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A New Global Index on Infrastructure: Construction, Rankings and Applications*

Julian Donaubauer, Birgit Meyer, and Peter Nunnenkamp

Abstract:
We construct comprehensive and comparable indices on the most relevant components of economic infrastructure. An unobserved components model is employed to cover the largest possible number of developing and developed countries over the period 1990-2010. We map major findings from the new indices on infrastructure and provide country rankings, which we also compare with subjective assessments of infrastructure in the World Economic Forum's Global Competitiveness Report. Finally, we exemplify possible applications related to trade and FDI. By overcoming several data limitations, our new global index can help assess the links between infrastructure and economic development more systematically.

Keywords: infrastructure, transport, ICT, energy, finance, unobserved components method, trade, FDI.

JEL classification: O18; C43; C82; F14; F21

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I. Introduction

In the empirical as well as the theoretical literature there is a broad consensus that a country's endowment with infrastructure represents a critical factor to sustain economic growth, attract foreign direct investment (FDI) and promote trade. Straub (2008) finds that most, though far from all empirical studies show a significantly positive effect of infrastructure on output and growth. Straub (2008: 4) also notes that "in surveys assessing the investment climate, businesses usually rank deficient infrastructure as an important barrier to their operations and growth." Particularly in developing countries, deficient infrastructure can seriously affect the people's daily life and work.

Asiedu (2002: 111) argues that "good infrastructure increases the productivity of investments and therefore stimulates FDI." Her empirical assessment of the determinants of FDI corroborates this view, though not necessarily in sub-Saharan Africa.[1] Focusing on trade, Limão and Venables (2001: 451) regard infrastructure as an important determinant of transport costs, especially for landlocked countries. Their analysis of African trade flows indicates that "their relatively low level is largely due to poor infrastructure."[2]

Vijil and Wagner (2012) address the links between foreign aid, infrastructure, and trade. They find that so-called aid-for-trade strengthens the export performance of recipient countries through aid's effects on infrastructure. Aid-for-trade largely consists of projects with the explicit objective to improve infrastructure. All (bilateral and multilateral) donors granted US$ 324 billion of aid related to infrastructure during the 1990-2010 period,[3] accounting for 3.4 percent of gross capital formation in all low and lower-middle income countries. Hence, donors could play a relevant role in promoting Third World development through improving infrastructure.[4]

Given the widely shared view on the vital role of infrastructure, Straub's (2008) verdict may be surprising; he concludes that better data sets would be required in order to address the links between infrastructure and development in a meaningful way. And indeed, there is no comprehensive and comparable measure available which encompasses all relevant components of economic infrastructure and is, at the same time, available for a large number of developing and developed countries and over a sufficiently long period of time.

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[1] In an earlier study, Cheng and Kwan (1999) found that better infrastructure had positive effects on FDI in Chinese regions.

[2] See also Brun et al. (2005) and Vijil and Wagner (2012).

[3] For details see: http://stats.oecd.org/index.aspx?DataSetCode=CRS1 (accessed: May 2014).

[4] Addison and Anand (2012) provide an overview of evidence on infrastructure needs, focusing on Africa, and possible magnitudes of funding from different sources.

The pioneering work of Canning (1998) focuses on the collection of data for specific indicators of infrastructure for a large sample of countries over the period 1950-1995. While Canning offers a detailed discussion and comparison of the coverage and reliability of six specific indicators [5] he does not attempt constructing a composite index of overall infrastructure. Likewise, most of the recent literature focuses on specific aspects of infrastructure, or relies on a narrow definition of infrastructure, when examining its impact on outcome variables such as growth, investment, and trade. For instance, Röller and Waverman (2001) assess the impact of telecommunications on economic development. Hoffmann (2003) considers single indicators – international telephone circuits, the total length of roads and the number of aircraft departures – to investigate the relationship between public infrastructure and international capital flows.

Limão and Venables (2001) and Brun et al. (2005) take a broader perspective and capture several aspects of infrastructure to analyze the links between infrastructure and transport costs. They use simple averages of specific indicators, assuming that all aspects of infrastructure have the same weight. A few recent studies relax this problematic assumption by performing principal components analysis (PCA). [6] Kumar (2006) and Francois and Manchin (2013) use PCA in a panel context.[7] However, employing PCA in a panel context tends to unduly restrict the set of countries and the data series that can be included in the analysis. Any gaps in the data series would have the effect that the constructed indices are no longer comparable over time.[8]

Our major contribution is that we overcome several data limitations by constructing a new global index of infrastructure, covering various dimensions of infrastructure for a large sample of developed and developing countries. Specifically, the index is based on a broad annual dataset of 30 indicators of the quantity and quality of infrastructure for up to 193 countries, covering the 1990-2010 period. In addition to an overall index, we build sub-indices for specific components: transport, information and communications technology (ICT), energy, and finance. To combine data from different sources into aggregate

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[5]For instance, Canning (1998) concludes that the datasets for telephone lines, railways and electricity generating capacity are more complete and reliable than the data sets on the length and type of roads.
[6]PCA provides a natural way of assigning weights to different indicators within an aggregate index.
[7]Kumar (2006) employs PCA to assess the effects of infrastructure on FDI. His PCA is based on just six specific indicators of road transport (2 indicators), telecommunication (1), information (2), and energy (1). Francois and Manchin (2013) rely exclusively on road and air transport and some indicators of telecommunication in their analysis of the effects of infrastructure and institutions on trade patterns. Vijl and Wagner (2012) employ PCA in a purely cross-section analysis on aid, infrastructure and trade.
[8]Calderón and Servén (2014) circumvent this PCA-related problem by using 5-year averages of all the data in their study of the impact of infrastructure on economic growth and income distribution. While a balanced dataset may be created in this way, the downside is a loss of information concerning the variation over time.

infrastructure indices we use an unobserved components model, where observed data in each area of infrastructure are a linear function of unobserved infrastructure and an error term. With this approach we are able to provide a consistent picture of the availability and quality of infrastructure in a large panel dataset of developing and developed countries.

The paper proceeds as follows. In Section II we introduce specific indicators in four areas of infrastructure and explain the data used. We provide details on the unobserved components method in Section III. In Section IV, we portray major findings from our new global index of infrastructure covering the 1990-2010 period. We also compare our index with other measures of infrastructure. Section V exemplifies possible applications related to trade and FDI. Section VI concludes.

II. Indicators and data

As mentioned earlier, our overall index is based on four sub-categories of infrastructure: transport (via air, land, and sea), ICT, energy, and financial infrastructure. In contrast to the former three categories, financial infrastructure is mostly neglected in the literature. However, the endowment of countries with a well-functioning financial infrastructure could be vital for their economic development. Hence, we create a sub-index of financial infrastructure and include it in our overall index.

We complement commonly used indicators of infrastructure with less widely used indicators to broaden the coverage of our index. In each sub-index we consider not only quantity aspects of infrastructure, but also quality measures.[9] Depending on the specific indicator, we normalize by geographic area, population size, or population density (population size divided by geographic area) to adjust for the wide disparities in country size in our sample.[10]

Transport infrastructure: Better networks of transport increase productivity by reducing the costs of transporting goods within the country. Moreover, the transport system can support the country's integration into world markets. We construct an index consisting of the three modes of transport: land, sea, and air.

Land transport. Our first indicator of land transport is the total length of road network, normalized by population density. To consider the quality of a country's road network at least

[9]This is in contrast to earlier studies. For a similar approach, see Calderón and Servén (2014). However, information on the quality of infrastructure is limited, compared to the quantity aspects of infrastructure.
[10]Data on a country's area and population are taken from World Bank's World Development Indicators (WDI) online database.

tentatively, we use data on the percentage of paved roads per country.[11] Furthermore, we use the proportion of motorways per country. All indicators are taken from the International Road Federation's (IRF) World Road Statistics[12] and the World Bank's World Development Indicators (WDI). As additional measures of road transport infrastructure, we consider the number of registered passenger cars and the number of registered commercial vehicles. These variables are taken from "Facts and Figures" of the German Association of the Automotive Industry (VDA) and are normalized by population. A country's endowment with railroads is accounted for by three variables: total length of the railway route, goods transported, and railway passengers. Data are taken from the World Bank's WDI database. Total length of the railway route is normalized by population density, goods transported by area, and the number of railway passengers by population size.

Sea transport. To account for an economy's sea transport capacity, we use two indicators taken from the United Nations Conference on Trade and Development (UNCTAD) database:[13] total carrying capacity of a country's ships, (i) relative to its geographic area and (ii) as a percentage of total world carrying capacity. Clearly, the prevalent practice of registering merchant vessels in a state different from that of the ship's owners renders this measure problematic. We correct for implausibly high values for so-called "flag of convenience" countries that are typically involved in this practice.[14]

Air transport. We measure a country's air transport capacity with two variables taken from the WDI: registered carrier departures in a country (relative to population), and the volume of air freight (relative to country size).

ICT infrastructure: Infrastructure in this area encompasses "telecommunications, internet, broadcasting and other networks through which information is transmitted, stored and delivered" (Guislain 2003). Investment in ICT is widely perceived to be an important driver of productivity, innovation and social inclusion. From the perspective of developing countries, ICT investment appears to be vital to bridge the digital divide and improve the dissemination of official and market-related information (International Telecommunication Union 2011; Williams et al. 2011).

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[11]As pointed out by Canning (1998), there are huge differences in the quality of paved roads across countries. Moreover, we do not have information about maintenance levels.

[12]The IRF's database distinguishes between different types of roads (e.g. motorways, secondary roads, etc.). However, detailed data on the type of roads are not available for most developing countries.

[13]Available at http://unctadstat.unctad.org (accessed: May 2014).

[14]"Flag of convenience" countries include Panama, Liberia, Marshall Islands, Bahamas, Malta, Antigua, and Bermuda. We limit the upper value for these countries to the 95 percentile which corresponds to values observed for countries like Japan or Greece.

Following the existing literature (e.g., Hanafizadeh et al. 2009) and based on data availability across countries and time, we select the following indicators: number of fixed telephone lines, mobile cellular telephone subscriptions, and the number of ISDN subscriptions. As a quality measure we add faults per 100 fixed telephone lines per year. Data are taken from the International Telecommunication Union's (ITU) Indicators 2012 database. From the same database we add an indicator for the number of personal computers. Data on the number of internet users are extracted from the WDI online database. All these variables (except telephone faults) are expressed in per capita terms.

Energy infrastructure: While energy may be regarded to be "the lifeblood of the global economy – a crucial input to nearly all of the goods and services of the modern world" (World Economic Forum 2012: 6), the production and consumption of energy depends on reliable infrastructure. In particular in developing countries, inadequate energy supply and deficient energy-related infrastructure can seriously hinder private sector development. In sub-Saharan Africa, only about one-fifth of the population has access to electricity (ibid: 37).

As a proxy for a country's energy generation capacity we use data on its yearly electric power consumption and production (both variables are measured in per capita terms). To measure the reliability and quality of the national electrical power supply we make use of data on electric power transmission and distribution losses (as percentage of output). All series are taken from the WDI online database.

Financial infrastructure: As noted by Čihák et al. (2012: 4), "the balance of theoretical reasoning and empirical evidence points towards a central role of finance in socio-economic development. Economies with higher levels of financial development grow faster and experience faster reductions in poverty levels." By contrast, deficient financial infrastructure tends to hinder growth and can destabilize economies.

