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Infrastructure and Productivity at Different Stages of Development
A Preliminary Analysis

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1. Introduction

The income gap between rich and poor countries is one the world's most pressing economic problems. The gap is enormous: income per capita in the U.S. was over $33,000 in 2000, while the corresponding figure for the countries of Africa was nearer to $1,000.[1] An important step in addressing this gap is to understand its cause. In this spirit, our first paper used the sources-of-growth framework to decompose the gap between output per worker (an important correlate of the poverty gap) into its capital formation and productivity efficiency (TFP) components. We found that the gap in output per worker was largely due to a large gap in TFP – that is, to large differences in the efficiency with which resources are used rather than differences in the amount of those resources.

This paper builds on our previous work by examining the sources of the gap in TFP. This leads us to focus on several possible explanatory factors. One is the gap in core infrastructure systems like roads, electricity generating capacity, and telecommunications. According to UNCTAD's LDC report 2006, from 1980 to 1998 spending (including official development assistance) on infrastructure decreased from 6 to 4 percent of total government expenditure in Africa, from 12 to 5 percent in Asia and from 11 to 6 percent in Latin America. The declining trend in infrastructure spending in the poorest countries of the world is thus a potential contributor to the gap in TFP, since infrastructure systems typically operate as background inputs rather than as directly inputs to the production of output and are therefore a part of measured

[1] These estimates are drawn from our earlier paper, "Why Development Levels Differ" (Hulten and Isaksson, 2007). In that paper, we group countries by their level of economic development, as determined by output per worker. For the group that included the core OECD countries, the average income per capita was estimated to be $26,595, in purchasing power parity corrected dollars. The average for the forty low income group of counties in our sample was $1,138 and $3,846 for the twenty-two lower middle income counties.

TFP. Another important contributor to the TFP gap includes differences in human capital and the failure to absorb best-practice technology, but in this paper we mainly focus on the role of infrastructure.

Our analysis of the TFP gap is based on a variant of the model developed by Hulten and Schwab (1991), and extended by Hulten, Bennathan, and Srinnivasan (2006), which links TFP to a number of underlying factors. Our study differs, in this regard, from the great majority of studies that examine the link between infrastructure and output per worker or income per capita. We are particularly mindful of two econometric problems, namely, unobserved country-specific effects that may be correlated with infrastructure (e.g. geography and institutions) and simultaneity bias. Increasing the TFP of through increased investment or technology transfer will tend to raise output per capita, some part of which is saved and turned into more human and infrastructure capital. There are thus feedback effects that can confound the direction of causality and bias the estimates of single-equation model of the process. In other words, poor countries have lower levels of TFP, less human capital, and more poorly developed infrastructure compared to richer countries, but sorting out the separate contributions of each effect to the income gap is a difficult task. This problem has dogged the literature on infrastructure since Aschauer (1989).

2. Model

The motivation for using TFP as the dependent variable of our analysis is based on the argument of Hirschman (1958), who notes that "inputs" of infrastructure (social overhead capital, SOC) differ in character from what he calls he calls "directly productive assets (DPA)." Hirschman points to four characteristics that distinguish SOC from DPA: (1) SOC is basic to (and facilitates) a great variety of economic activities, (2) it is typically provided by the public sector or by regulated private agencies, (3) it cannot be imported, and (4) it is "lumpy" in the sense of technical indivisibilities. He also argues that the function of SOC investment is to "ignite" DPA, and that "Investment in SOC is advocated not because of its direct effect on final output, but because it permits, and in fact, invites, DPA to come in (page 84)." One might also add that infrastructure tends to come in the form of interlocking networks of investments, as with road and rail systems, water and electricity distribution systems, and telecommunications. In such systems, the associated price is sometimes zero, and otherwise only loosely connected to marginal cost (particularly in LDCs). Systems externalities are typically important (and, in the, limit are the source of Hirschman's igniting effects). Infrastructure thus operates like a background input, often an unpaid factor of production (Meade (1952)), and it is natural to treat infrastructure as a component of TFP rather that a systematic input to production.

This line of argument suggests a model of the aggregate production in which direct inputs of DPA capital (plant and equipment) are combined with raw labor to produce output and in which infrastructure is in the background:

$$Q_{i,t} = A_i(X_{i,t}, Z_{i,t}, t)F_i(K_{i,t}, L_{i,t}). \tag{1}$$

Here we have adopted a multiplication (Hicksian) shifter to represent changes in the productivity efficiency of the DPA inputs $K_{i,t}$ and $L_{i,t}$. Since our data tends to includes publicly-owned capital as a component of the capital input variable, $K_{i,t}$, part of the infrastructure effect is captured directly. The remaining externality effect in located in the shifter $A(\bullet)$, which we specify to be a function comprising human capital, $X_{i,t}$, a time trend ('autonomous productivity growth'), and a vector of infrastructure variables, $Z_{i,t}$. The subscripts $\underline{i}$ and $\underline{t}$ indicate country and year, respectively. Locating infrastructure in both the DPA segment of the production function, F*(•),* and in the shifter segment, A*(•),* is a variant of the Lucas-Romer endogenous growth model, which implicitly locates the externalities associated with human capital and R&D in the shifter term (Hulten (2001)).

Our estimation procedure has two phases. The first step, taken in our first paper, is to estimate TFP levels using non-parametric procedures. This involves estimating the Solow residual associated with (1) by subtracting the share-weighted growth rates of labor and capital from the growth rate of output. Under the usual assumptions of the Solow framework, this is equivalent to the growth rate of the index *A(•)* in (1). We then convert this to level using a Caves-Christensen-Diewert (CCD) approach. However, because data limitations forces of to adopt the conventional assumption in cross-national studies that labor's share of income is two-thirds and with capital's share is one third, the production function (1) has the Cobb-Douglas form and the CCD index is equivalent to the ratio $TFP_{i,t} = A_i(X_{i,t}, Z_{i,t}, t) = Q_{i,t} / [(K_{i,t})^{1/3}(L_{i,t})^{2/3}]$.

The second stage of the analysis is carried out in this paper. Given the estimates of TFP by country and year, we then regress the natural logarithm of that variable on the logs of the explanatory variables $X_{i,t}$ and $Z_{i,t}$. The regression equation is based on

$$ln\, TFP_{it} = \beta' X_{it} + \lambda' Z_{it} + \mu_t + \eta_i + \varepsilon_{it} \qquad (2)$$

where, again, *ln X* includes human capital and a time trend and *ln Z* is a vector of infrastructure, μ represents an unobserved common factor affecting all countries, λ is unobserved country-specific effects, and ε is the standard i.i.d. residual. The point estimates of the parameters of (2) allows for the decomposition of mean TFP levels into the components effects, and thus to an assessment of the relative role played by infrastructure externalities

We start by estimating (2) using OLS and fixed-effects estimators. The fixed-effects estimator helps remove the cross-sectional endogeneity bias potentially present in OLS (rich countries have accumulated more infrastructure before the start of the sample period, and are considerably more productive). However, the FE estimator may still be subject to a time-related endogeneity bias (increases in TFP in a given country tend to raise the level of income and thus investment is infrastructure). Another way to deal with these issues (i.e., with both types of endogeneity bias) is to use the GMM estimation procedure in a first-difference version of (2), DIF-GMM:

$$TFP_{it} - TFP_{it-1} = \beta'(X_{it} - X_{it-1}) + \lambda'(Z_{it} - Z_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1}) \ . \qquad (3)$$

If the time-varying residual ε is not serially correlated and X is weakly exogenous, lagged values of *TFP* and X constitute valid instruments for dealing with endogeneity among right-hand side variables. Unfortunately, in the case where X and/or Z are persistent over time – which applies to our data – lagged instruments tend to be weak and create a small-sample bias.[2] The SYS-GMM procedure overcomes this problem by combining regressions in differences and levels.[3]

[2] The latter occurs because the instrument count is quadratic in time dimension and this generates moment conditions abundantly. Too many instruments may overfit endogenous variables and one rule of thumb is to keep the number of instruments below the number of groups (e.g. number of countries). Moreover, the test for validity of

3. Data

The data used in this study span the years 1970 to 2000, and include data for 112 advanced and developing countries (see Appendix Table A5 for a list of countries). As noted above, TFP levels are obtained from Hulten and Isaksson (2007), computed based on a simple constant returns to scale Cobb-Douglas production function using a conventional capital's share of one-third. Human capital (H) is measured as the average educational attainment level (years of schooling) for the population aged 15 and older (Barro and Lee, 2000). Infrastructure indicators are obtained from Canning (1998) and, in one case, the World Bank's World Development Indicators (World Bank, 2006). Variables observed every fifth year only, that is, human capital and institutional variables used for robustness tests, have been annualized by way of interpolation. A linear time trend is used to capture "autonomous" productivity change.

We obtain from the Canning data on the following six (processed) infrastructure stock indicators: number of telephones (PHONE), number of telephone main lines (TELMA), million kilowatts of electricity-generating capacity (ELGEN), kilometers of road (ROAD), kilometers of paved road (PVROAD) and kilometers of railway (RAIL).[4] Because infrastructure data are very slow moving, we decided to linearly extrapolate the six Canning infrastructure indicators, which end in 1995, so they include data up to 2000, which is the end year for the rest of our data.

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instruments, Sargan-Hansen, generates implausibly good probability values, as too many instruments tend to weaken the test.

[3] The system estimator called SYS-GMM, introduced by Blundell and Bond (1998), was partly developed for cases of persistent data and ensuing weak instruments problems.

[4] Canning (1998) argues that both the raw and processed data on PHONE, TELMA and ELGEN are of good quality, that the processed data on RAIL should be used (as opposed to the unprocessed version), and that ROAD and PVROAD are unreliable, although the processed series can possibly be used. Because of their increased reliability, we use the processed data series throughout. The reader is referred to Canning (1998) for details on data sources and collection.

Canning (1998) argues that both the raw and processed data on PHONE, TELMA and ELGEN are of good quality, the "processed" data on RAIL should be used (as opposed to the unprocessed version), and ROAD and PVROAD are unreliable, and recommends users to be careful when using these data. Air transport (AIR) – measured as registered carrier departure worldwide – is obtained from World Bank, and is used as a proxy for the capacity to engage in, for example, international trade. Finally, a measure of public capital is constructed based on data from Everhart and Sumlinski (2001) and OECD (2002), and is used as a 'catch-all', or composite, indicator of infrastructure (see the Appendix for details of its calculation). All infrastructure indicators are in logs, measure quantity of infrastructure (except for PVROAD, which is the only infrastructure indicator containing aspects of quality), and have been normalized by population (in millions).

Table A1 contains a collection of summary statistics for the entire sample. For purposes of exposition, we have followed our previous work and organized these data into groups of "meta" countries on the basis of (PPP-based) GDP level: High-income, Low income, Low-mid income, Upper-mid income, Old Tigers and New Tigers (the Appendix lists the countries in each meta-country group; for details, see Hulten and Isaksson, 2007). We have computed ratios between stocks of infrastructure across meta-countries to obtain a sense of the relative infrastructure gap (Table A3).[5] In the case of ELGEN, none of Low, Low-mid or New Tigers reaches even 10 percent of that of High-income, Uppermid reaches 20 percent, while Old Tigers, the second most developed country-group, attains 43 percent. Similar patterns hold for most of

[5] The story is reminiscent of those told in UNCTAD's LDC report (2006) and World Bank's World Development Report (1994). The former adds that also the quality of infrastructure is remarkably lower in developing countries and, in particular, in LDCs. For example, on average between 1999-2001, 20 percent of total electricity output in the LDCs was lost in transmission and distribution, compared with 13 percent in other developing countries and 6 percent in OECD.

the other infrastructures as well. An exception is AIR, which is almost as high for New Tigers as for High-income countries. The respective scores for ROAD and RAIL are not as low – in relative sense – compared with High-income countries, as are the other kinds of infrastructure. Nevertheless, it is beyond doubt that the quantity of infrastructure is much smaller in developing countries.

