TABLES

BOX

FIGURES

TABLES

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FILLING THE GAP: INFRASTRUCTURE INVESTMENT IN BRAZIL[1]

This chapter assesses Brazil's infrastructure. Brazil's infrastructure endowment ranks low by international standards, and its low quality affects productivity, market efficiency, and competitiveness. Boosting infrastructure investment is key to unleashing economic growth going forward.

A. Overview

1. Developing an economic strategy to scale up infrastructure investment requires establishing the link between infrastructure provisions and growth, determining the infrastructure gap, and identifying financing and optimal provisioning. Areas where Brazil's competitiveness has lagged include, but are not limited to, education, innovation, governance and justice. Yet, inadequate infrastructure is increasingly identified as the key bottleneck behind low productivity, stagnating export performance, insufficient domestic market integration, and weak growth potential. Market segmentation caused by divergence in relative prices can have potentially severe social and macroeconomic implications. Income inequality may also increase with market segmentation, as low income producers in rural areas are adversely impacted by difficulties accessing large consumer markets. Several years of underinvestment in infrastructure have contributed to reducing potential growth. It has been estimated that inefficiencies due to inadequate infrastructure subtract 10−15 percent from the country's GDP (Credit Suisse, 2013).[2]

2. To underscore Brazil's need for greater investment in infrastructure, we attempt to throw some light on Brazil's infrastructure gaps. Infrastructure investment is often seen as a strategy to promote internal integration and export competitiveness. Following this logic, we first look at how infrastructure affects domestic integration by analyzing price convergence across major cities. Second, using quantity and quality indicators, we look closely at infrastructure gaps across sectors against Brazil's current income levels and against infrastructure levels and quality of Brazil's competitors in its export markets. We then document historical infrastructure investment trends in Brazil, and describe the authorities' concessions program in light of the most pressing infrastructure needs. Finally, we discuss policies that could help close the infrastructure gap.

[1] Prepared by M. Garcia-Escribano, C. Goes, and I. Karpowicz.

[2] According to Credit Suisse (2013), most of the R$1 trillion investment gap is infrastructure related. Underinvestment is especially notable in greenfield projects as brownfield projects were granted to the private sector through concessions. Airports, ports, and rail are the most constrained sectors.

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B. How Integrated is Brazil?

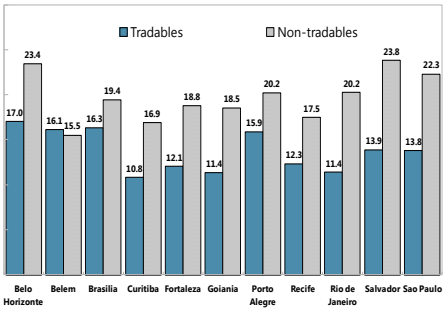
3. We assess market segmentation in Brazil by analyzing convergence of prices across major metropolitan areas. We construct price indices for 51 products across 12 metro areas over the past 14 years, from extended monthly CPI micro data, and test for panel unit root using the methodology developed by Im, Pesaran, and Shin (2003).[3] Intuitively, we are testing for the law of one price (LOOP): if goods markets are well integrated, the difference between the log of price levels (p_{it}) for tradable products in different i cities should be stationary, that is, mean reverting, with relatively fast reversion to the mean after some shock causes a divergence to appear.

Market Integration: Convergence of Tradable Prices

Null Hypothesis: Unit Root	
Reject	**Not Reject**
Cereals, seeds and oilseeds	Canned and preserved foods
Flours and pasta	Salt and spices
Tubers, roots and legumes	Cleaning chemicals
Sugars and derivatives	Furniture
Vegetables	Utensils and ornaments
Fruits	TV, stereos and computers
Meats	Women's clothes
Fishes	Shoes and accessories
Processed meat and fish	Jewelry
Poultry and eggs	Fabrics and haberdashery
Milk and dairy products	
Bakery products	
Oils and fats	
Beverages and infusions	
Pre-cooked meals	
Fuels (domestic)	
Residential electricity	
Bed, bath and table	
Domestic appliances	
Menswear	
Children clothes	
Fuels (vehicles)	
Tobacco	

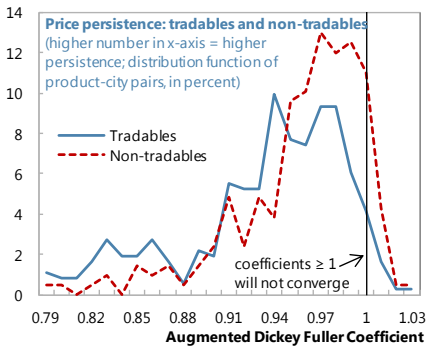
4. Empirical results suggest that most tradables prices converge to the mean, but slowly. We reject the null of unit root for about ⅔ of the tradable products, for which the LOOP holds. These are most notably food and fuels. However, we note that, following a shock to the relative price of a tradable good, prices converge to the long-run national trend only very slowly. The average time it takes for half of the initial price discrepancy to disappear (the so-called 'half-life') is 14 months, with the speed of convergence varying across cities significantly. In Curitiba, for example, the half-life of tradables price convergence is 11 months, while in Belo Horizonte it is 17 months. Around 90 percent of price convergence occurs over 3 years.

