the indices are highly correlated with a common indicator, say GDP per head, yet from one index to another the same country may jump all over the place. The authors conduct an econometric assessment of the GCI index. It shows that the weights given by regressions where the dependent variable is the growth rate of the economy and the explanatory variable is macroeconomic stability or public institutions or technological achievements differ considerably from those used by the WEF. For the core countries, the econometrics provides a weight twice as big for macroeconomic conditions as the WEF weighting. The results give almost no role to public institutions and 40 per cent less importance to technological capabilities. For the non-core countries, the econometrics confirm the weight given to macroeconomic conditions as about right, but attribute 40 per cent less influence to public institutions and a larger weight to technological achievements. This involves a significant change in the country rankings. Malaysia gains ten ranks, for instance, and Denmark loses eight. Finally, by re-weighting the technological index country by country and opposing the weights obtained by the WEF to those revealed by the econometrics, Gregoir and Maurel obtain two rankings which can be taken as statically orthogonal to each other. The rankings are closer for public institutions and for macroeconomic stability.

The WEF indices represent a pioneering, even brave effort to meet real analytic and policy needs of businesses and governments. Their popularity attests to their usefulness, notwithstanding their weaknesses. Moreover, one may doubt whether critiques of the quality of Gregoir and Maurel (2003) would have come forward in the absence of the WEF indices to test. Nonetheless, much remains to be accomplished in the general search for improved country-ranking techniques to better inform business and government policy choices. This paper attempts a step in that process, a step that tries to move towards rankings based on more hard data and relying less on mixing hard and qualitative data.

III. FACTORS OF PRODUCTION

In the analytical framework used here, countries' manufacturing productivity depends on five items: infrastructure, capital, trade, education and aggregate efficiency. This section looks at how these items are measured and compared across countries. First, however, it is necessary to examine the productivity measures themselves and how they are constructed and presented.

The data on workers' productivity are built from the United Nations Industrial Development Organisation (UNIDO) *Industrial Statistics Database*, which provides rich information on wages and investment across industries and countries in the manufacturing sector. A preliminary analysis suggests excluding a few sub-sectors clearly not representative of typical growth patterns, such as energy and other items dependent on raw materials[1] (see Appendix 1). Furthermore, to the extent that manufacturing is a tradable-goods sector, current values of manufacturing output should apply, but this raises the question of the relevant exchange rate. This paper uses data on the average of productivity values in 1990 and 1999, expressed in current dollars (except for a few countries where only 1990 data are available; this will be corrected in future work). The data are then arranged by groups of countries. A reference ("core") group, to which all values are compared and for which data are available consistently in the sample, consists of the richest countries: Canada, the United States, Japan, Austria, Belgium, Finland, France, Italy, the Netherlands, Norway, Spain, Sweden, the United Kingdom and Australia. A group of other high-income countries includes Singapore, Cyprus, Denmark, Greece and Portugal. Countries not in either of these groups are examined together in a broad "non-high-income" aggregation and in continental clusters — sub-Saharan Africa (SSA), Southeast Asia/Pacific (SEAP), Middle East/North Africa (MENA) and Latin America/ Caribbean (LATINCA). Table 1 shows the basic productivity statistics for the various groupings in relation to productivity in the reference group.

1. Using the three-digit ISIC Code, Rev. 2 classification, gives 28 industries. The analysis is based on 23 of them, excluding sectors where rent-seeking or tax distortions might lead to measurement error (see Appendix 1).

Table 1. **Manufacturing Workers' Productivity**
(Average of current dollar values in the 1990s)

Country group	Value
Reference	1.00
Other high	0.56
Non-high	0.25
Non-high w/o SSA	0.26
SSA	0.20
SEAP	0.23
MENA	0.20
LATINCA	0.30

Sources: UNIDO *Industrial Statistics Database* 2001; UNIDO *INDSTAT3* 2003; OECD *STAN* (Database for Structural Analysis) *Database* 2004; and authors' calculations. See Appendix 1 for country and group lists.

On average, workers' productivity in rich countries exceeds that in poor ones by a ratio of four to one, with few inter-continental differences. According to one line of research, these productivity gaps should be accounted for by a full list of relevant inputs that workers use, including their own education. If an unexplained residual emerges, more inputs should be added to the list. This line of research was made famous by Denison (1967) and recently emphasised by Caselli (2003). The research strategy here follows this approach. It investigates the role of four key inputs that potentially explain productivity differences: infrastructure, physical capital, trade capacity and education. This list goes a long way, at least on average, towards reaching the goal.

At the other end of the intellectual spectrum, one of the most quoted recent papers (Hall and Jones, 1999) claims that all the discrepancies in workers' productivity across countries arise from differences in institutions and government policies. They are measured by indices of rule of law, corruption, contract enforcement, openness, etc., and they determine endogenously the quantity and quality of inputs to which a country has access. Acemoglu *et al.* (2000) trace the origin of these institutional differences in the patterns of settlement of colonisers after the 16th century. Easterly and Levine (2001) argue that factor accumulation does not matter for explaining growth differentials, but that aggregate efficiency and the diffusion of technological progress have more importance.

The debate between these two extreme views is both empirical and philosophical. The empirical issue involves how much standard growth-accounting exercises actually do explain. The next section shows that productivity differences are in fact fairly well explained by factor accumulation. The key remaining question obviously involves why one country is better endowed than another in such and such a factor input. History, geography, climate and institutions, for example, all surely play critical parts. Yet for policy makers this question has a metaphysical cast. They want to know *hic* and *nunc* what priorities to address. In a recent paper, Glaeser *et al.* (2004) make the point, close in spirit to the analysis presented here, that the institutional differences supposed to reflect "deep parameters" of a country appear to be much more volatile than factors of production like human capital. They conclude that policy choices have more importance than features of the policy environment, such as constitutional restraint on the executive. On these grounds, the present paper adopts the perspective of how policies should best be targeted.

Infrastructure

Infrastructure plays an integral role in the development of any country. It involves less the construction of large projects than delivering basic services that people need for everyday life — water, sanitation, modern energy, roads, other kinds of transport and access to modern information and communication technology. World inequality in infrastructure provision and access remains impressive (Table 2).

Table 2. **Infrastructure: Key Indicators (2000)**

Country groups by income	Commercial energy use [a]	Improved sanitation facilities [b]	Improved water sources [b]	Paved roads [c]	Telephone mainlines, waiting time [d]	Telephone mainlines [e]	Internet telephone access charges [f]	GDP per unit of energy use [g]
High income	5 430.4			91.8	0.0	589.4	11.8	4.9
Low and middle income	970.7	51.3	78.9	30.9	2.0	82.2	0.4	4.0
Low income	568.6	43.7	76.1	16.1	4.4	26.8	0.4	4.0
Lower-middle income	1 206.1	55.3	80.5	53.0	1.9	120.3	0.2	3.7
Middle income	1 317.8	59.1	81.6	52.7	1.0	133.8	0.4	4.0
Upper-middle income	1 804.8	79.3	88.2	51.1	0.5	192.2	0.4	4.9

Notes:
a) Kg. of oil equivalent per capita.
b) Percentage of population with access.
c) Percentage of total roads for 1999.
d) Years.
e) Per 1 000 people.
f) $ per 30 off-peak hours for 2001.
g) PPP $ per kg of oil equivalent.
Source: World Bank, World Development Indicators (2003).

Anecdotal evidence suggests that infrastructure deficiencies have an important effect on manufacturing productivity, owing to the allocation of important business costs to the provision of own electricity (see World Bank, *Investment Climate Assessments*, various reports; World Bank, 2002; Reinikka and Svensson, 1999). This applies particularly to small firms, because power supply is characterised by large economies of scale. The heaviest burden thus falls on small enterprises, making it more difficult for them to run their activities or even to enter the market. At the margin, the retarding effect on potential new firms and existing firms increases in severity as firms' size gets smaller.

Comparable cross-country data on infrastructure users' costs would be extremely informative but are scarce, and the numbers available cover actual costs, so they include price distortions caused by the tax system or import controls. Moreover, government electricity subsidies distort the prices of both publicly and privately provided power in most developing countries. In Nigeria, the National Electric Power Authority (NEPA) reportedly produces electricity at a relatively high cost of 11 US cents/KwH compared with an international average of about 5-6 cents/KwH. It is allowed to charge only 3.5 cents/KwH and is supposed to receive the rest as a government subsidy (World Bank, 2002). Yet NEPA's accounts receivable run into billions of Naira. The government subsidises the cost of fuel (75 per cent of the total cost) for privately provided electricity, but there is a substantial difference between the costs of publicly and privately provided electricity. On average, the latter costs 2.42 times as much as electricity provided by NEPA (World Bank, 2002). Survey data on Uganda (Reinikka and Svensson, 1999) suggest that it costs about three times as much to run and own a generator than to buy power from the public grid when it is available.

Transportation infrastructure is a major concern for developing countries. Following the wave of trade liberalisation of the 1990s, tariff barriers no longer present the major hurdles to international trade. In Latin America, for instance, average tariffs declined from almost 26 per cent at the beginning of 1980 to 10 per cent by the end of the 1990s. Countries must now pay attention to transport costs if they want to integrate into the global economy. Limão and Venables (2001) suggest from empirical evidence that transportation infrastructure is a significant determinant of transport costs and trade flows. They show that raising transport costs by 10 per cent causes trade volumes to decline by more than 20 per cent and that poor infrastructure accounts for more than 40 per cent of predicted transport costs. If a country with a relatively poor infrastructure, at the 75th percentile in an international ranking, could upgrade to the 25th percentile, it would be able to reduce transport costs by between 30 per cent and 50 per cent. In a study of the determinants of maritime transport costs, Clark *et al*. (2001) find that if countries such as Ecuador, India or Brazil improved port efficiency to the levels attained by France or Sweden, they would reduce their maritime transport costs by more than 15 per cent. Infrastructure turns out to be one of the main determinants of port efficiency.

Some recent literature has focused on the links between trade facilitation, trade flows, and capacity building. Wilson *et al*. (2004) measure and estimate the relationship between trade facilitation and global trade flows in manufactured goods in 2000-01. They consider four important categories: port efficiency, customs environments, regulatory environments and service-sector infrastructure (with reference to e-business usage). Using simulation techniques, they estimate a total gain in trade flows from trade facilitation improvements at $377 billion. The most important source of these gains ($154 billion), particularly for exports to the OECD market, is a country's own trade facilitation efforts, particularly in service-sector infrastructure.

Evidence on infrastructure shortages as a major bottleneck to competitiveness in developing countries cannot be attributed solely to power deficiencies and transportation inefficiencies. It embraces the whole spectrum of infrastructure services. The data on infrastructure used in this study come from Canning (1998). They use electricity-generating capacity in kilowatts as the measure of infrastructure, for both practical and theoretical reasons:

— Data availability and quality problems abound. Canning points out that the data sets on electricity, telephones and telephone mainlines seem excellent and can be used without worry, whereas the use of transportation infrastructure data, particularly for roads, introduces important reporting errors leading to measurement issues in cross-section analysis. Despite good data, the telephone variables are not used here. Following Canning (2000), the inclusion of telephones as an explanatory variable has an estimated coefficient whose implied productivity effects are implausibly large; this could well reflect that the variable is more "demand determined" than other types of infrastructure. In other words, the endogeneity problem of the telephone variables may seriously bias the results.

— A high correlation between electricity-generating capacity and the other infrastructure variables suggests the use of its cross-country variation as an indicator of international differences in infrastructure levels generally. Table 3 shows the correlation among infrastructure stocks in Canning's data for 152 countries in 1985. Because infrastructure variables display such high correlation, including them separately in a cross-section setting will obviously yield important identification problems due to multicollinearity. This suggests either creating a synthetic index, which would imply the difficult and suspect aggregation of different volume measures (kilowatts and km, for example) or using a single type of infrastructure as a proxy.

