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Infrastructure in Latin America

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Abstract

An adequate supply of infrastructure services has long been viewed by both academics and policy makers as a key ingredient for economic development. Over the past quarter-century, the retrenchment of Latin America's public sector from its dominant position in the provision of infrastructure, and the opening up of these industries to private participation, have renewed the debate on the role of infrastructure in the region's development. The focus of this paper is three-fold. First, it documents, in a comparative cross-regional perspective, the trends in Latin America's infrastructure development, as reflected in the quantity and quality of infrastructure services and the universality of their access. Overall, this suggests the emergence of an *infrastructure gap* vis-à-vis other industrial and developing regions. Second, it provides an empirical assessment of the contribution of infrastructure development to growth across Latin America. Third, it examines the trends in the financing of infrastructure investment—documenting the changing roles of the public and private sectors—and analyzes how they have been shaped by macroeconomic policy constraints.

This paper—a product of the Office of the Chief Economist for Latin America and the Caribbean Region, and the Macroeconomics and Growth Team, Development Research Group—is part of a larger effort in the two departments to understand the evolution of infrastructure investment in Latin America and its role for growth. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at ccalderon@worldbank.org.

Infrastructure in Latin America

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1. Introduction

An adequate supply of infrastructure services has long been viewed as a key ingredient for economic development, by both academic economists and policymakers. Indeed, transport infrastructure played a central role in Adam Smith's vision of economic development. Over the last two decades, starting with the work of Aschauer (1989), academic research has devoted considerable effort to theoretical and empirical analyses of the contribution of infrastructure development to growth and productivity; see for example Sánchez-Robles 1998; Canning 1999; Demetriades and Mamuneas 2000; Röller and Waverman 2001; Esfahani and Ramirez 2003; Calderón and Servén 2004b, 2010). More recently, increasing attention has been paid also to the impact of infrastructure on poverty and inequality (Estache, Foster and Wodon 2002, Calderón and Chong 2004). While the empirical literature on these two topics is far from unanimous, on the whole a consensus has emerged that, under the right conditions, infrastructure development can play a major role in promoting growth and equity – and, through both channels, helping reduce poverty.

From the policy perspective, the renewed concern with infrastructure can be traced to two worldwide developments that took place over the last two decades. The first one was the retrenchment of the public sector since the mid 1980s, in most industrial and developing countries, from its dominant position in the provision of infrastructure, under the increasing pressures of fiscal adjustment and consolidation. The second was the opening up of infrastructure industries to private participation, part of a worldwide drive towards increasing reliance on markets and private sector activity, which has been reflected in widespread privatization of public utilities and multiplication of concessions and other forms of public-private partnership. While this process first gained momentum in industrial countries (notably the U.K.), over the 1990s it extended to most developing economies, with Latin America leading other developing regions in terms of both speed and scope of private involvement in infrastructure industries.

Against this background, there is a growing perception that poor infrastructure has become one of the key barriers to growth and development across Latin America. Such perception is found among policy-makers and observers, as well as in surveys of infrastructure users in the region. The underlying concern is that private sector participation has not offset the decline in public infrastructure spending under the pressures of fiscal consolidation, thus resulting in an inadequate provision of infrastructure services, with potentially major adverse effects on growth and welfare. As a result, infrastructure has become a priority theme in Latin America's policy debate; see for example Fay and Morrison (2005) and Corporación Andina de Fomento (2009).

This paper revisits the theme of infrastructure development in Latin America from a macroeconomic standpoint. The focus of the paper is three-fold. First, it documents, in a comparative cross-regional perspective, the trends in Latin America's infrastructure development, as reflected in the quantity and quality of infrastructure services and the universality of their access. Overall, there is evidence that an 'infrastructure gap' vis-à-vis other industrial and developing regions opened up in the 1980s and 1990s. Second, using a regression framework, we provide an empirical assessment of the contribution of infrastructure development to growth across Latin America. An outcome of this analysis is a quantitative illustration of the growth cost of the region's infrastructure gap. Third, we examine the changing roles of the public and private sector in Latin America's infrastructure. In this regard, the paper presents updated information on the trends in the financing of infrastructure investment, and analyzes how they have been shaped by macroeconomic policy constraints. Finally, we summarize the lights and shadows from two decades of private sector participation in Latin America's infrastructure development.

2. Infrastructure trends in Latin America and the Caribbean

We begin by offering a comparative overview of the trends in availability, quality and accessibility of infrastructure across Latin America and other world regions over the last 25 years. We work with a large sample of countries, but exclude very small economies (those with population smaller than 1 million in 2005) for which infrastructure may pose some special issues (such as indivisibilities). In the case of Latin America and the Caribbean (LAC), this leads to the exclusion of small-island economies and leaves us with 21 countries. However, some portions of our analysis may be restricted to a narrower set of countries as determined by data availability.

For the most part, our discussion focuses on three core infrastructure sectors: telecommunications, power, and land transportation, although we also review trends on access to water and sanitation.[1] We compare their evolution in the Latin American region with that of two comparator groups: (i) the middle and high-income countries of East Asia (which we call *EAP non-LICs*) and (ii) the group of middle-income countries excluding LAC countries (called *non-LAC MICs*). The first group comprises the seven "East Asian miracle" nations (Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan, and Thailand) and some of the region's fast-growing countries such as China, Cambodia, the Philippines and Vietnam. The second group —after dealing with issues of data availability— includes a total of 70 countries.[2] Furthermore, we assess the progress of infrastructure development in these developing areas vis-à-vis 21 OECD economies.[3] Finally, for reasons of space we focus mostly on region-wide performance, but we should point out that there is great deal of heterogeneity in infrastructure development (availability, quality and accessibility) across countries in each region.

2.1 Infrastructure quantity

The first three columns of Table 1 summarize the trends in the availability of telecommunications, electric power and roads over the last quarter century for the various comparator groups considered, as well as for the Latin America and the Caribbean region and its four sub-regions defined as (i) Central America: Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama, and El Salvador; (ii) the Caribbean: Bahamas, the Dominican Republic, Jamaica, and Trinidad and Tobago; (iii) the Andean countries: Bolivia, Colombia, Ecuador, Peru, and Venezuela; and (iv) the Southern Cone: Argentina, Brazil, Chile, Paraguay and Uruguay. For each country group, the table reports the median of the country averages over the periods 1981-5, 1991-5, and 2001-5. The table also shows separately the trends in each of the seven major LAC countries (Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela).

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[1] Appendix Table A-1 describes the definition and sources of the data for the physical indicators of infrastructure quantity, our proxies for the quality of infrastructure services, and the measures of access to infrastructure.

[2] We use middle-income economies rather than all developing countries because most Latin American countries belong to the former category.

[3] OECD is defined here excluding Korea and Mexico.

Telecommunications. Telephone density —as measured by the total number of phone lines (fixed and mobile) per 1000 workers[4]— has risen sharply in all regions after 1990, due to the impressive growth in the number of mobile phones. The LAC region has consistently lagged behind other regions in terms of telephone density, but the gap has changed over time. In 1981-5, LAC trailed non-LAC MICs by a relatively small margin, whereas in EAP non-LICs telephone density was three times as high as in LAC. By 2001-5, LAC had gained some ground relative to non-LAC MICs, but relative to EAP non-LICs the gap remained at levels similar to those of 1981-5 period – it widened during the 1980s and then narrowed in the 1990s. Finally, the gap between the LAC region and industrial economies has narrowed over time: the ratio of industrial country telephone density to that of LAC has more than halved: it has declined from almost 8 in 1981-5 to 3.6 in 2001-5. Across LAC sub-regions, Central America has consistently shown the lowest telephone density over the last 25 years, while the Andean countries had the highest until they were overtaken by the Caribbean sub-region in 2001-5.

Power. Electricity generation capacity (in megawatts per 1000 workers) is our approximate measure of the availability of electric power. Like with telecommunications, in this dimension the LAC region has fallen behind not only East Asia but also the rest of the middle-income countries. By 2001-5, the region reduced slightly the gap vis-à-vis non-LAC MICs; however, it fell further behind EAP non-LICs. Across LAC sub-regions, Central America and the Andean countries have lagged consistently behind the regional average – in fact, they practically made no progress at all during the 1980s -- while the Southern Cone countries have been ahead of the other sub-regions.

Land Transportation. Trends in the land transport network are captured by road density, measured by the total length of the road network[5] relative to the country's total area. This is in contrast with our measures of the availability of power and

[4] A perhaps more accurate measure of the availability of phone services is the connection capacity of local exchanges. Unfortunately, information on this measure is more limited, and does not extend to all the countries considered here.

[5] We should point out that the length of network in lane-km equivalent would be a preferable indicator. Unfortunately, such measure is not widely available.

telecommunications, which were normalized by the total labor force. We do this to adjust for the wide disparities in size across the countries in our sample.[6]

Table 1 reveals a big gap between industrial and developing regions in terms of road density. Latin America and the non-LAC MICs have fallen further behind rich countries and East Asia since 1990. Moreover, while Latin America was roughly on par with non-LAC MICs in 1981-5, by 2001-5 its road density has barely grown and, as a consequence, it is now well below that of middle-income countries, and even further below East Asia's. Across sub-regions, road density is below the LAC-wide norm in the Andean countries and in the Southern Cone. In contrast, road density in the Caribbean is similar to that of East Asia.

2.2 Infrastructure quality

Broadly speaking, the quality of infrastructure services can be proxied by two types of information: (a) officially-recorded data on quantitative measures of the quality of infrastructure services, and (b) surveys of experts or final users regarding the performance of infrastructure services —typically qualitative in nature.

The availability of officially-recorded statistics on infrastructure quality is scarce relative to that on its quantity. This is particularly problematic in the case of telecommunications. Cross-country data on the telecommunications quality indicators that on conceptual grounds should be most informative —such as the frequency of telephone faults and unsuccessful calls— are extremely sparse. Thus, we complement this information showing data on the waiting time for installation of main lines, which in theory is a measure of excess demand, but in practice shows a significant correlation (see Calderón and Servén 2004b) with the theoretically-preferable measures just cited, over the reduced sample for which the latter are available. Information on waiting times can be collected for a fairly large sample of country-years.[7]

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[6] Using arable land area rather than total area leads to very similar rankings. For this exercise, we exclude Singapore and Hong-Kong from the set of East Asian comparator countries, in view of the particular physical characteristics (small area and very high population density) of both city-states.

[7] Empirically, over the samples for which information is available, the waiting time for installation of main lines is associated with the frequency of telephone faults (the simple correlation is 0.19) and the percentage of phone faults cleared the next day (-0.18). Moreover, these correlations are statistically significant.

The situation is better for power and transport. There is fairly abundant data on two widely-used (albeit far from perfect) measures of quality – the percentage of power losses and the share of paved in total roads, respectively.

It is worth noting that all these infrastructure quality indicators show a high correlation with their corresponding quantity indicators reviewed above. In a large panel data set, Calderón and Servén (2004b) find sector-wise correlation coefficients (e.g., between power generation capacity and power losses, or between road density and road quality) around 0.5 and significantly different from zero at any reasonable significance level. The implication is that more abundant infrastructure typically comes along with better infrastructure.

In view of the limitations of these indicators of infrastructure quality, increasing effort has been devoted in recent years to the compilation of survey-based assessments of infrastructure performance. Two leading sources of such kind of data are (a) international surveys of business conditions that reflect the views of international experts, and (b) firm-level surveys that capture the perceptions of infrastructure users. At present, however, the time-series dimension is in both cases very limited (virtually nil, in the case of firm surveys), and comparability over time and across countries is sometimes hampered by changes in the relevant survey questions.

2.2.1 Officially-recorded statistics of infrastructure quality

Telecommunications. Table 1 reports the evolution of an indicator based on the waiting time (in years) for the installation of main telephone lines. This indicator has been rescaled such that it takes values between 0 and 1, with higher values indicating shorter wait times and, in this interpretation, higher quality of telecommunication services.

Along this dimension, LAC's progress over the last two decades was spectacular, as the region's median waiting time was reduced from six months in 1981-5 to a few days by 2001-5, well below the norm of non-LAC middle income countries. In rich countries waiting time fell to zero in the early 1980s, while in East Asia the same happened by 1991-5 (see Table 1). The fast improvement in the reduction of waiting time for main telephone installation extended to all LAC sub-regions, with Central America and the Southern Cone showing the fastest pace of improvement in the quality of service.

Other quality indicators, whose availability is more limited, tell a similar story. Calderón and Servén (2009) show that telephone faults per 100 main lines declined considerably across Latin America -- to a regional median of 5 in 2001-6 from 52 in 1991-6. In addition, not only the number of phone faults declined, but also the percentage of faults cleared next day rose considerably -- from 55% in 1991-6 to approximately 87% in 2001-6.

Power. The percentage of transmission and distribution losses relative to total output offers a rough measure of the efficiency of the power sector. However, observed power losses include both 'technical' losses, reflective of the quality of the power grid, and pilferage (i.e. power theft), and unfortunately it is virtually impossible to disentangle the relative importance of the two. The quality measure of power reported in Table 1 is based on these losses, rescaled to lie between 0 and 1, so that higher values indicate higher quality.