Most of the data concerning a country's financial infrastructure are from the World Bank's global financial development database.[15] It includes measures of stability, efficiency, access, and depth of financial systems. To capture all these aspects, we use the banks' Z-score and stock price volatility (stability); the stock market turnover ratio (efficiency); the number of bank accounts per capita, the value of all traded shares outside the largest ten traded companies as a share of the total value of all traded shares, and the number of publicly listed

[15] Available at http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTGLOBALFINREPORT/0,,contentMDK:23269602~pagePK:64168182~piPK:64168060~theSitePK:8816097,00.html (accessed: Mai 2014).

companies per capita (from Beck and Demirgüç-Kunt 2009) (access); private credit by deposit money banks relative to GDP, the value of total shares traded on the stock market exchange relative to GDP, and money and quasi money (M2) as % of GDP (depth).[16] All these variables (except the number of bank accounts and the number of publicly listed companies) are used in log form.

After careful inspection of all data series we eliminated what appeared to be misprints and corrected implausible yearly changes in the reported data. Considering that infrastructure tends to change relatively slowly over time, we followed standard practice in the literature (e.g., Canning 1998) and interpolated linearly some series with few gaps in the data.[17] Note also that all indicators need to point into the same direction (with regard to improved or, respectively, deteriorating infrastructure) to be able to aggregate them. Therefore, we transformed some indicators multiplying them by the factor (-1).[18] After that transformation, higher values of all our indicators of infrastructure reflect better conditions in terms of either quantity or quality. Furthermore, we standardize our data by rescaling all indicators from different sources to take on values between zero and one. Table 1 provides details on data sources and exact definitions of all indicators. Table 2 offers descriptive statistics for the full sample of (developed and developing) countries and for developing countries only. Table 3 presents correlations between the indicators belonging to a specific category of infrastructure.

III. Construction of the indices

The high collinearity (see Table 3) between various specific indicators of infrastructure would result in an identification problem if some or all of them were included jointly in a regression analyses. The individual effects of specific aspects of infrastructure could hardly be distinguished from each other. To be able to identify the effects of more broadly defined aspects of infrastructure, we construct composite indices for the four categories of infrastructure introduced in the previous section.

Principal components analysis (PCA) offers one possible approach to condense various indicators and build a composite index of infrastructure. Francois and Manchin (2013) and Calderón and Servén (2014) have employed this approach. However, our objective is to obtain a much broader index which should be available on an annual basis. This implies that

[16]The latter two variables are taken from Beck and Demirgüç-Kunt (2009) and the WDI, respectively.
[17]However, we interpolated over gaps of just one year, while Canning (1998) interpolated over gaps of up to five years.
[18]This applies to faults per 100 fixed telephone lines, electric power transmission and distribution losses, and stock price volatility.

we face an unbalanced panel with missing observations for particular years or countries. Using PCA in such a panel setup would produce misleading results as movements of the index over time calculated with this method might not only mirror changes in the actual data, but also variations in the availability of data across countries. Hence, we follow Kaufmann et al. (2011) and Calderón and Chong (2004) and employ an unobserved components model (UCM), rescaling the respective aggregate index from year to year.

The index is calculated in several steps as observed infrastructure score y_{cj} of country $c \in [1, C]$ and indicator $j \in [1, J]$ by a linear function of unobserved and imperfect measure of infrastructure I_c and an error term ε_{cj}:

$$y_{cj} = \alpha_j + \beta_j(I_c + \varepsilon_{cj}). \tag{1}$$

First to obtain weights, we estimate a function of these indicators j using the maximum likelihood method, assuming a normally distributed random variable I_c with mean zero and standard deviation one. The estimated parameters α_j and β_j map the unobserved indicators into the observed data space while accounting for different underlying data sources and units of measurement. These obtained parameters reflect the fact that different underlying data sources have different units of measurement and different ranges. They are estimated to minimize the error in the composite index.

The error term is assumed to be independent and identically distributed with mean $E[\varepsilon_{cj}] = 0$ and variance $Var[\varepsilon_{cj}] = \sigma_j^2$. Thus, the variance differs across indicators but is the same across countries. Further assuming the errors to be independent across sources ($E[\varepsilon_{ci}\varepsilon_{cj}] = 0$ for $i \neq j$) allows us to identify the particular information from each data source that feeds into the overall infrastructure index. Thus, the correlation between two different data sources can be attributed to the common underlying unobserved infrastructure I_c.

Next, to facilitate the calculations, we assume that I_c and ε_{cj} are jointly normally distributed. Given the different observed infrastructure indicators j the mean of the conditional distribution of the unobserved infrastructure represents the estimate of infrastructure in country c. Thus, the unobserved infrastructure is estimated as sum over all J observed available infrastructure indicators weighted by the individual sources according to their precision:

$$E[I_c | y_{c1}, \dots, y_{cJ}] = \sum_{j=1}^{J} w_{cj} \frac{y_{cj} - \alpha_j}{\beta_j} \tag{2}$$

where the weight w_{cj} is a decreasing function of the variance of the indicator j and an increasing function of the variance of all indicators:

$$w_{cj} = \frac{\sigma_j^{-2}}{1 + \sum_{j=1}^{J} \sigma_j^{-2}} \, . \tag{3}$$

Thus, the lower the variance of indicator j, the higher its precision and the weight assigned to the respective indicator.[19]

To obtain estimates for α_j, β_j, and σ_j^2 the likelihood function of the observed infrastructure data is maximized subject to α_j, β_j, and σ_j^2.[20] To be able to identify the unobserved infrastructure we need at least three representative infrastructure indicators in each of the four categories of infrastructure for each country per year.[21] To obtain our composite infrastructure indices the estimated values are substituted in equations (2) and (3). Our estimated indices have a mean of zero and a standard deviation of one in each period.

Our sample size is changing from year to year due to varying data availability for different indicators. This is why we finally need to rescale our indices of infrastructure to ensure comparability across years and countries. In particular, more data are available in more recent years for developing countries, which alters the infrastructure score of countries in the earlier periods. By rescaling we avoid that the index in earlier periods is distorted by the underrepresentation of low-performing countries in earlier periods. We use 2010, the most recent year of our period of observation with the broadest data range, as benchmark. Our estimated index for 2010 has a mean of zero and a standard deviation of one. For the previous year (2009) we adjust the score as if we had the same country sample as in the benchmark year (2010). Hence, we rescale the index in 2009 such that it has a mean of zero and standard deviation of one if we had included the estimated infrastructure scores of 2010 for those

[19] If the indicator is not available for all countries then weights are country specific. Comparability is assured by adjusting the standard errors each year according to the sample size of each indicator. Furthermore, the precision of the composite indicator is given by the variance of the conditional distribution $Var\left[I_c | y_{c1}, \dots, y_J\right] = \left[1 + \sum_{j=1}^{J} \sigma_j^{-2}\right]^{-1}$, which is a decreasing function in the number of indicators of the components of infrastructure for each country and an increasing function in the variance of each indicator.

[20] The log likelihood function which is maximized with respect to α_j, β_j, and σ_j^2 for each country c is given by $\ln L_{cj}\left(\alpha_j, \beta_j, \sigma_j\right) = -\frac{1}{2}\ln(2\pi) - \frac{1}{2}\ln\left(var\left[y_{cj}\right]\right) - \frac{1}{2}\left(\frac{y_{cj} - \alpha_j}{var\left[y_{cj}\right]^{\frac{1}{2}}}\right)^2$.

[21] To obtain our indices we use all series on infrastructure giving sufficient information and not following a global trend. We observe only very little evidence of statistically significant improvements in our data series worldwide (see Table 4).

additional countries entering the sample in 2010 and excluding those missing in 2010 (while being part of the sample in 2009). The adjusted index is thus

$$I_{c,t,adjusted} = I_{c,t} - I_{c,t+1,add}\frac{N_{t+1}-N_t}{N_t} - I_{c,t,miss}\frac{N_t-N_{t+1}}{N_t} \quad (4)$$

where $I_{c,t+1,add}$ corresponds to the mean indicator of the countries entering the sample in the following year, and $I_{c,t,miss}$ corresponds to the mean indicator of the countries missing in the following year (while being part of the sample in the current year). N is the number of countries in the sample in the respective year. The more countries enter the sample in more recent years, the lower the mean from the previous years.

Likewise, we need to rescale the standard deviation of the estimated index by a factor

$$\sqrt{\frac{N_{t+1}}{N_t} - \frac{N_{t+1}-N_t}{N_t}\left(var\left(I_{c,t+1,\,add}\right)+I^2_{c,t+1,\,add}\right) - \frac{N_t-N_{t+1}}{N_t}\left(var\left(I_{c,t,\,miss}\right)+I^2_{c,t,\,miss}\right)} \quad (5)$$

where $var(I_{c,t+1,add})$ is the variance of the additional countries entering the sample in the following year (while missing in the current year), and $var(I_{c,t,miss})$is the variance of the countries missing in the following year but present in the current year. Thus, the standard deviation corresponds again to a standard deviation of one for our adjusted index. The higher the dispersion in the scores of new entrants and the lower the dispersion of missing countries in the following year, the more the countries in the sample are affected.

This approach has the advantage that the calculation of weights for the indicators in our rescaled indices does not require any ad hoc restrictions. Hence, our rescaled indices are comparable across countries and time. On theoretical grounds this is clearly preferable to constructing unweighted averages as is often done for cross-sectional compound indices of infrastructure (e.g., in Limão and Venables 2001).

We estimate indices for each of our four categories of infrastructure introduced in Section II as well as for our aggregate index of overall infrastructure. Table 5 provides basic summary statistics on our infrastructure indices for the period 1990-2010 for the full sample and for developing countries only.

IV. Results and rankings

Our overall index of infrastructure and the four sub-indices cover up to 165 countries with annual observations over the period 1990-2010. The following presentation summarizes major results by mapping the overall index for three selected years (1990, 2000, and 2010) in Figure

1 and the four sub-indices for the final year 2010 in Figure 2. In addition, we use the same selected evidence to provide rankings in Table 6.[22] More detailed evidence is available from the authors on request. In particular, the world maps are available on an annual basis for the overall index as well as the sub-indices. Likewise, we may provide detailed information underlying the rankings, including standard deviations and lower/ upper bounds, to interested readers.

Not surprisingly, Figure 1 and columns (1) and (2) in Table 6 clearly reveal that most top performers with regard to overall infrastructure at the end of our period of observation (2010) are located in the North and belong to the high income group of countries, as defined in the World Bank's World Development Indicators. Outside the high income group, China represents the first upper-middle income country on rank 28 and India represents the first lower-middle income country on rank 35 in column (1) of Table 6.[23] The highest ranking low income countries (Tajikistan and Ethiopia) are far down on ranks 91 and 92, respectively. Conversely, low income and lower-middle income countries dominate the bottom third of the ranking. The few upper-middle income countries with particularly poor overall infrastructure are mostly oil-exporting countries and other resource-based economies (e.g., Azerbaijan, Gabon, Iraq, and Botswana).

Before turning to the more specific evidence on sub-indices and changes in rankings over time, we compare our ranking in column (1) of Table 6 with the World Economic Forum's (WEF) ranking of the quality of overall infrastructure as presented in its Global Competitiveness Report 2010-2011 (indicator 2.01 in World Economic Forum 2011). The approaches underlying the two rankings differ in various respects. Most importantly, the WEF ranking is based on subjective assessments of survey respondents.[24] The focus of the WEF ranking is on the quality of overall infrastructure, while we cover various indicators of the quantity and quality of infrastructure, as detailed in Section II. In contrast to our overall index, financial infrastructure is not part of the WEF's index on the quality of infrastructure. Finally, country coverage differs between the two indices, even though the total number of countries ranked in column (1) of Table 6 and in the WEF report is almost exactly the same (140 versus

[22]Table 6 also presents the index values for overall infrastructure in 2010 (column 2). It should be stressed that the differences between the index values for close neighbours in the ranking are not always statistically significant, as attested by the confidence intervals (not shown in the table).