Brazil: Metro-Area CPI Divergence Half-Lives
(in months)



Source: Staff estimates

5. The majority of non-tradable products fail to satisfy the LOOP. As expected, we fail to reject the null hypothesis of panel unit root for most non-tradables prices. Additionally, individual Augmented Dickey-Fuller equations show that, while only 5 percent of tradable product prices have explosive processes, about 16 percent of non-tradable prices do. Moreover, for all products that satisfy the LOOP, convergence is considerably slower for prices of non-tradable products. The average half-life of non-tradable price convergence is 20 months, whereas the half life of tradable price convergence is 14 months.



[3]See Appendix II for more detail on the estimation procedure. Half-life (h) is defined as: $h = \ln(0.5)/\ln(|\rho|)$.

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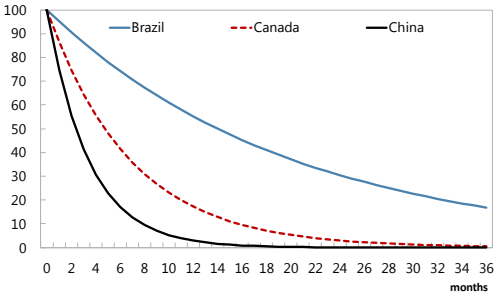
6. Price convergence in Brazil is slower than in comparator countries. International evidence using similar empirical approaches, also applied to monthly CPI data, points to significantly lower half-lives of price convergence in other countries. The average half-life of convergence for China between 1993 and 2003 (Li and Huang, 2006) was 2.4 months, and the half-life for Canada between 1978 and 1994 was 5 months (Fan and Wei, 2006). The results for both countries suggest that more than 90 percent of relative price shocks disappear within 18 months, much faster than in the case of Brazil.[4]

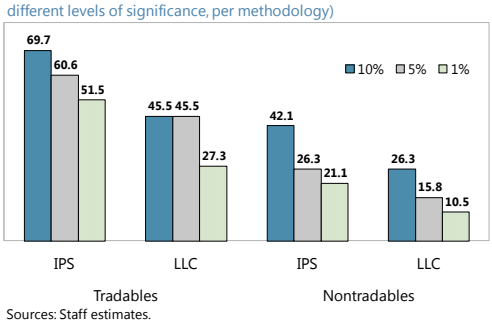
Path of Price Convergence: Response Functions
(shock = 100, x axis in months)



Note: Canada and China calculated from half-lives estimated by Li and Huang (2006) and Fan and Wei (2006).

7. Robustness checks confirm slow price convergence and evidence of market segmentation in Brazil. Using an alternative methodology proposed by Levin, Lin and Chu's (2002), the estimated average half-life of tradable products price convergence is slightly higher (16 months), with a smaller percentage of tradable products satisfying the LOOP. Estimates of convergence of prices using São Paulo as a reference[5] instead of the national mean yield broadly similar results with 61 percent tradable product satisfying the LOOP at slightly higher average half-life of 15 months.

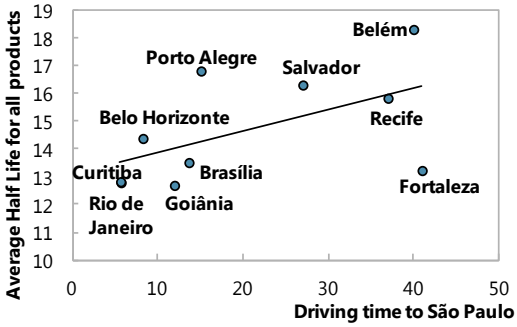
Panel Unit Root Tests Results
(percent rejection of null hypothesis of a panel unit root under different levels of significance, per methodology)



Sources: Staff estimates.

8. Poor infrastructure contributes to market segmentation. Using the São Paulo version of our model, we find a correlation between slower domestic price convergence and longer commuting times between cities. Half-lives of tradables price convergence are found to increase with the travel time between cities. Market integration could therefore benefit from an overall improvement in transport infrastructure, namely roads, that could bring considerably down travel times effectively lessening the shipping times between cities. Still, it is worth noting that even controlling for physical distance, convergence occurs too slowly in Brazil (see the vertical intercept of the chart above). This suggests that other barriers to inter-state trade are also

Brazil: Half Lives of Tradables and Driving Time to São Paulo (y-axis: half lives in months; x-axis, driving time to São Paulo in hours)



Sources: Staff estimates and Google Maps.

