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ABSTRACT

Industrial Productivity in 51 Countries, Rich and Poor*

This Discussion Paper analyses 23 industrial sector in a sample of 51 developed and developing countries. It distinguishes the contribution of five factors: private capital, infrastructure, education, trade integration, and net efficiency. Several relatively small handicaps, combined multiplicatively, can make a country poor or very poor. In average, the average productivity of the industrial sector is indeed the product of about five times 70%. But 0.70 to the power of five is 17%. The least productive country in the sample, Bangladesh, has a productivity level worth about 2% of that of the richest nations. From this perspective, industry is not much different from aggregate GDP such as analysed in Cohen and Soto (2004) where a similar picture emerged

The paper then sheds light on the effect of TFP differential between industry and GDP at large on the relative price of manufactured goods. We show that productivity differentials explain about half of the relative price discrepancy. It then analyses the extent to which this is an explanation of the Lucas Paradox. So far as manufacturing is concerned the paper highlights an "anti-Lucas" paradox whereby the capital output ratio is higher in poor countries than in rich countries. This result tends to deflate the theories according to which fear of expropriation is the critical explanation of the low level of capital in the economy at large.

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1. Introduction

Industrial productivity matters on at least two accounts. For one thing, industry is a tradeable sector, which directly contributes to command how many goods a country can import for abroad. Second, the industrial sector supplies most of equipment goods, so that a relatively low industrial productivity raises the relative price of capital, which in turn depresses investment in the country.

This paper analyses how manufacturing productivity is determined and then sheds light on the relative price of manufactured goods. The paper accounts for industrial productivity in 51 countries and 23 sectors by focusing on five items: private capital, infrastructure, education, trade integration, and a residual of net efficiency. Their contribution are each compared to the corresponding value in a core group of rich countries. On average, industrial productivity in rich countries exceeds that in poor ones by a ratio of four to one. We find that most countries are subject to the "tyranny of numbers" (Young, 1995). Several relatively small handicaps, combined multiplicatively, can make a country poor or very poor. In average, the average productivity of the industrial sector is indeed the product of about five times 70%. But 0.70 to the power of five is 17%… The least productive country in the sample, Bangladesh, has a productivity level worth about 2% of that of the richest nations. This discomforting figure turns out to be 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 two per cent! From this perspective, industry is not much different from aggregate GDP such as analysed in Cohen and Soto (2002) where a similar picture also emerged.

This accounting methodology leaves open the question of why factor of productions are so scarce in the poor countries. In the first section of the paper we give a broad overview of the reasons that have been put foreward for each item. Weak states, low initial education, poor health, long distances… all add up to explaining low achievements. Whatever the causes, however, we think that it is important for policy makers, including those of the donors' community, to identify where the critical bottlenecks lie, that prevent a country from becoming more productive.

On a continental level, the broad picture is the following. In Africa, the critical problem is the low level of infrastructure. In Middle East and North Africa, the problem has more to do with low human capital, while Latin America and Asia are closer to a model of "even underdevelopment" of evenly distributed handicaps. Beyond the continental comparisons a few cross-country patterns emerge. "Even underdevelopment" seem to be the standard for most middle income countries. The combination of low infrastructure and high private capital is instead frequent in Africa and in a few other countries such as Thailand. Low residual efficiency tends to be the pattern for the very least productive countries such as India or Egypt, although Indonesia and Bangladesh appear to belong to the even underdevelopment group despite dismal levels of industrial productivity.

The paper then proceeds to examine the Lucas Paradox, and what we shall call an anti-Lucas Paradox. As explained in Cohen and Soto (2002) or Hsieh and Klenow (2003) much of the Lucas paradox according to which capital is scarce in the poor countries owes to the fact that the relative price of capital good is high in the poorest countries. In this paper, we document the extent to which this can be attributed to a relatively lower industrial productivity. In average the relative price of capital good is about 50% lower in the poor countries. TFP differentials are about 25% lower. We show econometrically that this is about the rule: productivity differentials explain about half of the relative price discrepancy. We venture that the remaining part owes a lot to the direct effect of poverty on the price of GDP. In the case of Africa, however, TFP differentials explain little, and the direct effect of poverty on the price of GDP is too small to explain more than half of the relative price of capital.

At any rate, if the high relative price of capital goods explains the Lucas paradox, then it should not hold in the industrial sector, to the extent that it is a traded good. We show that this is indeed the case: the industrial capital-output ratio is not lower in the poor countries. In fact, it is rather the opposite: the poorer a country, the larger capital-output ratio. The lack of infrastructure comes to mind as an explanation (private generator must be purchased when public electricity is not functioning), but we shall see that the picture is more general. Scarcity of non-traded inputs tend to be compensated by a higher capital-output ratio. This "anti-Lucas" paradox tends to deflate the theories according to which fear of expropriation is the critical explanation of the low level of capital, since it is hard to see why industry could offer a better protection to foreign investors.