By this measure, the table shows that the quality of electric power services actually deteriorated in Latin America over the 1980s and 1990s. The same happened among middle-income countries. In contrast, quality showed a steady improvement in East Asia and industrial countries, so that Latin America's gap vis-à-vis these high-performing regions has widened over time. [8]

Land Transportation. The only quality indicator widely available for this sector is the percentage of paved roads in the total road network.[9] Table 1 shows that, by this measure, the LAC region lags the other country groups by a huge margin. By 2001-5, less than a quarter of the road network (25 percent) was paved in the typical Latin American country, far behind the non-LAC MIC norm (close to 50 percent), and much further behind East Asia and the industrial-country norm, both close to 100 percent. Not only the level of the indicator was low in Latin America; it also grew at a very slow pace -- from

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[8] In addition to transmission and distribution losses (sometimes considered a measure of operating performance), the World Bank Report "*Benchmarking data of the Electricity Distribution Sector in Latin America and the Caribbean 1995-2005*" computes quality measures such as the frequency and duration of interruptions of electricity services per subscriber (number and hours, respectively). However, we lack information over a longer time horizon, as well as for countries in other regions.

[9] An alternative measure of road quality is the international roughness index (IRI), developed in the 1980s, and used to define a key characteristic of the longitudinal profile of a traveled wheel-track (UMTRI, 1998). The calculation of this index is based on the ratio of a standard vehicle's accumulated suspension motion (say, in millimeters) divided by the distance traveled by the vehicle during the measurement (say, in kilometers). However, the information is sparse and has limited cross-country and time-series-coverage.

15% in 1981-5 to 23% in 2001-5. Across LAC sub-regions, road quality is lowest in the Andean countries and the Southern Cone, and highest in the Caribbean.

2.2.2 Survey measures of infrastructure quality

We next summarize the information available from the surveys of international experts conducted for the World Economic Forum's *World Competitiveness Report*. Rather than quality alone, they tend to capture perceptions on both the quality of infrastructure services and their availability —which is likely to be closely related to the volume of infrastructure stocks. The coverage of these data is more limited than that of the official statistics reviewed so far. The time series dimension is short, so for the most part we show data for 2000 and 2006 only. Country coverage of Latin America, as well as other middle-income countries, is somewhat limited, and hence the regional medians shown below have to be taken with some caution.

Figure 1.1 summarizes perceptions regarding the *overall* quality of infrastructure across world regions, with higher bars denoting higher quality, within a range from 1 to 7. It is clear from the figure that Latin America lags behind East Asia and the group of middle-income countries – as well as industrial countries. Moreover, the gap has, if anything, gotten worse since 2000.

Figure 1.2 reports perceptions of the reliability of power. In this case, we report data for 2002 and 2006. The subjective index shows a significant negative correlation with that on the percentage of power losses described earlier. Perceived quality is highest in industrial countries. Among developing regions, only East Asia shows a definite trend towards improving quality. In contrast, perceived quality seems to be on the decline among middle-income countries. Nevertheless, quality perceptions are still lowest in Latin America. This is in agreement with results found earlier when using power losses as quality proxy: in both cases Latin America does worst among the country groups shown.

Figure 1.3 depicts the perceived reliability of telephones. The regional rankings for 2000 show a counter-intuitive pattern, with industrial countries lagging behind all other country groups shown.[10] In 2006, in turn, Latin America placed on par with middle-income countries, and behind industrial and East Asian economies, although the differences across groups seem quite marginal.

Finally, Figure 1.4 shows the perceived quality of the road network. The cross-country correlation of the subjective index with the objective measure used above – the percentage of roads paved – is large and significantly positive. Unsurprisingly, therefore, the regional perspective is similar in both cases: Latin America lags behind the other country groups. In this case, it is also the only region not showing an improving trend.

2.3 Access to infrastructure services

So far we have been concerned with the overall quantity and quality of infrastructure. But from the point of view of equality of opportunity and poverty reduction, another important dimension is the universality of access to infrastructure services –*i.e.*, the extent to which existing infrastructure assets yield services to the broad population rather than just a few. One way to measure this phenomenon is through access rates. Table 2 offers a comparative perspective on standard indicators of access to telecommunications, electric power, roads, and water and sanitation. Coverage of information on access rates is limited, especially in the time series dimension, and therefore we confine ourselves to the cross-country dimension, except in the case of water, for which some time-series information is also available. We present median access rates by region for 2006.[11]

Table 2 shows that in Latin American countries typically 47 percent of the households have a fixed telephone—well below the rate of access for EAP non-LICs and industrial economies (52 and 93 percent, respectively). On the other hand, the cellular network covers more than 90 percent of the population among industrial countries and East Asia (99 and 91 percent, respectively) whereas the coverage of mobile phones reaches 85% of the population in the LAC region – a figure similar to that of non-LAC MICs. Finally, there are wide disparities across regions in access to internet services.

[10] Closer inspection reveals a negative correlation (-.30) between this subjective indicator and the objective measure of quality discussed earlier (the frequency of phone faults), although the sample for which both are available includes only 27 countries.

[11] Due to the lack of information for 2006 in some sub-groups of countries, we report the averages of the percentage of people with telephone for the period 2004-6.

While East Asia leads the pack, LAC has the lowest access rate — typically less than 10 percent of the homes have access to internet in LAC countries.

Table 2 also shows the percentage of households with access to electricity, an indicator which is only available for developing countries. Latin America's median access rate equals 87 percent, short of the 90 percent of other middle-income countries, and far behind the 98 percent observed in the successful East Asian economies. Across countries in the region, Venezuela, Chile and Costa Rica exhibit access rates on par with East Asia's. At the other end, less than two-thirds of the population enjoys access to electricity in Bolivia and Honduras.

Access to transport is approximated by the widely-used rural access index (RAI), which measures the percentage of the rural population living within a short distance (2 km) of an all-season passable road. Table 2 shows that Latin America trails East Asia as well as other middle-income economies along this dimension. Among LAC countries, access to transport is particularly poor in Nicaragua, where it reaches just over one-fourth of the population.

Regarding access to safe water, we report the percentage of population with access to safe water, including treated surface water and untreated but uncontaminated water such as from springs, sanitary wells, and protected boreholes. Latin America ranks below the group of other middle-income countries. At just under 80 percent, its access rate is still far from the almost-universal coverage observed among successful East Asian economies. Uruguay is the only Latin American country to have reached universal access. In Bolivia and Nicaragua, less than half of the population enjoys access to safe water.

Finally, regarding access to improved sanitation, Latin America has caught up with the norm of middle-income countries, reaching a median access rate of 93 percent. Both East Asia's successful economies as well as industrial countries enjoy universal access. In Latin America, a number of countries (notably Ecuador and Paraguay) have shown major progress since 1990, although at present few countries show access rates comparable to those of East Asia.

To summarize this section, on the whole Latin America has made major progress in infrastructure development. The availability, quality and accessibility of infrastructure services have improved considerably in the last quarter century. Still, the region lags behind other middle-income-countries, and even further behind East Asia, in almost all dimensions (quantity, quality and accessibility of services) and infrastructure sectors (telecommunication, electric power and roads). While details vary, overall much of the lag developed in the 1980s at the time of the public sector's retrenchment in the midst of macroeconomic instability. In some dimensions (particularly telecommunications), a partial catch-up has taken place since the mid 1990s, so that Latin America's gap vis-à-vis the other country groups has narrowed somewhat, but in most dimensions it remains considerable.

3. Infrastructure, growth and development

These trends in the quantity, quality and accessibility of infrastructure are of interest because, as an extensive theoretical and empirical literature has argued, infrastructure is a key ingredient for growth and development. There is abundant theoretical work on the contribution of infrastructure to output, productivity and welfare. Much of it is concerned with the effects of public capital expenditure on output and welfare under alternative financing schemes. Arrow and Kurz (1970) were the first to include public capital as an input in the economy's aggregate production function, in the context of a Ramsey model with long-run exogenous growth. Barro (1990), on the other hand, developed the endogenous growth version of this model where it was assumed that the government's productive expenditures drive their contribution to current production. Over the last fifteen years, this analytical literature has grown enormously.[12]

The empirical research, in turn, took off recently. It has boomed over the last fifteen years after the seminal work of Aschauer (1989). Literally, hundreds of papers have been devoted to assess the effects of infrastructure on growth, productivity, poverty, and other development outcomes, using a variety of data and empirical methodologies. Calderón and Servén (2010) offer a partial account of the literature on the growth and

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[12] See for example Turnovsky (1997), Glomm and Ravikumar (1997), Baier and Glomm (2001), and Ghosh and Roy (2004).

inequality effects of infrastructure; more comprehensive surveys include Estache (2006), Romp and de Haan (2007) and Straub (2007).

The bulk of the empirical literature on the effects of infrastructure has focused on its long-run contribution to the level or growth rate of aggregate income or productivity. It all starts with Aschauer's (1989) finding that the stock of public infrastructure capital is a significant determinant of aggregate TFP in the U.S. However, his estimate (based on time-series data) of the marginal product of infrastructure capital —as much as 100% per year— was implausibly high.

The massive ensuing literature on the output effects of infrastructure has employed a variety of data, empirical methods and infrastructure measures. The most popular approaches include the estimation of an aggregate production function (or its dual, the cost function) and empirical growth regressions. Infrastructure is variously measured in terms of physical stocks, spending flows, or capital stocks constructed by accumulating the latter. The majority of this literature finds a positive long-run effect of infrastructure on output, productivity, or their growth rate. This is mostly the case with the studies using physical indicators of infrastructure stocks, but results are more mixed among studies using measures of public capital stocks or infrastructure spending flows (Straub 2007).

Another strand of recent literature has examined the effects of infrastructure on income inequality. The rationale is that infrastructure provision may have a disproportionate effect on the income and welfare of the poor by raising the value of the assets they hold (such as land or human capital), or by lowering the transaction costs (e.g., transport and logistical costs) they incur to access the markets for their inputs and outputs. These effects may occur through a variety of mechanisms documented in the empirical literature —see for example Estache, Foster and Wodon, (2002), Estache (2003), and Calderón and Servén (2010). Of course, for infrastructure development to reduce income inequality, the key ingredient is that it must help expand access by the poor, as argued for example by Estache et al. (2000).[13]

[13] There may be two-way causality in this relationship, that is, income inequality may prevent the access of poorer people to infrastructure services. For example, Estache, Manacorda and Valletti (2002) show that income inequality adversely affects access to internet, while Alesina, Baqir and Easterly (1999) argue that more unequal societies devote less effort to the provision of public goods, including infrastructure.

Among the empirical studies that have tackled directly the inequality impact of infrastructure are those of López (2004) and Calderón and Servén (2010), both of which use cross-country panel data. In both cases, the finding is that, other things equal, infrastructure development is associated with reduced income inequality. Combined with the finding that infrastructure also appears to raise growth, the implication is that, in the right conditions, infrastructure development can be a powerful tool for poverty reduction.

3.1 Measuring aggregate infrastructure

In the remainder of this section, we provide an empirical illustration of the contribution of infrastructure development to growth across Latin America and other world regions. A preliminary question that needs to be addressed is what kind of measure of infrastructure should be used for this task. Infrastructure is a multi-dimensional concept, and both the availability and quality of infrastructure services matter for growth.[14] Yet most empirical studies measure infrastructure in terms of the quantity of assets in a particular infrastructure sector (most often main telephone lines). This is partly due to (i) the difficulty of capturing the multiple dimensions of infrastructure in a simple way, and (ii) the high correlation often found among indicators of availability of different types of infrastructure assets. [15]

To overcome this problem, while accounting for the multi-dimensionality of infrastructure, we use principal component analysis to build synthetic indices summarizing information on the quantity of different types of infrastructure assets as well as the quality of services in different infrastructure sectors.[16] These synthetic indices combine information on three core infrastructure sectors —telecommunications, power, and roads— and help address the problem of high co-linearity among their individual indicators. We denote the synthetic quantity and quality indices that result from this procedure **IK** and **IQ**, respectively. The indices can be expressed as linear combinations of the underlying sector-specific indicators, and hence their use in a regression context is

[14] The universality of access is more relevant for issues of equity.

[15] For instance, in our sample the correlation between standard measures of telephone density and power generation capacity (measured respectively by a country's total number of telephone lines, and its total power generation capacity, in both cases relative to the number of workers) exceeds 0.90, which makes it hard to disentangle in a regression framework the separate roles of the two types of assets.

[16] Alesina and Perotti (1996) used principal component analysis to create a measure of political instability, while Sanchez-Robles (1998) employed it to build an aggregate index of infrastructure stocks.

equivalent to imposing linear restrictions on the coefficients of the individual infrastructure indicators.

We define the synthetic infrastructure quantity index $\mathbf{IK}_1$ as the first principal component of three variables: total telephone lines (fixed and mobile) per 1000 workers (Z_1/L), electric power generating capacity expressed in MW per 1000 workers (Z_2/L), and the length of the road network in km. per sq. km. of arable land (Z_3/A). Each of these variables is expressed in logs and standardized by subtracting its mean and dividing by its standard deviation. The three rescaled variables enter the first principal component with roughly similar weights:

$$IK_1 = 0.603 * \ln\left(\frac{Z_1}{L}\right) + 0.613 * \ln\left(\frac{Z_2}{L}\right) + 0.510 * \ln\left(\frac{Z_3}{A}\right)$$

In turn, the index $\boldsymbol{IK}_1$ accounts for almost 80 percent of the overall variance of the three underlying indicators.

As a robustness check, we compute an alternative index of infrastructure quantity, $\boldsymbol{IK_2}$, which – in keeping with earlier empirical literature -- uses main telephone lines instead of the combined main lines and mobile phones employed in the first index. However, the correlation between the two synthetic quantity indices is very high (over 0.99). This is not surprising in view of the strong co-movement between the two indicators of telephone density underlying the respective synthetic indicators.