[4] Using the aforementioned half-lives (h), we derive the autoregressive term as $|\rho| = \exp(ln(0.5)/h)$ and plot their respective response functions.

[5] We estimate co-integration for every product between the price level in each city and the price level in São Paulo. See Appendix II for details.

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important—among them, the system of state-level indirect tax, the ICMS, is likely a significant factor. But the analysis of the ICMS is beyond the scope of this chapter.

C. The State of Infrastructure

9. Brazil scores low on a large variety of qualitative indicators of infrastructure adequacy. Based on overall infrastructure quality, Brazil ranked 120 out of 144 countries surveyed by the World Economic Forum in 2014, with particularly poor results for roads and air transport quality. In other areas, Brazil ranked in the bottom third of countries surveyed. Brazil's rankings have been low over the past decade, and have generally worsened over the past 5 years (see Figure in Appendix I).[6] But for a more meaningful set of comparisons, we have chosen to benchmark Brazil's infrastructure against that of its main competitors in its own export markets (Box 1 explains our approach to selecting Brazil's group of export rivals).

10. Brazil has inferior overall infrastructure quality relative to almost all its export competitors. Brazil's scores for adequacy of physical capital across all areas of transport infrastructure—roads, ports, railroads and air transport infrastructure—are substantially lower than those of its main export competitors. Only in the area of electricity and telecommunication does Brazil have a better ranking than some competitors, areas in which it has invested comparably more in recent years and more efficiently—through greater participation of the private sector. Still, according to the 2010 World Bank Enterprise Survey, 46 percent of firms in Brazil indicated that electricity was a major constraint to activity (against 38 percent in LAC) while 28 percent of firms considered transportation to be a major constraint (against 23 percent in LAC).

[6] The WEF Survey captures the opinions of 14,000 business leaders around the World on a broad range of topics, including the quality of infrastructure. As such, qualitative infrastructure indicators are based on the aggregation of subjective perceptions. (For the methodology see : World Economic Forum - Methodology)

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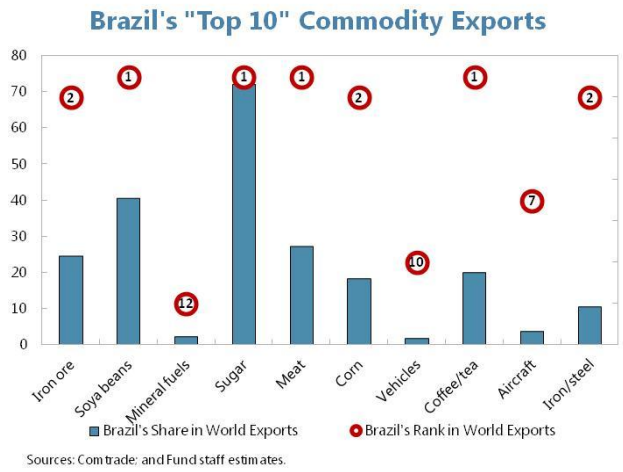
Box 1. The Choice of Infrastructure Comparators

One way of looking at infrastructure gaps is to assess the adequacy of Brazil's physical capital against that of its exports competitors. Infrastructure gaps are often measured in terms of distance from a benchmark defined by a country's level of development, or the level of infrastructure necessary to reach the next development stage. But a gap can also be considered to exist when infrastructure quality (and quantity) falls below that of trading competitors. When gaps exist, countries should be able to extract more rents from exports, and possibly gain market share by decreasing business costs from inadequate infrastructure.

The optimal infrastructure mix will also depend on the type of products exported. Brazil is a diversified economy and a closed one, where exports of goods represent only around 11 percent of GDP. However, Brazil is a leading exporter of some commodities, and the number-one exporter of soybeans, cane sugar, meats and coffee/tea. Over two thirds of the world's cane sugar is produced in Brazil. Yet, other commodity exports, such as iron ore, of which Brazil is the second largest exporter, generate higher revenues from exports.



Who are Brazil's main competitors? Brazil's 10 largest commodity exports by value are used to determine its competitors. Brazil's prospective competitors in each of these products are the 10–15 countries with the largest shares of world exports; Brazil's main competitors are those countries that compete in at least 3 of these products. According to this scale, Brazil's closest competitor is the U.S., competing in 6 of Brazil's export categories, closely followed by Canada and India, competing in 5 export categories. Other competitors include Argentina, Australia, China, Kazakhstan, Mexico, Russia and South Africa.