The paper runs as follows. Section 2 documents the low productivity of industry in the poor countries, and give a tentative overview of the nature and cause of the low endowments in each four items that are infrastructure, private capital, education and trade. Section 3 weight econometrically each four factors. Section 4 presents the key results on a country by country basis. Section 5 documents the Lucas paradox and the anti-Lucas paradox.

2. Industrial productivity: an accounting approach

Industrial Productivity

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 then 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). 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. The grouping is presented below.

Country grouping

Reference	Other Europe	Poor outside SSA	SSA	SEAP	MENA	Latinca
Canada		Egypt	Cameroon	Bngldsh	Egypt	Costa Rica
USA	Hungary	Morocco	CAR	India	Morocco	Honduras
Japan	Cyprus	Costa Rica	Senegal	Indonesia	Jordan	Mexico
Austria	Denmrk	Honduras	S. Africa	Korea,	Turkey	Panama
Belgium	Greece	Mexico	Zambia	Malaysia		Trinidad&T
Finland	Portugal	Panama	Zimbabwe	Philippine		Bolivia
France		Trinidad T		Thailand		Brazil
Italy		Bolivia		Fiji		Chile
Netherlands		Brazil		Singapore		Colombia
Norway		Chile				Ecuador
Spain		Colombia				Peru
Sweden		Ecuador				Uruguay
UK		Peru				Venezuela
Australia		Uruguay				
		Venezuela				
		Bangladesh				
		India				
		Indonesia				
		Jordan				
		Korea, rep.				
		Malaysia				
		Philippines				
		Thailand				
		Hungary				
		Turkey				
		Fiji				

Table 1 shows the basic productivity statistics for the various groupings in relation to productivity in the reference group.

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

Country Group	Value
Référence	1.00
Other European	0.43
Non-High	0.26
Non-High outside Sub-Saharan Africa	0.28
Sub-Saharan Africa	0.18

South East Asia & Pacific	0.31
Middle East and North Africa	0.20
Latin America and the Carribeans	0.30

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

Infrastructure

Infrastructure plays a critical 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

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

Note: 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.

The lack of proper electricity infrastructures has 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 another major concern for developing countries. Countries must pay attention to transport costs if they want to integrate into the global economy. Limao 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 ten 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, Dollar, and Micco (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, Mann and Otsuki (World Bank, 2004) measure and estimate the relationship between trade facilitation and global trade flows in manufactured goods in 2000-2001. 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.

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. In this paper however we shall only rely on electricity shortage such as measured by electricity-generating capacity in kilowatts as Canning (1998). This choice is motivated by practical reasons. Data availability and quality problems abound for many infrastructures, while they are fairly well measured for electricity. Canning points out that the data sets on electricity 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. 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 1. **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

Note: 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) furthermore 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.

When trying to explain the lack of infrastructure, the prime cause, besides the vicious circle of poverty itself, is certainly the weak nature of the state in the poorest countries. In Cohen, Soto and Causa (2005), this link is demonstrated, by showing that various institutional measures of weak institutions of the kind that have been favoured by Acemoglu *et al*. do appear to operate mainly through their impact on low infrastructure.

Capital[2]

Capital scarcity is subject to the Lucas Paradox according to which capital does not flow from the poor to the rich countries (Lucas, 1990). 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 Table 4.

Tableau 4
The Lucas Paradox

	GDP Per head	**Capital/ Output**
Reference	1.00	1.00
Other Europeans	0.68	0.87
Non-High	0.31	0.61
Non-High Outside Sub-Saharan Africa	0.34	0.64
Sub-Saharan Africa	0.19	0.45

	GDP Per head	Capital/ Output
South East Asia and the Pacific	0.32	0.69
Middle-East and North Africa	0.27	0.36
Latin America and Caraibes	0.35	0.63

The ratio of output to capital is one third lower in middle- and low-income countries as in rich countries — excluding sub-Saharan Africa, where it is more than twice lower. If the return to physical capital is so much larger in poor countries, as these figures would 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, which has been suggested in Cohen and Soto (2002) and Hsieh and Klenow (2003). While the data reported in Table 4 are computed in volume terms (as done by Summers and Heston, 1991), 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. 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 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.

Table 5

	K/Y Value terms
Reference	1.00
Other Europeans	1.10
Non-High	1.03
Non-High Outside Sub-Saharan Africa	1.03
Sub-Saharan Africa	1.05
South East Asia and the Pacific	0.94
Middle-East and North Africa	1.04
Latin America and Caribbean	1.05

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.

At any rate, 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 Table 6 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, cross countries comparisons show that the capital/output ratio is in general the highest among poor countries.