As already discussed, measuring infrastructure quality is less straightforward, due to the limited coverage of the objective quality indicators that should be most informative (e.g. frequency of power outages or phone faults), and the similarly limited availability of subjective indicators of perceived infrastructure quality. We opt for using the available objective indicators that allow broadest sample coverage. Specifically, we construct a synthetic index of infrastructure quality **IQ**, defined as the first principal component of the following indicators: waiting time (in years) for the installation of main telephone lines (Q_1), the percentage of transmission and distribution losses in the production of electricity (Q_2) and the share of paved roads in total roads (Q_3). As noted earlier, the first of these three variables is not a direct indicator of the quality of telecommunications networks, but is robustly positively correlated with the conceptually preferable measures over the sample for which these are available.[17]

All three variables are rescaled to lie between zero and one in such a way that higher values indicate better quality of infrastructure services. Using the weights obtained from the principal components procedure, the synthetic index of infrastructure quality can be expressed as:

$$IQ = 0.608 * Q_1 + 0.559 * Q_2 + 0.564 * Q_3$$

The index **IQ** captures approximately 60 percent of the total variation of the three underlying indicators.

Our indicators of quantity and quality of infrastructure share a good deal of common information —*i.e.*, their correlation ranges from 0.63 to 0.73 depending on the specific quantity index considered. In the individual infrastructure sectors the respective stocks and quality measures are also positively correlated (0.59 for telecommunication, 0.46 for electricity, and 0.54 for roads). In addition, we should also note that the indices of quantity and quality may also capture trends in access. Calderón and Servén (2010) show that households' access to infrastructure is typically broader in countries with greater availability and quality of infrastructure services.[18]

Our aggregate indicators of infrastructure quantity and quality are strongly and positively associated with economic growth (see Figures 2.1 and 2.2). Long-term growth, as measured by per capita GDP growth over 1960-2005, is higher in countries with larger infrastructure networks. The correlation is equal to 0.34 when quantity is proxied by the index IK_1. On the other hand, countries with higher quality of infrastructure services also tend to exhibit higher per capita growth rates. The correlation equals 0.42 when quality is measured by the index **IQ**.[19] Finally, Figures 2.3 and 2.4

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[17] In any case, dropping from the list of variables the indicator of waiting time for the installation of main telephone lines (Q_1) leads to a synthetic index highly correlated with the one described in the text, and to regression estimates of the growth contribution of infrastructure very similar to those reported below. Those estimates are not presented here to save space.

[18] However, access is not distributed evenly across the population. Households in the upper percentiles of the income distribution typically enjoy much better access than poorer households do (World Bank 2006) Nevertheless, expanding service coverage is typically associated with improved access by the poor.

[19] The correlation between growth and the alternative index of infrastructure quantity $\mathbf{IK}_2$ is equal to 0.34. Across infrastructure sectors, growth is positively correlated with telecommunication stocks (0.24 for total phone lines, and 0.21 for main phone lines), electricity generating capacity (0.15) and the length of the road

show that the aggregate indices of infrastructure quantity and quality exhibit a strong negative relationship with income inequality —as measured by the Gini coefficient of income distribution.[20] Although further analysis of the infrastructure-equity nexus is beyond the scope of this paper, we note that Calderon and Serven (2010) find that infrastructure development —as proxied by higher availability and quality of infrastructure services— leads to lower income inequality after controlling for standard determinants of inequality as well as reverse causality.

3.2 Assessing the contribution of infrastructure to growth

We empirically assess the contribution of infrastructure to growth by estimating a simple equation that relates growth per capita to a set of standard controls, augmented by measures of the quantity and quality of infrastructure. For this purpose, we construct a large macroeconomic panel data set spanning the period 1960-2005 and comprising a total of 136 countries. Table A-1 lists the variables and data sources. As before, we limit our coverage to countries with total population over one million. Also, to remove cyclical factors and focus on longer-term effects, we work with non-overlapping 5-year averages. Data is not available for all countries in all time periods, and hence the panel is unbalanced. To keep a meaningful time-series dimension, we restrict our regression sample to countries with at least three consecutive 5-year observations.

To deal with unobserved heterogeneity, as well as likely endogeneity of infrastructure and other growth determinants in a dynamic panel data context, we use the GMM-IV system estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). After controlling for period-specific effects, we account for unobserved country-specific effects by differencing and instrumenting. Endogeneity and reverse causality are addressed by using lagged levels and differences of the growth determinants (i.e. internal instruments). In addition, we also use external instruments to control for the potential endogeneity of the infrastructure indices. Following Calderón and Servén (2004,

network (0.22). In addition, growth is positively associated with the quality of telecommunications (0.23), quality of electricity supply (0.14) and road quality (0.23).

[20] This likely reflects the fact that increased quantity and quality of infrastructure typically come along with broader access to infrastructure services. Calderon and Servén (2010) show that access to infrastructure is negatively associated to income inequality. More specifically, the percentage of population with access to telecommunication, power and transportation services is negatively correlated with the Gini coefficient of income distribution.

2010), we use demographic variables —i.e. current and lagged values of urban population and population density of each country as instruments for the quantity and quality of infrastructure.[21]

Table 3 presents the GMM estimates of the parameters of the growth regression augmented by the synthetic indices of infrastructure performance. We report results using the two alternative indices of infrastructure quantity, $\mathbf{IK}_1$ and $\mathbf{IK}_2$, and the index **IQ** of quality of infrastructure services. The set of standard control variables included in the regressions comprises measures of human capital (secondary enrollment, from Barro and Lee 2001), financial depth (from Beck, Demirguc-Kunt and Levine 2000), trade openness, institutional quality, lack of price stability, government burden and terms of trade shocks – in addition to the lagged level of GDP per worker, to capture conditional convergence. The standard errors reflect Windmeijer's (2005) small-sample correction.

Column 1 of Table 3 reports the parameter estimates including the synthetic quantity indicator $\mathbf{IK}_1$ in the growth regression. Among the standard controls, the estimates show evidence of conditional convergence in real output per capita. They also suggest that human capital accumulation, lower inflation and positive terms of trade shocks significantly encourage economic growth. The coefficients of the remaining controls carry the expected signs, but none is statistically significant.

In turn, the infrastructure quantity index carries a positive and significant coefficient, suggesting that infrastructure contributes to economic growth. Infrastructure quality also carries a positive and strongly significant coefficient. Thus, both infrastructure quantity and quality contribute to growth. Further, the specification tests shown at the bottom of the table (Hansen and difference-Sargan tests, as well as the second-order serial correlation test) show little evidence against the validity of the moment conditions underlying the empirical specification.

The estimates in column 1of Table 3 assume that the effect of infrastructure development on growth is homogeneous across countries. We may wonder if Latin America is any different in this regard. To verify this, in column 2 of Table 3 we interact

[21] The use of external instruments to control for the endogeneity of infrastructure quantity and quality is attributed to: (a) infrastructure demand might respond to anticipated income growth, making lagged values of the aggregate indicators of quantity and quality invalid instruments, and (b) the aggregate indices— especially in the case of infrastructure quality -- might be subject to serially-correlated measurement error.

the aggregate indices of infrastructure quantity and quality with a dummy for Latin American countries, and add them to the regression. The estimates that result offer little evidence of a different effect for LAC countries. Neither of the interacted variables carries a statistically significant coefficient. In turn, the coefficients of the standard controls also show little change, as do the specification tests.

As a robustness check, we repeat the estimations in columns 1 and 2 replacing the synthetic index IK_1 with the alternative IK_2. The results, shown in columns 3 and 4 of Table 3, are virtually unchanged. This is unsurprising in view of the high correlation between the two synthetic indices of infrastructure quantities.

We can illustrate the economic significance of infrastructure development by assessing its contribution to growth performance over the last 30 years. Specifically, using the estimates in the first column of Table 3, we calculate the contribution of infrastructure development —as proxied by the aggregate indices of infrastructure quantity and quality, $\mathbf{IK}_1$ and **IQ** — to growth over the last 15 years of the sample vis-à-vis the previous 15-year period. That is, for each country in the sample we compare the average values of $\mathbf{IK}_1$ and **IQ** over 2001-5 with those observed in 1991-5, and multiply the observed change by the corresponding regression coefficient. We perform the same calculation comparing the average values of $\mathbf{IK}_1$ and **IQ** over 1986-90 with those observed in 1976-80. Of course, this calculation is illustrative rather than conclusive, because —among other simplifying assumptions— it is based on the implicit hypothesis that changes in infrastructure development are not systematically accompanied by changes in any of the other growth determinants.

On average, growth in LAC increased by only 0.32 percentage points in 1986-90 relative to 1976-80 due to infrastructure development. This is the lowest value among all country groups shown in Figure 3.1. It comprises growth of 0.51 percentage points due to the accumulation of infrastructure stocks, and a contraction in GDP growth of 0.19 percentage points due to lower quality of infrastructure services. Across comparator regions, the largest contribution of infrastructure development to growth during this period was achieved in East Asia, where it reached 1.93 percentage points per annum. Of this total, enlarged stocks increased growth by 1.32 percentage points per year, while enhanced infrastructure quality raised growth rates by 0.61 percentage points per year in 1986-90 relative to 1976-80.

Across LAC sub-regions, the Southern Cone achieved the largest contribution of infrastructure development to growth, with 1.03 percentage points per annum —of which 0.7 and 0.32 percentage points were respectively due to larger stocks and higher quality of infrastructure services. At the other end, infrastructure exerted a negative contribution to growth during this period in the Caribbean and the Southern Cone. While in the former sub-region both lower infrastructure quantity and quality contributed to a contraction in growth per capita of 0.11 percentage points, in the Southern Cone the lower quality of infrastructure offset the positive contribution of larger stocks—thus leading to a reduction in growth per capita of 0.28 percentage points.

Figure 3.2 reports a similar exercise, but based now on the comparison between 1991-5 and 2001-5. Interestingly, the LAC region is the one that achieved over this period the largest contribution of infrastructure development to growth (2.43 percentage points). Faster accumulation of infrastructure stocks accounts for a growth increase of 1.1 percentage points, whereas improved quality of infrastructure added a further 1.33 percentage points to the hike in growth. Across comparator regions, infrastructure development also contributed significantly to higher growth in middle-income economies (excluding LAC countries), by an average of 2.29 percentage points —of which 1.23 and 1.06 percentage points are attributed to faster accumulation of stocks and improved quality, respectively.

Within Latin America, the contribution of infrastructure to growth was largest in Central America and the Caribbean, where it added 2.67 and 2.51 percentage points to the growth rate, respectively. In turn, the Southern Cone exhibited the smallest contribution of infrastructure development to growth, although it was still a significant 1.9 percentage points per annum (1.01 percentage points explained by larger stocks and 0.88 percentage points due to enhanced quality). Interestingly, in all LAC sub-regions (except for the Southern Cone) the growth contribution of infrastructure quality was larger than that of infrastructure quantity, thus reversing the trend observed in the earlier period. Overall, comparison of Figures 3.1 and 3.2 provides a hint at the growth consequences of the incipient narrowing in recent years of Latin America's infrastructure gap vis-à-vis comparator regions.

What kind of growth benefits could be derived from closing the infrastructure gap? To be specific, assume a counterfactual under which the level of infrastructure development of each Latin American country rises to match the average level observed among non-LAC middle income countries. [22] Using our parameter estimates, it is easy to assess the consequences for growth. On average, growth in Latin America would rise by approximately 2 percentage points per year —mostly attributed to an expansion in the infrastructure network (1.5 percentage points). The Andean countries would gain the most -- 3.1 percentage points of growth on average, with most of it (2.4 percentage points) due to the considerable improvement in infrastructure quality that catch-up would entail. Central America, on the other hand, would reap an increase in its growth rate of almost 3 percentage points —with the bulk (1.9 percentage points) due to enlarged infrastructure stocks acquired in the catch-up. Finally, the sub-region that would collect the smallest benefits – because it is already ahead of the rest -- is the Southern Cone (0.98 percentage points), with most of the contribution coming from the improved quality of infrastructure services (0.61 percentage points).

Of course, it is important to stress that this counterfactual exercise says nothing about the desirability, on welfare grounds, of the assumed infrastructure expansion. More fundamentally, we illustrated only the growth benefits of catching up, ignoring the costs that it might involve – for example, in terms of public resources that could be diverted from other uses in order to support enhanced infrastructure development. Such costs are likely to be quite significant, and more so for those countries that are lagging further behind at present. Hence, these illustrative calculations should be viewed with a healthy dose of caution.

4. The changing roles of the public and private sectors

Until the 1980s, the public sector had an almost exclusive role in the provision of infrastructure services in industrial and developing countries. But things started to change

[22] To give a more concrete idea of the benchmarks considered, the middle income countries outside Latin America closest to the average level of infrastructure development are Turkey and Bulgaria in terms of quantity, and Saudi Arabia and Tunisia in terms of quality.

in the 1980s. Across the developing world, and in Latin America in particular, the debt crisis and the ensuing macroeconomic and financial turbulence forced governments to implement drastic expenditure cuts and tax increases to correct large fiscal imbalances, in a new global context of hardened budget constraints brought about by the evaporation of foreign financing. The drive to fiscal austerity of Latin American public sectors over the 1980s and much of the 1990s resulted, among other things, in a severe cut in their infrastructure expenditures.

