6. Article. Infrastructure Patterns in Emerging Markets: an empirical analysis with a focus on LatAm

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1. Introduction[1]

An adequate supply of infrastructure services is an essential ingredient for economic growth and to boost productivity. Furthermore, generalized access to infrastructure services plays a key role in reducing income inequality and fighting poverty.

In our Outlook of June 2009 we presented some preliminary results on infrastructure in emerging markets. In particular, we evaluated infrastructure stocks (telecommunication, energy and transport) across countries and regions by estimating "infrastructure patterns", using panel data techniques. These patterns correspond to the infrastructure stock a country would have according to their income level, demographic factors and geography if they had invested at the "global standard". Thus, we did not try to estimate infrastructure deficits, but rather presented an international comparison to have an idea of the relative positions. Regions far below their theoretical pattern are regions where infrastructure shortfalls are likely to be a major obstacle to growth and development. By contrast, regions with an infrastructure level close to or above its estimated pattern probably do not face such constraints.

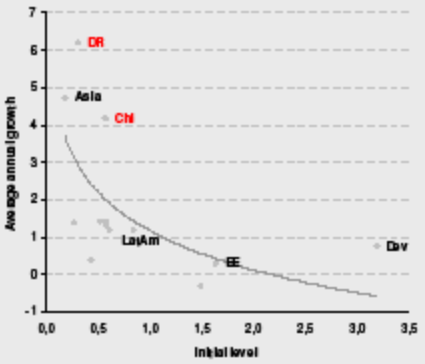
In the present report, we present additional results from this research. First, the sample has been enlarged both including more countries and years. Moreover, we have also increased the infrastructure coverage. We have added water and sanitation access (basic infrastructure) as well as number of personal computers (PCs) and internet access (telecommunications) to the already studied infrastructure types: telephone lines (fixed lines and mobiles), Electricity Capacity Generation (ECG), paved roads and rail lines (In the Annex Section A we describe the dataset in detail). Second, panel estimations have been improved by including variables related to the country's economic structure which is potentially as a key determinant of infrastructure investment. Finally, though it is still work in progress, we advance some explanatory factors of the ratio between the observed stock and the theoretical pattern (the degree of achievement, DoA) in terms of some variables amenable of policy action such as the fiscal conditions and the quality of institutions. It seems reasonable that countries more restrained in terms of fiscal conditions or with lower quality of institutions (in particular we study the quality of their bureaucracy) will exhibit lower ratios of observed infrastructures stock compared to their expected patterns.

Table 1. Average annual growth of infrastructure stocks (%)

	Basic		Energy	Transport		Telecos		
	Water	Sanitation	ECG	Paved roads	Rail lines	Teleph.lines	Number of PC	Internet users
	95-06	00-06	92-06	80-04	96-06	85-07	01-06	97-07
LatAm	0.4	0.8	2.8	2.0	0.7	70.1	28.4	434.5
Emerging Asia	1.5	1.8	11.0	10.5	0.6	543.4	43.1	1423.6
Eastern Europe	0.2	-0.3	0.7	6.0	-0.5	61.4	26.6	262.5
Developed	0.0	0.0	1.8	1.7	-0.3	12.8	10.5	46.3
World	0.9	0.9	2.3	3.3	-0.1	31.6	14.2	89.5

Transport infrastructure stocks are scaled relative to the land area of each country. The remaining indicators are in per capita terms.
Source: Own elaboration based on XXX.

Figure 1. Energy. Avg. annual growth of infrastructure stocks and initial level (80-06; world avg.: 1)



Source: Own elaboration.

[1] The present paper was presented in the Seminar "Financiando infraestructuras en América Latina" held in Bogota on May 13th and 14th, organized by CAF-IFC-OECD. Ximena Parra (CEMEX Economic Analysis), provided excellent research assistance. The views expressed here are those of the authors and should not be attributed to the OECD Development Centre and CEMEX.

2. Infrastructure Patterns: How good (or bad) is LatAm's position?

In general, infrastructure stocks have increased over the past decades. However, while there have been major improvements in telecommunications, transport, energy and basic infrastructure have not changed much. In particular, Latin America has lost ground relative to its main "competitors". Over the last years, growth rates have been relatively similar to those in Eastern Europe though far lower than in Emerging Asia (see Table 1). However, there is considerable heterogeneity within the region, partly explained by the different starting points (convergence). For instance, there are some Latin American countries which have exhibited "Asian growth rates": Chile or Dominican Republic in energy infrastructure, Peru in sanitation or Brazil in PCs (see Figures 1, 2 and 3). Notwithstanding, these simple historical comparisons do not take into account important differences in fundamentals.