Table 3. **Correlation across Infrastructures**

	TELMAIN	EGC	PAV	ROAD	RAIL
TELMAIN	1				
EGC	0.96	1			
PAVED ROAD	0.70	0.83	1		
ROAD	0.53	0.71	0.83	1	
RAIL	0.37	0.59	0.79	0.84	1

Notes: EGC = kilowatts of electricity generating capacity; TELMAIN = number of telephone mainlines; PAV = kilometres of paved roads; ROAD = kilometres of road; RAIL = kilometres of rail track.
Source: Canning (1998).

— Anecdotal evidence (see World Bank, *Investment Climate Assessments*, various reports) points to electricity quantity and quality as major bottlenecks for entrepreneurs in developing countries. The focus on manufacturing competitiveness thus justifies the use of that particular variable. Table 4 provides simple averages of infrastructure shortages for groups of developing countries relative to high-income countries.

Table 4. **Average Shortages of Infrastructure Stock Relative to High Income Countries**

Country groupings	Electricity	Paved roads	Railroads	Telephone mainlines
Reference	1.00	1.00	1.00	1.00
Non-high	0.19	0.10	0.33	0.16
Non-high w/o SSA	0.21	0.12	0.33	0.19
SSA	0.12	0.07	0.35	0.05
SEAP	0.14	0.10	0.35	0.05
MENA	0.21	0.05	0.19	0.20
LATINCA	0.25	0.10	0.48	0.21

Notes: Electricity: million kilowatts per 1 000 workers; Paved Roads: kilometres of paved roads per 1 000 workers; Railroads: kilometres per 1 000 workers; Telephone Mainlines: number of mainlines per 1 000 workers. See Appendix 1 for geographical group definitions.
Sources: Canning (1998) for infrastructure variables, 1990 data. Calculation of the number of workers in a country is based on Penn World Tables (PWT) 6.1.

Capital[2]

Investment does not flow adequately to the poor countries to bridge their poor endowments of physical capital. The literature has dubbed this the Lucas Paradox (Lucas, 1990). It bears investigation. First, how are aggregate GDP (which involves all sectors in the economy) and aggregate capital related to one another? Judging by the average productivity of capital (the ratio of GDP to the units of capital), the potential for capital mobility is huge, as shown in the first column of Table 5.

Table 5. **Investigating the Lucas Paradox**

Country groups	Output/capital ratio	Relative prices: capital/output	Return to capital (current dollars)	Capital/output ratios (k/y) in Mfg.
Reference	1.00	1.00	1.00	1.00
Other high	1.15	1.38	0.86	1.16
Non-high	2.07	1.96	1.03	1.46
Non-high w/o SSA	1.95	1.93	1.01	1.37
SSA	2.59	2.10	1.14	1.82
SEAP	2.46	2.06	1.13	1.63
MENA	2.81	3.20	0.91	1.36
LATINCA	1.46	1.52	0.98	1.22

Notes: See Cohen and Soto (2002). Data for 1990. Output per unit of capital is a simple average, measured at market prices. The capital/output ratio also is an average measure.

Sources: PWT 5.6; Easterly & Levine (2001); UNIDO *Industrial Statistics Database, 2001;* OECD *STAN Database*, 2004.

The ratio of output to capital is almost twice as large in middle- and low-income countries as in rich countries — excluding sub-Saharan Africa, where it is almost 2.6 times as high. If the return to physical capital is so much larger in poor countries, as these figures seem to suggest, why are capital inflows to poor countries so low? This is the question Lucas asked, and a number of papers have studied it. Lucas himself pointed to the role of externalities, while many others have analysed the risks of capital expropriation (see Gertler and Rogoff, 1990). Another interpretation is possible, however. The data reported in the first column of Table 5 are computed in volume terms (as done by Summers and Heston, 1991). Yet this is not appropriate for assessing the return to capital. An investor reasons in current prices rather than in purchasing-power terms. One must weight the physical productivity of capital by the relative prices of goods in order to assess the return in dollars of one dollar invested somewhere. The second column of Table 5 displays the relative prices of physical capital and output. They show wide variation, which reflects in part the problem that Summers and Heston intended to correct. To assess how much capital could flow into a given country, it is critical to take these price differences into account. The third column of Table 5 does this, using the Easterly-Levine (2001) figures for physical capital and correcting by the relative prices of physical capital to output. This correction wipes out the discrepancies in the return to capital. The adjusted return to capital (measured as output per unit of capital at market prices) is nearly equivalent in all the groups of

2. This section is based on Cohen and Soto (2002).

countries. It is slightly higher than for the reference group in sub-Saharan Africa and SEAP, slightly lower in MENA and in the rich countries outside the reference group, and almost at par in Latin America. Altogether the averages are almost identical in the poorest and the richest countries.

These results clearly need interpretation with great caution. Many measurement problems remain. Direct evidence on the returns to foreign investment in sub-Saharan Africa is reported in a number of papers, and the overall picture is mixed. Collier and Gunning (1999), for instance, argue that the return on capital in sub-Saharan Africa up to the early 1990s was on average about a third below the average in other emerging countries. Bhattacharya *et al.* (1996) report instead that returns on FDI fall in the range of 24-32 per cent in sub-Saharan Africa, but in the 16-18 per cent range in other developing countries. Nevertheless, in a thought-provoking paper based on macro data for Tanzania, Devarajan *et al.* (1999) argue that sub-Saharan Africa's low investment rate is due to its low return to capital. Collier and Patillo (2000) refer to all these points and argue quite convincingly that political risk is a major determinant of low investment in sub-Saharan Africa.

Even if the intuition about the role of relative prices in explaining the Lucas Paradox is correct, the paradox should nevertheless disappear in manufacturing. Manufacturing is essentially a tradable-goods sector, and one should not observe the kind of capital shortage that appears in macro PPP data, because the prices of manufactured goods are more or less the same across countries. UNIDO data on manufacturing support computing capital/output ratios relative to high-income countries. Calling k the capital per worker and y the corresponding worker productivity, the results shown in the final column of Table 5 appear. They indicate that poor countries have no shortage of manufacturing capital. In fact, Africa, among the least endowed regions in infrastructure, appears among the best capitalised. More generally, the capital/output ratio is in general the highest among poor countries. On investigation of this issue econometrically, the most significant relationship is a negative one between the capital/output ratio in manufacturing and aggregate GDP rather than any item in particular (infrastructure, education, trade or the relative price of capital). This can be dubbed an *anti-Lucas Paradox*. An intuitive explanation for it is that poor countries, lacking other inputs of all kinds, use physical capital as a substitute for those scarce missing inputs.

Trade

The idea that trade is good for productivity is a perennial and controversial topic. One of the most quoted papers on the subject (Sachs and Warner, 1995, SW in the text) constructs the argument that openness is good for growth upon a typology of "open" versus "closed" countries. The "open group" always grows significantly faster than the "closed group" both on average and annually. Furthermore, poor countries tend to grow faster than rich ones within the "open" group but not among the "closed" economies. SW interprets this finding as evidence that open countries move into a convergence club.

Rodrik and Rodriguez (1999) emphasise the problem that one cannot tell for sure what openness really means in SW. It may influence growth through other channels, such as the flow of ideas or simply good policies, which are poorly correlated with trade. Frankel and Romer

(1999, henceforth FR) try to circumvent this difficult question by using instrumental variables to account for the potential endogeneity of trade policy. They take advantage of natural barriers to trade, such as being landlocked or far from commercial centres, to determine the extent to which such barriers hinder growth. A counter-test by Irwin and Tervio (2002), however, shows that the effect of trade on productivity documented by FR disappears after controlling for distance to the equator, which would demonstrate that factors other than distance to commercial centres really matter.

That the volume of trade (even when corrected by population size and other factors such as country area) is itself barely correlated with growth is a puzzle. Why must we rely on proxies to analyse the influence of trade on growth? One interpretation (Cohen, 2002) suggests that trade is in fact significantly correlated with income in the subgroup of closed economies (according to the SW definition) while it is insignificant for the open group. This may demonstrate an optimum degree of openness. Open countries, having reached that optimum, lose a statistical correlation between trade and growth. Closed countries, constrained to stand below that optimum, remain positively affected by any positive trade shock.

In another interpretation, Alcalà and Ciccone (2001) offer a new measure of trade openness. They reconstruct openness by dividing trade (conventionally measured in dollars) by GDP measured at PPP prices. They call this measure “real openness”. Their argument assumes that the impact of trade on productivity falls disproportionately upon the tradable sector; in that case, openness may raise prices in the non-tradable sector and actually decrease the measured openness of a country. With their measure, they find a significant impact of openness on productivity.

The foregoing discussion suggests that trade integration is not well measured by aggregate data and that micro-related indices will likely better reveal the extent to which a country is indeed involved in international exchanges. In fact, the link between trade and growth usually is assessed at the aggregate level, so that the causality between the two is unclear[3]. This highlights the need to move beyond aggregate statistics and look in more detail at the product variety of traded goods. Recent work (Hummels and Klenow, 2002; Schott, 2004) investigates the extent to which trade between countries consists of a common set of goods, a larger set of goods from bigger countries or different quality goods. These authors identify an important role for product variety and quality in explaining trade flows. It is reasonable to expect, therefore, that these features will also have an influence on country productivity. Feenstra and Kee (2004) examine how export variety affects productivity using a broad cross-section of advanced and developing countries and disaggregating across sectors. Their findings confirm the importance of export variety as the mechanism (Hallak and Levinsohn, 2004) by which trade affects productivity. They demonstrate that tariffs and transport costs have an impact on productivity through export (and import) variety, showing for example that a ten percentage point increase in US tariffs would lead to a 3.8 per cent fall in exporting countries’ productivity. Finally,

3. Dollar (2003) reviews the main specifications of the macroeconomic literature on the subject and draws conclusions on the weaknesses of their identification strategies whenever the effects of trade have to be distinguished from other factors, such as institutions.

decomposing productivity differences across countries in the part explained by export variety and the remainder explained by other determinants, i.e. fixed effects, they find that export variety accounts for 8.5 per cent of the variation in country productivity.

Based on the idea that more disaggregated data may capture the impact of trade on productivity more appropriately than aggregate statistics, this paper uses the Grubel and Lloyd (1975) index of intra-industry trade as a measure of trade-integration in the empirical work. Specifically, the index is defined as follows:

$$Gliit_i = 1 - \frac{\sum_{j=1}^{n} \left| X_{ij} - M_{ij} \right|}{\sum_{j=1}^{n} (X_{ij} + M_{ij})},$$

where X_{ij} and M_{ij} indicate respectively total exports and imports of country *i* in sector *j*. This index varies between zero and one. Zero corresponds to a strict division of labour or specialisation across industries[4]; the country exports good *i* and imports good *j, i* and *j* being systematically different. The other extreme (one) depicts a country exporting and importing goods that belong to the same sector but obviously differ in either variety or quality. This index correlates very well with alternative measures of trade integration such as transportation costs[5], as well as with manufacturing productivity and infrastructure availability. There is of course the risk that such an index may be an endogenous reflection of a country's achievements on other fronts. This is a problem for the estimation of the weight to give to this coefficient, and an attempt will be made to resolve it by the use of instrumental variables (see Appendix 2).

One interpretation of the impact of trade on productivity may involve the role of prices. One usually expects prices in the manufacturing sector to equalise across countries as a result of trade. Yet price estimates in manufacturing seem to contradict this prediction. Prices of seemingly equivalent manufactured goods do differ across countries (see the work on comparisons of producer prices undertaken at the University of Groningen for interesting insights)[6]. These differences may simply reflect the impact of transportation costs. If so, trade does raise the value of manufacturing in a poor country and is akin to a productivity improvement. The link between trade and productivity may, however, be driven by the variety and quality issues addressed above, which the data do not take well into account.