The pattern seems to be that of positive correlation between productivity and income on the one hand, and infrastructure and income on the other. Figure 1, which shows nine scatter plots pairing human capital and each infrastructure indicator (on the X-axis) with TFP (on the Y-axis), with all variables in logs, indicate that there is a positive relationship between TFP and infrastructure, and is suggestive of a large impact of infrastructure on productivity.[6,7]

Figure 1 also suggests a correlation among the various types of infrastructure. This is verified in Table A2 in the Appendix, which shows that the sample correlations among all variables (including human capital) tend to be very high. This, in turn, points to the problem of multicollinearity and the difficulty of sorting out the separate contributions of the individual types of infrastructure in a regression framework like (3). One option is to examine the effects of one infrastructure indicator at a time, and another is to construct a composite infrastructure index. We have opted for the former, but have used the public capital variable as a proxy for infrastructure at large.[8]

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[6] Data have been cleansed of outliers using the Hadimvo command in Stata SE version 9.

[7] This is not necessarily the case for all income groups, as shown by graphs for individual income groups. These results can be obtained upon request from the authors.

[8] Correlations are not as strong within all income groups, however. For example, AIR is particularly poorly correlated with TFP and PUB, and negatively correlated with transport infrastructure in Low-income countries. In the case of Low-mid income countries, AIR is negatively correlated with TFP and weakly correlated with other infrastructures. PUB is negatively correlated with RAIL, which in turn is weakly or negatively correlated with most other infrastructures. More or less the same seems to hold for Uppermid as well, while for New Tigers, RAIL and

One implication of the way we have organized the data is worth noting, here. We have continued the procedure of organizing the data into meta-countries representing different stages of economic development, and have estimated our regression model for each meta-country separately, rather than pooling the data. We have done this because we believe countries at different levels of development may have very different production systems. Regrettably, data limitation required us to assume that the income shares are the same in all countries (a point discussed in detail in our first paper), but we do not want to impose this homogeneity on the efficiency of production, $A_i(X_{i,t}, Z_{i,t}, t)$. We have assumed, in equations (2) and (3), that the efficiency function has a Cobb-Douglas multiplicative form, but we also allowed the parameters to vary freely across countries and, in some cases, have added country specific institutional variables. Breaking the sample into meta-country groups also reduces the cross-sectional feedback bias implicit in analyzing the link between TFP and infrastructure in rich poor countries simultaneously. Our procedure, then, is to run separate OLS and FE regressions for each meta country and compare point estimates. We also report pooled results for comparison.

4. Results

Tables 1a-8a provide the results according to OLS, while Tables 1c-8c provide the corresponding fixed-effects results. Each table has seven columns, in turn showing the estimates for All (i.e. the entire sample), Low income, New Tigers, Low-mid income, Upper-mid income, Old Tigers, and

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human capital are negatively correlated, as is RAIL and AIR. Finally, for High-income AIR is negatively correlated with PVROAD and RAIL, while PUB and RAIL have a correlation of zero.

High income. A linear time trend is included to capture autonomous productivity growth and all variables are in logs so that parameters can be interpreted as elasticities.[9]

An immediate overall conclusion to be drawn is that the coefficient of human capital depends largely on which infrastructure indicator is included. This is the case for both its statistical significance and sign, probably reflecting a high degree of multicollinearity, as previously discussed, but it is also possible that average educational attainment is not a good proxy for human capital. On the other hand, the results of these tables generally support the hypothesis that infrastructure has a positive impact on TFP, independent of which estimator is used. However, the point estimates differ across estimators and, in particular, the FE estimates are smaller than those of OLS; that the OLS estimate is larger than the FE one holds across all meta countries.

Starting with the pooled OLS results, for the entire sample ('all') the point estimate for ELGEN is 0.26 As results can be interpreted as elasticities, in the case of ELGEN, a 10 percent increase in ELGEN is associated with a 2.6 percent increase in TFP (recall, here, that this is interpreted as an externality effect). The largest impact is obtained in both categories of Tigers (0.29 and 0.37 for New and Old, respectively), in other words, in those countries that have grown most rapidly during the sample period considered; the smallest effect occurs in high-income countries, where a 10 percent increase of ELGEN only associates with half a percent increase in TFP.

The impact of telecommunications – PHONE and TELMA – on TFP is slightly higher than the impact of ELGEN.[10] Again, the greatest impact obtains for the Tiger economies. Canning

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[9] We have investigated whether human capital and infrastructure interacts, i.e. is the impact of infrastructure larger in countries with much human capital? Except for the case of TELMA, the coefficient of the interaction term was not statistically significant and we, therefore, did not pursue this further.

warned of the quality of transport data and caution is indeed required. For example, although the ROAD coefficient overall is 0.1, it is negative in Uppermid and Old Tigers, while the point estimate is 0.39 for New Tigers (the other extreme). The impact of PVROAD is higher (0.18 for 'all'), is again negative for Old Tigers, largest for New Tigers (0.34), but statistically insignificant in the poorest countries. The effect of RAIL is essentially the same as for the other two transport variables. The overall impact of AIR is 0.08; again larger for fast-growing economies (i.e. Tigers), but is not statistically significant for other developing countries. The last OLS results to report pertain to public capital. While the overall effect is 0.3, it is interesting to note that such an impact occurs in Low and New Tigers only; thereafter, the effect tapers off and becomes nil for high incomers. Note that for Old Tigers, we only have data on PUB for Korea so the negative coefficient observed for Old Tigers is not representative for the group as a whole.

The OLS results suggest that infrastructure matters, in particular for fast-growers in Asia. Somewhat counterintuitive results (e.g. negative parameters) are occasionally obtained for transport infrastructures. It also seems that, generally, infrastructure has a larger impact in relatively poor countries, at least compared with high-incomers. Our first impression is that this result is plausible. For instance, it seems that in no case will investment in infrastructure in high-income countries have an implausibly large effect on TFP. However, we will return to this issue below for further scrutiny.

In the presence of fixed effects (e.g. unobserved country-specific effects such as geography or institutions) the pooled OLS estimate is biased. Tables 1c-8c, which correspond to Tables 1a-8a above, contain results obtained using the fixed-effects estimator (FE). An F-test for the

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[10] A third measure incorporating mobile phone lines in TELMA essential produced identical results and was therefore dropped.

presence of fixed effects indeed makes clear that the OLS estimates are likely to be biased. The parameters obtained from the fixed-effects estimator are generally lower for all cases. The overall ELGEN parameter has now fallen to 0.12, which is about half the size the OLS estimate. The relatively large Tiger coefficients have turned into *negative* 0.19 and 0.06 (statistically insignificant) for New and Old Tigers, respectively. For Lowmid-, Uppermid- and High-income groups, a 10 percent increase in ELGEN is associated with less than 1 percent increase in TFP, but the effect seems to be greater in developing countries.

In the case of telecommunications, while all other coefficients fall considerably in size, that of high incomers actually increases (from 0.09 to 0.14 for PHONE and 0.15 to 0.19 for TELMA). Again, the 'Tiger effects' are gone. While Old Tigers retain its negative parameter for ROAD, the 0.39 OLS estimate for New Tigers is now close to zero and statistically insignificant. In fact, roads per se seem to have positive impacts only in Low- and High-income countries. It could be that returns to, for example, connecting rural to urban areas has an important effect only in poor countries and that this elementary function of infrastructure quickly plays out. In addition, it is possible that productivity-inhibiting effects of congestion are apparent among High incomers only. In the case of Old Tigers, two of four countries are very small (Hong Kong and Singapore) so it is conceivable that the road system is sufficiently developed to render further additions of limited value. For New Tigers it appears to be the case that infrastructure might have captured the impact of geography or institutions (or other variables that might show up as fixed effects).

When the quality of roads, PVROAD, is considered, perverse results are obtained. For four out of six country groups is the point estimate negative; only in the case of Uppermid (and for the sample as a whole!) is a positive impact observed. At this point, we refrain from further commenting on PVROAD results. The impact of RAIL *increases* when fixed effects are accounted for. This is particularly the case for New and Old Tigers (from 0.48 to 0.83 and –0.39 to 0.65), which both register, we think, implausible point estimates.

The overall impact of AIR is somewhat higher with FE, a result pulled up by Low, Uppermid and High incomers, but moderated by a severe reduction in the parameter for Old Tigers (from 0.21 to 0.07). Finally, the overall effect of PUB on TFP is now only half as large. The impact in Low incomers has increased (from 0.33 to 0.46), while that of New Tigers is now negative. We register a small and statistically significant coefficient (0.02) for High incomers.

It is worth emphasizing that these are the separate elasticity estimates for each type of infrastructure studied. They are not additive, given the high degree of multicollinearity. This point is reinforced by the point estimates of public capital, which is our proxy for the overall effect of the infrastructure. The pooled public capital OLS point estimate is 0.296, which is comparable in magnitude to the estimates of many of the individual infrastructure systems. The corresponding FE estimate is 0.135. To pursue this issue further, we also ran regressions with several (selected) infrastructure indicators included jointly: ELGEN, TELMA, PVROAD and AIR. The effect is to lower each indicator's impact, and sometimes, in the case of OLS, to render PVROAD statistically insignificant, again suggesting multicollinearity and the difficulty of disentangling the impact of each indicator. These results are shown in Tables 9a (OLS) and 9b (FE). It is interesting to note summarizing the indicators' coefficients leads to approximately the point estimate of public capital, which gives some support to the notion that PUB may function quite well as a composite infrastructure indicator.

Finally, we also investigated the possibility that the impact of infrastructure externalities on TFP depends on the stage of development. In other words, if a country already has well-developed infrastructure, is the externality effects of additional infrastructure investment smaller compared with a situation of relatively undeveloped infrastructure? This issue is addressed in Table 10, where we collect and rank the FE estimates according to their size. While it is clear that different country-groups have different slope coefficients, i.e. parameter heterogeneity is observed, Table 10 make clear the fact that no consistent monotonic ranking of infrastructure elasticities is possible across low income, lower-middle income, upper-middle income, and high-income countries. Additional work with income levels in individual countries rather than meta-countries is probably needed to sort this issue out.

5. *Robustness*

It has often been argued that differences in institutions and institutional quality are important determinants of economic development, and it possible that this effect extends to the estimated impacts of infrastructure as well. Furthermore, Canning (1998) shows that geography is correlated with infrastructure. In this Section, for each meta country we therefore investigate whether our results hold up to inclusion of geography and institutional quality indicators. Geography is represented by the mean distance (in km) to nearest coastline or sea-navigable river (DIST), while economic freedom (FREE) and property rights (PROP) proxy for institutions.[11] In order not to overwhelm the reader, we chose to present the results in words only.[12]

[11] The source of DIST is World Development Indicators (World Bank, 2006), while FREE and PROP are both retrieved from www.freetheworld.com (Gwartney and Lawson, with Emerick: Economic Freedom of the World: 2003 Annual Report. Vancouver: The Fraser Institute, 2003). Several other indicators for geography (e.g. distance to the equator) and, in particular, institutions (e.g. regulation, civil rights and political freedom) were tested as well, but they were either statistically insignificant or entered with unexpected sign. More importantly, inclusion of any of them did not have any significant impact on our results. Those results are therefore not shown here, but can be obtained upon request.

[12] Tables with results can, of course, be obtained upon request.

In the case of High incomers, DIST does not alter our results. FREE, however, tends to lower the point estimates a little, but has no further impact on our conclusions. Inclusion of PROP renders the coefficients of ELGEN and PHONE statistically insignificant in OLS; the same holds for ELGEN in FE. Turning to Low incomers, adding FREE to the regression alters sign of the AIR coefficient from positive to negative, while inclusion of PROP in FE now supports the notion that ELGEN and PVROAD have a positive and statistically significant effect on TFP.

Adding DIST, FREE and PROP to Lowmid regressions strengthens the case for infrastructure (except for AIR), while they seem to somewhat proxy for transport infrastructure in Uppermid countries. Among New Tigers, FREE throws out ELGEN and deliver a negative coefficient on PUB, something that does not happen with PROP. Our conclusion is that inclusion of geography and institutional quality rather makes a more compelling case for infrastructure than the other way round. All in all, infrastructure appears very robust to controlling for geography and institutions.