[23]We will return to the cases of China and India in more detail below.

[24]The relevant question posed to respondents is: "How would you assess general infrastructure (e.g., transport, telephony, and energy) in your country? [1=extremely underdeveloped; 7= extensive and efficient by international standards];" the index is a weighted average for 2009-10.

142 countries). The subsequent comparison uses information about the 124 countries listed in both rankings.

The above noted differences notwithstanding, the correlation between the two rankings is surprisingly strong; the correlation coefficient of 0.72 is statistically significant at the one percent level. All the same, comparing the two indices in the scatter plot of Figure 3 points to some striking outliers for which the WEF ranking deviates widely from our ranking. On the one hand, there is a small group of four diverse economies at the bottom of our ranking (rank positions worse than 100) which rank more than 50 ranks higher according to the WEF's index: Botswana, El Salvador, Georgia, and Namibia. The better WEF ranking of these countries appears to be largely because the subjective assessments of the quality aspects of infrastructure are in stark contrast with the few quantitative aspects of infrastructure covered by some specific indicators in the Global Competitiveness Report. The latter are much more in line with our ranking which combines quantity and quality aspects. For instance, Botswana and Namibia rank below 100 with respect to airline seat kilometers (WEF indicator 2.06) and fixed telephone lines (WEF indicator 2.08). This also applies to Georgia and Namibia with regard to mobile telephone subscriptions (WEF indicator 2.09).

On the other hand, three high income OECD countries (Italy, Norway, and the United States) are much better placed in our ranking than in the WEF ranking. The same applies to a group of middle income countries, consisting of four transition economies (Bosnia and Herzegovina, Bulgaria, Mongolia, and Romania) and Lebanon. The inclusion of the United States and Norway among the top 10 performers in column (1) of Table 6 mainly results from top scores with regard to transport (US) and energy-related infrastructure (Norway). In contrast, the United States receives only mediocre subjective assessments with regard to quality aspects of transport infrastructure in the Global Competitiveness Report. Norway seems to be pulled down in the WEF ranking by an exceptionally poor score for the quality of roads (rank 84). The discrepancies for the transition countries and Lebanon may be attributed to the dominance of transport-related indicators in the WEF ranking. Bosnia and Herzegovina, Mongolia and Romania receive similarly poor scores with respect to our sub-index of transport infrastructure (column (3) in Table 6), but they score much better in other sub-categories which appear to be underrepresented in the Global Competitiveness Report. The most obvious case in point is Lebanon's favorable ranking in terms of financial infrastructure (column (6) in Table 6).

The rankings for the sub-indices shown in columns (3)-(6) of Table 6 reveal that few countries receive essentially the same scores for all four sub-categories of infrastructure.[25] Among the top 10 performers in column (1), Japan is clearly an exception insofar its rank positions differ only slightly across the four categories. Some top performers, notably Hong Kong, receive top scores in all categories with just one major exception (energy in the case of Hong Kong); other countries such as Norway belong to the top performers mainly because they receive exceptionally favorable rankings in just one category (again energy). On average, the top 10 performers in column (1) are ranked much better in terms of transport and ICT infrastructure (average ranks are 8.3 and 9.3, respectively) than in terms of energy-related infrastructure (16.2) and financial infrastructure (16.9).

Particularly wide deviations in ranks across sub-categories are observed for India, and to a somewhat lesser extent also for China. On the one hand, both countries resemble each other in that they score much better than one might have expected with regard to transport and financial infrastructure. On the other hand, in particular India ranks much lower than in column (1) with regard to ICT and energy-related infrastructure. At the bottom of the overall ranking in column (1), it is more common that countries receive taillight rankings in (almost) all sub-categories (e.g., Rep. of Congo, Namibia, Iraq, and Gabon). However, various countries with overall rank positions worse than 100 perform strikingly better in at least one sub-category. In particular, the ranks received with regard to transport infrastructure are often 50 or more positions better than in column (1); examples include: Guinea, Sudan, Yemen, Cambodia, Nigeria, Papua New Guinea, Cote d'Ivoire, and Botswana.

Notwithstanding the above noted deviations in country-specific ranks across the four categories of infrastructure, the rankings in columns (3)-(6) are all positively correlated with each other, at the one percent level of significance across all available countries (Table 7, Panel B). Furthermore, the correlation between the overall ranking in column (1) and that of the specific categories of infrastructure ranges from 0.74 in the case of transport to 0.88 in the cases of ICT and energy-related infrastructure.

Finally, columns (7)-(9) of Table 6 present changes over time in the ranking of overall infrastructure. This comparison is confined to a reduced sample of 103 countries for which the overall ranking could be computed for all three years – 1990, 2000, and 2010. First of all, we observe that most top 10 performers in 2010 belonged to this group in 2000 and 1990 already. Hong Kong is the most notable exception; the city state started from rank 18 in 1990 to reach

[25] See also the maps in Figure 2.

the top position in 2010. Third-ranked Germany moved up by 11 positions during the same period. By contrast, it was mainly Japan (and more recently also Norway) whose ranking deteriorated, though both countries were still among the top 10 in 2010. Sweden represents the clearest drop-out, falling from rank 5 in 1990 to 14 in 2010. This drop can be attributed to declining scores for Sweden with regard to transport and ICT infrastructure.

More pronounced changes occurred at the bottom of the ranking. Only two countries hold one of the ten taillight positions throughout the period of observation (Nigeria and Cote d'Ivoire). Compared to 1990, Sri Lanka and the Philippines improved their ranking most pronouncedly (by 19 and 18 positions, respectively) among the eight countries that left the taillight group. By contrast, the ranking of Yemen and Zambia deteriorated most pronouncedly (by 29 and 30 positions, respectively) among the countries that joined the taillight group in 2010.

In the wide middle ground between the top and the bottom of the ranking, we observe various upward and downward changes in the order of 20-40 rank positions. The ranking improved most significantly since 1990 for Morocco, Turkey, and Brazil – followed by China, Tunisia, and Chile. On the other hand, it was mainly for transition countries where the ranking deteriorated since 1990: Georgia, Lithuania and Macedonia are prominent cases in point. Strikingly, the decline was not restricted to the decade immediately after the regime change in these three transition economies, but continued until 2010.

Even though we observe pronounced changes over time in the ranking of various sample countries, the correlations between the rankings in 2010, 2000 and 1990 across all 103 sample countries prove to be strongly positive (Table 7, Panel A). In other words, the overall ranking with respect to our global index of infrastructure appears to be fairly persistent throughout the period of observation.

V. Trade and FDI-related applications

As noted in the Introduction, a country's endowment with infrastructure is widely regarded to be a critical factor with respect to growth, investment and trade. Recalling Straub's (2008) verdict that better datasets are required to address the links between infrastructure and economic development in a meaningful way, we present two simple applications to indicate how our global index of infrastructure may help analyze these links for a large panel of (developed and developing) countries by pooling annual observations since 1990. Specifically, we present pooled regressions to assess whether our overall index and the sub-indices of the four categories of infrastructure are relevant determinants of the countries' openness to trade and their attractiveness to foreign direct investment (FDI).[26]

In addition to our variables of principal interest, the indices of infrastructure described in detail above, we include a standard set of control variables in both applications. First, we account for the country's size in terms of its logged GDP (*Gdp*). Foreign trade and investment typically play a less important role for larger countries so that the coefficient on this control variable is expected to be negative. Second, higher growth of the country's GDP (*Growth*) is likely to be associated with more trade and FDI. Third, we tend to be agnostic about the coefficient on the country's level of economic development, as reflected in its logged GDP per capita (*Gdppc*), in the regression with openness to trade, while FDI has repeatedly been shown to be concentrated in more advanced countries (e.g., Nunnenkamp 2004; Nunnenkamp and Thiele 2013). Fourth, in extended specifications, we account for average years of schooling at all levels (*Schooling*). Schooling is expected to be positively associated with FDI in particular, as foreign investors increasingly rely on sufficiently qualified labor. Finally, we use the indices of trade and investment freedom from the Heritage Foundation; higher values of *HR_trade* and *HR_investment* reflect more liberal attitudes to trade and FDI, respectively, which should obviously be associated with more trade and FDI.[27] All right-hand-side variables, including the indices of infrastructure are lagged by one year in order to mitigate endogeneity concerns.

In Table 8, we present our estimations with logged openness to trade as the dependent variable. As is common practice in the literature, we define openness to trade as the ratio of the sum of the country's exports plus imports over its GDP. The coefficients on all control variables are highly significant with the expected signs.[28] Specifically, country size enters negative while higher levels of GDP per capita and higher economic growth enter positive. Not surprisingly, the coefficients on *Gdppc* are lower in the extended specification when additionally controlling for schooling.[29] Higher average years of schooling as well as greater freedom of trade, as given by the Heritage Foundation, are associated with higher exports and imports, relative to the country's GDP, at the one percent level of significance.

[26]For the sake of brevity we restrict ourselves to these two applications. In a companion paper, we use our index to estimate gaps in infrastructure in developing countries (relative to an expected 'normal' pattern) and then assess the effectiveness of foreign aid in closing these gaps.
[27]Note that the number of observations is reduced by about one third when extending the specification because data on *Schooling* and *HR_trade*/ *HR_investment* are frequently missing.
[28]From additional regressions using the between estimator (not shown here to avoid clutter) it appears that the statistical significance of the control variables mainly results from the variation across countries. The same applies to the subsequent results on the indices of infrastructure.
[29]Average years of schooling are typically correlated positively with the country's GDP per capita.

Turning to our indices of infrastructure, the overall index proves to be significantly positive at the one percent level in Table 8, independent of whether we estimate the baseline specification for the larger sample (column 1) or the extended specification for the reduced sample (column 2). This corroborates earlier studies such as Limão and Venables (2001) who regard poor infrastructure as an important determinant of Africa's relatively weak integration into world trade.[30] A one standard deviation increase in *Infrastruture* results in a 0.38 standard deviation increase in openness. This is a substantial effect, in particular for middle income countries. If, for example, a country like Cameroon, a lower-middle income country at the bottom of our infrastructure ranking, improved its overall infrastructure to the level of India, Cameroon's openness would increase by 37 percent to 83.6 percent of its GDP, just above the average openness level of middle income countries in 2010. The importance of infrastructure is stressed as well by the magnitude of the effect of a standard deviation change in infrastructure, which exceeds the effect of a one standard deviation change in the Heritage Foundation's index on freedom of trade or the country's endowment of human capital by more than threefold.

The results on the sub-indices of transport infrastructure in columns (3) and (4) and financial infrastructure in columns (9) and (10) closely resemble those for the overall index. The coefficients on these two sub-indices are statistically significant at the one percent level as well. At the same time, the quantitative impact is economically relevant. Improving the transport infrastructure by one standard deviation increases openness by more than 0.27 standard deviations. A country like Mexico, endowed with slightly below average financial infrastructure (-0.352 in 2010), could drastically increase its openness to trade by a small investment in financial infrastructure. A one unit improvement in financial infrastructure pays off with an increase in trading activities related to GDP by nearly 15 percent. As concerns the sub-index of ICT infrastructure in columns (5) and (6), the positive coefficients also prove to be statistically significant, at least at the five percent level, while the size of the coefficient varies considerably depending on whether we estimate the baseline specification for the larger sample or the extended specification for the reduced sample. The higher coefficient in column (6) suggests that the effects of ICT infrastructure are non-linear. Considering that mainly poor and small countries drop out of the sample in column (6) due to missing data on *Schooling* and *HR_trade*, it specifically appears that ICT infrastructure is positively related with

[30] In unreported additional estimations, we find interesting non-linearities in the effect of infrastructure on openness to trade, however. Specifically, it seems that the effect is positive mainly in middle income countries. When interacting *Infrastructure* with dummies for income groups, the pattern appears to be inversely U-shaped.

openness in relatively advanced countries.[31] The evidence is weakest for the sub-index of energy-related infrastructure. This sub-index loses its significance in the extended specification in column (8). This indicates that energy-related infrastructure plays at best a minor role for the world-market integration of countries, even though local production and consumption of energy may critically depend on reliable infrastructure.