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4. An ideal such measure would have to be calculated at a more highly disaggregated (product) level. Using the United States as the unique importing country (due to data availability) and a different trade index focusing only on the export side, Feenstra and Kee (2004) highlight the impact of variety on productivity based on a very fine level of product classification.
5. This paper does not, however, use those measures (CIF/ FOB values of trade as conventionally used to proxy for transport costs) by looking at them on a country-by-country basis, because, as has been highlighted in the literature, they exhibit large measurement error.
6. ICOP Industrial Database, http://www.eco.rug.nl/GGDC/icop.html.

Education

The data set used here for education and human capital comes from the OECD Development Centre[7]. It covers 95 countries, distributed among major world regions. The regions include the Middle East and North Africa (MENA, 8 countries), sub-Saharan Africa (SSA, 26), Latin America and the Caribbean (LAC, 23), East Asia and Pacific (EAP, 8), South Asia (SA, 3), Eastern Europe and Central Asia (ECA, 4) and high-income countries (HI, 23). The data (Table 6) have been computed for the beginning of each decade from 1960 to 2000 and are accompanied by a projection to 2010 — an extrapolation based on population projections by age from the US Census Bureau web site and the estimates of educational attainment for the year 2000.

Table 6. **Years of Schooling**
(Population aged 15-64, population-weighted averages)

Country groupings	1960	1970	1980	1990	2000	2010
All (95)	3.8	4.6	5.3	6.0	6.8	7.4
High-income (23)	8.7	9.8	10.9	11.6	12.1	12.5
Middle- and low-income (72)	2.1	2.9	3.7	4.8	5.7	6.5
Middle East and North Africa	0.9	1.6	2.7	4.3	5.9	6.9
Sub-Saharan Africa	1.3	1.7	2.1	3.0	3.9	4.3
Latin America and Caribbean	3.8	4.5	5.3	6.7	7.6	8.2
East Asia and Pacific	2.3	3.2	4.3	5.4	6.4	7.3
South Asia	1.2	1.9	2.6	3.1	4.3	5.3
Eastern Europe and Central Asia	5.3	5.8	6.5	7.1	7.8	8.4

Source: Cohen and Soto (2002).

Note the contrast in the relative and absolute differences between rich and poor countries. In relative terms, a mild convergence occurred over time as the ratios shifted from one to four to one to two. The absolute gap between rich and poor countries, however, essentially stayed constant over the decades. According to this criterion, no catch-up in schooling has taken place.

Among developing countries, the MENA region has had the highest increase in schooling since 1960 as well as the fastest annual growth rate in years of schooling, 4.8 per cent. The percentage change in years of schooling is also relatively high in the SSA region, which occupies third place among the most dynamic regions in the world according to this measure, but SSA has had the lowest absolute improvement. This highlights the importance of specifying the proper proxy for human capital in growth regressions — the logarithm of the number of years of schooling or its level — and confirms recent findings by Temple (2001) and Soto (2002).

By 2010, high-income countries will have twelve and a half years of schooling, followed well behind by ECA countries — the best-educated developing region — with only 8.4 years. In fact, the most educated regions of the developing world will have fewer years of study than those exhibited by the average of high-income countries half a century earlier. Moreover, SSA

7. See Cohen and Soto (2001) on which this section is based.

will be just as educated as LAC was in 1970. Summing up, since the 1960s and most probably before, sub-Saharan African labour forces have been among the least educated in the world and there are no signs that this will reverse in coming years.

Why is that so? The explanation developed in Cohen and Soto (2002) holds that the increase in life expectancy in poor countries has not been sufficient to trigger investment in human capital. Economists usually portray the relationship between inputs and outputs as concave functions, but this is not necessarily so for human capital. According to Mincer (1974), human capital is an exponential function of the number of years of study, implying that the marginal effect of education on human capital, and hence on wealth, is increasing on education. Cohen and Soto (2001) provide econometric estimates of a model with a non-linear relationship between life expectancy and education, such that the marginal propensity to educate oneself rises gradually towards one. This has dramatic implications. If life were infinite, people would decide to keep on educating themselves forever. Below a critical value, T*, life is entirely channelled into work; above it, education rises with life expectancy. This insight illustrates why rising life expectancy may not have the same effect on education in rich and poor countries (Table 7).

Table 7. **Life Expectancy and Education**

	Life expectancy at age 5 (L5)		Average years of schooling (YS)		$\Delta YS/\Delta L5$
	1960	1990	1960	1990	
Rich	72.3	76.9	7.6	10.5	0.63
Middle- and low-income countries excluding SSA	63.2	70.5	3.3	6.1	0.39
Sub-Saharan Africa (SSA)	54.3	60.1	1.6	3.6	0.34

Source: Cohen and Soto (2001).

A mild convergence has occurred in life expectancy across the world, in both relative and absolute terms. Cohen and Soto (2002) argue that absolute levels are what matter. Life expectancy in sub-Saharan Africa, 18 years lower than in rich countries on average in 1960, eased to less than 17 years lower by 1990. Faster convergence in the rest of the world narrowed the discrepancy with rich countries to 6.4 years in 1990 from nine years in 1960. Yet this broad convergence is not observed in educational achievement (see Cohen and Soto, 2001). The absolute discrepancy between rich and poor nations hardly changed over the period and actually increased in sub-Saharan Africa. As a result, the ratio of the average increase in years of schooling to the average increase in life expectancy in high-income countries was nearly double that of the rest of the world.

IV. KEY RESULTS

The Model

As explained above, the analysis relies on a model in which workers' productivity in manufacturing (Y_{ij}) depends on five items that interact multiplicatively: private physical capital (*K*), public infrastructure capital (*Z*), education or Human Capital (*H*), trade integration (*T*) and net efficiency (*A*). The approach assumes a Cobb-Douglas specification for production, that is:

$$Y_{ij} = TFP_{ij} \cdot K_{ij}^{\alpha} H_{ij}^{\beta} Z_{ij}^{\gamma} \quad (1)$$

where

$$TFP_{ij} = A_{ij} \cdot T_i^{\theta} \quad (2)$$

The subscript i denotes country and the subscript j denotes industrial sector. TFP is the conventional measure obtained from taking account of *K*, *Z* and *H*, and efficiency is the net residual *A* obtained from taking account of the role of trade on TFP. Trade integration thus affects manufacturing productivity through its effect on total factor productivity in the production function. Assuming constant returns to scale in *K*, *H* and *Z* in equation (1) (see Appendix 2 for econometric results pointing to that hypothesis), one can write (1) as:

$$Y_{ij} = A_{ij} T_i^{\theta} \cdot \left(\frac{K_{ij}}{H_{ij}} \right)^{\alpha} \cdot \left(\frac{Z_{ij}}{H_{ij}} \right)^{\gamma} H_{ij} \quad (3)$$

This is the basis of the decomposition offered below. The econometric method used to compute the various parameters is reported in Appendix 2. Data on education per worker at the disaggregated level, H_{ij} are calculated by weighting the country aggregate data H_i by sector wages w_{ij}, where H_i denotes education in country i, following Cohen and Soto (2002) and Soto (2002). Disaggregated data on human capital are thus calculated following the weighting procedure $H_{ij} = H_i \cdot w_{ij} / w_i$, where w_{ij} is nominal wage per employee in sector j and w_i is average wage per employee in manufacturing in country i.

Overall Results

This subsection presents the results at the continental level. They interact multiplicatively, so that labour productivity is the product of each of the five items. The contribution of each item in the rich countries is normalised as one (see Appendix 2 for analytical description of the contribution computations). The first four columns present the contributions of four standard inputs, capital, infrastructure, human capital and aggregate TFP. The last two columns show the contributions of trade and a new residual *(A)*, the product of which is equal to TFP, as in equation (2). The term *A* is called "net efficiency".

Table 8. **Key Results**

Country Groups	*Y*	*K*	Z	*H*	*TFP*	*Trade*	*A*
Reference	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other high income	0.56	0.95	0.94	0.78	0.80	0.92	0.87
Non-high income	0.25	0.81	0.80	0.63	0.60	0.83	0.72
Non-high income w/o SSA	0.26	0.78	0.82	0.66	0.61	0.84	0.72
SSA	0.20	0.92	0.75	0.52	0.57	0.78	0.73
SEAP	0.23	0.78	0.76	0.66	0.58	0.86	0.67
MENA	0.20	0.78	0.83	0.59	0.54	0.82	0.65
LATINCA	0.30	0.79	0.84	0.67	0.67	0.83	0.82

Note: Averages of 1990 and 1999.
Sources:
Y: UNIDO *Industrial Statistics* 2001 for 1990, UNIDO *INDSTAT3* 2003 for 1999, CD ROM Editions; OECD *STAN Database* (2004) for a subset of high-income countries;
K: UNIDO *Industrial Statistics* 2001;
Z: World Bank (2003) for electricity production in kwH.;
H: Cohen and Soto (2001, 2002);
Trade: OECD *ITCS* database.

This table indicates more resemblance than diversity. The poor countries are about one-fourth as productive as the rich ones, the reasons being almost evenly split among lower capital, lower infrastructure, lower human capital, lower access to global trade and lower efficiency. The table illustrates the power of multiplication (see Cohen and Soto, 2002). Human capital is the weakest link while the other items have roughly equal importance. Clearly this ranking is itself vulnerable to a change of categories. Lumping together physical capital and infrastructure, and comparing their contribution with either human capital or aggregate GDP, the three blocs would become equivalent; this was a feature in Cohen and Soto (2002). At this stage, all that one can say is that poor countries should roll up their sleeves and build schools, install infrastructure, trade more and invest more. For each continental grouping, the general thread remains the same, with a few interesting variations.

Africa

Africa's performance does not differ significantly from the world average. It does have more physical capital, almost on a par with the richest countries, and less infrastructure — important features that lend support to some degree of substitutability between the two. As noted above concerning power shortages, manufacturers make wide use of private generators as substitutes for publicly provided electricity. Africa also stands well behind the richest and the average of the other poor countries in education. Infrastructure and education present the key challenges for economic development in Africa.

SEAP

Asia provides a good example of balanced underdevelopment. All five items of interest equal or exceed 66 per cent of the rich countries' achievements — but net efficiency is below average. This confirms Alwyn Young's (1995) diagnosis. As Paul Krugman (1994) says, Asia needs more inspiration. It faces the key challenge of raising net efficiency.

MENA

This region has the same productivity as Africa. Compared to the other poor regions, both education and net efficiency remain below average. This suggests that human capital defined broadly as the product of education and its efficiency presents the critical problem for MENA. Raising both is the key challenge.

LATINCA

Latin America and the Caribbean, the most productive among the poor regions, also illustrates balanced underdevelopment, in which all items play about the same role. As will be seen below, however, a number of interesting peculiarities emerge in some Latin American countries.

Manufacturing and Aggregate GDP

Focusing on manufacturing left the bulk of GDP aside. How does productivity in manufacturing compare with that of the whole economy? Building on the work of Cohen and Soto and taking account of the role of infrastructure using Canning's (2000) estimates as a measure of the role of infrastructure in aggregate GDP, Table 9 provides some answers.

Table 9. **Aggregate GDP**

	y	*k*	*z*	*h*	*TFP*
Reference	1.00	1.00	1.00	1.00	1.00
Other high	0.69	0.93	0.96	0.76	1.02
Non-high	0.29	0.63	0.87	0.63	0.83
Non-high w/o SSA	0.33	0.67	0.88	0.66	0.86
SSA	0.11	0.49	0.84	0.51	0.54
SEAP	0.28	0.59	0.84	0.65	0.86
MENA	0.30	0.61	0.89	0.58	0.94
LATINCA	0.37	0.72	0.90	0.67	0.86

Notes: The table is based on the following specification $y = \left(\frac{k}{h}\right)^{(\alpha)} \cdot h \cdot \left(\frac{z}{h}\right)^{\gamma} \cdot TFP$, with $\alpha = 0.33$ and $\gamma = 0.085$. 1990 Data. See appendices for data description and econometric results.