This change in the global economic environment was accompanied by a similarly global change in the development paradigm. The pervasive government intervention in the economy, and the direct participation of the public sector in the production of goods and services that characterized the state-led development model – whose limitations had been exposed by the debt crisis -- gave way to a new model in which free markets and private sector initiative were expected to play the leading role.[23]

These two forces were behind the retrenchment of developing-country governments across the world from some of their traditional activities, including the involvement in the industrial and commercial sectors of their economies, with infrastructure prominently among them. Infrastructure industries, hitherto reserved to the public sector, were opened to various forms of private participation in many countries. Nowhere in the developing world was this opening up as fast and deep as in Latin America. The process was certainly uneven across the region, with some countries – notably Chile – moving ahead of the rest, but eventually it affected virtually all countries and all infrastructure sectors.[24]

These trends had important consequences for the development of infrastructure across Latin America over the last quarter century. Their most immediate impact was on the level and composition of infrastructure spending in the region, first documented by Easterly, Calderón and Servén (2003a) and updated by Calderón and Servén (2004a, 2009). Figure 4 depicts the trends in infrastructure investment,[25] as a ratio to GDP, in the

[23] To be sure, this was not a trend exclusive of developing countries. The economic policies of the Reagan and Thatcher administrations in the U.S. and U.K, respectively, played a central role in the paradigm shift.
[24] Detailed chronologies of the opening up of Latin America's infrastructure industries to private initiative are given by Calderón, Easterly and Servén (2003a) and Andrés et al (2008).
[25] Unfortunately, data on operations and maintenance (O&M) expenditures is not available, although it seems safe to assume that its trends were not very different from those of investment spending.

six largest Latin American economies.[26] It is immediately apparent from the figure that total infrastructure investment collapsed in the second half of the 1980s, and the fall has not been reversed in the ensuing two decades. [27] As a result, by 2006 total infrastructure investment in the six countries considered represented under 2 percent of their total GDP, barely half of its value in the early 1980s, and well below the level that, according to various estimates, would be required for sustained growth in the region (e.g., Fay and Morrison 2005).

The decline in overall investment was a result of the sharp contraction in investment of the public sector, which fell by two-thirds between the early 1980s and the 2000s. Private investment did show a noticeable rise after 1990, but it peaked in 1998 and stagnated thereafter. In the 2000s its volume has been on par with that of public investment, around 1 percent of GDP. Overall, the private investment expansion was insufficient to offset the fall in public investment.

To complement these aggregate figures, Table 4 provides the details for each of the individual countries and infrastructure sectors considered. In the early 2000s, total investment amounted to less than 3 percent of GDP in all countries except Chile. In all six countries, the fall in public investment between the early 1980s and the early 2000s ranges between 1.5 and 2.5 percent of GDP, with Argentina, Brazil and Mexico showing the biggest falls. The change in private investment over the same period ranges from a fall of 0.5 percent of GDP in Brazil, to a rise of more than 3.5 percent in Chile. As a result, Chile is the only country in which total infrastructure investment actually rose, and the rise extended to all the individual sectors considered.

Across sectors, total investment in telecommunications rose in all six countries shown. In contrast, investment in power fell everywhere except in Chile, and investment in land transportation fell in all countries except Chile (where it rose) and Peru (where it was roughly unchanged). In turn, the fall in public investment affected virtually all countries and sectors. Likewise, private investment rose virtually in all countries and sectors as well, but on the whole its volume has remained fairly modest. The exception is

[26] Argentina, Brazil, Chile, Colombia, México and Peru. The figures shown are GDP-weighted averages. Comparable data for other Latin American economies is not available.
[27] For the purposes of this figure, as well as Table 4 below, total infrastructure investment is defined as comprising power, telecommunications, roads and railways, and water and sanitation. See Calderón and Servén (2009) for details.

the telecommunications sector, which is also the only one in which total (public plus private) investment in 2006 was higher than in the early 1980s, owing to the large magnitude of the private investment expansion. In contrast, in power and land transportation – which account for the bulk of infrastructure investment – total investment in 2006 was, on average, less than half of its level in the early 1980s. It is also worth noting that, of the countries shown, the two that have maintained the highest public investment levels in the 2000s – Chile and Colombia – are also the two that have attracted the largest volumes of private investment, while the two countries where public investment is lowest – Mexico and Peru – also exhibit the lowest levels of private investment. This suggests that private and public infrastructure investment may be complements rather than substitutes, as commonly thought. Empirically, a cross-country cross-sector correlation analysis of public and private infrastructure investment rates shows that overall they are uncorrelated. Hence the presumption that private investment rises would offset the cuts in public investment – which was voiced by some observers as a reason why the public sector retrenchment should not be a concern – does not seem to be validated by the facts: there is no evidence that private investment rose the most in the sectors or countries in which public investment fell the most (Easterly, Calderón and Servén 2003a).

Obviously, from the perspective of growth and development, infrastructure spending is not an end in itself; what matters is its translation into growth- and welfare-enhancing infrastructure assets and services. Such translation is less than exact, as it is mediated by the efficiency of expenditure and the extent of waste and corruption, as a substantial literature has noted (e.g., Pritchett 2000; Keefer and Knack 2008). For the case of Latin America, the link between infrastructure investment and the accumulation of infrastructure assets – such as road network density, or power generation capacity – has been examined by Easterly, Calderón and Servén (2003a). They regress the rate of accumulation of infrastructure assets on sector-specific investment, using a dynamic specification to allow for time-to-build effects in the accumulation of assets, and variously adding country and time-specific effects. On the whole, they find that in most infrastructure sectors investment accounts for a large fraction of the observed variation in asset accumulation – as high as 80 percent in the case of telecommunications, and between 30 and 60 percent in other sectors. Ferreira and Araujo (2007) perform a similar exercise for the case of Brazil, likewise finding that investment has a high explanatory power in simple regressions of infrastructure asset accumulation – except in the case of paved road density, which they attribute to poor data quality.

The conclusion from these exercises is that the persistent fall in infrastructure spending documented above probably accounts for a major portion of the widening gap between Latin America's infrastructure performance and that of other world regions – in terms of quantity, quality and universality of access – over the 1980s and 1990s, which was described in detail earlier in Section 3. Given the substantial contribution that infrastructure development makes to growth– as illustrated in the preceding section -- the implication is that the infrastructure spending fall surely was a significant drag on Latin America's pace of poverty reduction over the last two decades.[28]

The fiscal dimensions of public infrastructure

Comparing the scale of Latin America's fiscal adjustment of the 1980s and 1990s with the declining trend of public infrastructure investment reveals that the fiscal consolidation had a strong bias against infrastructure. On average, the investment cuts accounted for some 40 percent of the observed improvement in the primary deficit in Latin America's major economies between the early 1980s and the late 1990s (Calderón, Easterly and Servén 2003a). But the fiscal pattern of infrastructure compression was not limited to that period. Afonso (2005) documents the case of Brazil, where the bulk of fiscal adjustment occurred later than in the other large economies of the region. Between 1995 and 2003, the primary surplus of the nonfinancial public sector rose by close to 4 percent of GDP. The decline in infrastructure investment over the same period contributed around 1.5 percent of GDP to that rise – that is, about40 percent of the total adjustment.

This is remarkable because public infrastructure investment typically represents a fairly small fraction of GDP, and a relatively small part of overall public expenditure as well. In the case of Brazil just mentioned, investment amounted to less than 3 percent of

[28] Calderón and Servén (2003b) present some estimates of the growth cost of the compression of infrastructure spending in Latin America.

GDP prior to the adjustment – a very modest fraction of the public sector's primary spending. To put it differently, in Latin America's fiscal adjustment investment as a ratio to GDP fell much more abruptly than public consumption. Indeed, in a majority of the countries for which data is available, public consumption rose relative to GDP, while public infrastructure investment fell, implying that the public investment cuts partly financed an expansion of public consumption.

This sort of bias, however, is not exclusive of Latin America's experience. Indeed, the international evidence suggests that it is the rule rather than the exception. Cuts in public investment, and infrastructure in particular, often account for the lion's share of fiscal deficit reduction.[29] And the phenomenon is observed also in rich countries. A case in point was the generalized compression of public investment witnessed across the European Union in the run-up to fulfilling the Maastritch deficit targets (see Balassone and Franco 2000).[30] This tendency towards compression of public investment at times of fiscal austerity underlies the fact that investment is the most volatile of all public spending items.[31]

The seeming anti-investment bias of fiscal discipline likely reflects several factors. Among them, political economy considerations are surely important: it is politically much harder to cut pensions or public sector wages than to cancel infrastructure projects. However, another key factor behind the bias is the fact that fiscal adjustment programs typically focus on the short-term path of the government's cash deficit and debt stock. These two magnitudes are closely scrutinized by multilateral institutions and private creditors and investors, and usually form the basis of loan conditions in the fiscal and macroeconomic dimensions.

However, debt and the cash deficit can be misleading as measures of solvency – which is the ultimate concern of fiscal adjustment programs. The reason is that they

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[29] For developing countries, this was documented by Hicks (1991) in a cross-regional context, and more recently by Estache (2004) for Sub-Saharan Africa. For industrial countries, Roubini and Sachs (1989) and De Haan, Sturm, and Sikken (1996) foud that capital expenditure falls disproportionately at times of fiscal stringency.

[30] Of the nine EU countries that exceeded the deficit target in 1992, eight met it in 1997; in all eight public investment had fallen relative to GDP, and in seven of them it had also fallen faster than other primary expenditure. On the other hand, three of the six countries that met the target already in 1992 raised their public investment in the subsequent years.

[31] This is shown by Talvi and Végh (2000) using data from developing countries, and by Lane (2003) using data from industrial countries.

measure liquidity rather than solvency, and hence do not take into account the assets and the future incomes that the government may acquire by spending and incurring debt today. Solvency assessments based on debt and the cash deficit treat all public expenditures in the same way, since they all pose the same claim on today's fiscal resources. This blurs the distinction between expenditures that yield future fiscal benefits and those that do not—even though they may have radically different implications for tomorrow's public revenues, and therefore for solvency itself. Many infrastructure expenditures fall in the former category: they have a positive impact on growth, and hence on the future expansion of tax bases (or user fee collection) and, ultimately, future government revenues.

Infrastructure cuts set this mechanism in reverse motion: when fiscal adjustment disproportionately cuts infrastructure spending that enhances growth, it can lead to a vicious circle in which low growth generates lower future tax revenues and unsustainable debt dynamics, which force further fiscal adjustment implemented through investment cuts, which lowers growth further, and prompts additional fiscal retrenchment and investment cuts. In other words, if debt stabilization is pursued primarily by cutting productive spending, the result can instead be destabilization (Easterly, Irwin and Servén 2008). Public infrastructure investment cuts therefore fall in the category of 'illusory fiscal adjustment' (Easterly 1999), whose result may be to weaken public sector solvency rather than enhance it.

All this casts doubt on the contribution of Latin America's public infrastructure spending cuts to strengthen the finances of the region's governments. Calderón, Easterly and Servén (2003b) offer some illustrative calculations suggesting that the solvency-enhancing impact of infrastructure investment cuts falls quickly as the initial level of government indebtedness rises. The reason is that the subsequent fall in real GDP growth detracts from future revenues and hence from the government's debt repayment capacity – a mechanism that becomes more important the higher is initial debt. In the Latin American context of the late 1980s and 1990s, this means that infrastructure cuts probably were much more effective at enhancing solvency in low-debt Colombia than in high-debt Bolivia. These exercises are subject to a host of caveats, which make them illustrative rather than conclusive, but they do suggest that, in some Latin American countries, fiscal austerity involving major infrastructure spending cuts not only entailed a substantial growth cost, but also may have been largely ineffective at strengthening public finances – it amounted to attempting to 'walk up the down escalator' (Easterly, Irwin and Servén 2008).

This begs the related question of whether infrastructure can pay for itself – i.e., whether public infrastructure projects can be 'self-liquidating' (Mintz and Smart 2007). Conceptually, the answer depends on three factors (Servén 2008). The first is the magnitude of the growth impact of infrastructure spending, given by the marginal productivity of infrastructure assets and the cost of acquiring them. Other things equal, the growth contribution is likely to be higher when the government has strong project selection capabilities, when the initial endowment of infrastructure capital is low, and when budgetary institutions ensure that the acquisition of infrastructure assets is free from waste and corruption. The second factor is the government's ability to capture at least part of the marginal product of infrastructure, directly via user fees or indirectly through taxes—which, in the latter case, depends on the strength of the tax system and its administration. If these are weak – as happens in many Latin American countries -- and fiscal revenues only capture a small fraction of the extra income, then even projects with high growth impact may weaken public finances. The third factor is the marginal cost of borrowing faced by the government, related to its level of debt and to investors' perceptions about the government's commitment to fiscal stability.

These ingredients involve a host of country-specific, and even project-specific features, so it is not surprising that empirical assessments of the self-financing potential of infrastructure reach different conclusions for different countries. For example, Perotti (2004) investigates whether public investment can "pay for itself" using data from five rich countries—the United States, Germany, the United Kingdom, Canada, and Australia. Perotti's conclusion, based on the estimation of structural VARs, is in the negative – which is not very surprising given that in these countries the public capital stock is probably among the highest in the world.

For Latin America, the only published empirical evaluation of this question is that of Ferreira and Araujo (2007) using Brazilian data in a framework very similar to that of Perotti. Overall, their conclusion is that public infrastructure investment is generally self-financing in Brazil, although in their experiments it takes at least 10 years for the government to collect sufficient tax revenues to recoup the initial investment expenses. Because of this long lag, their results are sensitive to the real interest rate used to discount future revenues.

The experience with private participation in infrastructure

Private sector participation (henceforth PPI) in Latin America's infrastructure surged in the 1990s. Following the opening up of infrastructure activities, private investment commitments rose from $10 billion in 1990 to over $70 billion in 1998. [32] After 1998, however, commitments declined sharply (Figure 5). In spite of an incipient recovery in the 2000s, in 2006-7 private investment commitments averaged less than half of their peak value.

This trend of boom and bust was observed also in East Asia, the other major destination of private infrastructure investment. The decline of the late 1990s can be traced to the retrenchment of global investors in the wake of the financial turmoil of the East Asia and Russia crises – as well as that of Argentina in the case of Latin America. Moreover, the near-completion of the utility privatization cycle in several Latin American countries – which had been a key ingredient in the earlier boom – was another contributing factor to the deceleration of private sector activity. Nevertheless, Figure 5 clearly shows that the scale of private involvement in infrastructure was much larger in Latin America than anywhere else.