6. *Fraction of productivity gap covered by infrastructure*

Our previous work decomposed the growth rte of output per worker into a capital-deepening effect and a TFP effect. We are now in a position to take the next step and further decompose TFP into the effects of infrastructure externalities, human capital, and autonomous productivity change (i.e. the time trend).[13] This is carried out by calculating the mean growth rate of each infrastructure indicator and human capital and weighting by the respective point estimates and

[13] We use the point estimates even when they are not statistically significant.

expressing the results as a fraction of mean TFP growth. The results are shown for OLS and fixed effects for each of the eight infrastructures below each relevant table: 1b-8b for OLS and 1d-8d for FE.

Results are clearly disappointing. Some results are obviously implausible in that infrastructure externalities alone (if larger than unity), or together with human capital, contributes more than the whole of TFP. In other case, the estimates indicate large negative contributions to TFP. The explanation is partly that developing countries have data of lower quality than do advanced economies. Another source of the problem may be specific to our data set. Table A4 shows that average annual growth rates of several infrastructure indicators appear too large to be credible. And this seems to be the case across the board, including for high-income countries with more highly developed infrastructure networks. Three systems, PHONE, TELMA, and public capital, exhibit average annual growth rates in excess of 6.5 percent, implying a 600-700 percent increase in these systems across all countries, rich and poor, over the 30 year sample period. This growth seems implausibly high, and implies a reevaluation of our infrastructure, which is derived from a fairly standard source.

5. Conclusions -- Good News and Bad

We observed, at the outset, that the income gap between rich and poor countries is one the world's most pressing economic problems and it was important to understand its cause. In Hulten and Isaksson (2007), we found that the gap in output per worker was largely due to a large gap in TFP – that is, to large differences in the efficiency with which resources are used rather than differences in the amount of those resources. The work contained in this paper builds on our previous work by taking the next step by examining the sources of the gap in TFP.

The good news is that infrastructure externalities appear to have a statistically positive effect on TFP, and thus output per worker. This confirms the general belief, as well as previous results, that investment in infrastructure systems is a potentially important tool of development policy. The problem is that infrastructure seems to explain all or more of TFP. This finding, plus the instability in the parameter estimates and the TFP decomposition, is the bad news. One possible explanation for this 'news' is that the infrastructure data seem to imply extraordinary rapid growth beyond the limit of the plausible.

Data problems are not at all unusual in analyzing the growth of developing economies. Indeed, these data problems were a major theme of our first paper. We noted, there, that the available data implied that labor's share of total income was in the 30-40 percent range for the poor countries, and that this was deemed so implausible that the literature on the subject typically took the share to be 67 percent for all countries. This may well be nearer to the truth, but it is not a happy situation.[14] Growth analysis needs good data, not assumptions about data. So, it seems, does the current effort to disentangle the effect of infrastructure on economic growth and to explain why development levels differ so much.

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[14] Another data issue is also noteworthy. Hulten (1996) has shown that the management of infrastructure and its condition might be more important than the supply of it. We have not included infrastructure quality indicator in our analysis, because of a lack of time series data, but this is another area where we hope to extend our study.

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Table 1a. Electricity-generating capacity and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.795***	1.140***	2.016***	1.917***	1.783***	1.597***	1.495***
	(45.64)	(18.35)	(3.98)	(26.89)	(22.16)	(13.98)	(38.03)
H	0.113***	0.054**	-0.183	-0.143***	0.123***	0.233***	0.213***
	(6.21)	(1.98)	(0.75)	(3.44)	(4.10)	(3.42)	(10.63)
ELGEN	0.264***	0.105***	0.286***	0.128	0.168***	0.368***	0.056***
	(35.89)	(7.66)	(3.88)	(1.26)	(8.62)	(11.95)	(4.80)
Time	-0.006***	-0.006***	-0.001	-0.002***	-0.003***	-0.004*	0.006***
	(8.34)	(3.41)	(0.33)	(10.84)	(2.16)	(1.68)	(10.84)
N	2754	805	150	551	442	93	713
R-sq	0.73	0.13	0.34	0.10	0.37	0.86	0.45
F[a]	2585.89***	39.73***	16.10***	28.05***	140.20***	132.04***	169.17***
	(3,2750)	(3,801)	(3,146)	(3,547)	(3,438)	(3,89)	(3,709)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 1b. Percentage contribution to TFP growth, OLS

	elgen	human	trend	residual	sum of tfp shares
Low	-0.445	-0.501	1.937	0.008	1.000
New Tiger	1.248	-0.194	-0.056	0.002	1.000
Lowmid	2.069	-1.311	-0.833	1.075	1.000
Uppermid	0.751	-0.243	-0.321	0.812	1.000
Old Tiger	0.960	0.158	-0.161	0.043	1.000
High	0.119	0.181	0.513	0.186	1.000
all	1.095	0.206	0.572	-0.873	1.000

Table 1c. Electricity-generating capacity and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.787***	0.824***	0.731***	1.471***	1.982***	0.968***	1.346***
	(59.68)	(9.72)	(4.15)	(20.85)	(18.51)	(3.91)	(14.72)
H	-0.161***	-0.038	-0.589***	0.128***	-0.171***	0.251**	0.290***
	(8.54)	(1.11)	(3.94)	(2.88)	(3.09)	(2.19)	(6.17)
ELGEN	0.119***	0.020	-0.185***	0.078***	0.053*	-0.056	0.043**
	(14.22)	(0.92)	(6.76)	(5.69)	(1.84)	(1.27)	(1.97)
Time	0.004***	-0.002*	0.046***	-0.005***	0.008***	0.023***	0.006***
	(8.64)	(1.67)	(10.97)	(4.80)	(5.28)	(11.06)	(10.20)
N	2754	805	150	551	442	93	713
R-sq	0.17	0.03	0.88	0.10	0.22	0.94	0.63
F[a]	182.23***	6.77***	333.69***	18.68***	39.00***	473.66***	389.07***
	(3,2658)	(3,773)	(3,142)	(3,530)	(3,424)	(3,87)	(3,687)
F[b]	154.70***	131.03***	779.03***	130.04***	35.60***	140.46***	75.13***
	(92,2658)	(28,773)	(4,142)	(17,530)	(14,424)	(2, 87)	(22,687)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

Table 1d. Percentage contribution to TFP growth, Fixed-effects

	elgen	human	trend	residual	sum of tfp shares
Low	-0.085	0.352	0.646	0.086	1.000
New Tiger	-0.807	-0.040	2.587	-0.740	1.000
Lowmid	-1.261	-0.348	-2.082	4.691	1.000
Uppermid	0.237	-0.075	0.855	-0.017	1.000
Old Tiger	-0.146	-0.026	0.927	0.245	1.000
High	0.092	-0.032	0.513	0.427	1.000
all	0.493	-0.294	0.381	0.419	1.000

Table 2a. Number of phones and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	0.484***	0.579***	1.381***	1.158***	0.971***	0.720***	1.040***
	(28.40)	(17.67)	(7.23)	(15.96)	(19.39)	(4.80)	(10.61)
H	-0.013	-0.051*	-0.855***	-0.177***	0.179***	-0.150*	0.186***
	(0.80)	(1.82)	(5.46)	(5.10)	(4.36)	(1.90)	(5.96)
PHONE	0.291***	0.171***	0.385***	0.180***	0.116***	0.240***	0.092***
	(50.61)	(9.38)	(15.15)	(12.56)	(5.85)	(12.90)	(3.59)
Time	-0.010***	-0.008***	-0.003	-0.007***	-0.003**	0.006***	0.004***
	(15.86)	(4.89)	(1.20)	(4.90)	(1.94)	(3.48)	(3.82)
N	2839	818	150	553	481	124	713
R-sq	0.77	0.12	0.68	0.24	0.38	0.80	0.45
F[a]	3706.09***	49.91***	100.08***	70.91***	82.30***	208.97***	169.81***
	(3,2835)	(3,814)	(3,146)	(3,549)	(3,477)	(3,120)	(3,709)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 2b. Percentage contribution to TFP growth, OLS

	phone	human	trend	residual	sum of tfp shares
Low	-0.265	-0.185	0.646	0.805	1.000
New Tiger	0.119	0.021	2.587	-1.728	1.000
Lowmid	0.533	0.183	-2.082	2.366	1.000
Uppermid	0.137	0.040	0.855	-0.032	1.000
Old Tiger	0.075	0.014	0.927	-0.015	1.000
High	0.076	0.017	0.513	0.394	1.000
all	1.909	-0.024	-0.953	0.068	1.000

Table 2c. Number of phones and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.125***	0.809***	0.514**	1.045***	0.939***	1.571***	0.842***
	(35.76)	(32.96)	(2.49)	(16.65)	(10.49)	(9.57)	(9.61)
H	-0.133***	-0.004	0.081	0.162***	0.113**	-0.182	0.149***
	(6.85)	(0.11)	(0.49)	(3.52)	(2.32)	(1.47)	(3.41)
PHONE	0.125***	-0.034*	0.107***	0.072***	0.152***	0.047**	0.141***
	(15.19)	(1.94)	(5.23)	(3.31)	(6.96)	(2.00)	(9.35)
Time	0.001**	-0.002*	0.008*	-0.007***	-0.003**	0.024***	0.002***
	(1.99)	(1.81)	(1.66)	(4.76)	(2.10)	(14.26)	(3.52)
N	2839	818	150	553	481	124	713
R-sq	0.18	0.04	0.86	0.07	0.33	0.93	0.67
F^a	194.15***	11.20***	296.33***	12.70***	75.86***	533.10***	463.83***
	(3,2740)	(3,785)	(3,142)	(3,532)	(3,462)	(3,117)	(3,687)
F^b	106.21***	115.53***	317.81***	101.46***	34.63***	132.05***	86.94***
	(95,2740)	(29,785)	(4,142)	(17,532)	(15,462)	(3,117)	(22,687)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

Table 2d. Percentage contribution to TFP growth, Fixed effects

	phone	human	trend	residual	sum of tfp shares
Low	0.451	0.037	0.646	-0.134	1.000
New Tiger	0.638	0.086	0.450	-0.174	1.000
Lowmid	1.917	1.485	-2.915	0.512	1.000
Uppermid	1.042	0.223	-0.321	0.055	1.000
Old Tiger	0.177	-0.124	0.967	-0.020	1.000
High	0.534	0.127	0.171	0.168	1.000
all	0.820	-0.243	0.095	0.328	1.000

Table 3a. Telephone, main lines and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	0.601***	0.653***	1.277***	1.170***	1.065***	0.846***	0.876***
	(31.92)	(20.67)	(6.92)	(16.47)	(22.57)	(5.78)	(8.26)
H	0.024	0.020***	-0.582***	-0.156***	0.216***	-0.170**	0.147***
	(1.09)	(0.60)	(4.05)	(4.43)	(5.05)	(2.11)	(5.35)
TELMA	0.284***	0.168***	0.339***	0.200***	0.093***	0.235***	0.146***
	(40.79)	(8.27)	(15.67)	(13.55)	(4.76)	(12.45)	(5.34)
Time	-0.013***	-0.012***	-0.010***	-0.009***	-0.003***	0.007***	0.002**
	(18.97)	(6.51)	(3.69)	(6.41)	(10.84)	(3.86)	(2.27)
N	2792	799	150	536	470	124	713
R-sq	0.78	0.14	0.67	0.27	0.34	0.79	0.47
F[a]	3250.31***	67.74***	106.69***	79.35***	71.21***	210.24***	184.51***
	(3,2788)	(3,795)	(3,146)	(3,532)	(3,447)	(3,120)	(3,709)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 3b. Percentage contribution to TFP growth, OLS

	telma	human	trend	residual	sum of tfp shares
Low	-2.537	-0.185	3.875	-0.152	1.000
New Tiger	2.420	-0.617	-0.562	-0.241	1.000
Lowmid	6.157	-1.430	-3.747	0.020	1.000
Uppermid	0.723	0.427	-0.855	0.705	1.000
Old Tiger	0.874	-0.116	0.282	-0.041	1.000
High	0.532	0.125	0.171	0.171	1.000
all	2.054	0.044	-1.239	0.141	1.000