Sources: GDP per worker estimates based on data from PWT 5.6; aggregate capital figures from Easterly and Levine (2001); human capital from Cohen and Soto (2001); Z is based on data from World Bank (2003).

Aggregate TFP is higher (in the poorest nations and in relative terms) for the economy at large than in manufacturing. For all non-high-income countries, TFP in manufacturing stands at 60 per cent of the core countries' levels while it reaches 83 per cent for aggregate GDP. This confirms the view that manufacturing is the weak link of the production chain in the poorest countries. The discrepancy is particularly important in MENA, where aggregate TFP is good (94 per cent of the core countries' levels) but manufacturing TFP is among the worst. Africa, on the other hand, is an exception; its TFP numbers are essentially identical in manufacturing (57 per cent) and in the economy at large (51 per cent).

According to Balassa-Samuelson, the lower productivity of manufacturing explains why the prices of manufactured goods are relatively higher in a poor country — to cover the cost differential for each unit produced. Thus the TFP differential should explain the price differential. The statistics developed here only partially confirm this proposition. The figures in Table 5 on the relative price of investment to GDP can serve as a proxy for the prices of manufactured goods relative to the "average good" in the economy. On average, the price differential so measured is 50 per cent and the productivity differential is about 25 per cent. Analysing this issue econometrically, the TFP differentials do significantly explain the price differentials, but with an elasticity of about 0.4 rather than the 1.0 predicted by Balassa-Samuelson. This needs more work, especially analysis of taxes on capital goods. At any rate, the results so far confirm the usefulness of a focus on manufacturing, where a productivity improvement obviously is good in itself and allows reduction of the price of physical capital.

V. NEW APPROACHES TO COMPETITIVENESS

Country Analysis

This sub-section reviews the results country by country, and the following one offers a new battery of "competitiveness indices". Table 10 ranks all the countries included in this study in order of decreasing productivity. The text that follows highlights a few typical scenarios.

Table 10. **Productivity Rankings**

Countries	*Y*	*K*	*Z*	*H*	*TFP*	*Trade*	*A*
Reference(Core) Group	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Japan	1.24	1.00	0.93	1.08	1.23	0.86	1.43
USA	1.24	0.84	1.03	1.12	1.27	1.05	1.20
Belgium	1.16	1.13	1.01	0.90	1.14	1.07	1.06
Sweden	1.11	1.05	1.08	1.04	0.94	1.02	0.92
France	1.10	1.17	1.00	0.91	1.04	1.07	0.96
Finland	1.10	1.10	1.04	0.97	0.99	0.97	1.02
Canada	1.00	0.91	1.08	1.13	0.91	1.01	0.90
Norway	0.97	1.02	1.15	1.10	0.75	0.95	0.79
Austria	0.96	1.03	0.97	0.97	0.99	0.96	1.03
Netherlands	0.95	1.06	0.94	0.96	1.00	1.06	0.94
United Kingdom	0.92	0.88	0.92	1.13	1.00	1.08	0.93
Denmark	0.88	0.84	0.90	1.03	1.13	1.00	1.13
Italy	0.83	1.09	0.94	0.84	0.97	1.00	0.97
Singapore	0.80	1.14	0.98	0.74	0.98	0.98	1.00
Republic of Korea	0.79	1.06	0.90	1.02	0.82	0.98	0.83
Australia	0.71	0.85	0.99	1.16	0.73	0.87	0.85
Spain	0.71	0.93	0.97	0.78	1.01	1.05	0.96
Chile	0.60	0.88	0.85	0.82	0.97	0.76	1.29
Brazil	0.54	0.91	0.87	0.62	1.09	0.88	1.23
Greece	0.47	1.01	0.94	0.81	0.61	0.87	0.70
Mexico	0.47	0.80	0.88	0.67	1.00	0.98	1.02
Turkey	0.40	0.94	0.84	0.56	0.90	0.88	1.03
Thailand	0.38	1.31	0.75	0.62	0.62	0.86	0.72
Peru	0.38	0.90	0.77	0.68	0.79	0.78	1.00
Cyprus	0.36	0.84	0.91	0.74	0.64	0.83	0.77
Colombia	0.32	0.72	0.81	0.61	0.88	0.82	1.08
Uruguay	0.30	0.70	0.88	0.71	0.69	0.77	0.89
Venezuela	0.27	0.80	0.98	0.55	0.62	0.83	0.74
Portugal	0.26	0.90	0.94	0.61	0.50	0.94	0.53
Panama	0.24	0.81	0.83	0.72	0.50	0.79	0.64
SouthAfrica	0.24	0.83	1.03	0.61	0.47	0.83	0.56
Cameroon	0.24	1.02	0.66	0.49	0.73	0.77	0.95

Table 10. **Productivity Rankings** (contd.)

Countries	*Y*	*K*	*Z*	*H*	*TFP*	*Trade*	*A*
Trinidad and Tobago	0.21	0.87	0.91	0.82	0.33	0.83	0.40
Malaysia	0.21	0.80	0.86	0.75	0.41	0.94	0.43
Zimbabwe	0.21	0.70	0.78	0.66	0.58	0.75	0.78
Bolivia	0.20	0.91	0.71	0.69	0.46	0.80	0.57
Senegal	0.20	1.11	0.63	0.40	0.71	0.84	0.85
Jordan	0.17	0.56	0.86	0.83	0.44	0.75	0.59
Zambia	0.17	0.80	0.85	0.55	0.45	0.72	0.62
Costa Rica	0.15	0.62	0.86	0.60	0.48	0.90	0.54
Central African Republic	0.15	1.03	0.57	0.40	0.65	0.75	0.86
Morocco	0.15	0.81	0.78	0.43	0.55	0.86	0.64
Ecuador	0.13	0.86	0.78	0.67	0.29	0.75	0.39
Fiji	0.12	0.75	0.83	0.68	0.29	0.79	0.37
Philippines	0.12	0.50	0.72	0.66	0.51	0.91	0.55
Hungary	0.12	0.61	0.88	0.91	0.24	0.98	0.25
Egypt	0.09	0.82	0.85	0.53	0.25	0.78	0.32
Honduras	0.09	0.53	0.78	0.52	0.40	0.84	0.48
Indonesia	0.08	0.66	0.68	0.62	0.29	0.83	0.35
India	0.07	0.78	0.75	0.46	0.25	0.83	0.30
Bangladesh	0.02	0.40	0.61	0.44	0.23	0.75	0.30

Notes: Averages of 1990 and 1999. Based on Instrumental Variable (IV) econometric estimates of a generalised production function. See Appendix for data description, sources and econometric results.

Sources: *Y*= UNIDO *Industrial Statistics* 2001 for 1990, UNIDO *INDSTAT3* 2003 for 1999, CD ROM Editions; OECD *STAN Database* (2004) for a subset of high-income countries; *K*= UNIDO *Industrial Statistics* 2001; *Z*= World Bank (2003) for electricity production in kwH.; *H*= Cohen and Soto (2001, 2002); Trade= ECD *ITCS Statistics*.

Balanced Patterns of Underdevelopment

This group includes countries that are on the right track, with no major bottlenecks; their factor deficiencies are well spread over the spectrum. They need to develop all factors together in order to grow. No fast-track scenarios are open to them, except perspiration, as Edison would say. Almost all developing countries with levels of productivity above 30 per cent of the richest belong to this group. They include: Singapore, Korea, Chile, Brazil, Greece, Mexico, Turkey, Peru, Cyprus, Colombia, Uruguay and Venezuela. The only exception is Thailand, which is discussed below.

Korea and Singapore have almost the same productivity (0.8 and 0.79 relative to the core countries). They show some difference, however, which gives a sense of different priorities. Singapore remains behind in education (at 74 per cent of the richest countries), while Korea lags in TFP. Brazil and Turkey form another pair with much in common, including their main apparent handicap, lower education. Brazil has higher net efficiency, however, and it could serve as a reference for Turkish firms. Trade integration almost on a par with the richest countries is a strong point for Mexico, but it remains handicapped by low capital accumulation.

African Scenario

The African scenario describes countries with high capital/labour ratios. Senegal and the Central African Republic perfectly exemplify this disease. Despite levels of productivity at 20 per cent and 15 per cent of the richest nations, their endowments of physical capital per unit of human capital exceed those of the richest countries. Thailand also appears to depend on higher than normal levels of physical capital. Some of the explanations offered for the Thai crisis underlined a low ICOR (incremental capital-output ratio)[8]. Note that rich Anglo-Saxon countries, such as the United States, the United Kingdom and Australia, stand on exactly the opposite side of the fence. Their capital endowments appear as extremely low given their levels of income. Countries like France, however, owe part of their productivity to high capital ratios.

Low Efficiency

The mirror image of the first group of "balanced" countries appears in the least productive countries, with productivity inferior to 15 per cent of that in the core group. They all face one key bottleneck, a very low level of efficiency. The sample includes seven such countries: Ecuador, Fiji, Hungary, Egypt, Indonesia, India and Bangladesh. India and Egypt are the two countries most representative of this low-efficiency group. Both have low education and net efficiency, resulting in remarkably low labour efficiency (defined as the product of the two terms). Cohen (2002) argued that for them more openness could play a critical role in fostering a better allocation of skilled workers away from less productive domestic tasks. Among the poorest countries, the Philippines and Honduras, both fairly balanced, are two exceptions. Bangladesh also may be better described as simply deprived of almost everything, combining low efficiency with low physical capital and very poor access to the world market.

Trade Paradoxes

The Philippines, Costa Rica and Hungary suggest that trade integration does not always lead directly to higher productivity. Although well integrated according to the index, they fall behind the other countries in labour productivity. On the other hand, most Latin American countries in the group (except Mexico) appear to have less integration with the world market yet to display above-average net productivity. This problem is especially acute in Chile and Brazil. This may reflect a measurement problem in their trade or, given their lower measured levels of education, a lower assessment of human education than they really have achieved.

8. ICOR denotes the additional capital required to produce an extra unit of output.

VI. NEW RANKINGS

This section returns to the subject of competitiveness indices. Based on the main work of the paper, it offers some new country rankings. They could have some utility for policy makers seeking to determine their priorities and for potential foreign investors looking for promising places in which to invest. Contrary to the approach of the WEF, these rankings weight only hard data and do so by using weights grounded in their contribution to aggregate productivity. Table 11 compares four rankings:

— By productivity itself, which simply replicates Table 10 for ease of comparison;

— By residual productivity, when the contribution of physical capital is left out. Technically, this index is the product of multiplying the contributions of *Z*, *H* and *TFP*. It represents the factors that can be taken as exogenous to the private firm, when its role amounts only to bringing capital. Under perfect capital mobility, private capital is the investor's asset. The investor need not take into account its impact on productivity;

— By the contributions of infrastructure and trade integration to productivity, obtained simply by taking the product of *Z* and *T* (trade). This index captures a country's ability to provide a good platform for reaching world markets. It includes infrastructure because of its apparently high correlation with trade integration, the former being quite often a condition for the latter; and

— By worker efficiency, measured as the interaction of human capital and net efficiency (*H* and *A*). The index aims at measuring the quality of the labour force, although net efficiency clearly is related to other factors as well.

These rankings are obviously not independent (the product of the third and the fourth is equal to the second), but each sheds light on one dimension of the sources of productivity. Note that the rankings are based on a cardinal rather than an ordinal approach. The numbers for each country can be compared mathematically (as measuring contributions to productivity), so that one may see not only how a country stands in the rankings but also how far it stands from others.