The PPI surge was unevenly distributed across sectors and countries in Latin America. As already noted, the telecommunications sector was the prime destination for private investment, both in Latin America as well as the rest of the developing world. In Latin America, close to 50 percent of total private investment commitments over 1990-2007 went to telecommunications. In the rest of the world, the figure exceeded 60 percent. The power sector took second place, with some 30 percent of total private investment in Latin America (25 percent elsewhere). The leading role of telecommunications can be explained by its rapid demand growth potential, the relatively

[32] It is important to emphasize that these figures refer to announced investment intentions, which can (and typically do) differ substantially from actual investment.

short payback period, and the limited social sensitivity and government interference relative to those of other infrastructure sectors. Across countries, Brazil took the lion's share of private infrastructure finance, followed by Argentina and Mexico. These three countries alone accounted for close to half of PPI investment worldwide over 1990-2005 (Andrés et al 2008).[33]

Private participation is often mistakenly equated with privatization. In reality, there is a broad range of private participation modes in the provision of infrastructure services, depending on the degree of government involvement, and the allocation of risk and investment responsibilities; see Guasch (2004) for a detailed typology. However, the most common forms are outright privatization, and concessions (also called public-private partnerships, henceforth PPPs). Concessions involve long-term contracts between the government and a private investor that bundle investment and service provision. Unlike privatization, concessions do not entail sale or transfer of assets. They last for a limited period of time, and involve close government oversight.

Relative to other world regions, the frequency of outright privatization has been higher in Latin America – although it lost steam after 1998. Across sectors, privatization has been the preferred mode of private participation in telecommunications and, to a lesser extent, power generation. In roads and water, however, PPPs have been much more common, in large part owing to legal restrictions on the sale of public assets (Andrés et al 2008).

Advocates of Latin America's shift to private financing of infrastructure offered two main arguments to justify its appeal. The first one was the superior efficiency of the private sector at managing and providing infrastructure services, relative to the inefficiency of state-owned enterprises, and the perception that the private sector would be better able than cash-strapped SOEs to expand access and improve the quality of services. We shall review below the evidence on this claim.

The second argument was that delegation of investment and service provision to the private sector would alleviate the fiscal burden of infrastructure development and release public funds for other uses. The validity of this claim, however, depends on that

[33] This refers to absolute investment figures. Relative to GDP, however, Bolivia stands out as the country attracting the largest PPI amounts.

of the previous one. In present value terms, privatization of public infrastructure assets (or the state enterprises that operate them) does not improve public finances unless the government is able to collect privatization proceeds in excess of the present value of the net returns it would have obtained from providing the infrastructure services. If investor myopia is ruled out, this can happen only if the private purchaser of the assets can operate them more efficiently, and hence obtain higher returns, than the government would have.

The same reasoning applies to PPPs, under which investment is done by the franchise holder in return for future service fees collected from the users (plus government subsidies in some cases). Resources saved by the government by not having to finance the upfront investment are offset one-for-one by ceding the future revenue flows to the private sector, so there is no net gain to the public sector in present value terms, regardless of whether raising public funds involves distortions or not (Engel, Fischer and Galetovic 2007).

Yet resort to privatization and PPPs was often guided by fiscal considerations rather than by the search for efficiency. In effect, these arrangements offered a way to place investment projects beyond the reach of short-term deficit and debt targets – not unlike the off-budget vehicles for infrastructure investment to which some governments resorted in order to hide investment costs (and the associated liabilities) from public view. In the case of PPPs, these explicit liabilities were typically replaced with contingent liabilities in the form of minimum revenue, credit and/or foreign-exchange guarantees granted to private investors – like in the cases of roads in Chile and Colombia (Irwin et al 1997) – or long-term purchase obligations (such as 'take or pay' agreements) under which the government commits to acquiring the service from the private provider.

In this fashion, the government may be left with essentially the same liabilities and risks that it would have acquired if the project had been undertaken directly by the public sector – except for the fact that the lack of clear standards for the budgetary accounting of contingent liabilities and long-term obligations allows them to go unnoticed. Because forecasts of the growth in demand for new services supplied by concessionaries at the time of contract negotiation tend to be overstated, minimum revenue and similar guarantees have been called relatively frequently, often with major fiscal consequences.[34] In the case of Colombia, for example, generous government guarantees eventually resulted in fiscal costs in excess of 50 percent of the total investment supplied by the private sector. In the case of power generation projects, the figure was as high as 90 percent. Even when guarantees were not formally offered ex-ante, they were often provided ex-post through renegotiation of concession agreements.[35] In the case of roads, the result of these ex-ante and ex-post guarantees is that, contrary to expectations, private financing of new highways freed up few government resources because large volumes of public funds were diverted to bailouts of franchise holders (Engel, Fischer and Galetovic 2003).

Of course, PPP arrangements involving contingent government obligations can, and sometimes do, have efficiency-increasing effects, but they often leave the public sector – that is, taxpayers -- bearing most or all of the investment risk (Hemming et al 2006, Irwin 2007a). And they pose the danger that the selection and design of infrastructure projects may be guided more by their repercussions on fiscal accounting than by their efficiency-enhancing potential.[36]

Finally, let us turn to the achievements of PPI in terms of the efficiency, quality and coverage of infrastructure services. In the early 1990s, advocates of private participation held high hopes that the private sector would take the leading role and help quickly realize major gains along all these dimensions. Almost two decades later, the view is much more nuanced. Gains from PPI have been uneven and, after the boom-and-bust cycle of private investment, it is increasingly clear that the public sector will continue to play a key role in Latin America's infrastructure for years to come.

One of the key disappointments was the extremely high frequency of renegotiation of concessions, which has been thoroughly examined by Guasch (2004).

[34] Guarantees are usually procyclical – i.e., they are often granted in the cyclical upswing, even though they are reflected in the fiscal accounts only at the time when they are called, typically in the downswing. Indirectly, this understatement of public liabilities in the upswing helps encourage overspending in good times, a chronic fiscal problem in Latin America.

[35] For example, the bailout of the Mexican toll road program in 1997 cost between 1 and 1.7 percent of GDP (World Bank 2005; see also Guasch 2004).

[36] The key source of efficiency gains arises from the 'bundling' of asset creation and operation under PPPs. Under appropriate conditions, this provides the right incentives for optimal design and maintenance of the assets; see e.g., Marimort and Pouyet (2008). However, the same result could conceivably be achieved under traditional public provision of services if adequate budgetary provisions for O&M expenditures are made at the time of initial investment.

Until 2001 renegotiation had affected over half the concessions in Latin America. Its incidence was particularly high in the water and transport sectors, in which the vast majority of contracts (81 and 65 percent, respectively) were renegotiated. Moreover, renegotiation of long-term contracts typically occurred soon after the concession agreement – around two years on average – which strongly suggests that renegotiation was not the response to events unforeseen in long-term incomplete contracts.[37]

In principle, renegotiation just implies a departure from the expected service improvements; in practice, its outcome has been almost always adverse for the users, in the form of delays, reduced investment obligations and higher tariffs. Renegotiation has been singled out as the key reason why highway privatization failed to deliver its expected benefits (Engel, Fischer and Galetovic 2003). Like explicit guarantees, access to renegotiation weakens operators' incentives to assess accurately expected project profitability, limit risk-taking and improve efficiency, which is the key rationale for private participation in the first place. Renegotiation in fact allowed operators to shift losses to taxpayers, a strategy facilitated by the lack of public scrutiny that characterized most renegotiation episodes.

Most observers attribute the incidence of renegotiation to the poor design and enforcement of PPP contracts. There were two main factors behind this. The first one was the weak regulatory framework under which concession agreements were reached – with the rush to private involvement taking priority over regulation. The lack of a clear contractual structure led to cost overruns and violation of the conditions of the original contracts. The fact that performance of the agency supervising the franchises was often measured by the scale of the concession program contributed to the regulator's lax enforcement of contract compliance. The second factor was the inadequate contractual allocation of risks, in large part due to the use of fixed-term contracts that in effect leave demand risk to the operator. This fueled operators' pressure for guarantees and renegotiation. Research suggests that it would have been preferable to design the concessions as variable-term franchises (Engel, Fischer and Galetovic 2007). But the main lesson is that without credible hard budget constraints on franchise holders and

[37] Engel, Fischer and Galetovic (2009) also find that concession renegotiations in Chile typically happened at the early stages of the contract, e.g., during construction.

independent regulatory and supervisory bodies, private provision may not be better than public provision of highways.

On the other hand, the lack of adequate accounting standards probably was another contributing factor to the ubiquitous renegotiation of concessions. In effect, it allowed governments to backload payments, by accepting lowball bids at the initial negotiation stage, and then compensating the concessionaries with additional payments after renegotiation. The reason is that, unlike the initially-negotiated amounts, the additional expenditures and future commitments acquired by the government in the renegotiation are typically not recorded in the budget. Engel, Fischer and Galetovic (2009) argue that this strategy offered governments the possibility of hiding part of their spending, and shift the burden of payments to future administrations.[38]

For sectors other than roads (that is, telecommunications, power and water), Andrés et al (2008) offer the most comprehensive evaluation to date of the results of PPI in Latin America. Their study distinguishes between transitional and long-run effects, and is based on counterfactual scenarios that are not static but assume instead the continuation of pre-PPI trends. While details vary across countries and sectors, overall the conclusion is that private participation did result in improved quality of service, higher technical efficiency – as measured by distributional losses and service reliability -- and increased sector productivity. On the other hand, PPI had no discernible effects on output volume or service coverage trends, resulted in higher prices more often than not – although in many cases pre-privatization prices were highly subsidized and fell short of cost recovery – and led to reduced sector employment (which was the main mechanism behind the productivity increases).

The study also highlights key factors that held up the gains from private participation. They echo those mentioned above in the context of highway privatization. The weak regulatory framework and poor supervisory capacity were often unable to prevent public monopolies from becoming private ones – a deliberate strategy on the part of the government in some cases, in order to maximize the concession (or divestiture) price. In addition, the poor design of concession agreements and privatization programs

[38] The most obvious way to close this loophole would have been to ensure that infrastructure assets procured through PPPs are fully counted as public investment. Of course, this would have reduced considerably the appeal of PPPs.

led to continuous conflicts and ended up costing governments enormous sums. The lack of transparency of the whole process of privatization, contract award and renegotiation contributed to fuel popular discontent with private participation.

To a large extent, the drive towards private sector participation was prompted by the severe governance difficulties and incentive problems posed by public sector provision of infrastructure services. Almost two decades later, the experience of Latin America shows that the governance and incentive problems posed by private participation are no less thorny.

5. Conclusions

Poor infrastructure is commonly viewed as a key obstacle to economic development. Across Latin America, there is an increasing perception that inadequate infrastructure is holding back growth and poverty reduction. As a result, infrastructure has become a major priority in the policy agenda. This paper has offered an overview of the trends in Latin America's infrastructure sectors over the last quarter-century, and an evaluation of the potential contribution of improved infrastructure to growth in the region.

We document the evolution of infrastructure availability, quality and accessibility across the region, in comparison with other benchmark regions. This is done for four basic infrastructure sectors: telecommunications, electricity, land transportation, and water and sanitation. In spite of the progress made in some specific cases, on the whole Latin America and the Caribbean still lags significantly other MICs and East Asian countries both in terms of quantity and quality of infrastructure. The same holds for the universality of infrastructure access in the region: it is still well behind that of East Asia and other MICs.

We also offered an empirical evaluation of the potential contribution of infrastructure to growth in the region. The quantitative assessment is based on the estimation of infrastructure-augmented growth regressions using a large time-series cross-country data set. The empirical approach encompasses different core infrastructure sectors, considers both the quantity and quality of infrastructure services, and employs instrumental variable techniques to account for the potential endogeneity of infrastructure and non-infrastructure determinants of growth. Overall, there is robust evidence that infrastructure development —measured by an increased volume of infrastructure stocks and an improved quality of infrastructure services— has a positive impact on long-run growth. Also, the evidence suggests that these effects are not different in Latin America vis-à-vis other regions. In short, given the gap in terms of infrastructure availability, quality and accessibility between the region and comparable country groups, the conclusion is that infrastructure development offers a considerable potential to speed up the pace of growth and poverty reduction across Latin America.

Over the last quarter-century, the roles of the public and private sector in Latin America's infrastructure have undergone big changes. A substantial retrenchment of the public sector has been accompanied by a surge in private participation. This paper has offered a detailed account of the trends in their respective contributions to infrastructure financing across the region, drilling down to the level of individual infrastructure subsectors.

The pressures of fiscal consolidation had a disproportionate adverse effect on public infrastructure spending. We have argued that much of this anti-investment bias can be traced to the use of cash deficit targets to guide fiscal adjustment. The reason is that cash deficit targets refer to the liquidity rather than solvency of the public sector: they disregard the future revenues that increased infrastructure can bring about through its effect on growth. Public infrastructure cuts achieve short-term fiscal adjustment at a potentially high cost in terms of growth –even at the cost of a future weakening of public finances. Because private sector participation was not sufficient to offset the contraction of Latin America's public infrastructure spending, the ensuing fall in total spending resulted in a slowdown in infrastructure development in the region, and a widening gap vis-à-vis other world regions in terms of both infrastructure and growth.