Table 6: Ratio k/y in manufacturing

Reference	1.00
Other Europeans	1.29
Non-High	1.43
Non-High Outside Sub-Saharan Africa	1.39
Sub-Saharan Africa	1.61
South East Asia and the Pacific	1.54
Middle-East and North Africa	1.57
Latin America and Caribbean	1.27

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. We return below on the explanation of this anti-Lucas Paradox in section 5.

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, 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. As we shall see, the index is well instrumented by geographical variables (see next section).

Education

The data set used here for education and human capital comes from the OECD Development Centre.[6] It covers 95 countries, distributed among major world regions. The data (Table 7) 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 7: **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 & 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 & Caribbean	3.8	4.5	5.3	6.7	7.6	8.2
East Asia & 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 & 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— 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 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? One obvious candidate is the legacy of poor past education achievements. As demonstrated in Glaeser *et al.* (2004), human capital is highly serially correlated across the years. Criticising the view presented in Acemoglu et al. that settler mortality operated through institutions, they argue that it owes more to the fact that the settlers brought their own human capital with them. Furthermore, settlers may simply tend to die where the health conditions are worse, which may translate into lower incentives to raise the stock of human capital. The explanation developed in Cohen and Soto (2002) for instance holds that life expectancy in poor countries remains too low to trigger high investment in human capital. The reasoning comes as follows. Following Mincer (1974), human capital is portrayed as an exponential function of the number of years of study. This implies, for one thing, that , 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. Below a critical value, T*, life is entirely channelled into work; above it, education rises with life expectancy, at the margin. Cohen and Soto shows empirically that T* is around 55 years. This insight illustrates why rising life expectancy may not have the same effect on education in rich and poor countries (Table 8).

Table 8: **Life Expectancy and Education**

	Life Expectancy at Age 5 (L5)		Average Years of Schooling (YS)		ΔYS/ΔL5
	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. In the poor countries outside SSA, the gap with rich countries narrowed to 6.4 years in 1990 from nine years in 1960. Yet this pattern is not observed in educational achievement. The absolute discrepancy between rich and poor nations hardly changed over the period. In SSA, where the discrepancy in life expectancy remained the same, at about 9 years, the educational discrepancy with the rich countries actually increased. 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. The message of hope, however, is that rising life expectancy will eventually trigger a more than proportionate increase in educational achievement in the poor countries, that can eventually boost the engine of growth.

3. Testing a macro-model

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

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

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), one can:

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

Taking logs, this can be written as :

$$\left(\frac{y_{ij}}{h_{ij}} \right) = a_{ij} + \theta . t_i + \alpha \cdot \left(\frac{k_{ij}}{h_{ij}} \right) + \gamma \cdot \left(\frac{z_{ij}}{h_{ij}} \right) \quad (4)$$

which is the form that we shall test. For the sake of data homogeneity, we chose to estimate this equation through UNIDO data only, such as available in 1990. This allows us to cover 53 countries (Ireland and New Zealand being available which were not before) and 23 sectors (see appendix 1 for sources of data).

Reverse causality clearly presents a critical problem. An increase in output leads to increased demand for infrastructure, so a positive correlation between inputs and output may simply not reflect any supply-side productivity effect. The normalisation where all variables are expressed relatively to the stock of human capital makes the parameter estimates of the impact of physical capital more robust to reverse causality. Furthermore, 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.

Empirical Results

The first column reports results for a standard Cobb-Douglas production function specification, i.e. equation (1) where the role of infrastructure and trade is ignored.. 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. We review in appendix 2 the main estimates of the output elasticities of infrastructure found in the literature.
Column seven of Table 9 shows results for efficient GMM estimation of equation (2), 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 1970-1980). and (the log of) population coastal density in 1965. Compared to estimation six, the coefficient on capital remains stable and consistent with the Solow model, the infrastructure weight declining to 0.14, a value in line with standard estimates as presented in appendix 2, reviewing the findings of previous studies. The estimated impact of trade declines from 0.94 to 0.47. suggesting endogeneity may well bias the OLS results upwards. The test accepts 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).

Table 9

A Generalised Cobb-Douglas Production Function

	Determinants of Manufacturing Productivity						
Estimation technique:	OLS	OLS	OLS	OLS	OLS	OLS	GMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
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)	0.23 *	(0.0931)	(0.125)
Lninfr					(0.0241)	0.18 *	0.14 *
						(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	1050	1050	1050	1050	1050	1050	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							0.99

(second stage)

Notes: Sources: See Appendix 1. 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. Instruments: log (FRANKEL & ROMER); log (population coastal density 65); log(CIFFOB ratio. 1970-1980 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 five per cent significance level.