Table 11. **Alternative Country Rankings**

Rank Order	Ranking 1	*Y*	Ranking 2	*ZTHA*	Ranking 3	*ZT*	Rank 4	*HA*
1	Japan	1.24	USA	1.47	Sweden	1.10	USA	1.42
2	USA	1.24	Japan	1.24	Norway	1.09	Japan	1.34
3	Belgium	1.16	Canada	1.11	USA	1.09	Denmark	1.16
4	Sweden	1.11	Sweden	1.05	Belgium	1.08	UK	1.13
5	France	1.10	Denmark	1.05	Canada	1.08	Canada	1.03
6	Finland	1.10	UK	1.04	France	1.07	Belgium	1.02
7	Canada	1.00	Belgium	1.03	Spain	1.01	Sweden	0.98
8	Norway	0.97	Finland	1.00	Finland	1.01	Finland	0.96
9	Austria	0.96	Norway	0.95	Netherlands	1.00	Austria	0.96
10	Netherlands	0.95	France	0.94	UK	0.99	Netherlands	0.96
11	UK	0.92	Austria	0.93	Singapore	0.96	France	0.94
12	Denmark	0.88	Netherlands	0.90	Italy	0.94	Australia	0.85
13	Italy	0.83	Australia	0.84	Austria	0.93	Korea	0.84
14	Singapore	0.80	Italy	0.76	Denmark	0.91	Norway	0.82
15	Korea	0.79	Spain	0.76	Portugal	0.88	Italy	0.81
16	Australia	0.71	Korea	0.75	Korea	0.88	Chile	0.80
17	Spain	0.71	Singapore	0.71	Hungary	0.87	Spain	0.78
18	Chile	0.60	Chile	0.68	Australia	0.86	Singapore	0.72
19	Brazil	0.54	Mexico	0.59	Mexico	0.86	Brazil	0.68
20	Greece	0.47	Brazil	0.59	South Africa	0.85	Mexico	0.67
21	Mexico	0.47	Greece	0.47	Greece	0.82	Colombia	0.54
22	Turkey	0.40	Colombia	0.44	Venezuela	0.81	Peru	0.54
23	Thailand	0.38	Cyprus	0.43	Malaysia	0.81	Turkey	0.51
24	Peru	0.38	Turkey	0.43	Japan	0.80	Greece	0.49
25	Cyprus	0.36	Uruguay	0.43	Costa Rica	0.77	Uruguay	0.49
26	Colombia	0.32	Peru	0.42	Brazil	0.77	Cyprus	0.47
27	Uruguay	0.30	Venezuela	0.34	Cyprus	0.76	Thailand	0.39
28	Venezuela	0.27	Jordan	0.31	Trinidad	0.75	Zimbabwe	0.38
29	Portugal	0.26	Panama	0.30	Turkey	0.74	Jordan	0.36
30	Panama	0.24	Zimbabwe	0.30	Uruguay	0.68	Panama	0.36
31	South Africa	0.24	South Africa	0.29	Morocco	0.67	Cameroon	0.36
32	Cameroon	0.24	Thailand	0.29	Colombia	0.67	Venezuela	0.34
33	Trinidad	0.21	Portugal	0.29	Egypt	0.66	Philippines	0.34
34	Malaysia	0.21	Malaysia	0.26	Fiji	0.66	Bolivia	0.31
35	Zimbabwe	0.21	Costa Rica	0.25	Honduras	0.66	Malaysia	0.31
36	Bolivia	0.20	Trinidad	0.25	Panama	0.66	Portugal	0.31
37	Senegal	0.20	Philippines	0.24	Philippines	0.65	Costa Rica	0.29
38	Jordan	0.17	Cameroon	0.24	Thailand	0.65	South Africa	0.28
39	Zambia	0.17	Bolivia	0.22	Jordan	0.65	Senegal	0.28
40	Costa Rica	0.15	Zambia	0.21	Chile	0.64	Trinidad	0.27
41	CAR	0.15	Hungary	0.20	India	0.62	CAR	0.26
42	Morocco	0.15	Morocco	0.18	Zambia	0.62	Zambia	0.25
43	Ecuador	0.13	Senegal	0.18	Peru	0.61	Morocco	0.23
44	Fiji	0.12	Fiji	0.16	Ecuador	0.59	Hungary	0.22
45	Philippines	0.12	Honduras	0.16	Zimbabwe	0.58	Honduras	0.21
46	Hungary	0.12	Ecuador	0.15	Indonesia	0.56	Fiji	0.20
47	Egypt	0.09	CAR	0.15	Bolivia	0.56	Ecuador	0.19
48	Honduras	0.09	Indonesia	0.12	Senegal	0.53	Indonesia	0.18
49	Indonesia	0.08	Egypt	0.11	Cameroon	0.51	Egypt	0.13
50	India	0.07	India	0.09	Bangladesh	0.46	India	0.12
51	Bangladesh	0.02	Bangladesh	0.06	CAR	0.43	Bangladesh	0.10

Notes: Averages of 1990 and 1999. Based on IV econometric estimates of a generalised production function. See Appendices for data description, sources and econometric results.

Sources: See Appendices.

The first ranking, manufacturing productivity, replicates the previous analysis. The two best countries in the table are Japan and the United States, which are about 20 per cent more productive than their core-country counterparts. The two worst are India and Bangladesh. Bangladesh's productivity stands at a mere 2 per cent of the core countries' levels. The median country is Colombia, with productivity at about one third of that of the richest countries.

The second ranking (which subtracts the role of physical capital) especially favours the Anglo-Saxon countries, where capital stocks are relatively low, and bad for countries that suffer from the African disease of high capital stocks and meagre infrastructures. Some other rich countries also fall behind when the role of capital is netted. France, for example, drops below Spain because France owes much of its productivity to a high capital/labour ratio. South Africa keeps exactly the same rank, which confirms that it is not a typical African economy.

Some critical changes emerge in the third ranking, which values infrastructures and integration in world markets. The winners are Sweden and Norway, while Japan moves from the first spot in the first ranking to number 24 in the third. At the other extreme, India, ranked 50th just ahead of Bangladesh in ranking two, has moved up to rank 41. Even more spectacularly, Egypt moves from rank 49 to rank 33.

Finally, ranking four tells the same story but in reverse order. The United States and Japan regain their top positions while Egypt and India fall back again. In the middle, Korea (ranked 13) comes above Singapore (ranked 18). Despite lower net efficiency, Korea can count on a better-educated workforce, which keeps an edge over Singapore. In fact, according to this ranking Korea is now well within the group of rich countries, ahead of Norway and Italy. A country such as Portugal, however, well ranked by index three (15th, just behind Denmark) now comes 36th, between Malaysia and Costa Rica; this shows that the road to better productivity is primarily one of improving the efficiency of labour.

VII. CONCLUSIONS

This paper remains very much an exercise in macroeconomic methodology. In order to make the diagnostic technique that it develops useful in describing reliable policy options that can help policy makers, more work is needed on several fronts. First, the results obtained need enrichment with more microeconomic information relevant to individual national situations. Second, problems inherent in the quality and age of the data must be dealt with. Third, the sample requires expansion to include more countries of interest and to make the geographical groupings more representative of their regions. The country sample used for this initial experiment has gaps. For example, the sub-Saharan Africa (SSA) group contains only six countries out of potentially about 50[9]. Future work will try to increase this number to a more representative level and to include some of Africa's more interesting economies — Mauritius and Uganda, for example. The Middle East-North Africa (MENA) regional group contains just four countries, two of which have data for 1990 only. The Asian group is very heterogeneous, which argues for a finer breakdown into sub-regions.

To capture more microeconomic features in individual countries on, say, skills, plant productivity, return on capital and distortions created by taxes and subsidies, probably is the most important task. It can serve two purposes, namely to suggest corrections and adjustments to the raw data used in the overall analysis and, at the same time, to shape the results of the analysis into realistic country-specific policy recommendations. Doing this for the entire group of poor countries in the sample would of course represent the work of years or a large staff indeed — but a more manageable goal could involve the selection of a few representative countries from the sample for this kind of detailed information-gathering and analysis. This would both further test the power of the methodology and lead to at least a few sets of serious policy recommendations. It would also demonstrate a way forward for other national policy makers interested in evaluating their own countries' situations.

9. One of the six is Zimbabwe, for which only 1990 data are available and whose situation probably would appear very differently if more contemporary information were available.

APPENDIX 1. DATA DESCRIPTION

Variable Definitions and Sources:

Industrial Data

The tables presented in the text are computed whenever possible from OECD Data (STAN Industrial Structural Analysis Database, 2004 Edition) for a subset of OECD countries, as explained below, and from the UNIDO Industrial Statistics Database REV. 2 of ISIC, editions 2001 and 2003 (INDSTAT3) otherwise.

Y_{ij} : value added in country i, sector j. Data are in current dollars. They are averages of 1999 and 1990 data when available; otherwise they are for 1990 (see Table A2 below).

Sources:

— UNIDO Industrial Statistics Database REV. 2 of ISIC, edition 2001 (CD ROM); UNIDO INDSTAT3 2003 REV. 2 of ISIC (CD ROM). The value-added measurement depends on the country, and may be at producers' prices or at factor value[10].

— OECD STAN Industrial Structural Analysis Database, 2004 Edition, for the following countries: Canada, USA, Japan, Austria, Belgium, Denmark, Finland, France, Italy, Netherlands, Norway, Spain, Sweden, UK, and Australia. STAN Data are for Total Manufacturing (according to the ISIC Rev. 3 Classification). The corresponding variable in STAN is VALU, representing value added at the valuation most commonly presented in national publications and/or officially submitted to OECD's Annual National Accounts database. For most countries, it refers to the *basic prices* measure, as recommended by SNA93[11].

10. The United Nations International Recommendations for Industrial Statistics give priority to the collection of data at producers' prices, but the choice of valuation is a matter of country discretion. (So, of course, are the national policies that determine which branches and/or industries should receive subsidies and how indirect taxes should be levied). The results of UNIDO's work on this suggest that the amalgamation of values on different definitions can produce inconsistent aggregate statements of regional shares in total world output. The more significant distortions occur in industries like alcoholic beverages, tobacco and petroleum products, which are generally the ones most heavily taxed (UNIDO, 2003*b*). These industries are not included in the analysis here.
11. The difference between producers' prices and basic prices is represented by taxes and/or subsidies on products.

L_{ij}: number of employees in country i, sector j.

Sources:

— UNIDO Industrial Statistics Database REV. 2 of ISIC, edition 2001 (CD ROM); UNIDO INDSTAT3 2003 REV. 2 of ISIC (CD ROM). The notion used depends on the country; but for most countries the data refer to number of employees.

— OECD STAN Industrial Structural Analysis Database, 2004 Edition. STAN Data are for Total Manufacturing (according to the ISIC Rev. 3 Classification). The corresponding variable in STAN is EMPN, referring to the number of persons engaged (total employment including the self employed and unpaid family workers)[12].

$Ln(h_i)$: Logarithm of human capital per worker in country i, defined as $h_i = \exp(\phi(s_i))$ where $\phi(s_i) = 0.1 \cdot s_i$. The variable s_i indicates average years of schooling in country i from the Cohen and Soto database (2001), and 0.1 represents a 10 per cent return to education estimated in Mincerian wage regressions. See Cohen and Soto (2001) and Soto (2002).

Source:

— Cohen and Soto (2001).

$Ln(h_{ij})$: Logarithm of human capital in country i, sector j. Human capital at the sectoral level is computed using a wage-weighting procedure, based on the availability of cross-country data on human capital from Cohen and Soto (Soto, 2002; Cohen and Soto, 2001), and sectoral data on wages and employees from UNIDO. The construction of the h_{ij} series, where j denotes industry and i country, follows the intuitive idea that the wage is an exponential function of education. The availability of data on human capital at the aggregate level and wages and employees at the disaggregated level allows the estimation of h_{ij} in the following manner:

$$h_{ij} = h_i \cdot \left(\frac{W_{ij}}{L_{ij}} / \frac{W_i}{L_i}\right)$$

where W_{ij} is the nominal wage in sector j, W_i is total wages in manufacturing in country i and L_{ij} and L_i denote respectively the number of employees in sector j and total number of employees in manufacturing in country i. The procedure implies that the average human capital in manufacturing in country i is equal to average human capital in country i across all sectors of the economy. Labour augmented by human capital in sector j is then given by:

$$H_{ij} = L_{ij} \cdot h_{ij}$$

12. Such a concept of employment, which corresponds to the domestic one, is recommended by SNA93 and is generally used by OECD countries. OECD (2001) recommends using the productivity indicator cited, unless hours-worked data are available. The latter data do not exist in the UNIDO database.