Table 9 presents the results on infrastructure as a determinant of the countries' attractiveness to FDI. The dependent FDI variable is measured as FDI inflows, relative to the host country's GDP. The signs and significance of the control variables are very similar to previous findings with regard to openness to trade in Table 8.[32]

The index of overall infrastructure enters positive and highly significant in columns (1) and (2) of Table 9. This underscores Asiedu's (2002) reasoning that good infrastructure helps attract more FDI.[33]Good infrastructure seems to be at least twice as important as the country's endowment of human capital or the Heritage Foundation's index of freedom of investment when comparing standardized coefficients. A one unit increase in infrastructure increases the FDI-to-GDP ratio by more than 1.1 points. This has huge implications in particular for countries at the bottom of our ranking. If, for example, Bolivia, a lower-middle income country ranking second last in our ranking of 2010, managed to move up by only 15 positions to the level of its neighboring country Peru (rang: 124, level of infrastructure: -1,0087), Bolivia's FDI inflows relative to its GDP would increase by 11.4 percent to a ratio of 3.65. If Bolivia managed to improve its infrastructure to the mean level of developing countries in 2010 (-0.515),its FDI inflows relative to its GDP would even increase by 31.8 percent to a level close to the mean of the FDI-to-GDP ratio of middle income countries.

Similar to the results on openness to trade, the sub-index of transport infrastructure closely resembles the findings with regard to overall infrastructure. Compared to Table 8, however, ICT infrastructure appears to be as important for a country's attractiveness to FDI. In contrast, the coefficient on financial infrastructure is smaller than the coefficient on overall infrastructure. This is plausible as foreign investors may largely rely on financial markets in their home country. Most strikingly perhaps, the coefficient on energy-related infrastructure

[31] Indeed, additional estimations that include interactions with dummies for income groups (not shown) indicate that better ICT infrastructure is associated with higher openness mainly in upper-middle income countries.

[32]The most notable exceptions are that *Gdppc* loses its significance in column (2) of Table 9, while *Schooling* is no longer significant in column (4). It should be recalled that these two variables tend to be correlated with each other.

[33] Similar to openness to trade, we find evidence on non-linearities in unreported additional estimations with FDI as the dependent variable. Again, the positive effects of infrastructure appear to be concentrated in middle income countries. This could explain Asiedu's (2002) weaker findings for sub-Sahara Africa.

proves to be significantly negative in columns (7) and (8) of Table 9. This result is counterintuitive, even when taking into account that energy-related infrastructure matters mainly for local production and consumption. However, the coefficient on energy-related infrastructure becomes significantly positive once the dependent FDI variable is related to the host country's population (instead of its GDP).[34]

VI. Summary

It is widely believed that a country's endowment with infrastructure represents a critical factor to sustain economic growth, attract foreign direct investment (FDI) and promote trade. As argued by Straub (2008), however, better datasets are required to address the links between infrastructure and economic development systematically. There was no comprehensive and comparable measure available so far which encompasses all relevant components of economic infrastructure and covers, at the same time, a large number of developing and developed countries over a sufficiently long period of time.

We overcome several data limitations by constructing a new global index of infrastructure. The index is based on a broad annual dataset of 30 indicators of the quantity and quality of infrastructure for up to 193 countries over the period 1990-2010. In addition to the overall index, we build sub-indices for specific components: transport, ICT, energy, and finance. To combine data from different sources into aggregate infrastructure indices we use an unobserved components model, where observed data in each area of infrastructure are a linear function of unobserved infrastructure and an error term. With this approach we are able to provide a consistent picture of the quantity and quality of infrastructure in a large panel dataset of developing and developed countries.

We map major findings for our indices of infrastructure and provide country rankings, which we also compare with subjective assessments of infrastructure in the World Economic Forum's Global Competitiveness Report. Not surprisingly, most top performers with regard to overall infrastructure are located in the North and belong to the high income group of countries. Low income and lower-middle income countries dominate the bottom third of the ranking. However, rankings for the sub-indices reveal that few countries receive essentially the same scores for all four categories of infrastructure. Assessing changes over time, we observe that most top 10 performers in 2010 belonged to this group in 2000 and 1990 already. More pronounced changes occurred at the bottom of the ranking. Yet, the overall ranking with

[34]This modification hardly affects the results in columns (1)-(6) of Table 9, while the results weaken for financial infrastructure (full results are available on request).

respect to our global index of infrastructure appears to be fairly persistent throughout the period of observation.

Finally, we offer two simple applications of our new indices of infrastructure by assessing their role as determinants of the countries' openness to trade and their attractiveness for FDI inflows. Including a standard set of control variables, our regressions suggest that the indices are statistically highly significant and quantitatively relevant in both applications. The magnitude of the effect of a standard deviation change in overall infrastructure on openness to trade, for example, considerably exceeds the effect of a one standard deviation change in the Heritage Foundation's index of freedom of trade or the countries' human capital endowment in terms of overall schooling. Similarly, a one unit increase in infrastructure is associated with an increase in the FDI-to-GDP ratio by more than 1.1 points, which is a quite substantial effect in particular for countries at the bottom of our ranking. In future research, the index may be used to estimate gaps in infrastructure in developing countries (relative to an expected 'normal' pattern) and then assess the effectiveness of foreign aid in closing these gaps. Other issues include deficient infrastructure as a possible bottleneck of the productivity of firms and economic growth. In summary, by overcoming previous data limitations, our new global index can help assess various links between infrastructure and economic development more systematically.

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Table 1 — Variables and data sources

Component of infrastructure	Indicator	Definition	Source
Transport			
Air	Air transport, registered carrier departures	Registered carrier departures worldwide are domestic takeoffs and takeoffs abroad of air carriers registered in the country, relative to population.	World Bank
	Air transport, freight	Air freight is the volume of freight, express, and diplomatic bags carried on each flight stage (operation of an aircraft from takeoff to its next landing), measured in metric tons times kilometers traveled and relative to geographic area.	World Bank
Land	Roads, paved	Paved roads are those surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones, as a percentage of all the country's roads, measured in length.	International Road Federation / World Bank
	Roads, total network	Total road network includes motorways, highways, and main or national roads, secondary or regional roads, and all other roads in a country, measured in kilometers and normalized by population density (population size divided by geographic area).	International Road Federation / World Bank
	Motorways	Kilometer length of roads, specifically designed and built for motor traffic, which does not serve properties bordering on it, and which: (a) is provided, except at special points or temporarily, with separate carriageways for the two directions of traffic, separated from each other, either by a dividing strip not intended for traffic, or exceptionally by other means; (b) does not cross at level with any road, railway or tramway track, or footpath; (c) is especially sign-posted as a motorway and is reserved for specific categories of road motor vehicles. Entry and exit lanes of motorways are included irrespectively of the location of the signposts. Urban motorways are also included. The variable is measured as percentage of the total road network.	International Road Federation
	Registered passenger cars	Passenger cars refer to the number of road motor vehicles, other than two-wheelers, intended for the carriage of passengers and designed to seat no more than nine people (including the driver). The variable is measured relative to population.	German Association of the Automotive Industry
	Commercial vehicles	Number of motor vehicles, intended for the carriage of passenger and goods and the haulage of trailers. Passenger cars and motorcycles are excluded. The variable is measured relative to population.	German Association of the Automotive Industry
	Railways, goods transported	Goods transported by railway are the volume of goods transported by railway, measured in metric tons times kilometers traveled and relative to geographic area.	World Bank
	Rail lines	Rail lines are the length of railway route available for train service, irrespective of the number of parallel tracks. The variable is measured in total route kilometers and normalized by population density (population size divided by geographic area).	World Bank
	Railways, passengers carried	Passengers carried by railway are the number of passengers transported by rail times kilometers traveled relative to population.	World Bank

Table 1 continued

Component of infrastructure	Indicator	Definition	Source
Sea	Total ship carrying capacity	DWT (deadweight ton) is weight measure of a vessel's carrying capacity. It includes cargo, fuel and stores. The variable is measured in thousands and relative to geographic area.	United Nations Conference on Trade and Development
	Total ship carrying capacity (as % of total world)	Percentages refer to the base data in DWT of total world carrying capacity.	United Nations Conference on Trade and Development
ICT			
Telephone	Fixed telephone lines	A fixed telephone line (previously called main telephone line in operation) is an active line connecting the subscriber's terminal equipment to the public switched telephone network (PSTN) and which has a dedicated port in the telephone exchange equipment. The number of fixed telephone lines is measured relative to population.	International Telecommunication Union
	Fixed telephone lines (faults)	The total number of reported faults to fixed telephone lines for the year. Faults, which are not the direct responsibility of the public telecommunications operator, should be excluded. The number of faults per 100 fixed lines per year should reflect the total reported by all PSTN service providers in the country. The variable is multiplied by (-1).	International Telecommunication Union
	ISDN subscriptions	The number of subscriptions to the Integrated Services Digital Network (ISDN), relative to population.	International Telecommunication Union
	Mobile cellular telephone subscriptions	Refers to the subscriptions to a public mobile telephone service and provides access to public switched telephone Network (PSTN) using cellular technology, including number of pre-paid SIM cards active during the past three months. This includes both analogue and digital cellular systems (IMT-2000 (Third Generation, 3G)) and 4G subscriptions, but excludes mobile broadband subscriptions via data cards or USB modems. The variable is measured relative to population.	International Telecommunication Union
Computer and Internet	Internet users	Internet users are people with access to the worldwide network. The variable is measured relative to population.	World Bank
	Personal computers	Computers measures the number of computers installed in a country. The statistic includes PCs, laptops, notebooks etc., but excludes terminals connected to mainframe and mini-computers that are primarily intended for shared use, and devices such as smart-phones and personal digital assistants (PDAs) that have only some, but not all, of the components of a PC (e.g. they may lack a full-sized keyboard, a large screen, an Internet connection, drives etc.). The variable is measured relative to population.	International Telecommunication Union

Table 1 continued

Component of infrastructure	Indicator	Definition	Source
Energy			
Production and Consumption	Electric power consumption	Electric power consumption (in kWh) measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. The variable is measured relative to population.	World Bank
	Electricity production	Electricity production (in kWh) is measured at the terminals of all alternator sets in a station. In addition to hydropower, coal, oil, gas, and nuclear power generation, it covers generation by geothermal, solar, wind, and tide and wave energy, as well as that from combustible renewables and waste. The variable is measured relative to population.	World Bank
Quality/Availability	Electric power transmission and distribution losses	Electric power transmission and distribution losses include losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage. The variable is measured in % of output and multiplied by (-1).	World Bank
Finance			
Access	Publicly listed companies	Number of publicly listed companies, relative to population.	Beck and Demirgüç-Kunt (2009)
	Bank accounts	Number of bank accounts, relative to population.	World Bank (Global Financial Development Database)
	Value traded	Value of all traded shares outside of the largest ten traded companies, as a share of total value of all traded shares in a stock market exchange (logged).	World Bank (Global Financial Development Database)
Depth	Stock market total value traded	Total shares traded on the stock market exchange, relative to GDP (logged).	Beck and Demirgüç-Kunt (2009)
	Money and quasi money (M2)	Money and quasi money comprise the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government. The variable is measured as % of GDP (logged).	World Bank
	Private credit by deposit money banks	The financial resources provided to the private sector by domestic money banks as a share of GDP (logged). Domestic money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits.	World Bank (Global Financial Development Database)
Efficiency	Stock market turnover	Total value of shares traded during the period divided by the average market capitalization for the period (logged).	World Bank (Global Financial Development Database)
Stability	Bank Z-score	It captures the probability of default of a country's commercial banking system. Z-score compares the buffer of a country's commercial banking system (capitalization and returns) with the volatility of those returns (logged).	World Bank (Global Financial Development Database)
	Stock price volatility	Stock price volatility is the average of the 360-day volatility of the national stock market index (logged).The variable is multiplied by (-1).	World Bank (Global Financial Development Database)