The paper has reviewed also the experience with private sector participation in Latin America's infrastructure over the last two decades. Private financing has not come to play the dominant role in the provision of infrastructure services in Latin America and elsewhere that some observers expected. Although private financing now dominates telecommunications and has a significant presence in other infrastructure industries in some countries, it still plays a small role in roads and water and sanitation. This is unlikely to change in the near term, and it is increasingly clear that the public sector will continue to play a major role in Latin America’s infrastructure for years to come.

There is no question that private participation did deliver some efficiency and quality gains. But they were held back by weak regulatory and supervisory frameworks, and poorly-designed concession and privatization agreements, which led to ubiquitous renegotiations and ended up costing governments enormous sums. The drive towards private sector participation was prompted by the governance difficulties and incentive problems posed by public sector provision of infrastructure services. Twenty years later, the experience of Latin America shows that the governance and incentive problems posed by private participation are not less difficult.

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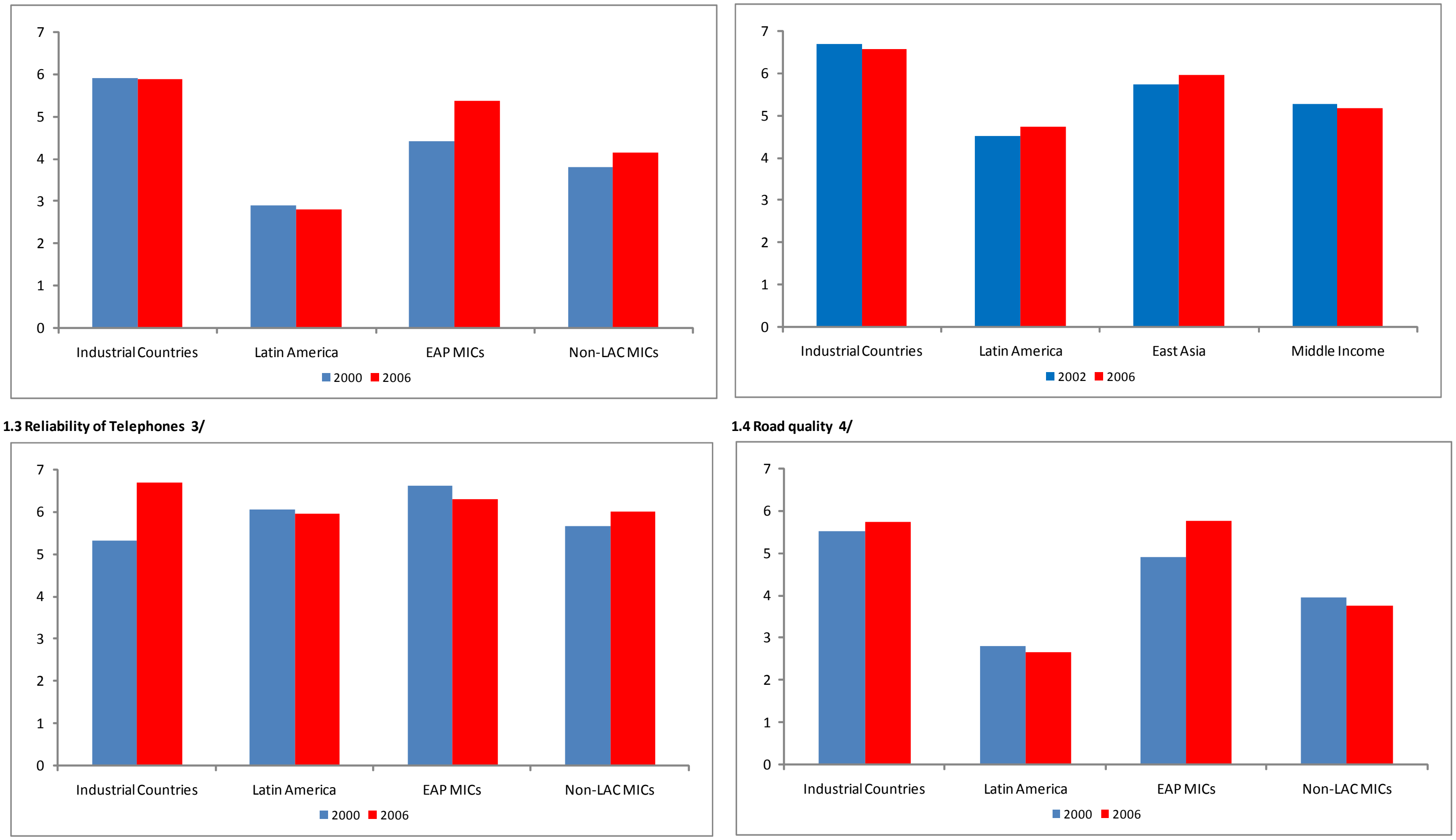
Figure 1
Survey measures of infrastructure quality

1.1 Overall quality of infrastructure 1/

1.2 Power supply 2/

1.3 Reliability of Telephones 3/

1.4 Road quality 4/



The measures of perception of the quality of infrastructure reported here are surveyed by the World Economic Forum's World Competitiveness Review. It gives marks from 1 (strongly disagree) to 7 (strongly agree) to the following statements: 1/ The quality of the infrastructure in your country is among the best in the world. 2/ Your country has sufficient power generation capacity. 3/ Telephone lines have ample capacity and are highly reliable. 4/ Roads are extensive and well maintained.

Figure 2
Infrastructure quantity, quality, growth and inequality

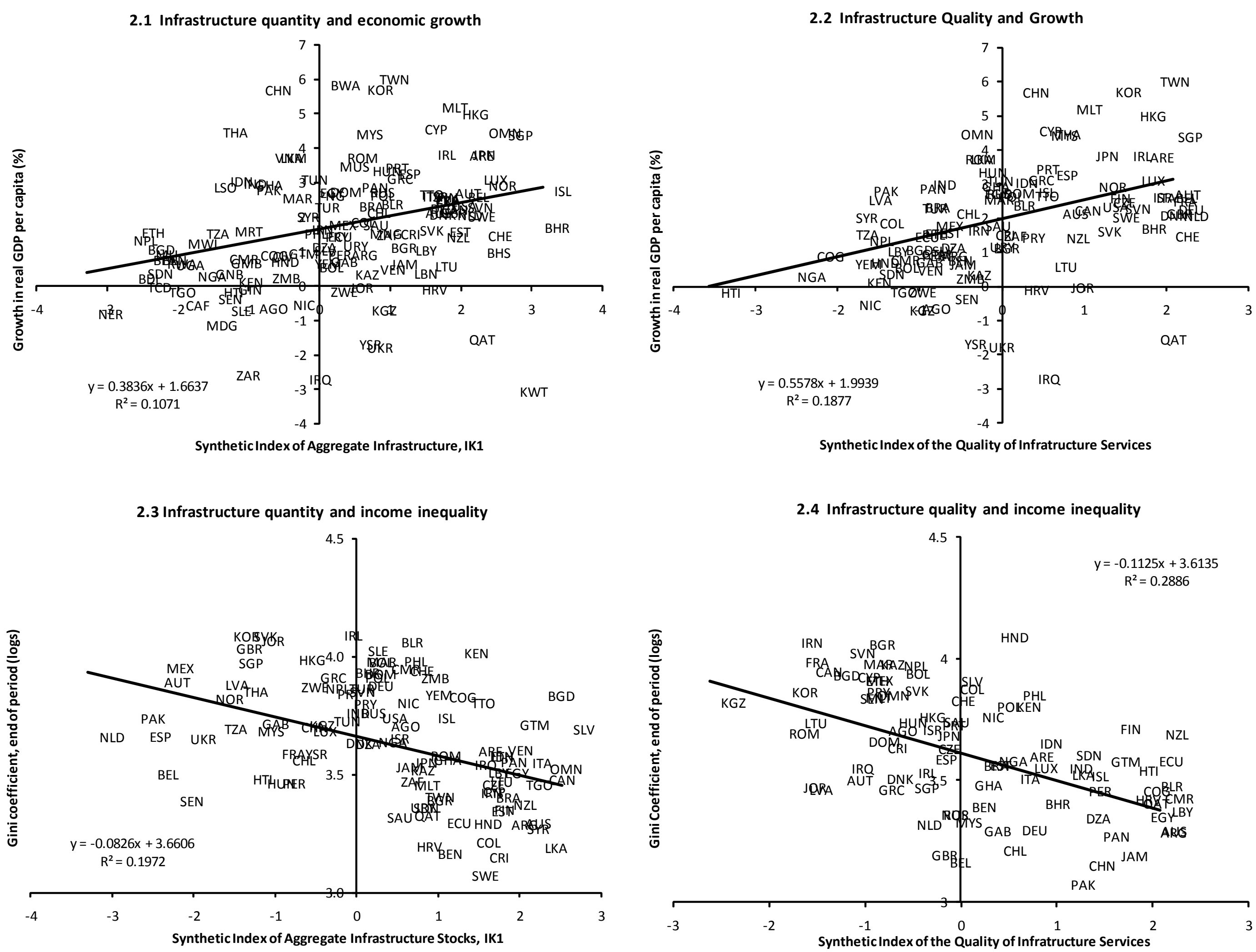
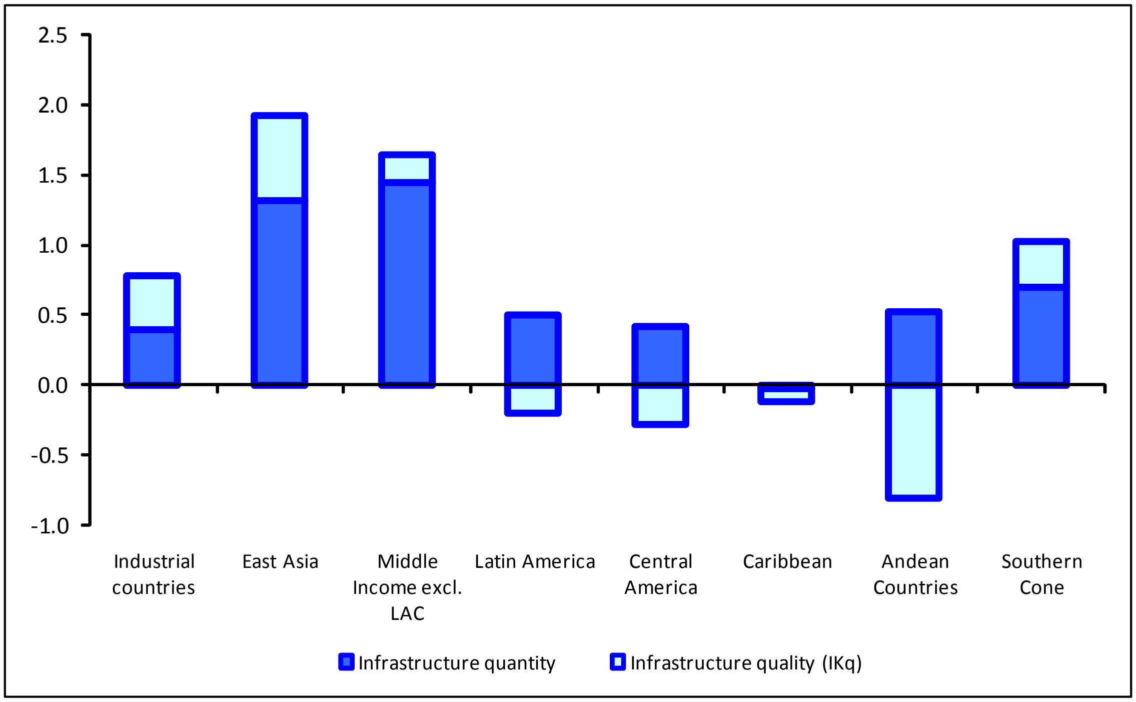


Figure 3
Growth changes across regions due to infrastructure development
(Change in average per capita growth)