4. Overall Results

Let us now analyse how the parameters obtained in the previous section sheds light on the cause of low productivity in the poorest countries. The first four columns in table 7 below, present the contributions of capital, infrastructure, human capital and aggregate TFP. The last two columns show the contributions of trade and a net residual *(A)*, the product of which is equal to TFP, as in equation (2). The term *A* is called "net efficiency". Each term interact multiplicatively (appendix 3 shows country results).

Table 10 **Determinants of Industrial Productivity**

	Y	**K**	**Z**	**H**	**TFP**	**Trade**	**A**
Other Europeans	0.43	0.81	0.92	0.82	0.71	0.92	0.76
Non-High	0.26	0.79	0.80	0.64	0.65	0.83	0.78
Non-High Outside Sub-Saharan Africa	0.28	0.77	0.81	0.67	0.68	0.85	0.81
Sub-Saharan Africa	0.18	0.92	0.75	0.51	0.50	0.77	0.64
South East Asia and the Pacific	0.31	0.80	0.79	0.67	0.74	0.88	0.84
Middle-East and North Africa	0.20	0.73	0.76	0.59	0.62	0.82	0.76
Latin America and Caraibes	0.30	0.77	0.84	0.67	0.70	0.83	0.84

Note: The decomposition follows: $Y = AT^{\theta} \cdot \left(\frac{K}{H}\right)^{\alpha} \cdot \left(\frac{Z}{H}\right)^{\gamma} H$, whereby industrial productivity (Y) is explained by the contribution of infrastructure (Z) and private capital (K) relatively to the stock of human capital, and appropriately weighted; the contribution of trade (T) follows the text.

This table indicates more resemblance than diversity across continents. 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. Altogether indeed the broad picture that emerges is that inputs do explain by themselves a bit chunk of the low level of industrial productivity. On can analyse the contribution of factor of productions and net efficiency by writing the following accounting device

$$\text{Var (Log y)= var(Log x) + var(Log a) + 2cov(Log x, Log a)}$$

In which y is industrial productivity, x are all factors lumped together and a is net efficiency. One finds :

Table 11 **Variance decomposition**

Var(Log x)/ Var(Log y)	Var(Log a)/ var(Logy)	2covar(Log x,Log a)/ Var(Log y)
0.46	0.21	0.33

Y: industrial productivity, x: factors, a: net efficiency

This is confirms the critical role of the factor of production in explaining the dispersion of productivity.

Continents

For each continental grouping, the general thread remains the same, with a few interesting variations. When comparing the aggregate performance of continents, 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.

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 on the weakness of TFP in Asia.

MENA has the same average 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.
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.

Let us now analyze how other country groupings may shed light on the performance of individual countries.

Balanced Patterns of Underdevelopment

This group includes countries that evidence no major bottlenecks, their factor deficiencies being well spread over the spectrum. These are countries which need to raise all factors together in order to grow. No fast-track scenarios are open to them, except hard work. 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 differences, however, which give 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 pattern. 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).[7] 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, which face one key bottleneck, a very low level of efficiency. Ecuador, Fiji, Hungary, Egypt, and India are representative of this low-efficiency group. Egypt and India for instance have both 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 and Indonesia 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.

5. Lucas and anti-Lucas paradoxes

Manufacturing and Aggregate GDP

Let us now investigate how the manufacturing data can be compared to the data on GDP. 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 12 provides some answers.

Table 12 : **GDP per worker**

	GDP	**K**	**Z**	**H**	**TFP**
References	1.00	1.00	1.00	1.00	1.00
Other Europeans	0.69	0.91	0.95	0.84	0.95
Non-High	0.32	0.65	0.88	0.64	0.87
Non-High Outside Sub-Saharan Africa	0.35	0.68	0.89	0.66	0.86
Sub-Saharan Africa	0.18	0.49	0.87	0.54	0.80
South East Asia and the Pacific	0.35	0.69	0.86	0.66	0.90
Middle-East and North Africa	0.26	0.59	0.88	0.48	1.03
Latin America and Caribbean	0.35	0.69	0.90	0.67	0.84

Note: The table is based on the following specification $y = (k/h)^{(\alpha)} \cdot (z/h)^{\gamma} .h \cdot TFP$, with $\alpha = 0.33$ and $\gamma = 0.085$. 1990 Data. See appendix 1 for data description.

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).

Understanding the relative price of investment

A number of studies have analysed the relative price of investment goods in the poorest countries (Jones (1994), Lee (1995), Chari et al. (1996), Mc Grattan et Schmitz (1999), Eaton et Kortum (2001), Restuccia et Urrita (2001), Schmitz (2001)). The major thread of these papers is that the relative price is often the outcome of distorsions which are produced by governments: tariffs, taxes… which raise the price of capital. Summers et Heston (1997) also make the remark that the share in local prices of investment is more similar across country than the corresponding share in PPP terms.