Sources:

— UNIDO Industrial Statistics Database REV. 2 of ISIC, edition 2001 (CD ROM);

— UNIDO INDSTAT3 2003 REV. 2 of ISIC (CD ROM) and Cohen and Soto (2001).

K_{ij} : physical capital in country i, sector j. Data are in current dollars. UNIDO provides data on investment on an industry-level basis. The variable refers to the value of purchases and own-account construction of fixed assets during the reference year, less the value of corresponding sales. The perpetual inventory method is used to construct the capital series, assuming a 10 per cent depreciation rate. The investment series begin in 1963 for most countries, which gives a reasonable period for the capital stock estimates to lose their dependence on an initial-conditions assumption. Following the assumption that the steady-state investment/capital ratio equals 10 per cent, K_{j0} is estimated at date t (year 1990) using data on the average investment-value added ratio over the period for sector j. The physical capital stock is updated for 1999 using the same database for real investment flows (in 1990 dollars), which yields a physical capital stock in 1990 dollars. When computing the capital stock in current dollars, it was assumed that the capital/output ratio in 1999 in 1999 dollars is equal to the same ratio in 1999 in 1990 dollars.

Sources:

— UNIDO Industrial Statistics Database, edition 2001 (CD ROM);

— Cohen and Soto (2001).

$Ln(k_{ij})$: Logarithm of physical capital per worker in country i, sector j (country and industry indexes are omitted in the regression results), defined as follows:

$$k_{(ij)} = \left(\frac{K_{ij}}{L_{ij}} \right)$$

where the number of workers corresponds to UNIDO disaggregated data on employment.

Infrastructure Data

$Ln(\inf r)$: This variable measures (in logarithms) infrastructure in country i. It is defined as $\ln(\inf r) = \ln(EGCW_i / h_i) \equiv \ln(z_i / h_i)$, where z_i refers to electricity generating capacity (in kw) per worker $(EGCW_i)$. Workers are defined as total workers in the country.

Sources:

— Canning (1998) for electricity generating capacity in 1990 (raw data), World Bank (2003) for electricity production in kwH. Unfortunately, Canning's dataset does not contain data on infrastructure after the beginning of the 1990s; therefore, data for 1999 are based on World Bank (2003). The 1990 data are consistently recomputed with the World Bank (2003) figures, using electricity production in kwH and constructing the Ln (infr) measure in the same way as for the 1990 cross-section[13]. The figures on workers are from Penn World Tables 6.1, with the number of workers being obtained as follows: RGDPCH*POP/RGDPW where RGDPCH is real GDP per capita computed with the chain method.

Trade Data

The Grubel and Lloyd intra-industry trade index is defined as follows:

$$Gliit_i = 1 - \frac{\sum_{j=1}^{n} \left| X_{ij} - M_{ij} \right|}{\sum_{j=1}^{n} (X_{ij} + M_{ij})}$$

where index j indicates sector, and X_{ij} and M_{ij} indicate country *i*'s total exports and imports in sector j. Exports and imports are aggregated over the trading partners using mirror statistics for non-OECD countries. Data on bilateral trade flows at the disaggregated level do not include flows reported by non-OECD countries; thus, data on OECD countries are used to mirror non-OECD countries' flows, which implies that the trade estimates for low-income countries refer to North-South trade only.

Source:

— OECD ITCS database, 3-digit ISIC classification, REV. 2.

CIF/FOB Ratio: transport costs are estimated as follows:

$$CIF / FOB = \frac{\tilde{M}_{cif}}{\tilde{X}_{fob}}$$

where CIF indicates costs including customs, insurance and freight and FOB indicates free on board. Exports and imports are total trade figures from IMF, *IFS*. The measure used is an average of yearly data over the decades 1970-1980 and 1980-1990.

Source:

— Brunner and Naknoi (2003), (http://www.imf.org/external/pubs/ft/wp/2003/wp0354.pdf).

Aggregate Data (1990 cross section)

Aggregate data for GDP at PPP per worker and capital per worker are taken from Cohen and Soto (2001). They refer to RGDPWOK (real GDP per worker at international prices, 1985 I$, chain index) in Penn World Tables 5.6, and to Easterly and Levine (2001) estimates of the stock of physical capital per worker (based on Penn World Tables 5.6 investment rates at 1985 I$).

13. A re-estimation of the 1990 cross section based on WDI data did not find any significant difference.

Remark on Data Sources

Note that the reference countries belong to the OECD, meaning that OECD STAN data appear in all summary tables on average manufacturing labour productivity (unless otherwise stated). For data on countries for which the unique source is the UNIDO Industrial Statistics Database, however, country performance is benchmarked to the average of the reference countries' corresponding figure as computed from the UNIDO Industrial Statistics Database. On average, manufacturing labour productivity figures for reference countries relative to the average of that group do not change using one source or the other. The possibility of using OECD STAN Database, however, allows the use of very high quality data for a subset of countries. As previously emphasised, however, the econometric applications rely consistently on a unique dataset (UNIDO, available for all countries within the sample for the 1990 cross section).

Country and Regional Averages

The dataset contains cross-country and cross-industry variations. Averages are simple arithmetic averages:

— Average productivity in country i:

$$y_i = \frac{\sum_{j=1}^{n} Y_{ij}}{\sum_{j=1}^{n} L_{ij}}$$

where j refers to industries. The same computation holds for physical capital and human capital[14].

— Average productivity in the reference countries:

$$y_k = \frac{\sum_{i=1}^{m_k} y_i}{m_k}$$

where i refers to countries and m_k refers to the number of countries within the reference group (see country coverage and group definitions, below). Averages of 1990 and 1999 are presented after first computing an average figure per country within the reference group.

14. Note that for human capital, considering the whole spectrum of manufacturing industries yields by definition the measure defined for h_i (Cohen and Soto, 2001).

Industry and Country Classifications

The sector disaggregation in the database follows the International Standard Industrial Classification (ISIC) and provides 28 industries (as well as the four-digit level of ISIC classification). The table below lists manufacturing sectors at the ISIC Revision 2 three-digit level.

Table A1. **International Standard industrial Classification of All Activities,**
3-digit level of revision 2

ISIC CODE	Description
300	Total Manufacturing
311	Food products
313	Beverages
314	Tobacco
321	Textiles
322	Wearing apparel, except footwear
323	Leather products
324	Footwear, except rubber or plastic
331	Wood products, except furniture
332	Furniture, except metal
341	Paper and products
342	Printing and publishing
351	Industrial chemicals
352	Other chemicals
353	Petroleum refineries
354	Misc. Petroleum and coal products
355	Rubber products
356	Plastic products
361	Pottery, china, earthenware
362	Glass and products
369	Other non-metallic mineral products
371	Iron and steel
372	Non-ferrous metals
381	Fabricated metal products
382	Machinery, except electrical
383	Machinery, electric
384	Transport equipment
385	Professional & scientific equipment
390	Other manufactured products

Sources: UNIDO Industrial Statistics Database, edition 2001 (CD ROM) and authors' calculations.

The paper presents results on 51 countries, classified as follows:

Table A2. **Country Coverage and Classification**

Reference	Other high	Non-high w/o SSA	SSA	SEAP	MENA	LATINCA
Canada		Egypt	Cameroon	Bangladesh (*)	Egypt (*)	Costa Rica
United States	Singapore	Morocco	Cent. Af. Rep (*)	India	Morocco	Honduras (*)
Japan	Cyprus	Costa Rica	Senegal	Indonesia	Jordan (*)	Mexico
Austria	Denmark (*)	Honduras	South Africa	Korea, Rep.	Turkey	Panama
Belgium	Greece	Mexico	Zambia (*)	Malaysia		Trinidad & Tobago (*)
Finland	Portugal	Panama	Zimbabwe (*)	Philippines (*)		Bolivia
France		Trinidad & Tobago		Thailand (*)		Brazil (*)
Italy		Bolivia		Fiji (*)		Chile
Netherlands		Brazil				Colombia
Norway		Chile				Ecuador (*)
Spain		Colombia				Peru (*)
Sweden		Ecuador				Uruguay
United Kingdom		Peru				Venezuela (*)
Australia		Uruguay				
		Venezuela				
		Bangladesh				
		India				
		Indonesia				
		Jordan				
		Korea, Rep.				
		Malaysia				
		Philippines				
		Thailand				
		Hungary				
		Turkey				
		Fiji				

Notes: The data are presented relative to the average for the reference countries. Averages over 1990-1999 cross-sections use 1990 data in the cases of missing 1999 values, both for the country concerned and for the reference-group average (for which all the countries have data for both years). (*) denotes that the data refer to the 1990 cross-section.

Data Adjustment

The procedure described below was applied to the 1990 industrial data cross-section; the same adjustments were made in the 1999 data to make them temporally comparable.

Outlying Observations

The results from the physical capital estimates revealed the presence of outlying observations, a feature that became apparent in the capital-output ratios. The reasons for the presence of implausibly low or, very often, high ratios are multiple. They may include, for example:

— Simple measurement error;

— Differences in statistical accounting (some countries report value added at factor cost while others report it at producer prices). Outliers never cover the whole spectrum of industrial sectors within any country, so it may be that tax distortions are higher in some sectors than in others;

— Price distortions related to policies affecting capital imports under import-substitution regimes.

Outlying observations were eliminated by regressing the capital/output ratio (per country and per sector) on industry and country dummies and conditioning the standard error of each estimate to the range $[-1,1]$. Table A3 lists all the outliers and Table A4 displays average industrial capital/output ratios[15] before and after adjustment. Note that in the process of eliminating outliers, data on human capital, physical capital, and productivity for the specific country and sector were dropped. Outliers corresponded mostly to ISIC 351, Industrial Chemicals. Intermediate sectors seem to exhibit the most data problems, and measurement error mainly affects developing countries across the entire geographical spectrum.

Table A3. **Outlying Observations**

Country Name	ISIC	k/y	Description
Bangladesh	323	0.71	Leather products
Bangladesh	361	0.70	Pottery, china, earthenware
Bolivia	341	14.73	Paper and products
Bolivia	351	1.90	Industrial chemicals
Bolivia	361	16.28	Pottery, china, earthenware
Cameroon	323	82.78	Leather products
Cameroon	331	15.66	Wood products, except furniture
Cameroon	351	51.93	Industrial chemicals
Costa Rica	361	19.72	Pottery, china, earthenware
Costa Rica	362	9.07	Glass and products
Cyprus	361	18.35	Pottery, china, earthenware
Ecuador	314	12.89	Tobacco
Egypt	323	11.24	Leather products
Egypt	353	12.41	Petroleum refineries
Egypt	361	1.06	Pottery, china, earthenware
Egypt	369	8.74	Other non-metallic mineral products
Honduras	351	0.32	Industrial chemicals
Indonesia	351	1.81	Industrial chemicals
Jordan	311	12.39	Food products
Jordan	313	13.47	Beverages
Jordan	321	7.67	Textiles

15. Specifically, define the average capital/output ratio in manufacturing as follows: $\left(\frac{k}{y}\right)_i = \left(\frac{\sum_{j=1}^{28} K_{ij}}{\sum_{j=1}^{28} Y_{ij}}\right)$.

Table A3. Outlying Observations (contd.)