3.1 Change in average per capita growth, 1986-90 vis-à-vis 1976-80



3.2 Change in average per capita growth, 2001-5 vis-à-vis 1991-5

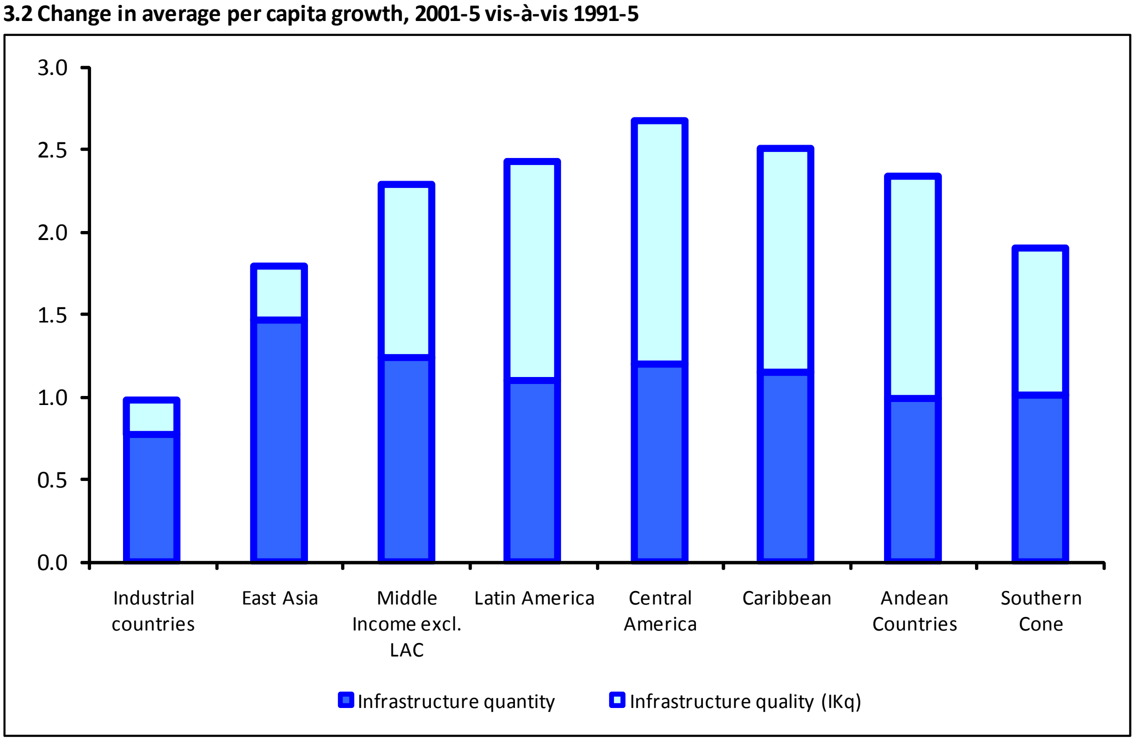
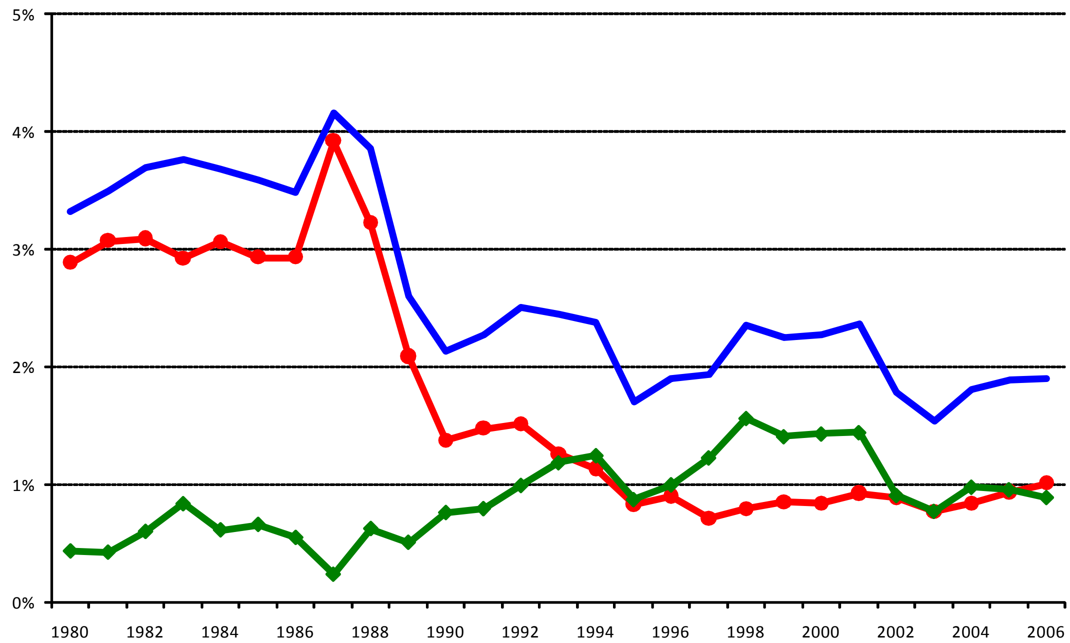
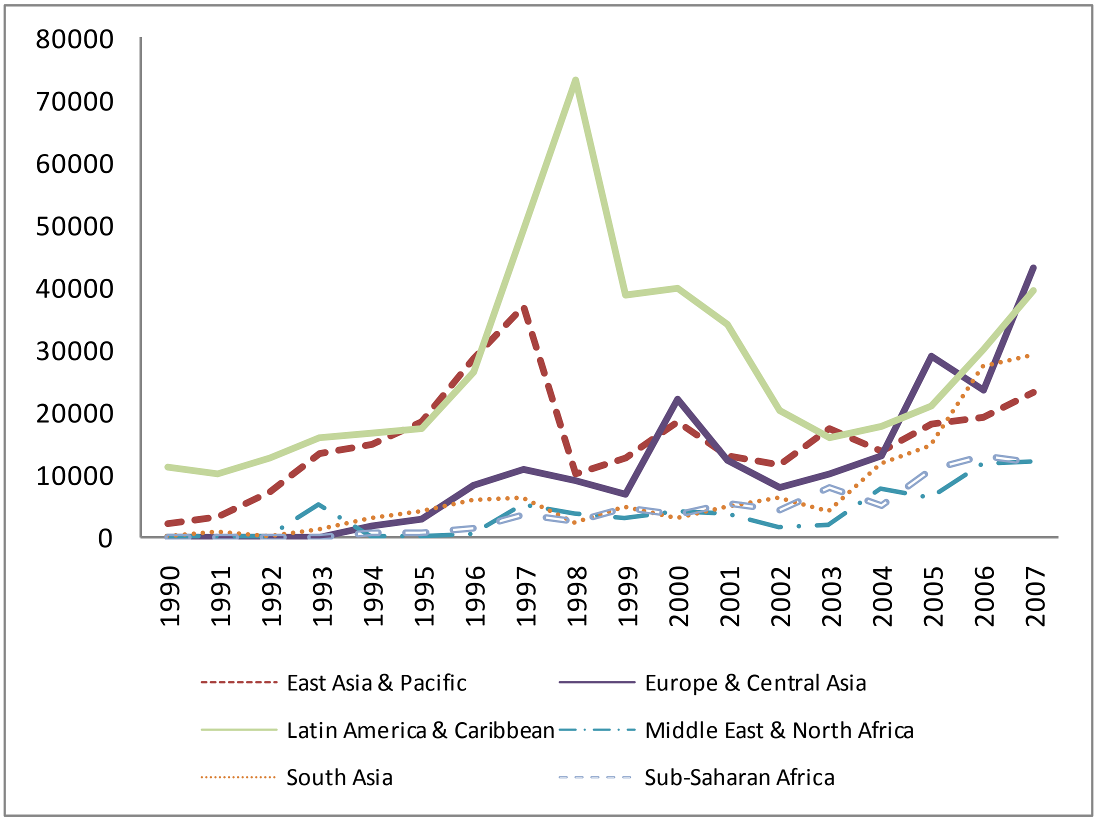


Figure 4
Total Infrastructure Investment in Latin America
(as a percentage of the GDP, GDP-weighted average)



Note: Total infrastructure investment includes investment outlays in telecommunications, electric power, land transportation (roads and railways), and water and sanitation. The regional figure is the GDP-weighted average of investment outlays in infrastructure for Argentina, Brazil, Chile, Colombia, Mexico and Peru.

Figure 5
Private sector participation in infrastructure
Investment commitments by region, US$ million



Source: World Bank PPI database

Table 1

Infrastructure Quantity and Quality: LAC vis-à-vis Other Regions

(5-year period averages)

Region		Infrastructure Quantity 1/ Synthetic Index	Telecom	Electric Power	Total Roads	Infrastructure Quality 2/ Synthetic Index	Telecom	Electric Power	Total Roads
Industrial countries	1981-5	1.61	774	2.83	0.992	1.49	0.998	0.929	0.811
	1991-5	1.81	1095	3.48	1.031	1.71	1.000	0.938	0.915
	2001-5	2.09	2778	3.96	1.363	1.84	1.000	0.936	0.919
East Asia	1981-5	0.63	298	0.71	0.528	0.90	0.912	0.917	0.831
	1991-5	1.20	796	1.14	0.602	1.46	1.000	0.919	0.870
	2001-5	1.92	2437	2.36	0.961	1.49	1.000	0.943	0.958
Middle income countries	1981-5	0.10	121	0.73	0.123	0.16	0.208	0.894	0.309
	1991-5	0.52	228	0.99	0.160	0.59	0.287	0.887	0.494
	2001-5	1.02	872	1.27	0.179	0.97	0.675	0.885	0.481
Latin America (LAC)	**1981-5**	**0.16**	**93**	**0.56**	**0.118**	**-1.19**	**0.293**	**0.881**	**0.145**
	1991-5	**0.40**	**186**	**0.77**	**0.136**	**-1.17**	**0.329**	**0.865**	**0.183**
	2001-5	**0.88**	**758**	**1.02**	**0.144**	**-0.44**	**0.821**	**0.856**	**0.234**
Central America	1981-5	-0.14	49	0.36	0.146	-1.27	0.304	0.876	0.140
	1991-5	-0.03	94	0.37	0.136	-1.31	0.212	0.872	0.183
	2001-5	0.57	729	0.47	0.157	-0.66	0.719	0.828	0.286
Caribbean	1981-5	0.33	61	0.56	0.602	-0.90	0.168	0.791	0.300
	1991-5	0.67	186	0.65	0.763	-0.27	0.379	0.837	0.585
	2001-5	1.39	972	1.25	0.833	-0.23	0.570	0.836	0.608
Andean Countries	1981-5	0.16	93	0.55	0.071	-1.21	0.222	0.883	0.108
	1991-5	0.31	143	0.50	0.096	-1.65	0.329	0.839	0.119
	2001-5	0.86	610	0.61	0.101	-0.99	0.700	0.832	0.152
Southern Cone	1981-5	0.32	122	0.85	0.076	-0.92	0.451	0.891	0.111
	1991-5	0.50	280	1.28	0.078	-0.64	0.567	0.868	0.152
	2001-5	0.96	933	1.47	0.081	-0.11	0.854	0.865	0.205
Selected LAC Countries									
Argentina	1981-5	0.32	225	1.34	0.076	-1.18	0.223	0.881	0.262
	1991-5	0.40	309	1.28	0.078	-1.02	0.567	0.840	0.284
	2001-5	0.77	964	1.47	0.081	-0.29	0.838	0.865	0.279
Brazil	1981-5	0.46	122	0.75	0.169	-0.92	0.451	0.899	0.071
	1991-5	0.59	167	0.78	0.206	-1.17	0.517	0.865	0.083
	2001-5	1.12	933	0.93	0.221	-0.66	0.854	0.856	0.111
Chile	1981-5	0.37	110	0.85	0.109	-1.29	0.283	0.885	0.111
	1991-5	0.82	280	1.00	0.105	-0.64	0.524	0.901	0.152
	2001-5	1.57	1656	1.69	0.106	0.50	0.883	0.941	0.205
Colombia	1981-5	0.32	134	0.55	0.086	-1.49	0.314	0.864	0.102
	1991-5	0.64	207	0.65	0.096	-1.85	0.339	0.825	0.119
	2001-5	1.07	657	0.64	0.101	-1.51	0.467	0.832	0.152
Mexico	1981-5	0.10	144	0.83	0.111	-1.21	0.051	0.894	0.327
	1991-5	0.32	240	0.90	0.136	-0.94	0.284	0.881	0.338
	2001-5	0.88	1075	1.04	0.176	-0.85	0.569	0.871	0.335
Peru	1981-5	-0.03	56	0.53	0.051	-1.21	0.222	0.902	0.108
	1991-5	0.02	81	0.46	0.055	-1.56	0.329	0.854	0.109
	2001-5	0.49	370	0.48	0.061	-0.52	0.578	0.906	0.137
Venezuela	1981-5	0.79	180	2.02	0.071	-1.01	0.203	0.883	0.368
	1991-5	1.12	278	2.39	0.101	-1.65	0.136	0.839	0.344
	2001-5	1.37	864	1.81	0.105	-1.65	0.174	0.799	0.336

1/ The synthetic index of infrastructure quantity summarizes the information of (the log of) the following infrastructure variables: a) telephone main lines and mobile phones, b) electricity generating capacity (inmegawatts); and, c) length of the road network (in km.). Note that all these variables are in logs. The synthetic index is the first principal component of the log of these three measures. Telephone main lines and mobile phones (our proxy of telecommunications) are expressed in lines per 1000 workers. Electricity generating capacity is calculated in megawatts per 1000 workers. Finally, the road length is computed in km. per sq.km. of surface area of the country. 2/ The synthetic index of infrastructure quality summarizes the information of the following measures: a) quality of telecommunication services, b) quality of electric energy provision, and c) road quality. Note that all these variables are normalized such that higher values indicate higher quality of ser The synthetic index is the first principal component of the log of these three measures. On the other hand, the quality of telecommunication services is approximated by the (inverse of) waiting time of main line installation. Quality of electric energy provision is measured as the (arithmetic inverse) of the share of the transmission and distribution losses in electric energy production. Finally, road quality is measured as the share of paved roads in total roads.

Table 2
Access to Infrastructure
(Averages for the latest available year)

	Industrial Countries	East Asia	Non-LAC MICs	Latin America
Access to fixed telephone *1/*	92.5	51.8	50.9	46.6
Coverage of mobile cellular network *1/*	99.0	90.9	85.7	84.8
Access to internet *1/*	47.2	60.0	14.9	8.6
Rural Road Access (RAI) *2/*	93.7	85.3	76.0	64.3
Access to electricity network *3/*	..	98.4	90.2	86.7
Access to improved water sources *4/*	100.0	95.0	83.5	79.0
Access to improved sanitation facilities *4/*	100.0	98.5	94.5	93.0

1/ Access to telecommunication services is measures by the percentage of households with fixed telephones, the coverage mobile cellular network (population, in percentages), and the percentage of homes with internet. The data is obtained from the International Telecommunications Union (ITU) database. 2/ The rural access index (RAI) was constructed by Roberts et al. (2006) and is obtained from household survey results. 3/ The indicator reported is the percentage of households with access to electricity. The data is compiled from household surveys by Cieslowski (2008), and it refers to commercial sales of electricity (excluding unauthorized connections). 4/ We show the percentage of the population with improved water sources and sanitation facilities. Data collected from the World Health Organization and UN Children's fund, Joint Monitoring Program.