Table 3c. Telephone, main lines and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.173***	0.785***	0.589***	0.921***	1.048***	1.545***	0.809***
	(39.23)	(40.54)	(2.66)	(15.10)	(12.32)	(9.46)	(9.97)
H	-0.145***	-0.004***	0.076	0.138***	0.129**	-0.137	0.062
	(7.14)	(0.12)	(0.42)	(3.19)	(2.56)	(1.16)	(1.44)
TELMA	0.132***	-0.063***	0.077***	0.163***	0.135***	0.037*	0.191***
	(15.24)	(2.81)	(3.85)	(7.26)	(5.99)	(1.67)	(12.33)
Time	0.000	-0.001***	0.009*	-0.014***	-0.004***	0.025***	0.001*
	(0.45)	(0.68)	(1.74)	(8.17)	(2.09)	(14.22)	(1.94)
N	2792	799	150	536	470	124	713
R-sq	0.18	0.05	0.85	0.13	0.31	0.93	0.69
F[a]	190.71***	13.92***	270.93***	26.08***	66.57***	527.27***	521.68***
	(3,2693)	(3,766)	(3,142)	(3,515)	(3,451)	(3,117)	(3,687)
F[b]	103.05***	119.8***	302.85***	109.78***	31.97***	133.71***	91.80***
	(95,2693)	(29,766)	(4,142)	(17,515)	(15,451)	(3,117)	(22,687)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

Table 3d. Percentage contribution to TFP growth, Fixed effects

	telma	human	trend	residual	sum of tfp shares
Low	0.951	0.037	0.323	-0.311	1.000
New Tiger	0.550	0.081	0.506	-0.136	1.000
Lowmid	5.018	1.265	-5.829	0.546	1.000
Uppermid	1.049	0.255	-0.427	0.124	1.000
Old Tiger	0.138	-0.093	1.007	-0.052	1.000
High	0.697	0.053	0.086	0.165	1.000
all	0.955	-0.265	0.000	0.310	1.000

Table 4a. Km road and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	0.531***	0.682***	0.050	1.447***	1.206***	1.888***	1.333***
	(22.18)	(22.62	(0.28)	(20.80)	(24.90)	(23.88)	(32.28)
H	0.608***	0.128***	0.602***	-0.083*	0.369***	-0.296***	0.272***
	(47.29)	(5.49)	(4.35)	(1.87)	(13.41)	(6.47)	(12.95)
ROAD	0.101***	0.080***	0.394***	0.074***	-0.044***	-0.242***	0.019***
	(13.71)	(7.38)	(8.94)	(3.69)	(3.52)	(23.94)	(3.36)
Time	-0.008***	-0.009***	-0.008**	0.003**	-0.000	0.031***	0.007***
	(9.41)	(4.63)	(2.33)	(2.22)	(0.02)	(24.00)	(12.37)
N	2764	808	149	521	451	124	711
R-sq	0.58	0.10	0.47	0.04	0.34	0.92	0.43
F[a]	1723.74***	45.41***	38.34***	5.51***	71.21***	357.61***	173.89***
	(3,2760)	(3,804)	(3,145)	(3,517)	(3,447)	(3,120)	(3,707)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 4b. Percentage contribution to TFP growth, OLS

	road	human	trend	residual	sum of tfp shares
Low	0.271	-1.187	2.906	-0.990	1.000
New Tiger	0.771	0.638	-0.450	0.041	1.000
Lowmid	-0.066	-0.761	1.249	0.577	1.000
Uppermid	0.017	0.730	0.000	0.254	1.000
Old Tiger	-0.024	-0.201	1.249	-0.023	1.000
High	0.011	0.232	0.599	0.158	1.000
all	0.045	1.110	-0.763	0.608	1.000

Table 4c. Km road and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.381***	0.623**	1.056***	1.190***	1.373***	1.266***	1.152***
	(51.74)	(18.10)*	(4.96)	(23.14)	(19.30)	(7.79)	(14.35)
H	-0.122***	-0.062*	-0.293	0.222***	0.330***	0.065	0.233***
	(5.98)	(1.77)	(1.64)	(4.79)	(6.12)	(0.73)	(5.27)
ROAD	0.077***	0.152**	-0.036	-0.007	-0.103***	-0.211***	0.120***
	(7.66)	(4.81)*	(1.44)	(0.47)	(6.37)	(3.15)	(5.75)
Time	0.008***	-0.001	0.027***	-0.004***	-0.001	0.025***	0.007***
	(15.21)	(0.64)	(6.92)	(3.22)	(0.45)	(16.51)	(14.01)
N	2764	808	149	521	451	124	711
R-sq	0.13	0.07	0.84	0.05	0.31	0.94	0.65
F^a	127.75***	19.50***	244.05***	9.14***	63.30***	561.04***	416.02***
	(3,2666)	(3,775)	(3,141)	(3,501)	(3,432)	(3,117)	(3,685)
F^b	214.25***	134.97***	460.90***	123.80***	41.97***	30.38***	83.50***
	(94,2666)	(29,775)	(4,141)	(16,501)	(15,432)	(3,117)	(22,685)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

Table 4d. Percentage contribution to TFP growth, Fixed effects

	road	human	trend	residual	sum of tfp shares
Low	0.516	0.575	0.323	-0.414	1.000
New Tiger	-0.070	-0.310	1.519	-0.138	1.000
Lowmid	0.006	2.035	-1.665	0.624	1.000
Uppermid	0.040	0.652	-0.107	0.415	1.000
Old Tiger	-0.021	0.044	1.007	-0.030	1.000
High	0.069	0.198	0.599	0.133	1.000
all	0.034	-0.223	0.763	0.426	1.000

Table 5a. Km paved road and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	0.879***	0.737***	0.174	1.451***	1.260***	1.795***	1.272***
	(33.66)	(16.70)	(1.15)	(18.00)	(26.92)	(11.49)	(13.29)
H	0.419***	0.154***	0.748***	-0.010	0.238***	-0.304***	0.274***
	(28.41)	(6.94)	(6.96)	(0.19)	(7.93)	(3.30)	(5.34)
PVROAD	0.180***	0.009	0.337***	0.047***	0.107***	-0.185***	0.038***
	(25.20)	(0.51)	(15.54)	(2.96)	(6.02)	(6.11)	(3.66)
Time	-0.006***	-0.009***	-0.007***	0.002	0.002*	0.035***	0.008***
	(7.03)	(4.64)	(3.05)	(1.44)	(1.91)	(18.40)	(10.88)
N	2534	821	150	475	419	124	545
R-sq	0.64	0.07	0.68	0.02	0.38	0.75	0.42
F[a]	1963.93***	18.51***	89.23***	4.76***	61.29***	180.22***	113.75***
	(3,2530)	(3,817)	(3,146)	(3,471)	(3,415)	(3,120)	(3,541)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 5b. Percentage contribution to TFP growth, OLS

	pvroad	human	trend	residual	sum of tfp shares
Low	-0.043	-1.428	2.906	-0.435	1.000
New Tiger	0.695	0.793	-0.394	-0.094	1.000
Lowmid	0.253	-0.092	0.833	0.006	1.000
Uppermid	0.218	0.471	0.214	0.098	1.000
Old Tiger	-0.213	-0.207	1.410	0.009	1.000
High	0.063	0.233	0.685	0.019	1.000
all	0.376	0.765	-0.572	0.431	1.000

Table 5c. Km paved road and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.458***	0.695***	0.934***	1.141***	1.635***	0.699***	0.993***
	(58.53	(19.32)	(5.81)	(17.65)	(25.31)	(2.71)	(8.99)
H	-0.132***	-0.007	-0.443***	0.289***	-0.077	0.367***	0.487***
	(6.07)	(0.22)	(3.25)	(5.68)	(1.52)	(2.74)	(8.56)
PVROAD	0.103***	-0.046**	-0.297***	0.012	0.245***	-0.106***	-0.034***
	(9.02)	(1.98)	(8.31)	(0.42)	(11.68)	(3.60)	(2.85)
Time	0.006**	-0.003***	0.039***	-0.007***	0.007***	0.023***	0.007***
	(11.66)	(2.75)	(12.27)	(5.48)	(6.30)	(13.01)	(10.24)
N	2534	821	150	475	419	124	545
R-sq	0.13	0.04	0.89	0.08	0.46	0.94	0.66
F[a]	118.78***	1185***	381.18***	12.63***	144.88***	575.34***	344.96***
	(3,2441)	(3,788)	(3,142)	(3,454)	(3,401)	(3,117)	(3,524)
F[b]	164.86***	140.42***	411.50***	116.83***	39.84***	187.92***	86.64***
	(89,2441)	(29,788)	(4,142)	(17,454)	(14,401)	(3,117)	(17,524)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

Table 5d. Percentage contribution to TFP growth, Fixed effects

	pvroad	human	trend	residual	sum of tfp shares
Low	0.219	0.065	0.969	-0.252	1.000
New Tiger	-0.612	-0.469	2.193	-0.112	1.000
Lowmid	0.065	2.650	-2.915	1.200	1.000
Uppermid	0.499	-0.152	0.748	-0.095	1.000
Old Tiger	-0.122	0.250	0.927	-0.054	1.000
High	-0.057	0.415	0.599	0.043	1.000
all	0.215	-0.241	0.572	0.454	1.000

Table 6a. Km railroad and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	0.759***	0.789***	1.667***	1.591***	1.187***	1.866***	1.538***
	(21.52)	(18.20)	(5.87)	(21.65)	(22.63)	(13.98)	(44.82)
H	0.629***	0.105***	0.161	-0.015	0.303***	-0.886***	0.213***
	(39.04)	(4.22)	(1.06)	(0.28)	(9.53)	(12.14)	(12.38)
RAIL	0.110***	0.048***	0.475***	0.083***	-0.006	-0.385***	0.031***
	(15.70)	(3.29)	(6.83)	(8.55)	(0.54)	(25.47)	(6.19)
Time	-0.005***	-0.005**	0.024***	0.004***	0.000	0.042***	0.007***
	(5.49)	(2.18)	(4.89)	(2.89)	(0.15)	(27.61)	(12.80)
N	2315	589	150	484	372	69	651
R-sq	0.56	0.04	0.45	0.06	0.26	0.97	0.47
F[a]	1350.16***	13.68***	29.86***	35.40***	37.05***	1080.88***	217.58***
	(3,2311)	(3,585)	(3,146)	(3,480)	(3,368)	(3,65)	(3,647)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 6b. Percentage contribution to TFP growth, OLS

	rail	human	trend	residual	sum of tfp shares
Low	0.456	-0.974	1.615	-0.097	1.000
New Tiger	-0.442	0.171	1.350	-0.079	1.000
Lowmid	-0.938	-0.138	1.665	0.410	1.000
Uppermid	0.007	0.599	0.000	0.394	1.000
Old Tiger	0.162	-0.603	1.692	-0.251	1.000
High	-0.033	0.181	0.599	0.253	1.000
all	-0.186	1.148	-0.477	0.514	1.000

Table 6c. Km railroad and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.496***	1.101***	2.698***	1.170***	1.053***	3.294***	1.633***
	(48.47	(21.28)	(10.46)	(15.58)	(13.83)	(6.83)	(23.00)
H	0.036	0.033	-0.030	0.234***	0.399***	-0.128	0.173***
	(1.61)	(0.78)	(0.21)	(5.15)	(6.64)	(0.78)	(4.88)
RAIL	0.134***	0.255***	0.830***	-0.002	-0.022	0.651**	0.077***
	(11.02)	(8.23)	(8.18)	(0.08)	(1.24)	(2.46)	(2.92)
Time	0.007**	0.006***	0.036***	-0.005***	-0.002***	0.037***	0.008***
	(13.23)	(3.38)	(11.81)	(3.30)	(1.40)	(20.34)	(14.83)
N	2315	589	150	484	372	69	651
R-sq	0.16	0.12	0.89	0.06	0.29	0.96	0.45
F[a]	142.51***	26.02***	376.79***	9.16***	48.14***	550.44***	405.19***
	(3,2231)	(3,563)	(3,142)	(3,464)	(3,357)	(3,63)	(3,627)
F[b]	245.42***	166.73***	721.20***	117.77***	26.10***	15.32***	82.48***
	(80,2231)	(22,563)	(4,142)	(16,464)	(11,357)	(2,63)	(20,627)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