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. We consequently estimated the following relationship:

$$Log\frac{P_I}{P_Q} = \delta \log\frac{A_I}{A_Q} + \varepsilon$$

in which the ration P_I / P_Q is the relative price of investment goods to GDP, and A_M / A_q is the ratio of TFP in manufacturing and in aggregate GDP.

The results are shown in table 13.

Table 13

Relative Price of investment (in log)

Méthode d'estimation	**OLS (1)**	**OLS (2)**	**OLS (3)**	**OLS (4)**	**GMM (5)**	**GMM (6)**	**GMM (7)**
LTFPGDP	0.51* (0.22)						
LTFPMANU	- 0.35** (0.10)						
DIFFLTFP		-0.38** (0.117)	-0.37** (0.105)	-0.934* (0.333)	-1.04** (0.197)	-1.093* (0.295)	-1.026** (0.202)
LNRGDPW			-0.25** (0.072)		-0.278* (0.126)		-0.149 (0.162)
Continental dummy?	YES	YES	YES	YES	YES	YES	YES
SSA included?	YES	YES	YES	YES	YES	NO	NO
Sample (number of	53	53	53	53	53	47	47

Méthode d'estimation	OLS (1)	OLS (2)	OLS (3)	OLS (4)	GMM (5)	GMM (6)	GMM (7)
countries)							
Year	1990	1990	1990	1990	1990	1990	1990
R 2	0.6759	0.669	0.7345	-	-	-	-
F Statistic	14.36	16.64	18.35	-	-	-	-
Tests GMM:							
Hansen J Statistic (overidentification test). P-val				0.033	0.0483	0.167	0.219
Centred R2 (second stage)				0.299	0.205	0.056	0.1765
Uncentred R2 (second stage)				0.4389	0.364	0.185	0.288

Note: Year 1990. OLS White heteroskedasticity. Standard errors in parentheesis.
GMM : instruments: log(k/h) in aggregate economy log (k/h) in manufacturing
* 5% significant

One sees that the manufacturing productivity is positively correlated to the price of investment good while aggregate productivity is negatively correlated with it. Interestingly, TFP differentials yield more significant resutlts than average productivity (not reported). When one imposes the coefficient on TFP to be identical in absolute value, one finds a coefficient worth about 0.4 ((2) et (3)). To the extent that there is many measurement errors in our computation of TFP, this is likely to be a lower bound to the true value. By instumenting the coefficient with the aggregate and industrial K/H ratios (which explain why TFP is badly measured) one finds equation (4), which yields an elasticity of -0.9, not significantly different from the theoretical value of –1. By taking Africa outside the sample; one actually does find a value of –1 (equations (6) and (7)). Note that the results are not affected by the inclusion of GDP per head in the regression.

Hsieh and Klenow (2003) also note that most of the discrepancy in the relative price originate from the lower price of consumption than from the higher price of capital, which is linked to the view that the non-traded prices are lower in poor countries, which is mostly what Summers and Heston correction is about. We therefore also analyse directly the price of GDP, as a function of TFP differential and other factors. Table 14 presents the results.

Table14

Price of GDP (in log)

	OLS (1)	**OLS (2)**	**OLS (3)**	**OLS (4)**	**GMM (5)**	**GMM (6)**	**GMM (7)**	**GMM (8)**
LTFPGDP	-0.263	-0.561*						
	(0.193)	(0.194)						
LTFPMANU	0.442*	0.350*						
	(0.116)	(0.094)						
DIFFLTFP			0.408*	0.394**	1.192*	0.784**	1.065*	0.734**
			(0.112)	(0.0852)	(0.396)	(0.174)	(0.277)	(0.165)
LNRGDPW		0.356*		0.292**		0.273*		0.259*
		(0.091)		(0.0674)		(0.074)		(0.093)
Geographic dummy?	YES	YES	YES	YES	YES	YES	YES	YES
SSA included?	YES	YES	YES	YES	YES	YES	NO	NO
Sample (countries)	53	53	53	53	53	53	47	47
Year	1990	1990	1990	1990	1990	1990	1990	1990
Observations	53	53	53	53	53	53	47	47
R 2	0.7988	0.8447	0.7940-	0.8403	-	-	-	-
F Statistic	31.91	36.52	36.21	38.45	-	-	-	-
Tests MMG:								
Hansen J Statistic (overidentification test). P-val					0.594	0.177	0.850	0.299
Centred R2 (second stage)					0.429	0.747	0.5930	0.7863
Uncentred R2 (second stage)					0.705	0.869	0.7817	0.8854

Instruments : log(k/h) in aggregate economy and log (k/h) in manufacturing
* 5% significance

Results are quite similar to those reported for the relative price, although they show in average better fits, due presumably to higher quality of the data. The last equation shows nicely that the price of GDP is a combination of 75% times the Balassa-Samuelson effect and 25% times the level of GDP per head. This shows that absolute poverty and TFP differential are needed to understand why life is cheap in poor countries.