Table 2 — Summary statistics for indicators of infrastructure

	Total sample					Developing countries only				
Indicator	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Transport										
Air transport, registered carrier departures	3187	0.0157	0.0700	0.0000	1.1320	2239	0.0066	0.0235	0.0000	0.2682
Air transport, freight	3034	0.0956	0.8173	0.0000	12.1732	2121	0.0017	0.0092	0.0000	0.1077
Roads, paved	3074	51.0512	32.9995	0.0400	100.0000	2231	41.0785	30.3102	0.0400	100.0000
Roads, total network	3242	20200000.0000	98000000.0000	2414.9330	1710000000.0000	2341	17400000.0000	109000000.0000	2414.9330	1710000000.0000
Motorways	1314	2.1638	8.9111	0.0000	100.0000	660	1.9197	8.8932	0.0000	91.1948
Registered passenger cars	3184	0.1363	0.1697	0.0001	0.6759	2256	0.0491	0.0706	0.0001	0.4976
Commercial vehicles	3173	0.0340	0.0406	0.0000	0.3907	2245	0.0176	0.0185	0.0000	0.2293
Railways, goods transported	1891	0.0542	0.0823	0.0000	0.7853	1321	0.0378	0.0754	0.0000	0.7853
Rail lines	1883	981928.7000	2572923.0000	2119.8000	23800000.0000	1293	788969.1000	2730336.0000	2119.8000	23800000.0000
Railways, passengers carried	1771	0.0004	0.0004	0.0000	0.0024	1211	0.0002	0.0003	0.0000	0.0020
Total ship carrying capacity	3182	3.3472	22.2846	0.0000	432.3746	2228	1.4434	18.2684	0.0000	432.3746
Total ship carrying capacity (as % of total world)	3206	0.6397	1.9884	0.0000	20.2758	2232	0.4574	2.0920	0.0000	20.2758
ICT										
Fixed telephone lines	3992	0.1753	0.1911	0.0001	0.9037	2921	0.0844	0.0939	0.0001	0.5031
Fixed telephone lines (faults)	2365	-50.3945	75.9273	-1500.0000	-0.0400	1762	-61.7390	84.5308	-1500.0000	-0.0400
ISDN subscriptions	2122	0.0088	0.0275	0.0000	0.2920	1270	0.0007	0.0030	0.0000	0.0509
Mobile cellular telephone subscriptions	4033	0.2682	0.4060	0.0000	7.0829	2962	0.1830	0.3419	0.0000	7.0829
Internet users	3199	0.1399	0.2172	0.0000	2.9872	2245	0.0689	0.1267	0.0000	2.9872
Personal computers	2267	0.1038	0.1624	0.0000	0.9624	1522	0.0340	0.0475	0.0000	0.3661
Energy										
Electric power consumption	2805	3597.8710	4728.5260	10.6543	51439.9100	1902	1313.4400	1252.3250	10.6543	6673.1790
Electricity production	2812	3877.6350	4958.8340	4.3996	53637.7400	1909	1600.5310	1632.4760	4.3996	10143.0800
Electric power transmission and distribution losses	2775	-14.1936	10.4446	-108.5642	-0.0375	1872	-17.4300	11.0644	-108.5642	-0.0375
Finance										
Publicly listed companies	2077	0.0000	0.0000	0.0000	0.0005	1221	0.0000	0.0000	0.0000	0.0003
Bank accounts	446	0.5392	0.5584	0.0000	3.2410	392	0.4623	0.5132	0.0000	3.2410
Value traded	516	3.6177	0.7712	0.2904	4.5916	232	3.7749	0.5341	1.3798	4.5564
Stock market total value traded	1851	2.0847	1.5975	0.0001	6.6268	1073	1.3620	1.2703	0.0001	6.6268
Money and quasi money (M2)	3504	3.7939	0.9219	0.6047	36.1189	2615	3.6055	0.9250	0.6047	36.1189
Private credit by deposit money banks	3171	3.2815	0.9991	0.1090	5.6124	2280	2.9220	0.8641	0.1090	5.1168
Stock market turnover	1787	3.0828	1.3909	0.0134	6.2901	1000	2.5988	1.3562	0.0134	6.2901
Bank Z-score	2017	36.0993	9.8647	0.0000	86.5085	1421	35.7375	10.3254	0.0000	86.5085
Stock price volatility	1175	3.0996	0.4730	1.2219	4.9599	569	3.2079	0.5302	1.2219	4.9599

The shown values are rescaled but not normalized.

Source: Authors' calculations

Table 3 — Correlation matrix

Transport	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**
T1: Air transport, registered carrier departures	1											
T2: Air transport, freight	0.6188	1										
T3: Roads, paved	0.3206	0.1211	1									
T4: Roads, total network	-0.0686	-0.0270	0.0312	1								
T5: Motorways	0.0010	0.0554	0.0880	-0.0303	1							
T6: Registered passenger cars	0.5526	0.1826	0.5780	0.0138	-0.0182	1						
T7: Commercial vehicles	0.4434	0.1840	0.3034	0.2025	-0.0235	0.5373	1					
T8: Railways, goods transported	0.0484	0.0502	0.3482	0.1821	0.0155	0.3809	0.1830	1				
T9: Rail lines	-0.0629	-0.0357	0.1659	0.8744	-0.0067	0.1414	0.2294	0.3418	1			
T10: Railways, passengers carried	0.1794	0.0614	0.4753	0.2865	-0.0315	0.5676	0.3244	0.4848	0.3597	1		
T11: Total ship carrying capacity	0.3365	0.4111	0.2304	0.0019	0.0138	0.2470	0.3095	-0.0297	-0.0260	0.1405	1	
T12: Total ship carrying capacity (as % of total world)	-0.0181	-0.0307	0.1673	0.3834	-0.0336	0.0875	0.3119	-0.0162	0.3797	0.2047	0.6655	1
ICT	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**						
I1: Fixed telephone lines	1											
I2: Fixed telephone lines (faults)	0.4721	1										
I3: ISDN subscriptions	0.4341	0.2084	1									
I4: Mobile cellular telephone subscriptions	0.4005	0.3696	0.5037	1								
I5: Internet users	0.5006	0.3403	0.5395	0.8687	1							
I6: Personal computers	0.7075	0.3803	0.5014	0.6625	0.8264	1						
Energy	**E1**	**E2**	**E3**									
E1: Electric power consumption	1											
E2: Electricity production	0.9612	1										
E3: Electric power transmission and distribution losses	0.3887	0.4013	1									
Finance	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**			
F1: Publicly listed companies	1											
F2: Bank accounts	0.7352	1										
F3: Value traded	0.2013	0.1969	1									
F4: Stock market total value traded	0.4720	0.5979	0.5481	1								
F5: Money and quasi money (M2)	0.5364	0.5551	0.5068	0.8403	1							
F6: Private credit by deposit money banks	0.5511	0.5738	0.3964	0.8194	0.9251	1						
F7: Stock market turnover	0.1614	0.4061	0.4515	0.8899	0.6719	0.6461	1					
F8: Bank Z-score	0.4070	0.1205	0.5025	0.4615	0.4234	0.3357	0.3079	1				
F9: Stock price volatility	0.2938	0.2140	-0.0045	0.1563	0.2633	0.3370	0.0967	0.1700	1			

Source: Authors' calculations

Table 4 — Global trends in infrastructure 1990-2010

		Differences in means				p-values			
Indicator	Sample	1990-2010	1995-2010	2000-2010	2005-2010	1990-2010	1995-2010	2000-2010	2005-2010
Transport									
Air transport, registered carrier departures[1)]	124	0.00	0.00	0.00	0.00	0.08	0.11	0.61	0.63
Air transport, freight	140	-0.12	-0.10	-0.03	0.02	0.14	0.27	0.78	0.86
Roads ,paved[1)]	79	-19.83	-17.76	-16.07	-10.11	0.22	0.27	0.63	0.66
Roads, total network	162	-24400000.00	-23700000.00	-20100000.00	-11900000.00	0.22	0.23	0.32	0.59
Motorways	88	-3.39	-2.58	-2.56	-2.43	0.13	0.26	0.27	0.28
Registered passenger cars[1)]	58	-0.16	-0.15	-0.14	-0.12	0.02	0.05	0.17	0.43
Commercial vehicles[1)]	58	-0.03	-0.03	-0.03	-0.03	0.04	0.08	0.22	0.63
Railways, goods transported	94	0.00	-0.02	-0.01	-0.01	0.87	0.12	0.24	0.60
Rail lines	96	-367722.10	-253240.20	-228529.90	-216929.00	0.38	0.56	0.60	0.62
Railways, passengers carried	91	0.00	0.00	0.00	0.00	0.49	0.46	0.42	0.26
Total ship carrying capacity	132	-1.07	-1.00	-0.82	-0.52	0.25	0.29	0.41	0.62
Total ship carrying capacity (as % of total world)	132	0.20	0.12	0.08	0.07	0.45	0.64	0.75	0.80
ICT									
Fixed telephone lines	165	-0.03	-0.03	0.00	0.00	0.12	0.15	0.92	0.95
Fixed telephone lines (faults)[1)]	56	-56.60	-65.13	-34.56	-11.46	0.00	0.00	0.00	0.03
ISDN subscriptions	102	-0.03	-0.03	-0.02	-0.01	0.26	0.27	0.47	0.60
Mobile cellular telephone subscriptions[1)]	160	-0.93	-0.91	-0.77	-0.51	0.00	0.00	0.00	0.00
Internet users[1)]	160	-0.32	-0.32	-0.25	-0.14	0.00	0.00	0.00	0.00
Personal computers[2)]	151	-0.08	-0.05	-0.01	0.04	0.17	0.31	0.81	0.45
Energy									
Electric power consumption	131	-831.74	-825.38	-508.64	-179.29	0.10	0.11	0.34	0.74
Electricity production	131	-892.71	-887.81	-529.76	-201.24	0.10	0.10	0.35	0.73
Electric power transmission and distribution losses	130	1.18	-1.49	-1.76	-1.05	0.28	0.22	0.17	0.42
Finance									
Publicly listed companies	107	0.00	0.00	0.00	0.00	0.31	0.64	0.76	0.68
Bank accounts	60	-	-	-	-0.18	-	-	-	0.11
Value traded[1)]	39	-	-	0.30	0.21	-	-	0.13	0.29
Stock market total value traded	103	-0.51	-0.26	-0.08	-0.07	0.04	0.28	0.76	0.78
Money and quasi money (M2)	150	-0.20	-0.29	-0.34	-0.24	0.04	0.00	0.00	0.00
Private credit by deposit money banks	144	0.10	-0.06	-0.39	-0.33	0.45	0.63	0.00	0.00
Stock market turnover	101	0.14	0.19	0.44	0.17	0.53	0.37	0.04	0.42
Bank Z-score	147	-	-	-0.77	-0.63	-	-	0.53	0.60
Stock price volatility	83	-0.02	-0.15	0.06	-0.32	0.90	0.12	0.42	0.00

1) Due to a drastically changing number of countries we equalized the number of countries for the compared series.
2) Due to a lack of data for the year 2010 the comparison is made with 2009 data, respectively.