Country Name	ISIC	k/y	Description
Jordan	331	35.51	Wood products, except furniture
Jordan	332	7.76	Furniture, except metal
Jordan	341	10.26	Paper and products
Jordan	351	58.48	Industrial chemicals
Jordan	352	8.81	Other chemicals
Jordan	353	17.95	Petroleum refineries
Jordan	356	33.14	Plastic products
Jordan	371	14.24	Iron and steel
Jordan	383	13.84	Machinery, electric
Jordan	390	8.68	Other manufactured products
Mexico	351	1.11	Industrial chemicals
Malaysia	351	0.89	Industrial chemicals
Norway	353	12.50	Petroleum refineries
New Zealand	361	17.01	Pottery, china, earthenware
New Zealand	371	18.06	Iron and steel
Panama	351	0.44	Industrial chemicals
Panama	390	17.07	Other manufactured products
Peru	351	1.44	Industrial chemicals
Peru	361	0.76	Pottery, china, earthenware
Philippines	351	0.96	Industrial chemicals
Senegal	321	12.09	Textiles
Senegal	351	16.24	Industrial chemicals
Senegal	383	19.37	Machinery, electric
Thailand	311	11.77	Food products
Thailand	314	6.13	Tobacco
Thailand	322	6.84	Wearing apparel, except footwear
Thailand	341	7.62	Paper and products
Thailand	356	7.87	Plastic products
Thailand	361	14.70	Pottery, china, earthenware
Thailand	372	40.96	Non-ferrous metals
Thailand	381	8.39	Fabricated metal products
Thailand	390	13.47	Other manufactured products
Trinidad and Tobago	331	9.25	Wood products, except furniture
Trinidad and Tobago	332	9.64	Furniture, except metal
Trinidad and Tobago	362	43.92	Glass and products
Trinidad and Tobago	384	8.89	Transport equipment
Turkey	351	1.21	Industrial chemicals
Uruguay	351	0.61	Industrial chemicals
Venezuela	351	0.80	Industrial chemicals
South Africa	385	16.37	Professional & scientific equipment
Zambia	351	65.88	Industrial chemicals
Zambia	361	26.17	Pottery, china, earthenware

Note: 1990 data.

Sources: UNIDO Industrial Statistics Database, edition 2001 (CD ROM) and author's calculations.

Table A4. **Average Capital/Output Ratios Before and After Adjustment**

Country name	K/Y before adjustment	K/Y after adjustment	Country name	K/Y before adjustment	K/Y after adjustment
Australia	0.88	0.88	Italy	1.63	1.63
Austria	1.31	1.31	Jordan	11.98	0.68
Belgium	2.14	2.14	Japan	0.75	0.75
Bangladesh	1.02	1.03	Korea, Republic of	1.32	1.32
Bolivia	1.75	1.71	Morocco	1.59	1.59
Brazil	2.02	2.02	Mexico	0.66	0.62
Central African Republic	3.50	3.50	Malaysia	1.46	1.51
Canada	0.99	0.99	Netherlands	1.46	1.46
Chile	0.85	0.85	Norway	1.79	1.63
Cameroon	5.75	2.43	New Zealand	2.55	1.63
Colombia	0.84	0.84	Panama	1.72	1.17
Costa Rica	1.00	0.84	Peru	1.16	1.15
Cyprus	1.20	1.16	Philippines	0.58	0.57
Denmark	0.88	0.88	Portugal	1.67	1.67
Ecuador	2.80	2.79	Senegal	3.96	3.06
Egypt	5.37	3.34	Singapore	1.43	1.43
Spain	0.83	0.83	Sweden	1.18	1.18
Finland	1.44	1.44	Thailand	5.66	4.47
Fiji	2.33	2.33	Trinidad and Tobago	3.86	2.96
France	1.57	1.57	Turkey	0.87	0.85
United Kingdom	0.79	0.79	Uruguay	0.61	0.61
Greece	1.74	1.74	United States of America	0.60	0.60
Honduras	0.77	0.77	Venezuela	0.67	0.66
Hungary	1.78	1.78	South Africa	1.64	1.54
Indonesia	1.54	1.52	Zambia	3.11	1.66
India	2.64	2.64	Zimbabwe	1.11	1.03
Ireland	0.73	0.73			

Notes: 1990 Data. Capital output ratio is defined as follows:

$$\left(\frac{k}{y}\right)_i = \left(\frac{\sum_{j=1}^{28} K_{ij}}{\sum_{j=1}^{28} Y_{ij}}\right).$$

Sources: UNIDO Industrial Statistics Database, edition 2001 (CD ROM) and authors' calculations.

Industrial Sectors: Data Adjustments

Because most outliers occurred in intermediate industries, the analysis concentrated on 23 of the 28 sectors, eliminating those considered more likely prone to measurement error related to the possible presence of rent-seeking activities. Specifically, it dropped sectors where the measure of h_{ij}, basically an index of wage dispersion across sectors (see description and computation above), was the highest. In fact, these are the same sectors in both high-income and non-high-income countries: petroleum refineries, industrial chemicals, other chemicals, tobacco, miscellaneous petroleum products and coal products. Table A5 lists the 23 manufacturing sectors retained. They represent on average more than 90 per cent of manufacturing employment (see table) in both in high-income and non-high-income countries.

Table A5. **Selected ISIC Core Sectors**

ISIC	Description
311	Food products
313	Beverages
321	Textiles
322	Wearing apparel, except footwear
323	Leather products
324	Footwear, except rubber or plastic
331	Wood products, except furniture
332	Furniture, except metal
341	Paper and products
342	Printing and publishing
355	Rubber products
356	Plastic products
361	Pottery, china, earthenware
362	Glass and products
369	Other non-metallic mineral products
371	Iron and steel
372	Non-ferrous metals
381	Fabricated metal products
382	Machinery, except electrical
383	Machinery, electric
384	Transport equipment
385	Professional & scientific equipment
390	Other manufactured products

Per cent of Manufacturing employment (ISIC 300 Level, 1990)	
High income countries	93.9
Non high income countries	90.6
Non high income countries w/o SSA	90.5
MENA	90.5
LATINCA	90.9
SEAP	90.1
SSA	92.0

Note: 1990 data.

Sources: UNIDO Industrial Statistics Database, edition 2001 (CD ROM) and author's calculations.

APPENDIX 2. ECONOMETRIC RESULTS

Analytical Framework

As explained in the text, the approach uses a simple Cobb-Douglas production function:

$$Y_{ij} = TFP_{ij} \cdot K_{ij}^{\alpha} \cdot H_{ij}^{\beta} \cdot Z_{ij}^{\gamma} \qquad \text{(a1)}$$

where index i denotes the country and index j the denotes industrial sector. Assume constant returns to scale for *K*, *H*, and *Z* (see table A8 below), so that one can write (a1) as:

$$\frac{Y_{ij}}{H_{ij}} = TFP_{ij} \cdot \left(\frac{K_{ij}}{H_{ij}}\right)^{\alpha} \cdot \left(\frac{Z_{ij}}{H_{ij}}\right)^{\gamma} \qquad \text{(a2)}$$

Taking logs,

$$\left(\frac{y_{ij}}{h_{ij}}\right) = tfp_{ij} + \alpha \cdot \left(\frac{k_{ij}}{h_{ij}}\right) + \gamma \cdot \left(\frac{z_{ij}}{h_{ij}}\right) \qquad \text{(a3)}$$

The possible incidence of reverse causality within the production function framework is lessened by equation (a3), because the variables are measured *relative to* human capital h_{ij}. Data on education per worker at the disaggregated level, h_{ij}, are calculated based on h_i following a manufacturing-wage weighting procedure, where h_i denotes education in country i, following Cohen and Soto (2002) and Soto (2002)[16].

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16. Specifically $h_i = \exp(\phi(s_i))$ where $\phi(s) = 0.1 \cdot s$ where s is average years of schooling in country i, and 0.1 represents a 10 per cent return to education (see Cohen and Soto, 2001and Soto, 2002). Disaggregated data on human capital are calculated based on weighted industrial wages, namely $h_{ij} = h_i \cdot \left(\frac{w_{ij}}{w_i}\right)$, where w_{ij} is nominal wage per employee in sector j and w_i is average wage per employee in manufacturing in country i.

It seems reasonable to assume that endogeneity is less pronounced with respect to the h variable than to physical capital stock. Thus, the ratio $\left(\frac{k_{ij}}{h_{ij}}\right)$ is less prone to simultaneity bias with respect to y_{ij} than is k_{ij}.

Assume next that total factor productivity can be modelled as follows:

$$tfp_{ij} = tfp_i + \delta_j + \eta_{ij} \qquad \text{(a4)}$$

According to (a4), tfp_{ij} is a function of a country-specific effect (tfp_i), a sector-specific effect (δ_j) and an idiosyncratic disturbance term (η_{ij}).

Moreover, country-level but not disaggregated industrial data are available for infrastructure. Thus, one cannot observe $\frac{z_{ij}}{h_{ij}}$ but rather $\frac{z_i}{h_i}$, where z_i represents the (log of) the total stock of electricity- generating capacity per worker (in million kilowatts per 1 000 workers[17]) and h_i (the log of) average human capital in country i. The measure z_i serves as a proxy for the production function input z_{ij}:

$$\frac{z_{ij}}{h_{ij}} = \frac{z_i}{h_i} + \omega_{ij} \qquad \text{(a5)}$$

with ω_{ij} denoting an idiosyncratic measurement error.

As is described in Appendix 1, the data cover a cross-section of 53 countries with 23 of the 28 ISIC manufacturing industries[18] for 1990. Output per worker is represented by value added per worker in each 3-digit ISIC industry. Physical Capital is constructed using a perpetual inventory method, using disaggregated investment figures and assuming a 10 per cent depreciation rate. The investment series begin in 1963 for most of the countries, which provides a reasonable period for the capital stock estimates to lose their dependence on an initial-conditions assumption. Physical capital does not include public infrastructure capital, but rather represents the accumulation of industrial capital through private investment in each sector. Note that the purchase of a generator by a firm has to be considered as a productive private investment within its sector and as appearing in the capital stock. Unfortunately, it is not possible to have the expense decomposition of investment figures, information that would prove extremely useful to estimate the weight of private electricity provision in industrial investment. Cross-section data on human capital per worker are based on Cohen and Soto (2002) and Soto (2002). The average level of education in the country (h_i), appropriately specified (see Cohen and Soto, 2002), is used to calculate cross-industry

17. Obtained as RGDPCH*POP/RGDPW in PWT 6.1 where RGDPCH is real GDP per capita computed with the chain method.
18. The empirical estimates are based on 1990 UNIDO industrial statistics only for consistency; the econometric sample includes New Zealand and Ireland, for which no results and rankings are presented in the main text. Excluding those countries from the regressions does not change the results.

series on human capital per worker (h_{ij}), following a wage-weighting procedure. Data on electricity generating capacity in million kilowatts is taken from Canning (1998).

Empirical Strategy

The goal is to assess the impact of infrastructure, physical capital, education and trade on manufacturing productivity through the calibration of equation (a3). Following the preceding considerations, the empirical counterpart of (a3) will be:

$$\left(\frac{y_{ij}}{h_{ij}}\right) = \alpha \cdot \left(\frac{k_{ij}}{h_{ij}}\right) + \gamma \cdot \left(\frac{z_i}{h_i}\right) + \delta_j + u_{ij} \qquad \text{(a6)}$$

where $u_{ij} = \varepsilon_i + \rho_j + \omega_{ij} + \eta_{ij}$.

Reverse causality presents the main problem in estimating the effect of infrastructure on output. An increase in output leads to increased demand for infrastructure, so a positive correlation between infrastructure stock and output may simply not reflect any supply-side productivity effect. Opting for a disaggregated data set (i.e. manufacturing value added by sector) deals with one of the main criticisms of stressing the importance of infrastructure, which argues that a high degree of aggregation would lead to high output elasticities (Munnel, 1992). At a disaggregated level, one would not expect industrial productivity to determine the overall infrastructure stock. In addition, the specification (a3) implied by the Cobb-Douglas production function with constant returns to scale to *H*, *K*, and *Z* allows estimating the effect of a normalised variable on output $\left(\frac{z_i}{h_i}\right)$. This normalisation makes the parameter estimates of the impact of physical capital more robust to reverse causality.