With these estimations in mind, where do we stand with respect to the Lucas paradox? We see from tables 10 and 12 that TFP in poor countries outside SSA stand respectively at 0.68 in manufacturing and 0.86 in total GDP. This implies a relative differential of 1.26. The Lucas paradox itself, as seen from table 4, implies a price differential of 1/0.64 that is 1.56. Strictly speaking the TFP differential explains about half of the Lucas paradox.

When the correction is computed from the price of GDP such as estimated in table 14, the fit is better. Using poverty and TFP differential as stated in column (8) of table 14 above, one gets that GDP price is 1.61 higher in the rich countries, which is even more than what is needed for the Lucas paradox. The reason why poverty lowers the price of GDP beyond the

TFP differential is intuitive: poor countries cannot afford to pay for the luxury of rich countries: lower quality good are supplied, which are cheaper. More work is needed here, but at this stage a simple summary of the results obtained so far lead to a simple conclusion: the Lucas paradox is well explained by the higher relative price of investment goods. Strictly speaking, TFP differential explain about half the phenomenon, the remaining half having to do with the sheer effect of absolute poverty on the price of goods.
In the case of Africa, however, similar calculations lead to a quite different conclusion. For one thing, as already outlined, TFP differential explain basically nothing. When poverty is taken into account through the analysis of GDP prices, then we can compute that half of the Lucas paradox is explained. The remaining half must then rely on other factors, taxation being the prime suspect.

The anti-Lucas paradox

In order to study the anti-Lucas Paradox that is apparent in the data, we now analyse how the capital ratio in manufacturing can be explained. Equation (1) shows that the key parameter is indeed the initial income per head of the country (aggregate GDP). GDP has a larger explanatory power than industrial productivity itself (1), or any of the factor of production that underlies it: human capital (2), trade integration (3) or infrastructure (4). Equation (5) shows that the results are robust to instrumentation.

Table 15: **k/y in manufacturing (in log)**

Méthode d'estimation	**OLS (1)**	**OLS (2)**	**OLS (3)**	**OLS (4)**	**GMM (5)**
Ln (y)	-.0508512 (.0495524)				
Ln(rgdpw)	-.3139662 * (.0739081)	-.3119257 * (.0564857)	-.352489 * (.0578126)	-.5241535 * .(070172)	-.6346067* (0.093934)
ln(h)		-.216135 (.1325437)			
Ln(kel)					
Gliit			-.0815047 (.152977)		
Lninfr				.135325 * (0506718)	
Sector dummy?	YES	YES	YES	YES	YES
Continental dummy?	YES	YES	YES	YES	YES
Sample (countries)	53	53	53	53	53
Année	1990	1990	1990	1990	1990
Observations	1050	1050	1050	1050	921
F Statistic	9.66	9.39	9.40	9.95	-
R 2	0.1895	0.1906	0.1886	0.1943	-
Adjusted R square	-	-	-	-	-
Tests MMG::	-	-	-	-	-
Shea Partial R 2 (First stage)	-	-	-	-	.4741
Hansen J Statistic	-	-	-	-	.14245

Méthode d'estimation	OLS (1)	OLS (2)	OLS (3)	OLS (4)	GMM (5)
(overidentifation test), P-val					
centered R2 (second stage)	-	-	-	-	.2014
Uncentered R2 (second stage)	-	-	-	-	.2325

Instruements : life expectancy in 1965, log coastal density in 1965 (Sachs et Warner (1995))
* 5% significance.

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.[8] 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.

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Appendix 1: Data Description

Variable Definitions and Sources:

Industrial Data

Sources: UNIDO Industrial Statistics Database REV. 2 of ISIC, edition 2001 (CD ROM), UNIDO INDSTAT 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.[9] 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.[10]

Econometrics are based on UNIDO data for 1990 only and for 53 countries: the 51 presented in tables plus Ireland and New Zealand.

Human Capital

Aggregate data: Cohen and Soto (2001).

Sectoral level: 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: $h_{ij} = h_i \cdot (\frac{W_{ij}}{L_{ij}} / \frac{W_i}{L_i})$

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:

Sources:

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

UNIDO INDSTAT 2003 REV. 2 of ISIC, (CD ROM) and Cohen and Soto (2001).

Physical capital

K_{ij}: physical capital in country i, sector j. Data are in current US 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 ten 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 ten 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 US dollars), which yields a physical capital stock in 1990 US dollars. When computing the capital stock in current US$, it was assumed that the capital/output ratio in 1999 in 1999 US dollars is equal to the same ratio in 1999 in 1990 US 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.[11] 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:

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

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$, chain index) in Penn World Tables 5.6, and to Easterly and Levine (2001) estimates of the stock of physical capital per worker (based on Penn World Tables 5.6 investment rates at 1985 I$).