Table 6d. Percentage contribution to TFP growth, Fixed effects

	rail	human	trend	residual	sum of tfp shares
Low	2.424	-0.306	-1.937	0.819	1.000
New Tiger	-0.772	-0.032	2.025	-0.221	1.000
Lowmid	0.023	2.145	-2.082	0.914	1.000
Uppermid	0.024	0.789	-0.214	0.401	1.000
Old Tiger	-0.274	-0.087	1.491	-0.130	1.000
High	-0.082	0.147	0.685	0.250	1.000
all	-0.226	0.066	0.667	0.493	1.000

Table 7a. Airports and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	-0.091**	0.509***	1.312***	1.525***	1.162***	0.763*	0.933***
	(2.08)	(5.15)	(6.55)	(16.28)	(19.97)	(1.72)	(18.81)
H	0.574***	0.178***	0.775***	-0.053	0.316***	-0.874***	0.208***
	(41.96)	(8.79)	(4.23)	(1.06)	(12.54)	(7.87)	(18.06)
AIR	0.079***	0.016	0.119**	-0.006	0.006	0.207***	0.051***
	(15.75)	(1.46)	(1.96)	(0.56)	(1.25)	(3.44)	(12.80)
Time	-0.008***	-0.006***	-0.006	0.002*	0.000	0.030***	0.006***
	(8.79)	(3.14)	(0.87)	(1.77)	(0.32)	(11.24)	(11.64)
N	2717	767	150	550	465	72	713
R-sq	0.59	0.09	0.25	0.01	0.26	0.80	0.57
F[a]	1783.75***	29.46***	19.57***	1.58	63.77***	179.95***	310.81***
	(3,2713)	(3,763)	(3,146)	(3,546)	(3,461)	(3,68)	(3,709)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 7b. Percentage contribution to TFP growth, OLS

	air	human	trend	residual	sum of tfp shares
Low	0.022	-1.651	1.937	0.691	1.000
New Tiger	0.426	0.821	-0.337	0.091	1.000
Lowmid	-0.029	-0.486	0.833	0.682	1.000
Uppermid	0.026	0.625	0.000	0.349	1.000
Old Tiger	0.499	-0.594	1.209	-0.114	1.000
High	0.156	0.177	0.513	0.153	1.000
all	0.260	1.048	-0.763	0.455	1.000

Table 7c. Airports and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	0.310***	-0.271***	-0.287	1.129***	1.330***	0.769***	-0.126
	(5.56	(2.96)	(0.96)	(9.33)	(10.05)	(4.63)	(-0.84)
H	-0.045***	-0.032	-0.057	0.214***	-0.036	-0.008	0.352***
	(2.57)	(1.03)	(0.37)	(4.76)	(0.73)	(0.10)	(9.23)
AIR	0.112***	0.114***	0.101***	0.004	0.040***	0.069***	0.121***
	(21.77)	(10.86)	(5.53)	(0.33)	(3.21)	(3.94)	(10.73)
Time	0.004***	0.001	0.015***	-0.004***	0.006***	0.018***	0.002***
	(9.01)	(1.11)	(4.23)	(3.47)	(4.93)	(12.55)	(3.66)
N	2717	767	150	550	465	72	713
R-sq	0.25	0.15	0.86	0.05	0.22	0.95	0.68
F^a	288.45***	42.36***	302.92***	8.87***	41.74***	390.44***	488.61***
	(3,2620)	(3,735)	(3,142)	(3,529)	(3,446)	(3,66)	(3,687)
F^b	285.95***	172.57***	814.34***	139.39***	64.82***	289.42***	64.82***
	(93,2620)	(28,735)	(4,142)	(17,529)	(15,446)	(2,666)	(22,687)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

Table 7d. Percentage contribution to TFP growth, Fixed effects

	air	human	trend	residual	sum of tfp shares
Low	0.159	0.297	-0.323	0.867	1.000
New Tiger	0.361	-0.060	0.844	-0.144	1.000
Lowmid	0.019	1.962	-1.665	0.684	1.000
Uppermid	0.173	-0.071	0.641	0.257	1.000
Old Tiger	0.166	-0.005	0.725	0.114	1.000
High	0.370	0.300	0.171	0.159	1.000
all	0.368	-0.082	0.381	0.332	1.000

Table 8a. Public capital and TFP, OLS

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	0.783***	0.579***	1.312***	1.467***	1.205***	0.013	1.418***
	(26.05)	(10.39)	(6.55)	(17.47)	(28.19)	(0.02)	(46.26)
H	0.217***	0.243***	-0.474***	-0. 130**	0.198***	0.788	0.271***
	(8.81)	(5.85)	(2.76)	(2.49)	(6.23)	(1.66)	(13.18)
PUB	0.296***	0.333***	0.377***	0.126***	0.117***	-0.224*	-0.000
	(29.75)	(8.65)	(8.46)	(5.03)	(4.44)	(1.84)	(0.02)
Time	-0.011***	-0.010***	-0.000	-0.001	-0.002	0.030***	0.006***
	(13.36)	(3.40)	(0.09)	(0.52)	(1.48)	(6.18)	(6.30)
N	1902	269	150	398	403	31	651
R-sq	0.74	0.46	0.48	0.06	0.25	0.95	0.46
F[a]	1343.76***	76.34***	34.21***	11.98***	58.27***	342.67***	241.01***
	(3,1898)	(3,265)	(3,146)	(3,394)	(3,399)	(3,27)	(3,647)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 8b. Percentage contribution to TFP growth, OLS

	pub	human	trend	residual	sum of tfp shares
Low	-1.887	-2.254	3.229	1.912	1.000
New Tiger	1.466	-0.502	0.000	0.037	1.000
Lowmid	2.199	-1.192	-0.416	0.409	1.000
Uppermid	0.576	0.391	-0.214	0.246	1.000
Old Tiger	-1.176	0.536	1.209	0.432	1.000
High	0.000	0.231	0.513	0.256	1.000
all	1.824	0.396	-1.048	-0.172	1.000

Table 8c. Public capital and TFP, Fixed-effects

	All	Low	New Tigers	Low-Mid	Upper-Mid	Old Tigers	High
Constant	1.304***	0.744***	1.346***	0.985***	1.730***		1.561***
	(36.88	(21.39	(6.52)	(16.41)	(20.02)		(22.03)
H	-0.003	-0.317***	-0.539***	0.326***	-0.178***		0.170***
	(0.11)	(3.94)	(3.09)	(6.48)	(3.39)		(4.49)
PUB	0.135***	0.455***	-0.104***	0.089***	0.124***		0.020**
	(15.04)	(6.49)	(3.44)	(3.55)	(6.33)		(2.14)
Time	0.001	0.005**	0.038***	-0.009***	0.004***		0.006***
	(1.18)	(2.32)	(7.80)	(6.05)	(3.14)		(9.81)
N	1902	269	150	398	403		651
R-sq	0.28	0.16	0.85	0.13	0.27		0.66
F[a]	240.10***	15.67***	264.90***	19.01***	4751***		402.64***
	(3,1836)	(3,256)	(3,142)	(3,382)	(3,387)		(3,627)
F[b]	146.39***	92.46***	489.77***	132.56***	57.72***		82.90***
	(62,1836)	(9,256)	(4,142)	(12,382)	(12,387)		(20,627)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects
In the case of Old Tigers, only one out of the four countries had data on public capital, in which case the OLS results apply.

Table 8d. Percentage contribution to TFP growth, Fixed effects

	pub	human	trend	residual	sum of tfp shares
Low	-2.579	2.940	-1.615	2.253	1.000
New Tiger	-0.452	-0.571	2.137	-0.114	1.000
Lowmid	1.554	2.989	-3.747	0.205	1.000
Uppermid	0.610	-0.352	0.427	0.314	1.000
Old Tiger					
High	0.128	0.145	0.513	0.214	1.000
all	0.832	-0.005	0.095	0.078	1.000

Table 9a. Infrastructure and TFP, regressions with several infrastructures, OLS

	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Constant	1.795***	0.873***	1.730***	1.678***	0.860***	0.722***	0.727***
	(45.64)	(17.39)	(41.78)	(23.89)	(17.04)	(10.25)	(10.16)
H	0.113***	-0.005	0.100***	0.114***	-0.020	-0.008	-0.022
	(6.21)	(0.25)	(5.35)	(6.31)	(0.91)	(0.38)	(0.95)
ELGEN	0.264***	0.060***	0.228***	0.262***	0.058***	0.049***	0.045***
	(35.89)	(5.65)	(25.77)	(30.41)	(5.32)	(4.31)	(3.89)
TELMA		0.240***			0.249***	0.249***	0.258***
		(20.25)			(19.31)	(20.78)	(19.55)
PVROAD			0.057***		-0.003		-0.000
			(8.36)		(0.50)		(0.981)
AIR				0.010**		0.009**	0.007*
				(2.07		(2.43	(1.83)
Time	-0.006***	-0.011***	-0.005	-0.006***	-0.012	-0.011***	-0.011***
	(8.34)	(17.13)	(6.84)	(7.63)	(15.71)	(16.28)	(14.83)
N	2754	2691	2435	2658	2381	2596	2294
R-sq	0.73	0.79	0.72	0.73	0.78	0.80	0.79
F[a]	2585.89***	2370.19***	1798.85***	1878.64***	1695.18***	1898.99***	1422.34***
	(3,2750)	(4,2686)	(4,2430)	(4,2653)	(5,2375)	(5,2590)	(6,2287)

Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.

Table 9b. Infrastructure and TFP, regressions with several infrastructures, Fixed-effects

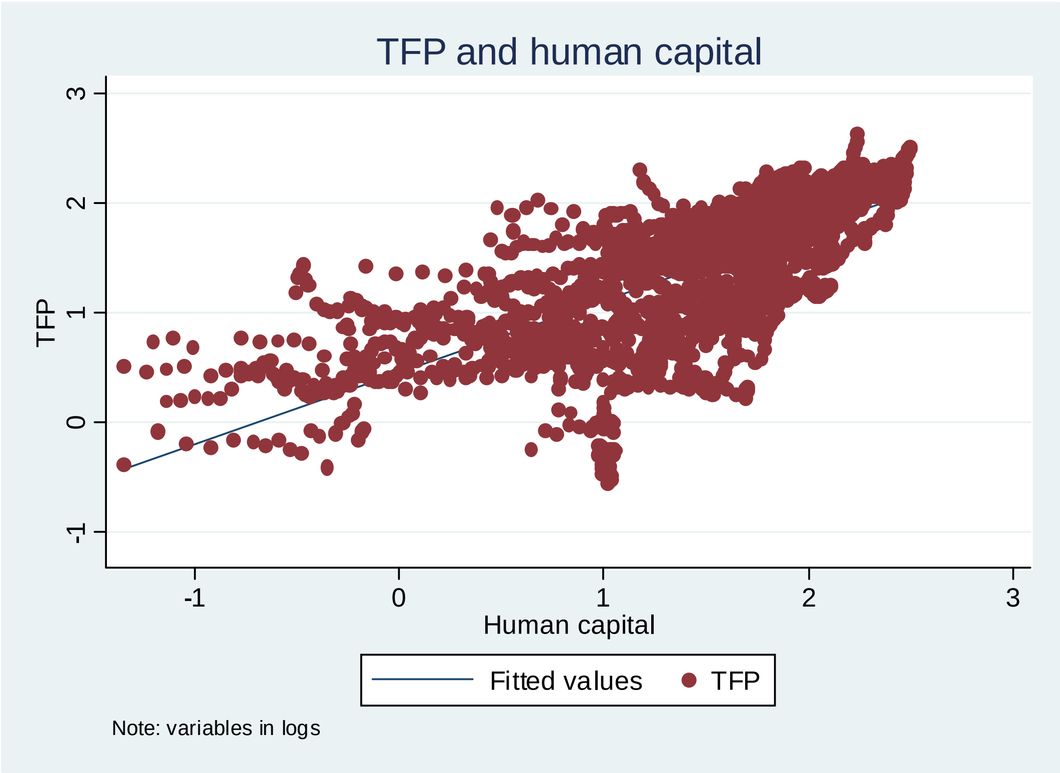
	FE	FE	FE	FE	FE	FE	FE
Constant	1.787***	1.546***	1.772***	0.662***	1.517***	0.536***	0.463***
	(59.68)	(36.32)	(54.53)	(9.79)	(33.11)	(7.59)	(6.13)
H	-0.161***	-0.204***	-0.186***	-0.090***	-0.225***	-0.130***	-0.145***
	(8.54)	(10.36)	(8.97)	(5.10)	(10.33)	(6.94)	(7.10)
ELGEN	0.119***	0.085***	0.115***	0.072***	0.078***	0.047***	0.040***
	(14.22)	(9.05)	(12.00)	(8.57)	(7.40)	(5.05)	(3.78)
TELMA		0.086***			0.088***	0.070***	0.065***
		(9.24)			(8.59)	(7.64)	(6.43)
PVROAD			0.037***		0.037***		0.030**
			(2.96)		(2.95)		(2.34)
AIR				0.097***		0.091***	0.096*
				(17.83		(16.20	(15.67)
Time	0.004***	0.001*	0.005	0.003***	0.001	0.000	0.001
	(8.64)	(1.93)	(7.90)	(6.39)	(1.86)	(0.82)	(1.41)
N	2754	2691	2435	2658	2381	2596	2294
R-sq	0.17	0.20	0.17	0.27	0.19	0.29	0.30
F[a]	182.23***	157.81***	116.49***	241.92***	109.82***	206.37***	155.18***
	(3,2658)	(4,2594)	(4,2344)	(4,2562)	(5,2289)	(5,2499)	(6,2202)
F[b]	154.70***	115.49***	141.68***	189.30***	107.23***	107.23***	131.03***
	(92,2658)	(92,2594)	(86,2344)	(91,2562)	(86,2289)	(91,2499)	(85,2202)