Table A6 presents some summary statistics on the industrial dataset. Table A7 indicates the pair-wise correlation between the variables, and Table A8 at the start of the next section provides the main econometric results, the estimates of equation (a6).

Table A6. **Descriptive Statistics**

Statistics	Variables				
	log value added per worker (lny)	log capital per worker (lnk)	Log human capital per worker (lnh)	log infrastructure per worker (lnegcw)	Grubel & Lloyd intra-industry trade index Gliit
mean	9.79	9.94	0.77	0.14	0.42
sd	1.04	1.18	0.41	1.28	0.24
p50	9.93	10.06	0.81	0.27	0.38
iqr	1.66	1.52	0.56	1.53	0.37
min	6.75	4.43	-1.30	-3.46	0.02
max	12.22	12.73	1.97	2.53	0.86

Sources: See Appendix 1 for Data description and sources.

Notes: sample: 53 countries, 23 manufacturing sectors according to 3-digit ISIC Classification. 1990 cross section data.

Table A7. **Pair-wise Correlation**

	lny	lnh	lnk	lnegcw	gliit
Lny	1.00				
Lnh	0.72*	1.00			
Lnk	0.79*	0.62*	1.00		
Lnegcw	0.69*	0.51*	0.51*	1.00	
Gliit	0.60*	0.42*	0.47	0.62*	1.00

Notes: Sample: 53 countries, 23 manufacturing sectors according to 3-digit ISIC Classification. 1990 cross section Data. * denotes 5 per cent significance level.

Sources: See Appendix for data description and sources.

Empirical Results

Table A8. **Econometric Results: The Generalised Cobb-Douglas Production Function**

Determinants of Manufacturing Productivity							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Estimation technique:	OLS	OLS	OLS	OLS	OLS	OLS	GMM
Dependent variable:	ln(y)	ln(y/h)	ln(y/h)	ln(y/h)	ln(y/h)	ln(y/h)	Ln(y/h)
Explanatory variables:							
ln(k)	0.22*	0.22*					
	(0.0242)	(0,0242)					
ln(k/h)			0.41*	0.36*	0.38*	0.34*	0.30*
			(0.0240)	(0.0236)	(0.0219)	(0.0223)	(0.020)
ln(h)	0.74*	-0.039					
	(0.0698)	(0,0600)					
Gliit				1.09*		0.94*	0.47*
				(0.0928)		(0.0931)	(0.125)
Lninfr					0.23*	0.18*	0.14*
					(0.0241)	(0.0228)	(0.0226))
Country fixed effects?	YES	YES	NO	NO	NO	NO	NO
Industry fixed effects?	YES	YES	YES	YES	YES	YES	YES
Geographical controls?	-	-	YES	YES	YES	YES	YES
Sample (number of countries)	53	53	53	53	53	53	53
Year	1990	1990	1990	1990	1990	1990	1990
Observations	1 050	1 050	1 050	1 050	1 050	1 050	933
F-Statistic	309.46	303.97	87.73	108.94	94.26	107.93	-
R square	0.94	0.94	0.63	0.67	0.66	0.69	
Adjusted R square	-	-	-	-	-	-	-
F Test lnh=0 (P-value)		0.514					
GMM Estimation related tests:							
Shea Partial R^2 (First stage)							0.425
Hansen J Statistic (overidentification test). P-val							0.093
centred R^2 (second stage)							0.73
Uncentred R^2 (second stage)							0.99

Notes: sample: 53 countries, 23 manufacturing sectors according to 3-digit ISIC Classification. 1990 cross section data. OLS estimation with White robust standard errors. Robust SE are reported under the coefficient estimates. GMM estimation indicates two-step efficient generalised method of moments estimator. Robust SE are reported under the coefficient estimates. (Excluded) Instruments: log (FRANKEL & ROMER); log (population coastal density 65); log(CIFFOB ratio. 1970-80 average). Geographical controls refer to four geographical dummies (SSA. MENA. SEAP. LATINCA). Country fixed effects refer to the inclusion of country dummies and industry fixed effects refer to the inclusion of industry dummies. All regressions include a constant. * denotes 5 per cent significance level.

Sources: See text and Appendix 1.

GMM estimation indicates a two-step efficient generalised method of moments estimator. The efficiency gains of this estimator relative to the traditional IV/2SLS estimator derive from the use of an optimal weighting matrix; the efficient GMM estimator is robust to the presence of heteroskedasticity of an unknown form. Under the assumption of conditional homoskedasticity, the efficient GMM becomes the traditional 2SLS estimator. The Hansen J-statistic is consistent in the presence of heteroskedasticity, the Sargan statistic is not. Under the assumption of conditional homoskedasticity, the Hansen J-statistic becomes Sargan's statistic.

The first column reports results for a standard Cobb-Douglas production function specification including only physical capital per worker and human capital per worker. The regression includes country fixed effects and industry fixed effects (not reported). Both coefficients are statistically significant and can be interpreted as the elasticity of output with respect to each input. The coefficients found are consistent with the Solow theoretical model in which the capital share of value added equals 0.3 and labour's share equals 0.7. These coefficients, given the human-capital functional specification, are consistent with results of calibrating of microeconomic studies on private rates of return to physical and human capital (see Klenow and Rodriguez Clare, 1997), indicating that any externalities on human and physical capital are small on average.

The second column indicates that the data fail to reject the null hypothesis that the coefficient on h_{ij} is 0 in the specification with y_{ij}/h_{ij} as dependent variable. This confirms the hypothesis that one cannot reject constant returns to scale, at least from this specification.

Columns three to seven omit country fixed effects and integrate in the analysis the variables for which only country data exist, namely the trade and infrastructure indices. Column three simply skips the country fixed effects; column four adds the trade variable alone, and column five adds the infrastructure variable alone. Column six estimates their joint impact. The significance and magnitude of the estimated coefficients are robust to the inclusion of both variables. The sixth column shows a coefficient of 0.34 for the capital share, suggesting that the potential simultaneity problem may be not very severe in this disaggregated dataset. The elasticity of output with respect to infrastructure stock is 0.18; this is interpreted as the average effect of the infrastructure stock on manufacturing productivity. The disaggregated capital figures, as noted above, do not include infrastructure capital. This implies that the results here do not compare with Canning's (1999, 2000) elasticities. Canning's data on investment do cover investment in infrastructure as part of an aggregate production function estimation. Thus a positive and significant coefficient within his framework suggests that infrastructure has a higher effectiveness in raising output than other types of capital. Furthermore, the present paper focuses on manufacturing productivity. Anecdotal evidence suggests that infrastructure, particularly electricity generating capacity, should have a non-trivial effect on industrial competitiveness. This effect could be homogenous between the manufacturing and non-manufacturing sectors, but the authors suspect it to be slightly different. As Golub and Yeaple (2002) point out, the effect of infrastructure on productivity is different even within industries, depending on the infrastructure intensity of each sector. One would thus expect the estimation here to bear higher elasticities. In fact, a review of the literature suggests that the parameter estimate is in line with production-function estimates of the output elasticities of public capital (Table A9).

Table A9. **Production Function Estimates of the Output Elasticity of Public Capital**

Author	Geographical aggregation	Specification	Elasticity of output to capital stock
Mera (1973)	Japanese Regions	Cobb -Douglas	0.20
Silva Costa *et al.* (1987)	States (USA)	Translog	0.20
Aschauer (1989)	National (USA)	Cobb -Douglas	0.39
Deno (1988)	Metropolitan Areas (USA)	Log-Levels	0.08
Munnel (1990*a*)	States (USA)	Cobb -Douglas	0.34
Munnel (1990*b*)	National (USA)	Cobb -Douglas	0.15
Eisner (1991)	National (USA)	Cobb -Douglas	0.17
Mamatzakis (1992)	National Industries (Greece)	Cobb -Douglas	0.14
Holtz-Eakin (1994)	National (USA)	Cobb -Douglas	0.39
Dessus and Herrera (1996)	Cross- country	Cobb -Douglas	0.21
Esfahani and Ramirez (1999)	Cross- country	Cobb -Douglas	0.14
Canning (2000)	Cross- country	Cobb -Douglas	0.08[a]
Canning (2000)	Cross- country	Translog	0.06-0.09[a]
Mitra *et al.* (1998)	Indian industrial sectors. State level	Cobb -Douglas	0.14-1.09 [a, b]

Notes:

a) Only power generation estimates.

b) Elasticity of long run TFP with respect to electricity consumption.

Column seven of Table A8 shows results for efficient GMM estimation of equation (a6), instrumenting the trade index with the (log of) the Frankel and Romer (1999) predicted trade share, the (log of) transport costs as proxied by the CIF/FOB ratio (average over 1970-80) and (the log of) population coastal density in 1965. Compared to estimation six, the coefficient on capital remains slightly stable and consistent with the Solow model, the infrastructure weight declining to 0.14, a value in line with standard estimates as presented in the above table. The estimated impact of trade declines from 0.94 to 0.47, suggesting endogeneity may well bias the OLS results upwards. The authors accept the over-identifying restrictions implied by the instrumentation strategy at standard confidence level. The trade coefficient is robust to the use of other “geography” instruments provided in the literature — the percentage of land within 100km of the coast, for example, from the same dataset as the density variable but for which the causality towards trade is considered less obvious. The trade coefficient also is robust to the use of the total factor productivity residual as the dependent variable (maintaining the same set of instruments).

APPENDIX 3. CONTRIBUTION OF FACTORS AND EFFICIENCY TO MANUFACTURING PRODUCTIVITY

The main development accounting exercises in this paper are based (unless otherwise stated) on equation (a6), and the corresponding estimates are presented in the last column of Table A8. These coefficients then serve to calibrate the data for each country relative to the average corresponding value for the core high-income countries in the reference group. The average contribution of each multiplicative factor (*k, h, z and t*) in the reference group is computed as follows:

$$\ln(k/h)_k = \frac{\sum_{i=1}^{m_k} \ln(k/h)_i}{m_k}$$

where, as before, i refers to countries. m_k is the number of countries in the reference group. The same holds for human capital and infrastructure. The trade variable is averaged in levels.

In the contribution calculations detailed below for individual countries, index *k* indicates country k (recall that each contribution is computed relative to the reference group). Thus:

For physical capital: $"k_k" = \exp[\hat{\alpha} \cdot \ln(k/h)_k]$, where $\hat{\alpha}$ is the estimated capital share from the production function.

For human capital: $"h_k" = \exp[1 \cdot \ln(h)_k]$, because the data do not reject the hypothesis of constant returns to scale.

For infrastructure: $"z_k" = \exp[\hat{\gamma} \cdot \ln(z/h)_k]$, where $\hat{\gamma}$ is the estimated elasticity of manufacturing productivity to infrastructure.

For the trade factor: $"t_k" = \exp[\hat{\theta} \cdot t_k]$, where $\hat{\theta}$ is the estimated parameter on the trade variable, Gliit.

Net efficiency (TFP is the product of the net efficiency and trade contributions) is then estimated as:

$$a_k = \frac{y_k}{"t_k" \cdot "k_k" \cdot "h_k" \cdot "z_k"}$$

, where y_k is manufacturing productivity in country k relative to the reference group.

The contributions for groups of countries relative to the reference group are simple averages of the country contributions; the net efficiency contribution is again treated as a residual from this calculation. For example, the physical capital contribution for group j is:

$"k_j" = \frac{\sum_{k=1}^{m_j} k_k}{m_j}$, where k indicates countries and m_j refers to the number of countries within group j.

A two-step procedure applied to the average figures over the 1990 and 1999 cross sections. First, the average over the period was computed for each country of the log of each factor (except for trade which is taken in levels), so that every computation is log-linear. Second, the calculations proceeded as described above.

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