Source: Authors' calculations

Table 5 — Summary statistics: Sub-indices and overall index

	Obs	Mean	Std. dev.	Min	Max
		Total sample			
Transport	3336	-0.0010	0.9970	-1.6830	4.1267
ICT	3269	0.0021	0.9971	-2.4586	3.9784
Finance	2456	-0.0150	0.9965	-2.4840	3.5513
Energy	2719	-0.0018	0.9963	-3.4696	4.7203
Total	2923	-0.0024	0.9967	-2.2698	3.1748
		Developing countries only			
Transport	2479	-0.4142	0.6101	-1.6830	2.3003
ICT	2410	-0.4638	0.4125	-2.4586	1.1089
Finance	1674	-0.4059	0.7921	-2.4840	2.4331
Energy	1879	-0.4844	0.5831	-3.4696	1.1598
Total	2080	-0.5119	0.4672	-2.2698	1.0933

Source: Authors' calculations

Table 6 — Country rankings: Overall infrastructure and sub-categories

		Rank 2010						Rank (Overall Index)		
		Rank	(Index value)	Transport	ICT	Energy	Finance	2010	2000	1990
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Hong Kong	High	1	(3.216)	1	2	42	1	1	11	18
Singapore	High	2	(2.673)	2	9	16	2	2	3	4
Germany	High	3	(2.519)	4	1	21	18	3	6	14
United States	High	4	(2.399)	3	19	7	10	4	2	1
Switzerland	High	5	(2.015)	8	4	18	13	5	4	7
Canada	High	6	(2.012)	18	14	3	15	6	12	6
Norway	High	7	(1.924)	23	18	1	36	7	1	2
Luxembourg	High	8	(1.872)	5	3	8	55	8	7	17
Japan	High	9	(1.861)	10	15	14	11	9	5	3
United Kingdom	High	10	(1.850)	9	8	32	8	10	10	8
Austria	High	11	(1.715)	7	11	17	31	11	14	16
France	High	12	(1.695)	12	6	19	22	12	15	12
Korea, Rep.	High	13	(1.685)	25	5	11	12	13	18	21
Sweden	High	14	(1.573)	31	10	6	27	14	8	5
Finland	High	15	(1.461)	32	26	4	28	15	16	10
Australia	High	16	(1.457)	44	17	10	9	16	21	9
Belgium	High	17	(1.441)	15	12	15	35	17	17	27
Netherlands	High	18	(1.390)	24	13	23	17	18	9	11
Israel	High	19	(1.302)	40	22	20	6	19	24	19
Spain	High	20	(1.271)	30	25	33	4	20	22	25
New Zealand	High	21	(1.249)	41	16	13	19	21	20	15
Kuwait	High	22	(1.248)	50	42	2	20	22	28	29
Denmark	High	23	(1.187)	22	7	27	38	23	13	13
Italy	High	24	(1.168)	14	31	36	24	24	19	23
Ireland	High	25	(1.102)	13	23	30	51	25	26	26
Qatar	High	26	(1.094)	37	24	5	56	26	27	24
United Arab Emirates	High	27	(1.060)	28	29	9	44	27	31	20
China	Upper	28	(0.943)	17	71	47	5	28	35	58
Czech Rep.	High	29	(0.852)	16	30	25	68			
Slovenia	High	30	(0.794)	19	20	26	88	29	30	33
Portugal	High	31	(0.767)	36	37	38	23	30	25	48
Cyprus	High	32	(0.707)	35	35	34	37	31	23	28
Bahrain	High	33	(0.686)	27	50	12	54	32	34	31
Croatia	High	34	(0.652)	42	28	58	25	33	41	44
India	Lower	35	(0.579)	6	117	109	16	34	37	52
Greece	High	36	(0.547)	43	21	35	58	35	29	37
Ukraine	Lower	37	(0.485)	11	65	51	64	36	53	22
Malaysia	Upper	38	(0.485)	72	76	41	7	37	33	42
Belarus	Upper	39	(0.467)	21	34	52	71	38	40	30
Saudi Arabia	High	40	(0.447)	102	41	22	34	39	51	47
Lebanon	Upper	41	(0.447)	54	63	55	14			
Estonia	High	42	(0.443)	104	27	24	53	40	36	34
Jordan	Upper	43	(0.415)	45	83	71	3	41	48	39
Poland	High	44	(0.351)	29	43	45	66	42	38	41
Russian Federation	High	45	(0.325)	38	32	29	96	43	55	32
Panama	Upper	46	(0.321)	26	55	79	42	44	42	56
Slovak Rep.	High	47	(0.244)	34	39	31	102	45	32	38
Bulgaria	Upper	48	(0.223)	46	33	40	82	46	45	36
Oman	High	49	(0.108)	71	44	44	60	47	57	61
Latvia	High	50	(0.078)	20	38	57	120	48	47	40
Trinidad and Tobago	High	51	(0.071)	47	49	28	95	49	54	53
Bosnia and Herzegovina	Upper	52	(0.029)	92	54	48	46			

Table 6 continued

		Rank 2010						Rank		
		Total	(Index value)	Transport	ICT	Energy	Finance	2010	2000	1990
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
South Africa	Upper	53	(0.029)	76	89	43	30	50	43	55
Serbia	Upper	54	(0.023)	86	51	53	49			
Egypt, Arab Rep.	Lower	55	(0.020)	48	78	68	33	51	50	73
Chile	High	56	(-0.002)	126	56	49	29	52	58	76
Mauritius	Upper	57	(-0.015)	87	60		45	53	39	46
Thailand	Upper	58	(-0.033)	112	86	54	21	54	44	51
Guyana	Lower	59	(-0.056)	89	46		62			
Vietnam	Lower	60	(-0.062)	94	72	77	32			
Libya	Upper	61	(-0.065)	53	74	46				
Turkey	Upper	62	(-0.068)	90	68	69	39	55	62	90
Morocco	Lower	63	(-0.152)	121	67	88	26	56	56	93
Suriname	Upper	64	(-0.161)	66	66		72			
Brazil	Upper	65	(-0.203)	128	48	78	41	57	63	91
Iran, Islamic Rep.	Upper	66	(-0.243)	73	69	65	63	58	78	64
Hungary	Upper	67	(-0.254)	93	40	50	110	59	46	49
Tunisia	Upper	68	(-0.278)	85	87	76	40	60	60	89
Moldova	Lower	69	(-0.281)	70	57	107	59			
Bhutan	Lower	70	(-0.317)	88	96		47			
Uruguay	High	71	(-0.366)	78	45	56	116	61	68	62
Lithuania	High	72	(-0.375)	84	36	91	113	62	52	35
Fiji	Upper	73	(-0.385)	39	85		107			
Mongolia	Lower	74	(-0.414)	80	112	74	43	63	83	57
Honduras	Lower	75	(-0.417)		91	116	48	64	65	63
Uzbekistan	Lower	76	(-0.419)	79	95	63				
Kazakhstan	Upper	77	(-0.440)	33	93	39	124			
Armenia	Lower	78	(-0.449)	96		70	89	65	71	45
Cuba	Upper	79	(-0.454)	58	98	93		66	72	59
Guatemala	Lower	80	(-0.466)	63	90	83	69	67	74	66
Venezuela, RB	Upper	81	(-0.470)	52	47	72	127	68	76	74
Albania	Upper	82	(-0.470)	122	58	73	70	69	91	88
Turkmenistan	Upper	83	(-0.490)	81	108	61				
Costa Rica	Upper	84	(-0.505)	119	62	64	87	70	59	60
Mexico	Upper	85	(-0.515)	116	61	82	81	71	70	75
Romania	Upper	86	(-0.518)	108	59	59	106	72	49	54
Swaziland	Lower	87	(-0.521)	75	88		94	73	95	81
Macedonia, FYR	Upper	88	(-0.555)	120	52	67	103	74	61	50
Syrian Arab Rep.	Lower	89	(-0.559)	111	70	81	85	75	82	70
Philippines	Lower	90	(-0.567)	105	92	86	57	76	64	94
Tajikistan	Low	91	(-0.606)	99	105	84				
Ethiopia	Low	92	(-0.617)	61	130	92		77	85	79
Sri Lanka	Lower	93	(-0.622)	113	82	97	67	78	86	97
Dominican Rep.	Upper	94	(-0.626)		80	122	78	79	66	68
Ecuador	Upper	95	(-0.637)	55	64	98	123	80	98	77
Colombia	Upper	96	(-0.681)	107	73	96	101	81	89	95
Jamaica	Upper	97	(-0.693)	69	79	105	108	82	67	72
Lao PDR	Lower	98	(-0.709)	65	120		109			
Tanzania	Low	99	(-0.721)	67	124	112	61	83	101	83
Burkina Faso	Low	100	(-0.723)	68	132		100			
Paraguay	Lower	101	(-0.731)	131	94	37	90			
Indonesia	Lower	102	(-0.738)	106	106	80	74	84	77	85
Algeria	Upper	103	(-0.741)	91	97	104	75	85	75	67

Table 6 continued

		Rank 2010						Rank		
		Total	(Index value)	Transport	ICT	Energy	Finance	2010	2000	1990
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Angola	Upper	104	(-0.743)	59	121	95	86			
Argentina	Upper	105	(-0.765)	100	53	60	132	86	80	100
Gambia, The	Low	106	(-0.768)	109	111		99			
Mauritania	Lower	107	(-0.772)	125	119		65			
Congo, Dem. Rep.	Low	108	(-0.798)	95	136	94				
Guinea	Low	109	(-0.811)	49	134		112			
Zimbabwe	Low	110	(-0.816)		138	62	97	87	93	102
Bangladesh	Low	111	(-0.823)	127	113	90	52			
Georgia	Lower	112	(-0.839)	74	84	66	130	88	73	43
Azerbaijan	Upper	113	(-0.840)	118	77	100	105			
Senegal	Lower	114	(-0.847)	123	107	114	50	89	84	82
Kenya	Low	115	(-0.848)	117	100	103	73	90	103	99
Pakistan	Lower	116	(-0.851)	83	116	102	84	91	69	96
El Salvador	Lower	117	(-0.893)	82	81	89	128	92	90	71
Sudan	Lower	118	(-0.895)	64	123	117	93	93	92	80
Yemen, Rep.	Lower	119	(-0.940)	62	114	118	104	94	79	65
Cambodia	Low	120	(-0.941)	57	129	121	80			
Nigeria	Lower	121	(-0.955)	60	104	108	118	95	100	103
Nicaragua	Lower	122	(-0.976)	110	110	119	76			
Papua New Guinea	Lower	123	(-0.980)	56	133		129			
Peru	Upper	124	(-1.009)	129	75	75	122	96	81	98
Mozambique	Low	125	(-1.011)	103	131	99	92	97	88	78
Madagascar	Low	126	(-1.045)	115	135		111			
Myanmar	Low	127	(-1.049)	124	137	106		98	97	92
Zambia	Lower	128	(-1.051)		125	115	119	99	94	69
Cote d'Ivoire	Lower	129	(-1.068)	51	122	113	121	100	99	101
Ghana	Lower	130	(-1.069)		99	110	131	101	102	86
Cameroon	Lower	131	(-1.077)	130	128	87	77			
Gabon	Upper	132	(-1.078)	101	109	101	115			
Iraq	Upper	133	(-1.086)	97	115	123	79			
Nepal	Low	134	(-1.160)		126	124	114	102	87	84
Botswana	Upper	135	(-1.206)	77	101	125	91			
Haiti	Low	136	(-1.243)		127	126	83			
Kyrgyz Rep.	Low	137	(-1.265)	98	139	111	98			
Namibia	Upper	138	(-1.282)	114	102	120	125			
Bolivia	Lower	139	(-1.347)	132	103	85	126			
Congo, Rep.	Lower	140	(-1.435)		118	127	117	103	96	87

Notes: High = High income (OECD/non-OECD); Upper = Upper-middle income; Lower = Lower-middle income; Low = Low income.