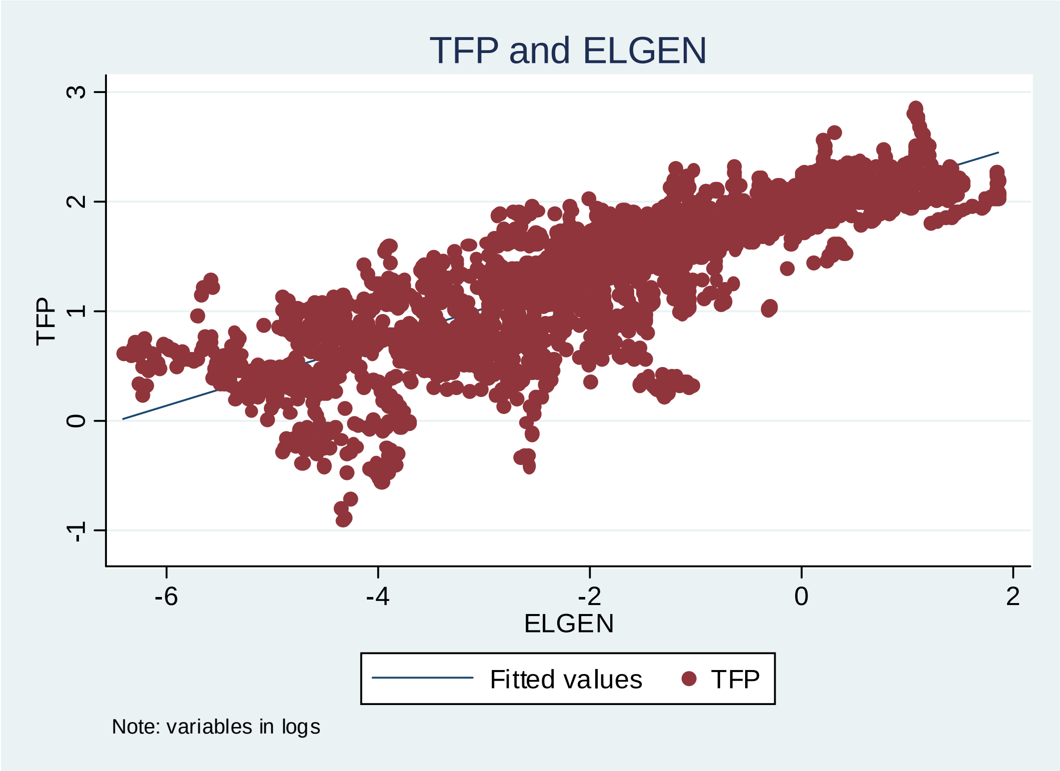
Note: All variables are in logs and absolute t-values in parentheses. N=number of observations.
***, ** and * denote statistical significance at the 1, 5 and 10 percent, respectively.
[a] Test for joint significance of parameters.
[b] Test for significant of fixed effects

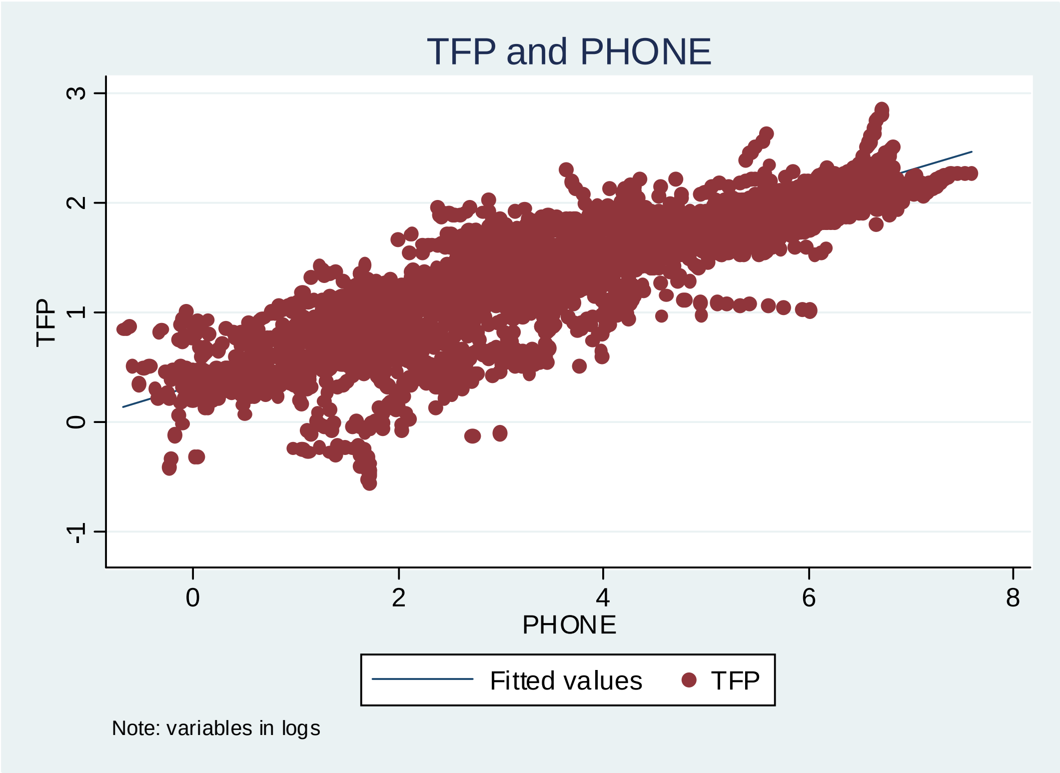
Table 10. Role of Infrastructure at different stages of development, fixed effects estimates

	LOW	NEW TIGER	LOW-MID	UPPER-MID	OLD TIGER	HIGH
0.85		RAIL				
0.65					RAIL	
0.60						
0.55						
0.50						
0.45						
0.40						
0.35						
0.30						
0.25	RAIL			PVROAD		
0.20						TELMA
0.15	ROAD		TELMA	PHONE TELMA		PHONE
0.10	AIR	PHONE TELMA AIR	ELGEN PHONE			ROAD RAIL AIR
0.05				ELGEN AIR	PHONE TELMA AIR	ELGEN
0.00	ELGEN ins		PVROAD ins AIR			
NEG	PHONE TELMA PVROAD	ELGEN ROAD ins PVROAD	ROAD ins RAIL	ROAD RAIL	ELGEN ins ROAD PVROAD	PVROAD

Figure 1. TFP, human capital and Infrastructure






TFP and PHONE
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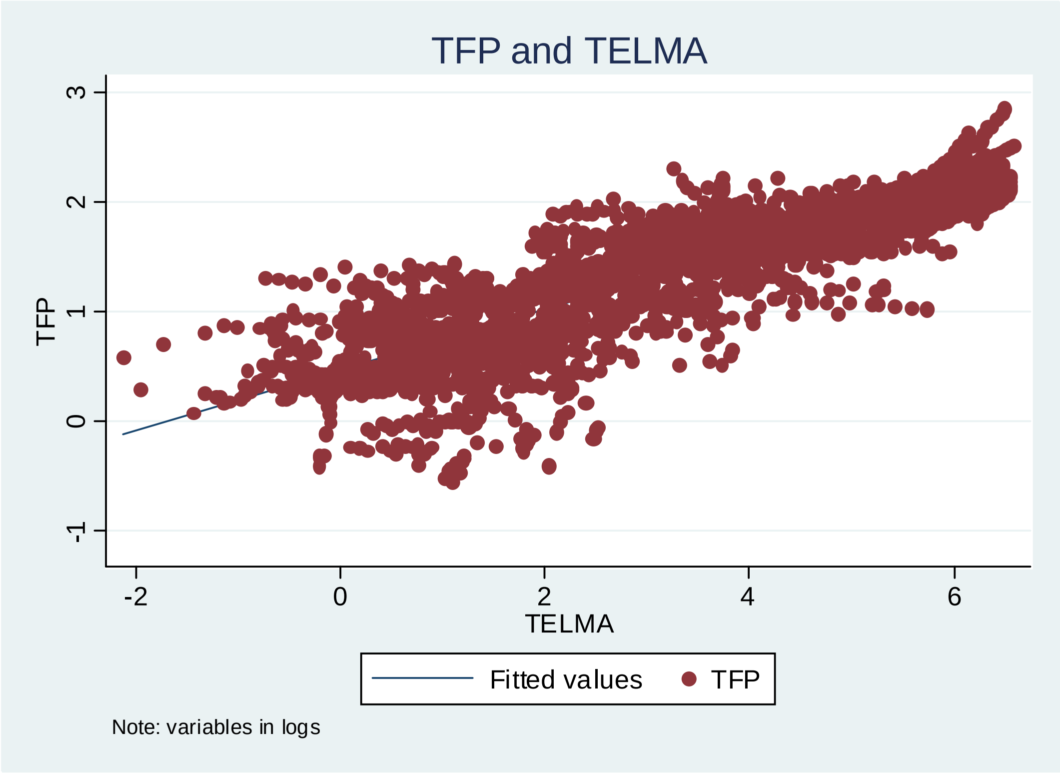
2
1
0
-1
0
2
4
6
8
PHONE
Fitted values
TFP
Note: variables in logs