The evaluation of infrastructure stocks needs to consider not only the degree of development but also other demographic variables such as the population density (ratio population/land area) or social variables such as the urbanization ratio (% of population living in urban areas). Moreover, as aforementioned, the economic structure might also be relevant. Thus, the share of industry and services on the total value added are new variables included in our analysis (see Figure 4). In principle, countries with higher population density, higher degree of urbanization and relaying more on the services and industry sectors (in contrast to agriculture) would tend to accumulate infrastructure faster. In addition, infrastructure has network effects which become more remarkable under those features. It is noteworthy to mention that the precise shape of a country, as well as the location of mountain ranges and rivers might also be important. Nonetheless we do not include these additional geographic variables in our estimations given the lack of data availability[2].

In order to estimate the infrastructure patterns we run the following panel equations:

$$S_{ait} = \alpha + \alpha_{i0} + \alpha_1 gdp_{it} + \alpha_2 urb_{it} + \alpha_3 density_{it} + \alpha_4 SSshare_{it} + \alpha_5 Indust shar + \alpha_5 time_t + \varepsilon_{it}$$

[2] The concentration of the population (proxied by the % of population in the largest city) might also be important. The higher the concentration of the population the higher the infrastructure stock, given the network effects. Nonetheless, we finally did not include it in our estimations since it has a high correlation with the urbanization ratio: the higher the urbanization rate the higher the probability that population is concentrated in one (or few) large cities.

Figure 2. Basic infrastructure Avg. annual growth of infrastructure stocks and initial level (90-06; world avg.: 1)

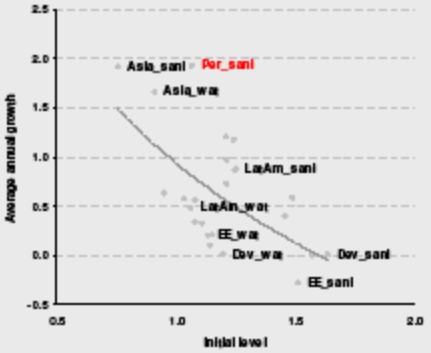


Figure 3. Telecos. Avg. annual growth of infrastructure stocks and initial level (80-07 for lines, 93-06 for PCs and 93-07 for internet; world avg.: 1)

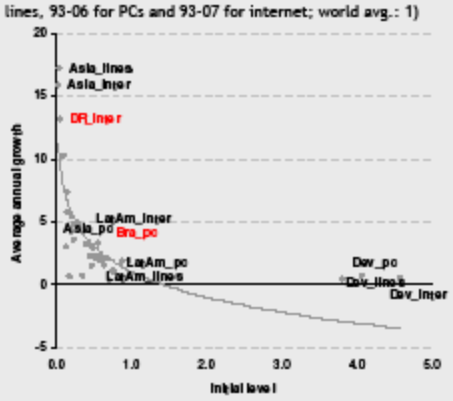
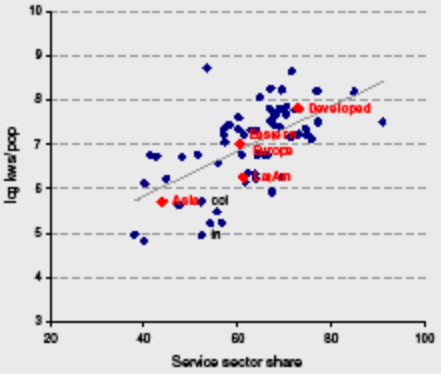


Figure 4. ECG per area (in logs) **and Economic Structure (Services share)**



Source: Own elaboration.

where S is the infrastructure stock of type *n* (telephone lines, internet access, number of PCs, ECG, rail lines, paved roads, Improved Water Source and Sanitation access). Following the literature, the stock of transport infrastructure is scale by the land area while the rest are expressed in per capita terms; *gdp* is the per capita gross domestic product in constant dollar PPPs (Purchasing Power Parity); *urb* is the urbanization ratio; density is the ratio pop/land area; *SSshare* and *Industshare* are the shares of Services and Industry on the Total Gross Value Added respectively; α_{i0} is a differential constant of the country *i* with respect to the sample average and $time_t$ is the time period fixed effect. All variables are expressed in logarithms, except for the urbanization ratio, so coefficients can be interpreted as elasticities.