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).

Data Adjustments

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). 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.

The 23 manufacturing sectors retained represent on average more than 90 per cent of manufacturing employment in both in high-income and non-high-income countries.

DESCRIPTIVE STATISTICS

Table A1presents 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 a5.

Table A1. **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

Notes: sample: 53 countries, 23 manufacturing sectors according to 3-digit ISIC Classification. 1990 cross section data.
Sources: See Appendix 1 for Data description and sources.

Table A2. **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 five per cent significance level.
Sources: See Appendix 1 for data description and sources.

Appendix 2 Returns to Infrastructures

Table A3. **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
Costa da Silva *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 (1990a)	States (USA)	Cobb – Douglas	0.34
Munnel (1990b)	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, Varoudakis & Véganzonès (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.

Appendix 3 Individual country results

Table A4 Industrial Productivity

	Y	K	Z	H	TFP	T	A
Reference	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Japan	1.31	0.99	0.93	1.08	1.32	0.86	1.53
USA	1.19	0.88	1.03	1.12	1.16	1.05	1.11
Finland	1.12	1.14	1.04	0.97	0.97	0.97	1.00
France	1.11	1.12	1.00	0.91	1.09	1.07	1.02
Sweden (*)	1.10	1.04	1.08	1.04	0.94	1.02	0.92
Belgium	1.08	1.20	1.01	0.90	0.99	1.07	0.92
NDL	0.99	1.09	0.94	0.96	1.01	1.06	0.95
Austria	0.98	1.02	0.97	0.97	1.02	0.96	1.06
Canada	0.96	0.95	1.08	1.13	0.83	1.01	0.83
Norway	0.96	0.99	1.15	1.10	0.77	0.95	0.80
Denmark	0.92	0.84	0.90	1.04	1.17	1.00	1.17
UK	0.88	0.85	0.92	1.13	1.00	1.08	0.93
Korea	0.87	1.01	0.90	1.02	0.94	0.98	0.95
Singapore	0.84	1.02	0.98	0.74	1.14	0.98	1.16
Italy	0.79	1.02	0.94	0.84	0.99	1.00	0.99
Australia (*)	0.70	0.84	0.99	1.16	0.73	0.87	0.84
Spain	0.70	0.91	0.97	0.78	1.03	1.05	0.98
Chile	0.61	0.82	0.85	0.82	1.07	0.76	1.42
Brazil	0.60	0.94	0.87	0.63	1.16	0.88	1.32
Greece	0.50	0.97	0.94	0.81	0.68	0.87	0.78
Mexico	0.43	0.76	0.88	0.67	0.96	0.98	0.98
Turkey	0.42	0.94	0.56	0.56	1.45	0.88	1.64
Thailand	0.38	1.32	0.75	0.63	0.61	0.86	0.72
Peru	0.36	0.89	0.77	0.69	0.76	0.78	0.97
Cyprus	0.36	0.80	0.91	0.74	0.66	0.83	0.80
Colombia	0.33	0.70	0.81	0.61	0.95	0.82	1.16
Uruguay	0.33	0.72	0.88	0.71	0.74	0.77	0.96
Venezuela	0.27	0.81	0.98	0.56	0.61	0.83	0.74
Portugal	0.26	0.85	0.94	0.61	0.52	0.94	0.56
Panama	0.24	0.77	0.83	0.72	0.52	0.79	0.66
S. Africa	0.26	0.85	1.05	0.58	0.50	0.80	0.63
Malaysia	0.22	0.75	0.86	0.75	0.45	0.94	0.48
Bolivia	0.21	0.84	0.71	0.69	0.51	0.80	0.64
Trinidad Tobago	0.18	0.80	0.91	0.82	0.30	0.83	0.36
Zimbabwe	0.18	0.74	0.78	0.66	0.46	0.75	0.61
Senegal (**)	0.17	1.22	0.63	0.40	0.56	0.84	0.67
Ecuador	0.17	0.87	0.78	0.69	0.36	0.76	0.48
Zambia	0.17	0.81	0.85	0.55	0.45	0.72	0.61
Philippines	0.17	0.59	0.72	0.67	0.59	0.91	0.65
Jordan	0.17	0.48	0.86	0.83	0.49	0.75	0.65
CAR	0.15	1.04	0.57	0.40	0.64	0.75	0.85
Cameroun	0.14	0.85	0.66	0.49	0.50	0.77	0.65
Morocco	0.13	0.77	0.78	0.43	0.51	0.86	0.60
Fiji	0.12	0.76	0.83	0.68	0.29	0.79	0.36
Hungary	0.12	0.61	0.88	0.91	0.25	0.98	0.26