TFP and TELMA
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1
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-2
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2
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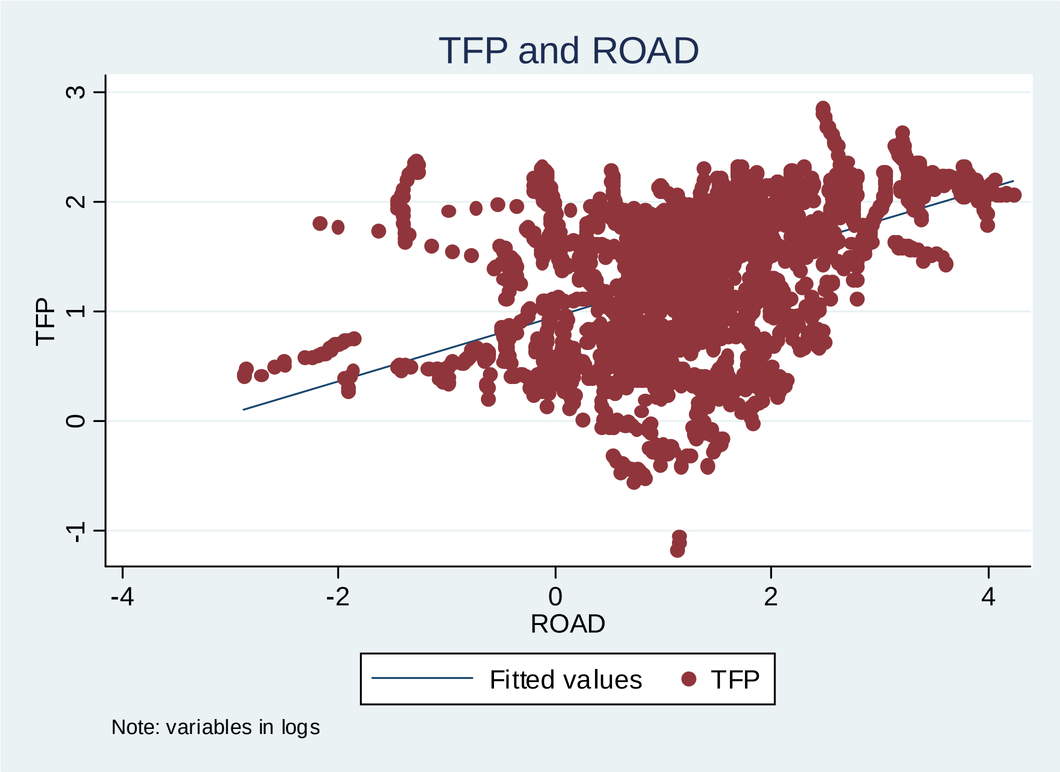
6
TELMA
Fitted values
TFP
Note: variables in logs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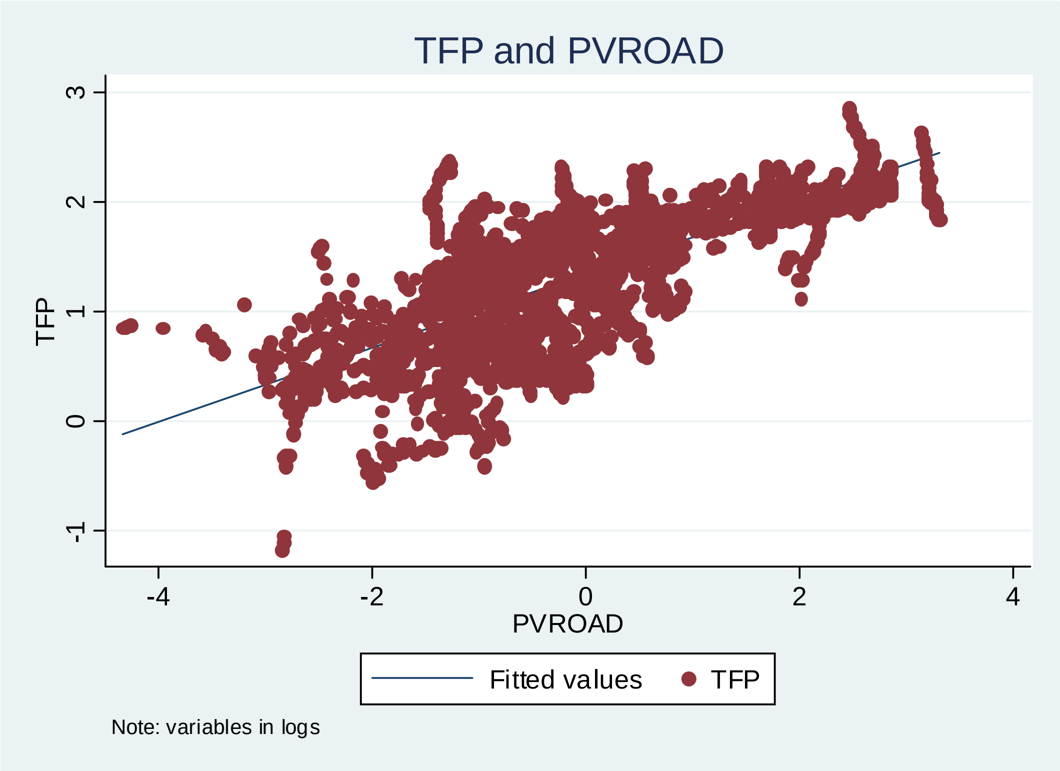
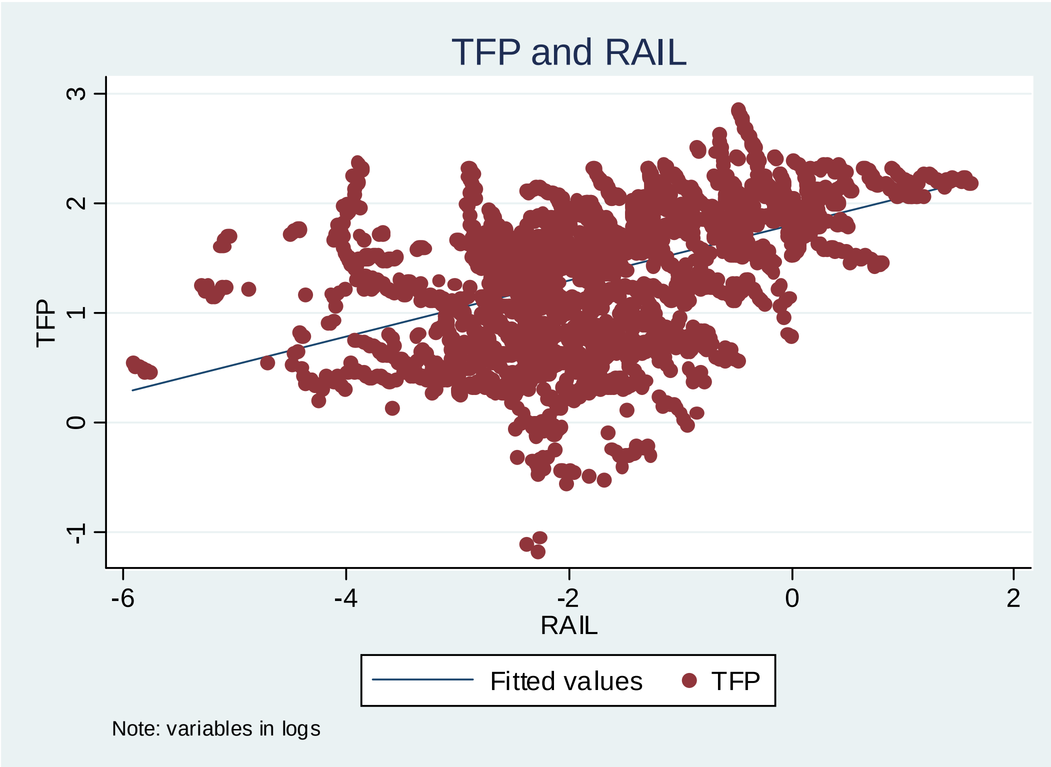
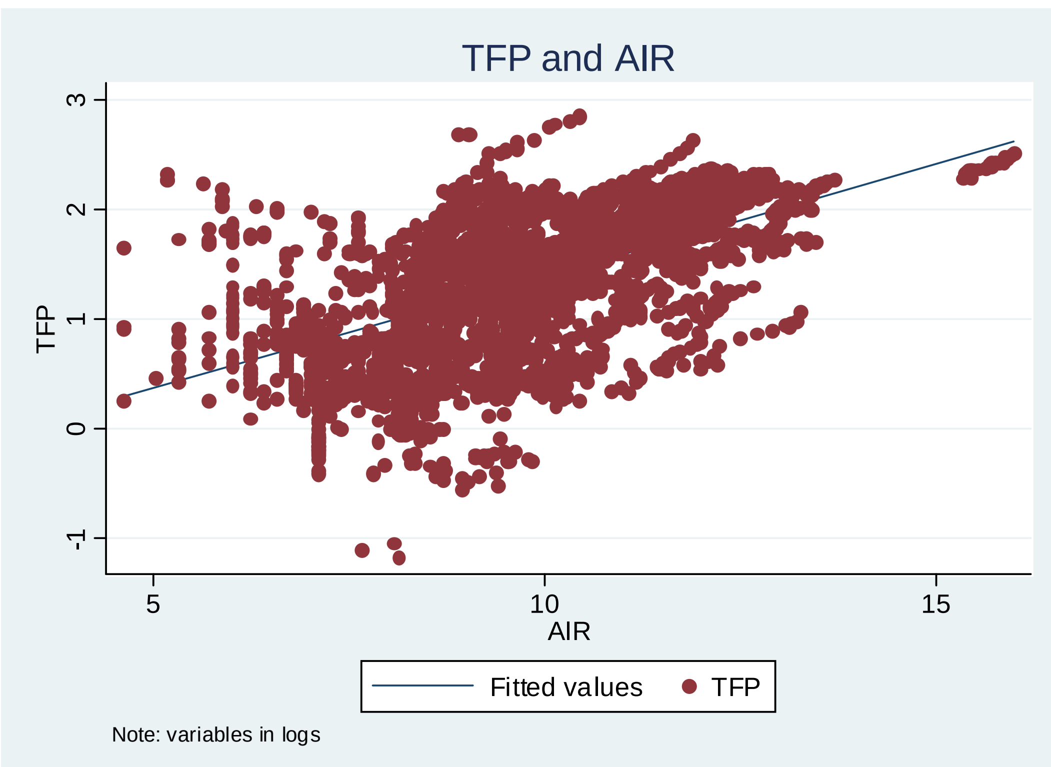
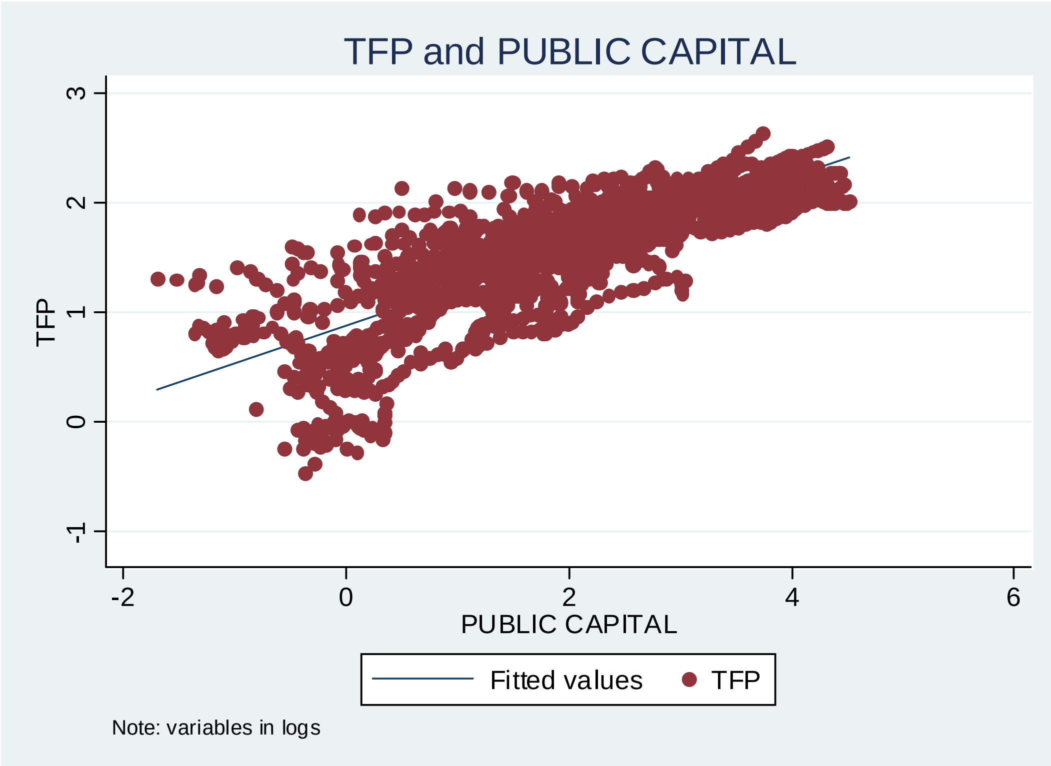
-1
-4
-2
0
2
4
ROAD
Fitted values
TFP
Note: variables in logs


TFP and PVROAD
TFP
3
2
1
0
-1
-4
-2
0
2
4
PVROAD
Fitted values
TFP
Note: variables in logs


TFP and RAIL
TFP
3
2
1
0
-1
-6
-4
-2
0
2
RAIL
Fitted values
TFP
Note: variables in logs


TFP and AIR
TFP
3
2
1
0
-1
5
10
15
AIR
Fitted values
TFP
Note: variables in logs



Note: Graphs show pair-wise log relationships between TFP and human capital on the one hand, and TFP and infrastructure indicators on the other. TFP is measured along the Y-axis, while the other variables are measured along the X-axis.