Detailed panel regressions are reported in Section B in the Annex. As expected, we find strong relationship between infrastructure and fundamentals. In particular, the economic structure proves to be relevant to explain infrastructure stocks. We also included as a regressor the squared per capita GDP in order to capture the possible presence of non-linear responses to income (e.g. an income level at which infrastructure has a saturation point). Indeed, we found strong evidence of non-linearity for almost all infrastructure types.

Based on the panel estimations we compute the regions' infrastructure patterns as it is described in the Figure 5. We compute the investment patterns by country and by year which in turn are compared to the observed investment levels. Results are broadly in line with those in the previous version of the paper. Latin America is below its predicted pattern for most infrastructure types. On average, the DoA is 80% in the last year of data availability. The largest gap occurs in transport infrastructure with a DoA of 25% in the case of paved roads and 27% for railroads. The region is not in a good position regarding ECG neither, with a DoA of 55%.Despite the large heterogeneity within the region, the challenge is unanimous in transport infrastructure, mainly in paved roads. Notice that LatAm's best performer each year is still below Emerging Asia as a whole ((see Figures 6 and 7).

In telecommunications, the region has a far better relative position in comparison to transport infrastructure. Nonetheless, although LatAm's leader is above other emerging areas, this does not hold for all countries in the region. In any case, heterogeneity is still significant (see for instance Figure 8 for PCs). In the case of basic infrastructure, Asia is the region that clearly lags behind (e.g. see Figure 9 for Sanitation access).

All in all, according to our analysis LatAm should boost its infrastructure expenditure, mainly in some sectors such

Figure 5. Methodology of estimation of Infrastructure Pattern

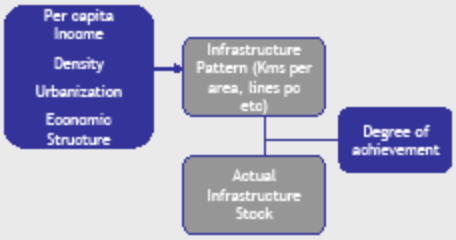


Figure 6. Paved Roads, DoA

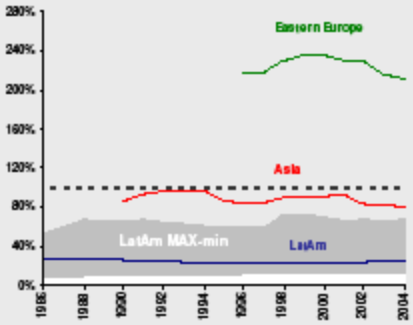
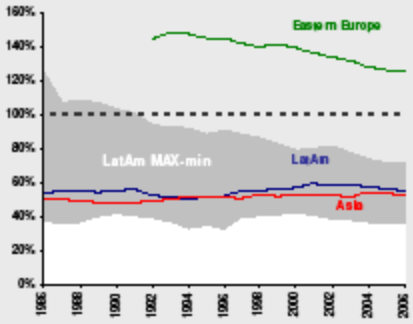


Figure 7. ECG, DoA



Source: Own elaboration.

as transport or energy, in order to raise potential growth, reduce inequality and fight poverty.

❖ 3. Policy implications

As anticipated in the previous version of the paper, many interrelated factors could contribute to explain our findings that the region lags somewhat behind in terms of infrastructure accumulation. From an institutional perspective, and leaving aside the long lasting effects of the balance of payment crisis in the 1990s, Latin-American policymakers have been recently prioritizing fiscal discipline to restore macro and financial stability. As shown by Calderón and Serven (2004) and Martner and Tromben (2005), improvements in primary structural fiscal balances achieved since the 1990s in many countries in the region came at the expense of sharp declines in public infrastructure investment. Furthermore, the crowding-in effect, both in terms of higher private participation infrastructure or via Public Private Partnerships (PPPs) has not been enough to offset this public investment retrenchment. Generally speaking, low quality institutions, such as opaque procurement and concession processes, periodical re-negotiations of contracts, or an inadequate regulatory framework for PPPs might explain the weakness of this effect.