Table 3

Infrastructure and Economic Growth

Dependent Variable: Growth in GDP per capita (annual average percent)

Estimation: GMM-IV System Estimation

Sample: 97 countries, 1960-2005 (non-overlapping 5-year period observations)

	Synthetic index of infrastructure quantity IK1		Synthetic index of infrastructure quantity IK2	
Variable	**[1]**	**[2]**	**[3]**	**[4]**
Infrastructure Development (synthetic indexes):				
Infrastructure Quantity (IK) 1/	2.1927 **	1.9795 *	2.1765 **	2.0227 *
(first principal component of stocks)	(0.981)	(1.107)	(0.986)	(1.132)
IK * Latin America	..	0.197	..	0.595
		(0.993)		(0.961)
Quality of Infrastructure Services (IQ) 2/	1.9581 **	2.0247 **	1.9237 **	2.0248 **
(first principal component of quality measures)	(0.549)	(0.607)	(0.552)	(0.628)
IQ * Latin America	..	-1.2934	..	-1.7010
		(2.074)		(2.038)
Control Variables				
Initial Output per capita / per worker	-6.2404 **	-6.2391 **	-6.2093 **	-6.2818 **
(in logs)	(1.285)	(1.454)	(1.287)	(1.500)
Education	2.7857 **	2.7981 **	2.7535 **	2.6430 **
(secondary enrollment, in logs)	(1.160)	(1.232)	(1.130)	(1.230)
Financial Development	-0.0147	-0.0638	0.0325	0.0057
(private domestic credit as % of GDP, logs)	(0.492)	(0.553)	(0.511)	(0.557)
Trade Openness	1.0965	1.0849	1.0211	1.0041
(trade volume as % of GDP, logs)	(1.410)	(1.372)	(1.378)	(1.350)
Lack of Price Stability	-0.0510 *	-0.0501 *	-0.0543 *	-0.0525 *
(inflation rate)	(0.033)	(0.033)	(0.033)	(0.032)
Government Burden	-1.9217 *	-1.7394	-1.8897	-1.6098
(Government consumption as % GDP, logs)	(1.281)	(1.330)	(1.319)	(1.306)
Institutional Quality	-0.3029	0.6421	-0.2986	0.6508
(ICRG Political risk index, logs)	(1.735)	(2.012)	(1.763)	(2.111)
Terms of Trade Shocks	0.0944 *	0.0659	0.0839 *	0.0562
(first differences of log terms of trade)	(0.051)	(0.052)	(0.053)	(0.051)
Period-Specific Effects				
1966-70	-0.705	-0.729	-0.673	-0.642
1971-75	-1.094	-1.171	-1.133	-1.187
1976-80	-1.978 *	-2.019 *	-2.002 *	-2.030 *
1981-85	-3.312 **	-3.394 **	-3.364 **	-3.427 **
1986-90	-3.102 **	-3.074 **	-3.105 **	-3.056 **
1991-95	-3.860 **	-3.936 **	-3.865 **	-3.883 **
1996-00	-3.919 *	-3.948 **	-3.784 *	-3.762 *
2001-05	-4.532 **	-4.480 **	-4.013 *	-3.925 *
Countries / Observations	97/ 582	97/ 582	582	582
Instruments	89	89	89	89
Specification Tests (p-values)				
(a) A-B test for 2nd-order serial correlation	(0.482)	(0.455)	(0.449)	(0.439)
(b) Hansen test of overidentifying restrictions	(0.275)	(0.309)	(0.299)	(0.336)
(c) Difference-Sargan tests				
All GMM instruments for levels	(0.340)	(0.174)	(0.645)	(0.427)

Numbers in parenthesis are robust standard errors. Our regression analysis includes an intercept and period-specific dummy variables.

** (**) denotes statistical significance at the 10 (5) percent level. Standard errors are computed using the small-sample correction by Windmeijer (2005)*

1/ The synthetic indices of quantity of infrastructure are computed as the first principal component of normalized measures of quantity in telecommunications, electricity and roads. IK1 summarizes information of telephone main lines (ML), electricitity generating capacity (EGC) and length of road network (RD). IK2 summarizes analogous information but uses telephone main lines and mobile phones (MLC) rather than ML. The weights, as obtained from the principal component analysis are: IK1 = 0.606 ML + 0.614 EGC + 0.506 RD, and IK2 = 0.603 MLC + 0.613 EGC + 0.510 RD.

2/ The synthetic index of the quality of infrastructure subsumes information on the quality of the infrastructure services mentioned above: waiting time for main line installation, transmission and distribution losses of electric energy production, and the quality of the road network. Our principal component analysis yields the following weights: IQ = 0.608 QML + 0.559 QECG + 0.564 QRD.

Table 4

Investment in Infrastructure in Latina America, 1981-2006

(Percentage of GDP)

		Electric Power			Land Transportation 1/			Telecommunications			Water and sanitation			Total Infrastructure 2/		
Coutnry	Period	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private
Argentina	1981-6	1.53%	1.53%	0.00%	0.81%	0.81%	0.00%	0.30%	0.30%	0.00%	0.12%	0.12%	0.00%	2.76%	2.76%	0.00%
	2001-6	0.50%	0.06%	0.44%	0.68%	0.56%	0.13%	0.38%	0.00%	0.38%	0.10%	0.06%	0.04%	1.67%	0.68%	0.98%
	Change	-1.02%	-1.47%	0.44%	-0.13%	-0.25%	0.13%	0.08%	-0.30%	0.38%	-0.02%	-0.06%	0.04%	-1.09%	-2.08%	0.98%
Brazil	1981-6	3.30%	2.44%	0.86%	0.82%	0.51%	0.31%	0.72%	0.36%	0.37%	0.30%	0.30%	0.00%	5.15%	3.60%	1.54%
	2001-6	0.63%	0.36%	0.28%	0.41%	0.24%	0.17%	0.78%	0.29%	0.50%	0.28%	0.26%	0.02%	2.11%	1.15%	0.97%
	Change	-2.67%	-2.08%	-0.59%	-0.41%	-0.26%	-0.14%	0.06%	-0.07%	0.13%	-0.02%	-0.04%	0.02%	-3.03%	-2.45%	-0.58%
Chile	1981-6	1.65%	1.65%	0.00%	1.04%	1.04%	0.00%	0.47%	0.47%	0.00%	0.29%	0.29%	0.00%	3.44%	3.44%	0.00%
	2001-6	1.84%	0.32%	1.52%	1.69%	0.71%	0.97%	0.90%	0.00%	0.90%	0.78%	0.64%	0.14%	5.21%	1.68%	3.53%
	Change	0.19%	-1.33%	1.52%	0.65%	-0.33%	0.97%	0.43%	-0.47%	0.90%	0.49%	0.36%	0.14%	1.77%	-1.76%	3.53%
Colombia	1981-6	1.56%	1.56%	0.00%	0.94%	0.94%	0.00%	0.32%	0.32%	0.00%	0.31%	0.31%	0.00%	3.13%	3.13%	0.00%
	2001-6	0.58%	0.45%	0.13%	0.67%	0.48%	0.20%	1.01%	0.36%	0.65%	0.50%	0.40%	0.10%	2.77%	1.68%	1.08%
	Change	-0.98%	-1.11%	0.13%	-0.27%	-0.47%	0.20%	0.69%	0.04%	0.65%	0.19%	0.09%	0.10%	-0.37%	-1.45%	1.08%
Mexico	1981-6	0.51%	0.51%	0.00%	1.50%	1.50%	0.00%	0.24%	0.24%	0.00%	0.19%	0.19%	0.00%	2.44%	2.44%	0.00%
	2001-6	0.20%	0.20%	0.00%	0.37%	0.22%	0.15%	0.54%	0.01%	0.53%	0.11%	0.10%	0.01%	1.23%	0.53%	0.69%
	Change	-0.31%	-0.31%	0.00%	-1.12%	-1.27%	0.15%	0.30%	-0.24%	0.53%	-0.08%	-0.09%	0.01%	-1.21%	-1.91%	0.69%
Peru	1981-6	1.35%	1.34%	0.01%	0.36%	0.34%	0.02%	0.32%	0.32%	0.00%	0.08%	0.07%	0.01%	2.11%	2.07%	0.04%
	2001-6	0.44%	0.16%	0.28%	0.37%	0.09%	0.28%	0.64%	0.26%	0.38%	0.04%	0.02%	0.02%	1.49%	0.54%	0.96%
	Change	-0.92%	-1.18%	0.27%	0.01%	-0.25%	0.26%	0.32%	-0.06%	0.38%	-0.04%	-0.05%	0.01%	-0.62%	-1.54%	0.92%
Weighted Avg.	**1981-6**	**1.91%**	**1.56%**	**0.35%**	**1.02%**	**0.90%**	**0.12%**	**0.46%**	**0.31%**	**0.15%**	**0.23%**	**0.23%**	**0.00%**	**3.62%**	**3.00%**	**0.62%**
(by GDP)	**2001-6**	**0.51%**	**0.26%**	**0.24%**	**0.50%**	**0.29%**	**0.20%**	**0.66%**	**0.14%**	**0.52%**	**0.23%**	**0.20%**	**0.03%**	**1.89%**	**0.89%**	**0.99%**
	Change	**-1.40%**	**-1.30%**	**-0.10%**	**-0.52%**	**-0.60%**	**0.08%**	**0.20%**	**-0.17%**	**0.37%**	**0.00%**	**-0.03%**	**0.03%**	**-1.73%**	**-2.11%**	**0.38%**

1/ Land transportation includes investment in roads and railways. *2/ Total infrastructure consists of power, land transportation, telecommunications, and water.*

Table A-1
Definitions and Sources of Variables Used in Regression Analysis

Variable	Definition and Construction	Source
Real Income per capita	Ratio of real GDP (in US$ at 2000 prices) to total population, beginning of period, and expressed in logs.	Authors' construction using Summers, Heston and Aten (2006)
Economic Growth	Log difference of real GDP per capita.	Authors' construction using Summers, Heston and Aten (2006)
Education	Ratio of total secondary enrollment, regardless of age, to the population of the age group that officially corresponds to that level of education.	Easterly and Sewadeh (2002) and The World Bank's WDI
Financial Development	Domestic credit to the private sector as a percentage of GDP, in logs	Beck, Demirguc-Kunt and Levine (2001) and The World Bank's WDI
Trade Openness	Exports and imports as a percentage of GDP, in logs. All magnitudes expressed in US dollars at 2000 prices.	Easterly and Sewadeh (2002) and The World Bank (2003).
Lack of price stability	CPI inflation rate, in logs. It is computed as log((1+*dp*)*100), where *dp* is the inflation rate. This transformation smooths the original variable and gives less weight to hyperinflation episodes.	Author's calculations using data from IFS and the publications of the Central Bank. The method of calculations is based on Beck, Demiguc-Kunt and Levine (1999).
Government Burden	General Government Consumption Expenditure as percentage of GDP, average of period, and expressed in logs.	The World Bank's World Development Indicators and IMF's Government Financial Statistics
Institutional Quality	ICRG Political Risk Index (in logs). The index includes the following categories: Government Stability, Socio-Economic Conditions, Investment Profile, Internal Conflict, External Conflict, Corruption, Military in Politics, Religion Tensions, Rule of Law, Ethnic Tensions, Democratic Accountability, Bureaucratic Quality	International Country Risk Guide
Terms of Trade	Net barter terms of trade index (2000=100)	The World Bank, World Development Indicators CD-ROM
Terms of Trade Changes	Log differences of the terms of trade index	Authors' construction using WDI
Telecommunications Infrastructure Stock	(a) Main telephone lines per 1000 workers (in logs). (b) Main telephone lines and mobile phones per 1000 workers (in logs).	Authors' construction using Canning (1999) and International Telecommunication Union's World Telecommunication Report
Quality of Telecommunication Services	Waiting time for main telephone line installation. The variable was rescaled such that it takes values between 0 and 1, with higher numbers implying higher quality of telecommunication services.	International Telecommunication Union's World Telecommunication Report and the World Bank's World Development Indicators
Infrastructure Stock of the Electricity Sector	Electricity Generating Capacity (in MW per 1000 workers). The variable was expressed in logs.	Authors' construction using Canning (1999), United Nation's Energy Statistical Yearbook, and national sources where available.
Quality of Electricity Services	Electric Power Transmission and Distribution Losses (as percentage of electricity output). The variable was rescaled such that it takes values between 0 and 1, with higher numbers implying higher quality of telecommunication services.	The World Bank's World Development Indicators and national sources where available.
Road Network	(a) Length of total road network, and (b) Length of paved road network. Both variables are measured in kilometers per sq. km. of surface area of the country, and then expressed in logs	International Road Federation's World Road Statistics, the World Bank's World Development Indicators, and national sources where available.
Quality of the Road Network	Share of paved roads in the overal road network. This variables takes values between 0 and 1, with higher numbers implying higher quality of the road network.	International Road Federation's World Road Statistics, the World Bank's World Development Indicators, and national sources where available.
Synthetic Index of Infrastructure Quantity	First principal component of the three different dimensions of infrastructure considered in our analysis: telecommunications, electricity and roads. IK1 comprises information on main lines, EGC, and total roads; IK2 on main lines, EGC and paved roads. On the other hand, IK3 uses main lines and mobile phones, EGC and total roads, while IK4 uses main lines and mobile phones, EGC and paved roads	Author's calculations.
Synthetic Index of Infrastructure Quality	First principal component of the three different dimensions of infrastructure quality considered in our analysis: telecommunications, electricity and roads. The synthetic index considered transformations of waiting time for main line installation, electricity transmission and distribution losses, and share of paved roads.	Author's calculations.
Period-specific Shifts	Time dummy variables.	Authors' construction.