	Y	K	Z	H	TFP	T	A
Costa Rica	0.12	0.58	0.85	0.59	0.41	0.90	0.46
Egypt	0.09	0.72	0.85	0.54	0.27	0.78	0.35
Indonesia	0.08	0.61	0.68	0.62	0.31	0.83	0.37
Honduras	0.08	0.53	0.78	0.52	0.37	0.84	0.43
India	0.06	0.69	0.75	0.46	0.25	0.83	0.30
Bangladesh	0.04	0.44	0.61	0.44	0.33	0.75	0.43

Note: The decomposition follows: $Y = AT^{\theta} \cdot \left(\frac{K}{H}\right)^{\alpha} \cdot \left(\frac{Z}{H}\right)^{\gamma} H$, whereby industrial productivity (Y) is explained by the contribution of infrastructure (Z) and private capital (K) relatively to the stock of human capital, and appropriately weighted; the contribution of trade (T) follows the text.

Table A5 **GDP per worker**

	Y	K	Z	H	TFP
Reference	1.00	1.00	1.00	1.00	1.00
USA	1.27	0.99	1.02	1.12	1.12
Belgium	1.12	1.06	1.00	0.90	1.16
Italy	1.09	1.08	0.96	0.84	1.24
NDL	1.06	1.02	0.96	0.96	1.13
Canada	1.04	0.97	1.05	1.13	0.91
Norway	1.01	1.05	1.09	1.10	0.81
Australia	1.00	0.95	0.99	1.16	0.92
France	0.99	1.05	1.00	0.91	1.04
Austria	0.99	1.02	0.98	0.97	1.02
Finland	0.96	1.03	1.02	0.97	0.94
Sweden	0.91	0.95	1.05	1.04	0.89
Denmark	0.91	0.96	0.94	1.04	0.98
Spain	0.90	1.04	0.98	0.78	1.13
UK	0.87	0.85	0.95	1.13	0.96
Singapore (*)	0.87	1.18	0.99	0.66	1.12
Japan	0.79	0.98	0.95	1.08	0.78
Greece	0.71	0.93	0.97	0.81	0.98
Portugal	0.67	0.97	0.97	0.61	1.17
Korea	0.65	0.86	0.94	1.02	0.79
	0.54	0.76	1.03	0.58	1.19
Trinidad Tobago	0.52	0.73	0.94	0.82	0.93
Mexico	0.49	0.81	0.92	0.67	0.98
Hungary	0.48	0.78	0.93	0.91	0.73
Venezuela	0.47	0.88	0.99	0.56	0.96
Malaysia	0.47	0.77	0.91	0.75	0.88
Chile	0.45	0.71	0.91	0.82	0.85
Uruguay	0.43	0.69	0.93	0.71	0.94
Brazil	0.40	0.79	0.92	0.63	0.86
Costa Rica	0.33	0.70	0.91	0.59	0.88
Panama	0.32	0.69	0.89	0.72	0.71
Colombia	0.28	0.61	0.88	0.61	0.87
Egypt	0.27	0.52	0.90	0.54	1.08
Ecuador	0.27	0.68	0.87	0.71	0.65
Peru	0.26	0.69	0.86	0.69	0.64
Morocco	0.24	0.65	0.86	0.43	1.01
Thailand	0.21	0.66	0.84	0.63	0.61
Philippines	0.19	0.55	0.82	0.67	0.63
Indonesia	0.17	0.55	0.79	0.62	0.65
Honduras	0.17	0.52	0.86	0.52	0.72
Bolivia	0.16	0.48	0.81	0.69	0.58
Zimbabwe	0.14	0.47	0.86	0.66	0.52
India	0.11	0.47	0.84	0.46	0.62
Bangladesh	0.10	0.44	0.74	0.44	0.72

Cameroon	0.09	0.41	0.78	0.49	0.60
Zambia	0.07	0.45	0.91	0.55	0.31
Senegal	0.07	0.36	0.76	0.40	0.64

Notes: Average over the 90s.
(*) 1990

Note: The decomposition follows: $Y = TFP \cdot \left(\frac{K}{H}\right)^{\alpha} \cdot \left(\frac{Z}{H}\right)^{\gamma} H$, whereby industrial productivity (Y) is explained by the contribution of infrastructure (Z) and private capital (K) relatively to the stock of human capital.

Endnotes

[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).

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

[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.

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

[7] ICOR denotes the additional capital required to produce an extra unit of output.

[8] 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.

[9] 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). These industries are not included in the analysis here.

[10] The difference between producers' prices and basic prices is represented by taxes and/or subsidies on products.

[11] A re-estimation of the 1990 cross section based on WDI data did not find any significant difference