Appendix

Table A1: Summary statistics

ALL

Variable	Obs	Mean	Std. Dev.	Min	Max
tfp	3472	1.338157	.6477161	-1.167223	2.854617
h	2859	1.470865	.6928629	-1.347074	2.489065
elgen	3287	-1.927315	1.854708	-6.419175	1.855989
phone	3390	3.607446	1.9855	-.6871055	7.586053
telma	3311	3.217774	2.051821	-2.122266	6.581648
road	3239	1.376435	1.096984	-2.878483	4.234766
pvroad	3060	-.1197527	1.451623	-4.336671	3.304687
rail	2690	-1.65904	1.197855	-5.914504	1.606207
air	3259	9.767196	1.838366	4.60517	15.9905
pub	2103	1.964211	1.383092	-1.696795	4.515023

LOW

Variable	Obs	Mean	Std. Dev.	Min	Max
tfp	1240	.6707892	.4111547	-1.167223	1.75691
h	838	.7189705	.656371	-1.347074	1.719189
elgen	1192	-3.731556	1.151934	-6.419175	-1.041316
phone	1189	1.634608	.9540171	-.6871055	4.229759
telma	1165	1.12668	.9793461	-2.122266	4.368983
road	1132	.9163123	.921945	-2.878483	2.560078
pvroad	1202	-1.238531	.8328861	-4.336671	.5594672
rail	867	-2.084092	.9488859	-5.914504	-.2488717
air	1130	8.36177	1.130998	4.60517	11.17605
pub	398	.1998065	.7584598	-1.696795	1.572077

NEW TIGERS

Variable	Obs	Mean	Std. Dev.	Min	Max
tfp	155	1.015055	.4101704	.2613603	1.881608
h	150	1.512	.2525158	.8197798	1.916923
elgen	152	-2.390592	.9697709	-4.876979	-.042271
phone	155	2.525156	1.330304	.4712965	5.381948
telma	150	2.37934	1.428596	.196093	5.70695
road	154	.526457	.5888101	-.7856792	1.733049
pvroad	150	-.4452814	.8231465	-2.298693	.9149979
rail	155	-2.66058	.4582267	-3.497598	-1.61435
air	151	11.49669	.7329953	9.961757	13.25847
pub	155	1.15267	.9844648	-1.098204	3.037215

LOWMID

Variable	Obs	Mean	Std. Dev.	Min	Max
tfp	682	1.403143	.2796982	.5526074	2.030977
h	553	1.497877	.371132	.4317824	2.116256
elgen	618	-2.004739	.8567812	-4.591267	.407676
phone	651	3.5019	.959683	.9504332	6.169862
telma	623	3.135578	1.011031	.1165378	5.727205
road	590	1.109711	.8218195	-2.174896	3.602361
pvroad	543	-.3022659	.7368761	-1.44333	1.226425
rail	539	-2.267485	.9405566	-5.300319	.8129903
air	651	9.522613	1.300889	5.703783	12.36606
pub	465	1.373546	.6877592	-.444823	2.876601

UPPERMID

Variable	Obs	Mean	Std. Dev.	Min	Max
tfp	527	1.745351	.2202137	.7888082	2.325182
h	481	1.655823	.3517386	.3920421	2.273156
elgen	488	-1.165675	.6474114	-2.989353	.1352911
phone	527	4.369618	.8807575	1.80313	6.173731
telma	505	4.039734	.9148154	1.283896	5.944234
road	497	1.624325	.5958766	-.9963626	2.913856
pvroad	465	.345178	.621115	-2.237266	1.840561
rail	393	-1.180386	1.180293	-5.127731	.6302872
air	511	9.85554	1.692278	4.60517	13.44821
pub	403	2.243047	.5372341	.4139213	3.13859

OLD TIGERS

Variable	Obs	Mean	Std. Dev.	Min	Max
tfp	124	1.858035	.2906183	1.292259	2.375894
h	124	2.002212	.2068803	1.591274	2.383243
elgen	93	-.399819	.7388377	-2.456553	.6200172
phone	124	5.568536	.9503474	2.997768	6.869591
telma	124	5.277722	.9519889	2.700979	6.459676
road	124	-.2862593	.6556587	-1.468069	.7239091
pvroad	124	-.5868489	.6044291	-2.186225	.5331134
rail	69	-2.81942	.4029888	-3.94403	-2.312635
air	72	10.95994	.7636847	9.680344	12.36606
pub	31	2.462375	1.100005	-.0788441	3.832299

HIGH

Variable	Obs	Mean	Std. Dev.	Min	Max
tfp	744	2.083105	.1891109	1.124844	2.854617
h	713	2.107791	.2544565	.9555114	2.489065
elgen	744	.4318018	.6527562	-1.420927	1.855989
phone	744	6.211383	.5734948	4.314775	7.586053
telma	744	5.828763	.5216684	3.90386	6.581648
road	742	2.57872	.7497771	.9448237	4.234766
pvroad	576	2.196971	.6407353	-.6521396	3.304687
rail	667	-.5440979	.8572542	-2.384989	1.606207
air	744	11.58867	1.461272	7.600903	15.9905
pub	651	3.461704	.6437309	.2509027	4.515023

Table A2: Correlations

	tfp	h	elgen	phone	telma	road	pvroad	rail	air	pub
tfp	1.000									
h	0.734	1.000								
elgen	0.845	0.836	1.000							
phone	0.879	0.845	0.925	1.000						
telma	0.875	0.838	0.928	0.987	1.000					
road	0.495	0.460	0.603	0.552	0.525	1.000				
pvroad	0.754	0.675	0.807	0.828	0.816	0.688	1.000			
rail	0.483	0.372	0.554	0.512	0.490	0.763	0.593	1.000		
air	0.578	0.575	0.665	0.624	0.637	0.370	0.494	0.324	1.000	
pub	0.837	0.807	0.919	0.925	0.933	0.686	0.827	0.525	0.606	1.000

Table A3. Comparison of infrastructure stocks across meta-countries, relative to high-income, %

	ELGEN	PHONE	TELMA	ROAD	PVROAD	RAIL	AIR	PUB
High	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Low	1.56	1.03	0.91	18.96	3.21	21.44	3.96	3.84
New Tigers	5.95	2.51	3.18	12.85	7.12	12.05	91.39	9.93
Low-mid	8.78	6.65	6.79	23.04	8.23	17.80	12.62	12.37
Upper-mid	20.15	15.88	16.71	38.37	15.69	52.94	17.73	29.52
Old Tigers	43.52	52.73	57.75	5.70	6.18	10.27	54.26	36.79

Table A4. Annual average growth rates of infrastructure stocks and human capital

	ELGEN	PHONE	TELMA	ROAD	PVROAD	RAIL	AIR	PUB	H
High	0.013	0.041	0.047	-0.011	0.015	-0.029	-0.004	0.018	0.029
Low	0.078	0.106	0.127	0.035	0.037	-0.017	0.064	0.077	0.019
New Tigers	0.025	0.044	0.043	0.007	0.020	-0.012	0.036	0.075	0.010
Low-mid	0.039	0.064	0.074	-0.002	0.013	-0.027	0.012	0.042	0.022
Upper-mid	0.042	0.064	0.073	-0.004	0.019	-0.010	0.041	0.046	0.019
Old Tigers	0.065	0.093	0.092	0.002	0.029	-0.010	0.060	0.130	0.017
All	0.043	0.069	0.076	0.005	0.022	-0.018	0.035	0.065	0.019

Table A.5. Sample countries, Organized by Meta Country

HIGH-INCOME	LOW-INCOME	LOW-MID	UPPER-MID	OLD TIGERS	NEW TIGERS
Australia	Angola	Algeria	Argentina	Hong Kong	China
Austria	Bangladesh	Cape Verde	Barbados	Korea, Republic of	India
Belgium	Benin	Colombia	Botswana	Singapore	Indonesia
Canada	Bolivia	Costa Rica	Brazil	Taiwan	Malaysia
Cyprus	Burkina Faso	Dominican Republic	Chile		Thailand
Denmark	Burundi	Ecuador	Gabon		
Finland	Cameroon	Egypt	Mauritius		
France	Central African Rep.	El Salvador	Mexico		
Greece	Chad	Equatorial Guinea	Panama		
Iceland	Comoros	Fiji	Seychelles		
Ireland	Congo	Guatemala	South Africa		
Israel	Cote d'Ivoire	Guyana	Syria		
Italy	DR Congo	Iran	Trinidad and Tobago		
Japan	Ethiopia	Jamaica	Tunisia		
Luxembourg	Gambia	Jordan	Turkey		
Netherlands	Ghana	Morocco	Uruguay		
New Zealand	Guinea	Namibia	Venezuela		
Norway	Guinea Bissau	Pakistan			
Portugal	Haiti	Paraguay			
Spain	Honduras	Peru			
Sweden	Kenya	Philippines			
Switzerland	Lesotho	Sri Lanka			
UK	Madagascar				
USA	Malawi				
	Mali				
	Mauritania				
	Mozambique				
	Nepal				
	Nicaragua				
	Niger				
	Nigeria				
	Papua New Guinea				
	Rwanda				
	Senegal				
	Sierra Leone				
	Tanzania				
	Togo				
	Uganda				
	Zambia				
	Zimbabwe				

Public capital

We use a perpetual inventory method (PIM) to estimate the stock of capital from the public investment data. Under the PIM, the stock of capital at the end of year t that is available for production in the following year, K_{t+1}, is equal to the depreciated amount of capital left over from the preceding year, $(1-\delta)K_t$, plus the amount of new capital added through investment during the year, I_t:

$$K_{t+1} = (1-\delta)K_t + I_t, \qquad \text{(A.1)}$$

The δ denotes the depreciation rate here, as in the text. By substituting backward in time to some initial period, equation A.1 can be expressed in terms of the depreciated stream of investment plus the initial capital stock, K_0 :

$$K_t = (1-\delta)^t K_0 + \sum_{i=1}^{t} (1-\delta)^{t-i} I_i. \qquad \text{(A.2)}$$

This method of estimating the stock of capital requires time-series data on real investment, which we obtain from the Penn World Tables 6.1 (Heston, Summers and Aten, 2002), in purchasing power parity 1996 US dollars. The share of public investment in total investment for 48 developing countries is acquired from the International Finance Corporation, World Bank (World Bank, 2001), and we simply multiply real investment by this share to arrive at real public investment. Similar information on public investment shares for 22 OECD countries source from OECD Analytical Database, Version June 2002. We have no information as to country-specific depreciation rates, so we assume a common 3 percent rate for each country.

To obtain a starting value for the capital stock of each country, we assume the country is at its steady state capital-output ratio. The steady-state benchmark value is obtained from the equation:

$$k = i/(g+\delta), \qquad \text{(A.3)}$$

where k = K/Y (i.e. capital-output ratio), g = the growth rate of real Y (i.e. growth of GDP), and i = I/Y (i.e. investment rate). The steady-state growth of GDP (g) and the investment rate (i), respectively, are calculated as the annual average over 10 years (1970-1979). Inserting these into (A.3) gives k and the benchmark is obtained by multiplying k by initial GDP. Thereafter, we add 10 years of investment to the benchmark and this marks the initial capital stock, K_0.