Both sets of institutional factors may contribute to explain in particular the relatively unfavorable position of Latin America vs. Eastern Europe, a region that has benefited from Structural Funds support from Western Europe as well as from the industrial delocalization from West to East which has involved a greater infrastructure development. What do the data say about these hypotheses? We take a quite direct approach to test some of these hypotheses. We regress the DoA by type of infrastructure, country and over time, on proxies for fiscal space (observed deficit and public debt over GDP), and for the quality of institutions (from the International Country Risk Guide, since they allow both regional and time variance. Our preliminary results confirm empirically the priors. Both, the ratio of public debt to GDP and the political risk (in particular, the quality of the bureaucracy) contribute to close significantly the infrastructure DoA.

The results are shown graphically in Section C in the Annex by plotting the partial correlations of the DoA and each institutional variable, both controlling for the effects of the other variable (orthogonal errors). More indebted countries exhibit lower DoA, as illustrated by the negative slope in Figures 1 and 2 (specified for telephones and electricity). Additionally, countries with high quality bureaucracies tend to exhibit higher ratios, as illustrated by the positive slopes in Figures 3 and 4 (paved roads and rail lines).

Figure 8. PCs, DoA

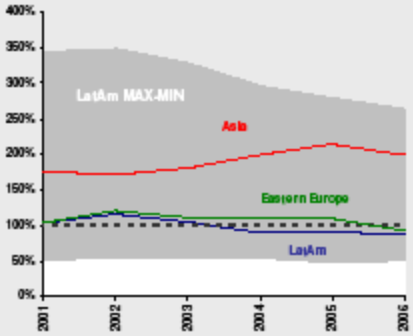
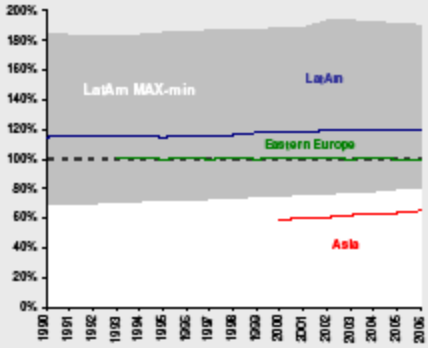


Figure 9. Sanitation access, DoA



Source: Own elaboration.

Table 2. Public debt and Bureaucracy quality

	Debt to GDP ratio	Bureaucracy quality *
LatAm	30.6	2.11
Emerging Asia	41.8	2.43
Eastern Europe	28.3	2.45
Developed	58.1	3.60

Source: Own calculations based on IMF and ICGR. Regional readings are simple country averages. *Highest risk: 0. Lower Risk: 4. High points are given to countries where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services.

The implications of these results for Latin America are quite straight forward. A rough analysis of the relative levels of public indebtedness and bureaucracy quality of Latin America vs. Eastern Europe and Emerging Asia highlights that the main goal of the region as a whole should be to increase the quality of the bureaucracy. Of course, there is heterogeneity among countries in the region and fiscal sustainability remains a challenge in many countries. However, the lesson from the 1990s is that fiscal consolidation when necessary should not come at the expense of infrastructure investments. Table 2 shows that LatAm, like the other emerging areas, presents low levels of public debt thanks to the fiscal and debt consolidation process over the last two decades. Nonetheless, Latin America has the worst quality of bureaucracy. Again, differences among countries are significant, with Dominican Republic and Venezuela posting the worst qualifications while Chile and Mexico lead.

❖ References

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- Calderón, C. and L. Servén (2004): "Trends in Infrastructure in Latin America, 1980-2001", Policy Research Working Paper 3401, World Bank.
- Martner and Tromben (2005), "Public investment and fiscal adjustment in Latin American countries", In D. Franco (ed), Public Expenditure, pp.827-857. Banca d'Italia. Rome.