Source: Authors' calculations

Table 7 — Rank correlations: Overall infrastructure and sub-categories (based on Table 6)

A. Overall infrastructure, ranks

	2010	2000	1990
2010	1	0.952*** (103)	0.889*** (103)
2000		1	0.901*** (103)
1990			1

Number of observations in parentheses; *** p<0.01, ** p<0.05, * p<0.1

B. Overall and sub-categories, ranks 2010

	Total	Transport	ICT	Energy	Finance
Total	1	0.739*** (132)	0.875*** (139)	0.878*** (127)	0.775*** (132)
Transport		1	0.583*** (131)	0.602*** (119)	0.418*** (124)
ICT			1	0.836*** (126)	0.540*** (131)
Energy				1	0.558*** (119)
Finance					1

Number of observations in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' calculations

Table 8 — Regression results: Infrastructure and openness to trade

	Total	Total	Transport	Transport	ICT	ICT	Energy	Energy	Finance	Finance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Infrastructure	0.160***	0.184***	0.110***	0.130***	0.0299**	0.0639***	0.0252**	0.0186	0.144***	0.150***
	(0.0180)	(0.0219)	(0.0144)	(0.0170)	(0.0150)	(0.0196)	(0.0125)	(0.0146)	(0.0151)	(0.0156)
Gdp	-0.199***	-0.198***	-0.174***	-0.190***	-0.172***	-0.182***	-0.201***	-0.184***	-0.206***	-0.208***
	(0.00593)	(0.00710)	(0.00567)	(0.00690)	(0.00557)	(0.00676)	(0.00599)	(0.00715)	(0.00650)	(0.00724)
Growth	0.00691***	0.00957***	0.00675***	0.00878***	0.00566***	0.00893***	0.00624***	0.0105***	0.0115***	0.0103***
	(0.00159)	(0.00252)	(0.00162)	(0.00247)	(0.00156)	(0.00258)	(0.00162)	(0.00279)	(0.00205)	(0.00257)
Gdppc	0.148***	0.0868***	0.186***	0.121***	0.216***	0.137***	0.208***	0.151***	0.177***	0.123***
	(0.0104)	(0.0121)	(0.00830)	(0.0100)	(0.00980)	(0.0125)	(0.0104)	(0.0135)	(0.00859)	(0.0118)
Schooling		0.0264***		0.0274***		0.0352***		0.0168***		0.0389***
		(0.00528)		(0.00534)		(0.00527)		(0.00574)		(0.00536)
HR_trade		0.00304***		0.00368***		0.00345***		0.00523***		0.00343***
		(0.000694)		(0.000699)		(0.000726)		(0.000787)		(0.000704)
Constant	7.919***	7.991***	6.985***	7.473***	6.713***	7.121***	7.528***	7.112***	7.870***	7.849***
	(0.146)	(0.188)	(0.118)	(0.152)	(0.125)	(0.164)	(0.127)	(0.158)	(0.150)	(0.162)
Observations	2,617	1,765	2,943	1,822	2,890	1,843	2,416	1,609	2,229	1,666
R-squared	0.352	0.396	0.317	0.388	0.298	0.362	0.332	0.359	0.383	0.423

Robust standard errors in parentheses;*** p<0.01, ** p<0.05, * p<0.1

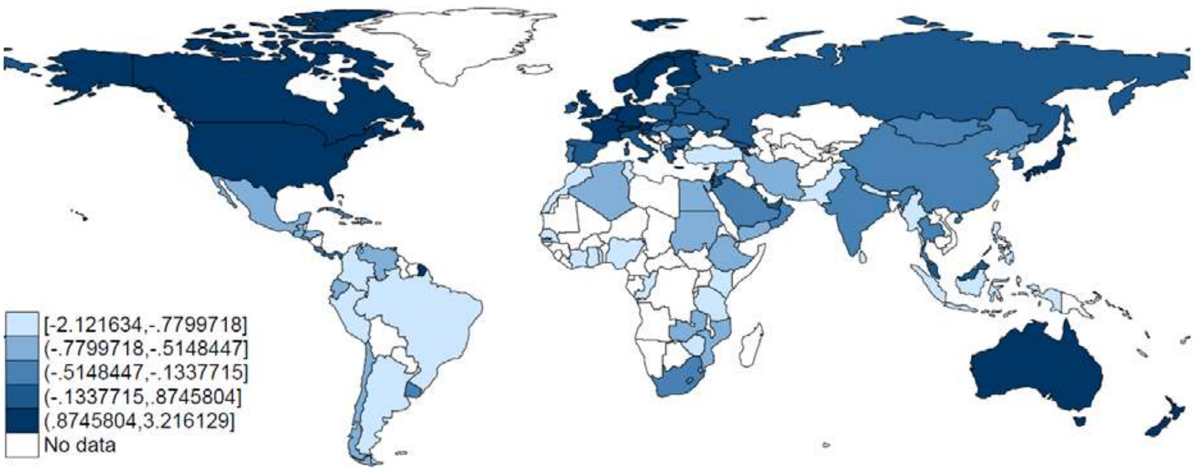
Table 9 — Regression results: Infrastructure and FDI inflows

	Total	Total	Transport	Transport	ICT	ICT	Energy	Energy	Finance	Finance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Infrastructure	1.004***	1.103***	1.051***	1.025***	1.006***	0.926***	-0.336**	-0.580**	0.629***	0.727***
	(0.206)	(0.269)	(0.231)	(0.254)	(0.262)	(0.296)	(0.165)	(0.236)	(0.167)	(0.192)
Gdp	-0.662***	-0.834***	-0.697***	-0.825***	-0.694***	-0.766***	-0.737***	-0.771***	-0.732***	-0.871***
	(0.0797)	(0.105)	(0.0944)	(0.106)	(0.0931)	(0.0976)	(0.0795)	(0.108)	(0.0792)	(0.0889)
Growth	0.123***	0.167***	0.227***	0.163***	0.241***	0.185***	0.119***	0.180***	0.125***	0.180***
	(0.0185)	(0.0248)	(0.0381)	(0.0241)	(0.0397)	(0.0291)	(0.0181)	(0.0266)	(0.0303)	(0.0265)
Gdppc	0.325***	0.226	0.464***	0.392***	0.391**	0.283*	1.063***	1.009***	0.684***	0.513**
	(0.119)	(0.174)	(0.130)	(0.148)	(0.153)	(0.153)	(0.149)	(0.225)	(0.153)	(0.220)
Schooling		0.112*		0.0854		0.126**		0.166***		0.178***
		(0.0588)		(0.0638)		(0.0594)		(0.0616)		(0.0608)
HR_investment		0.0400***		0.0403***		0.0383***		0.0421***		0.0461***
		(0.00713)		(0.00697)		(0.00691)		(0.00799)		(0.00779)
Constant	16.55***	18.62***	15.82***	17.22***	16.28***	16.33***	12.75***	10.44***	15.65***	16.42***
	(1.705)	(2.137)	(2.208)	(2.057)	(2.329)	(2.140)	(1.439)	(1.912)	(1.489)	(1.482)
Observations	2,655	1,767	2,993	1,823	2,943	1,844	2,418	1,609	2,260	1,663
R-squared	0.058	0.114	0.092	0.120	0.089	0.107	0.066	0.111	0.058	0.123

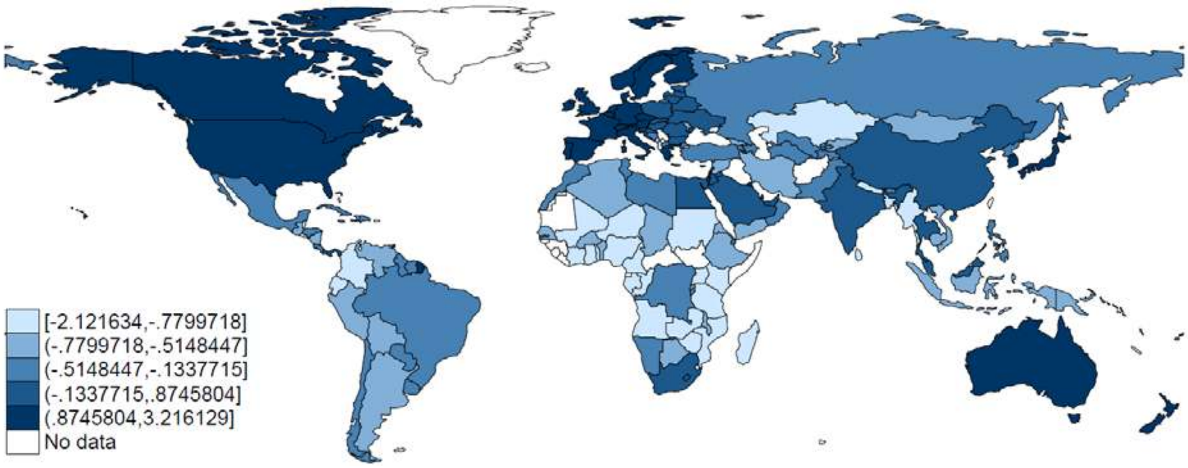
Robust standard errors in parentheses;*** p<0.01, ** p<0.05, * p<0.1

Figure 1 —Mapping results for overall index of infrastructure, 1990, 2000, and 2010

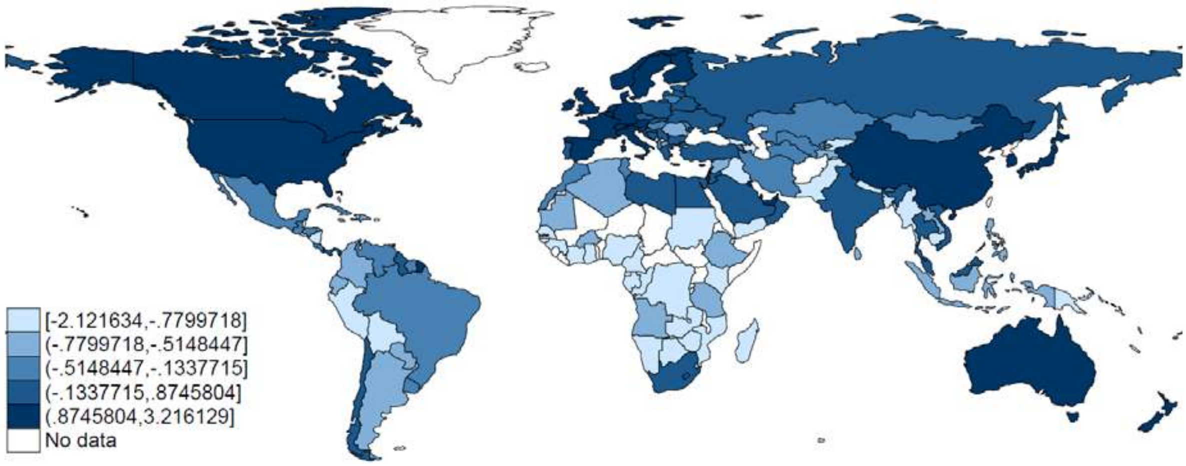
A. Total 1990



B. Total 2000



C. Total 2010

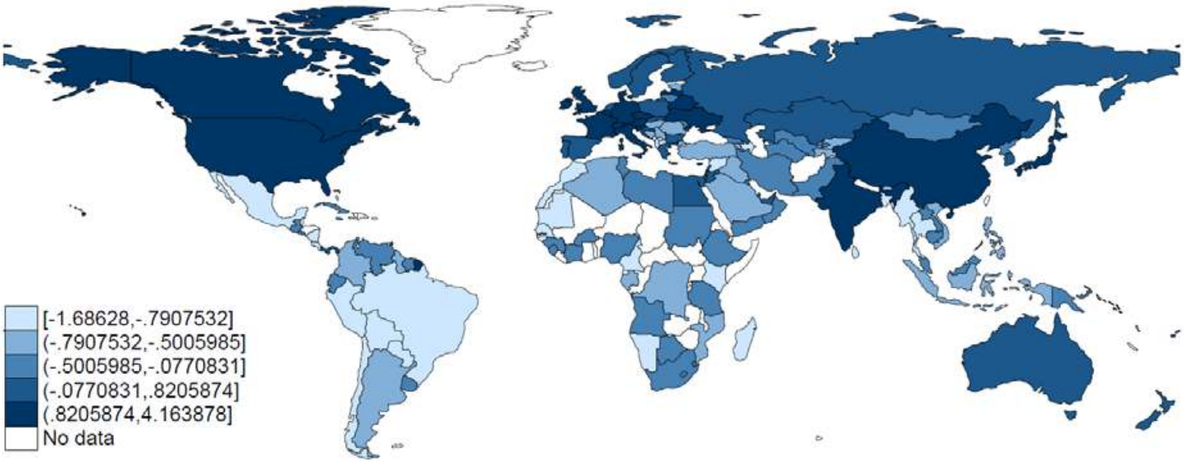


The maps are colored according to average quintiles over the1990-2010 period. The intervals on the left show the respective quintile ranges of the absolute index value.

Source: Authors' calculations

Figure 2 —Mapping results for sub-indices of infrastructure, 2010

A. Transport 2010



B. ICT 2010

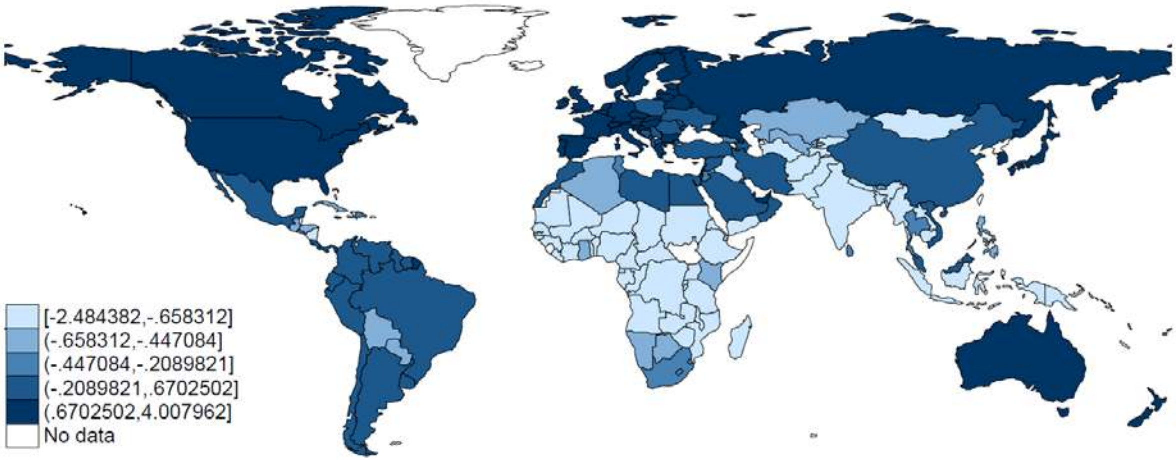
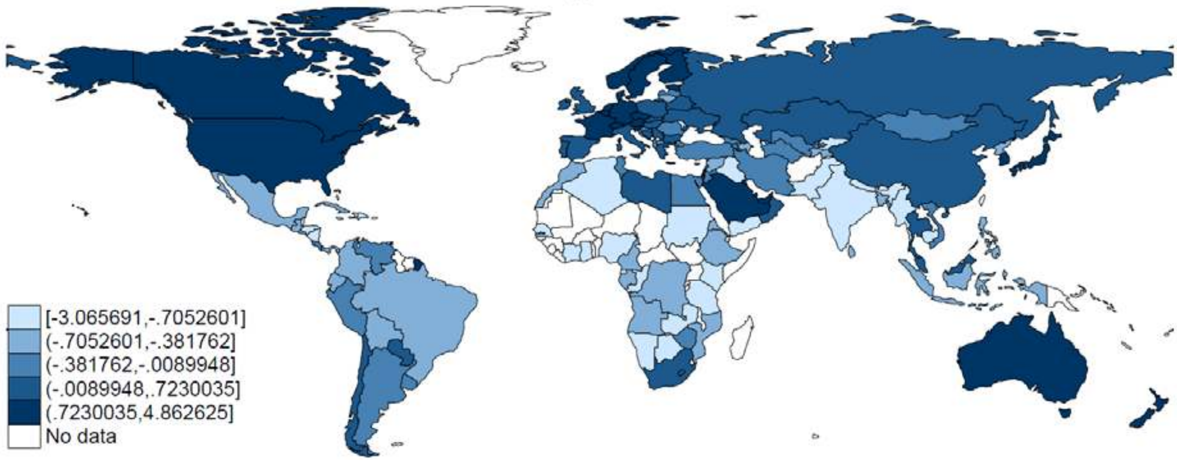
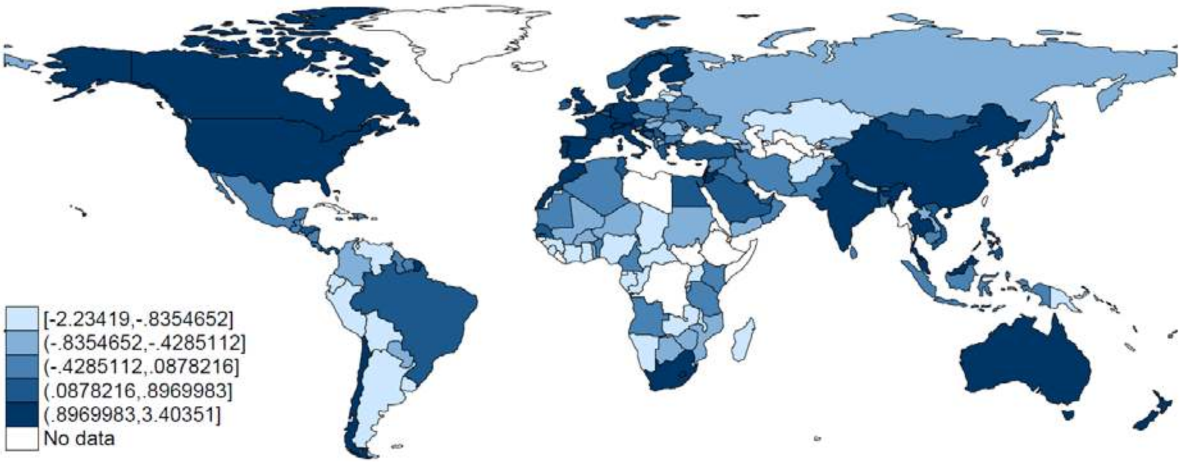


Figure 2 continued

C. Energy 2010



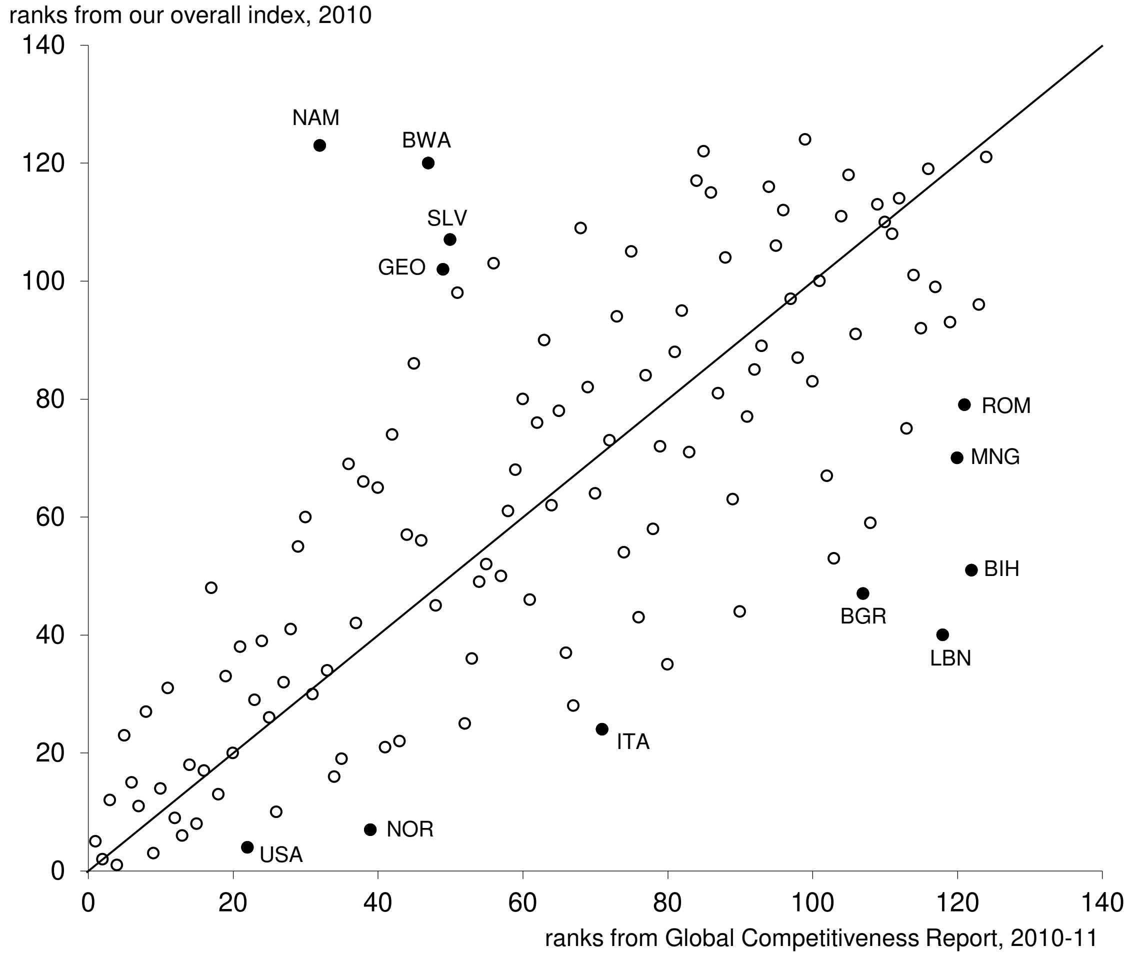
D. Finance 2010



The maps are colored according to average quintiles over the1990-2010 period. The intervals on the left show the respective quintile ranges of the absolute index value for each of our sub-indices.

Source: Authors' calculations

Figure 3 — Country rankings: Our overall index of infrastructure compared with the Global Competitiveness Report



Source: Authors' calculations