A. Dataset

Variable	Units	Coverage: Number of countries	Coverage: Sample	Source
Infrastructure Stocks				
Telephone lines (mobile and fixed)	Number of lines	61	80-07	Series by Canning (1998) and Canning and Farahani (2007) were extended with the most recent data available in the World Bank's *World Development Indicators*. For electricity we extended the data to year 2006 from the United Nations' Energy Statistics.
Electricity Generating Capacity	Kilowatts	60	80-06	
Paved Roads	Kilometers	61	80-04	
Rail-lines	Kilometers	60	80-06	
Improved water source (% of population with access)	%	51	90-06	
Sanitation (% of population with access)	%	46	90-06	World Development Indicators
Number of Personal Computers	In million	61	93-06	
Number of Internet users	In million	61	93-06	
Other variables				
Population	In million	61	80-07	
Gross Domestic Product	In constant 2005 PPPs	61	80-07	
Land area	In squared kilometers	61	80-07	World Development Indicators
Urbanization ratio	% of urban population over total	61	80-07	
Share of Industry, Services, Agriculture on GVA	%	61	80-07	

Source: Own elaboration

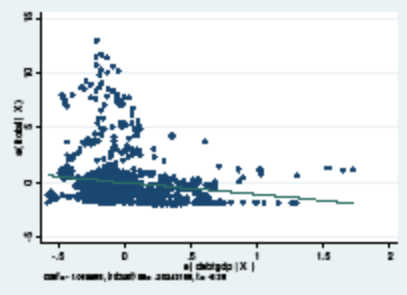
B. Estimated Panel Regressions

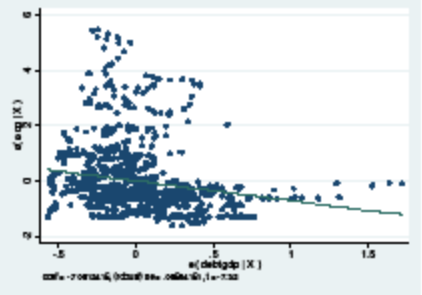
	Telephone lines		PC		Internet		ECG		Paved Roads		Rail lines		Water		Sanitation	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
C	8.474	13.6	3.916	3.4	-7.470	-2.5	4.616	18.7	4.865	21.2	3.023	16.1	-0.162	-2.3	0.080	0.8
GDPpc	3.525	32.2	1.312	10.4	1.346	4.0	0.899	22.7	0.998	17.2	0.089	1.8	0.245	15.8	0.460	21.5
GDPpc Sq.	-0.613	-29.5	...	...	...	...	-0.110	-14.3	-0.102	-8.5	-0.025	-2.3	-0.055	-17.6	-0.097	-21.3
Urb. Ratio	0.007	1.7	0.017	2.1	0.134	6.6	0.015	9.0	...	...	...	...	...	...	...	...
Density	1.094	6.8	0.237	0.8	0.997	1.3	0.192	3.2	0.640	10.3	0.097	1.8	0.232	14.1	0.419	16.9
Ss. share	0.025	5.9	0.037	6.5	0.080	5.2	0.000	0.1	0.009	8.2	...	...	0.005	11.4	0.005	7.3
Indust. share	0.023	5.1	0.044	6.8	0.103	6.0	0.004	2.2	...	...	...	...	0.006	10.1	0.005	6.1
Fixed Effects	CS and Period		CS and Period		CS and Period		CS and Period		CS		CS		CS		CS	
Number of countries	61		61		61		60		61		60		51		46	
Sample	80-07		93-06		93-07		80-06		80-04		80-06		90-06		90-06	

Note: Non-balanced panel regressions
Source: Own calculations

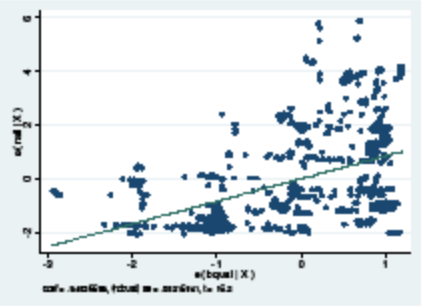
C. Orthogonal Errors

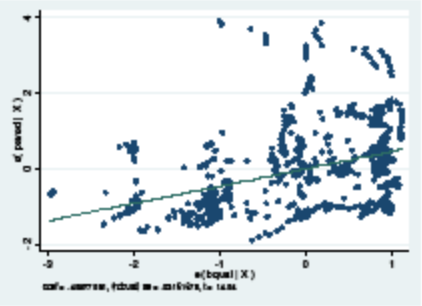
Figures 1 and 2. Telephones and Electricity





Figures 3 and 4. Rail lines and Paved roads





Source: Own calculations