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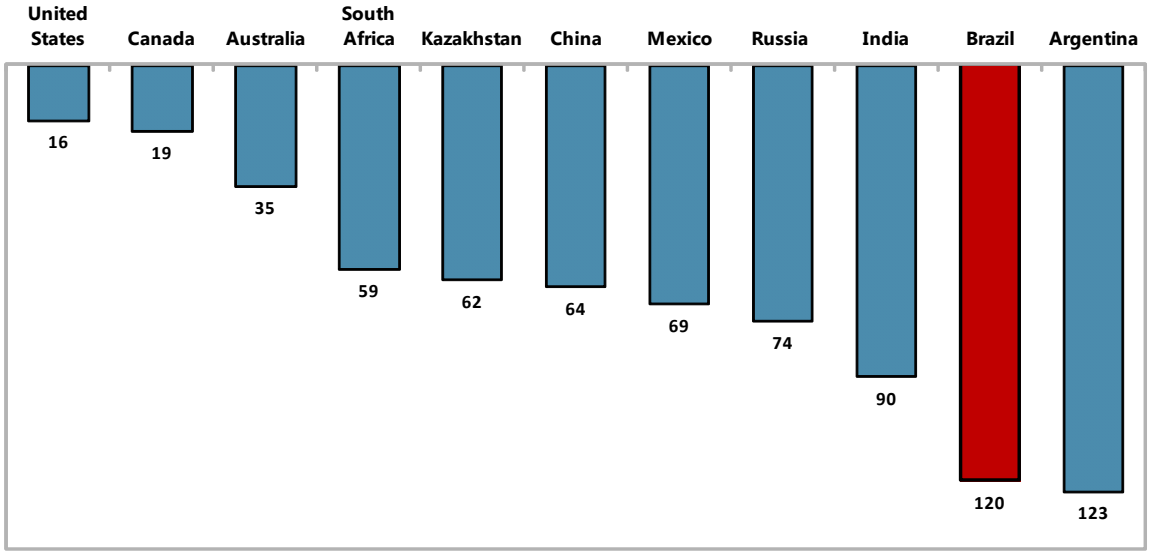
Figure 1. Infrastructure Quality Indicators

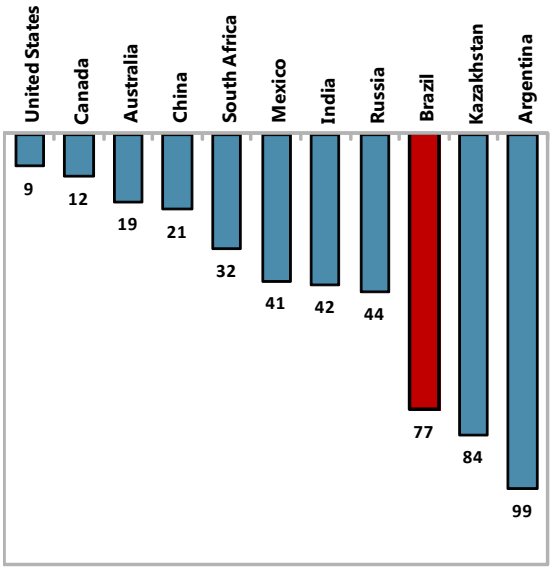
Quality of Overall Infrastructure

(1 = best; 144 = worst)



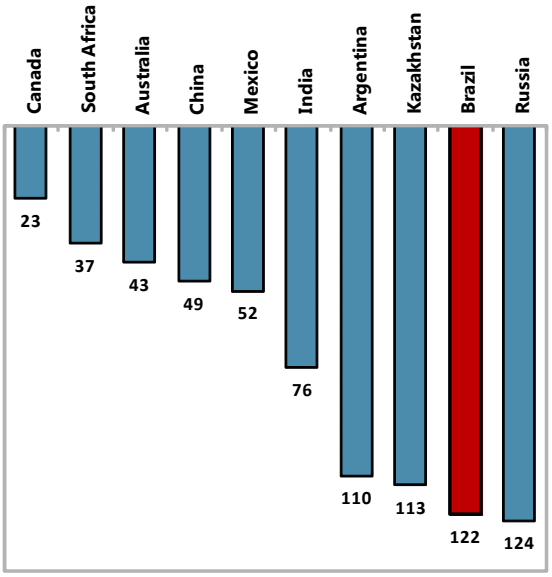
Quality of Transport Infrastructure

(1 = best; 144 = worst)



Quality of Electricity Infrastructure

(1 = best; 144 = worst)



Source: World Economic Forum

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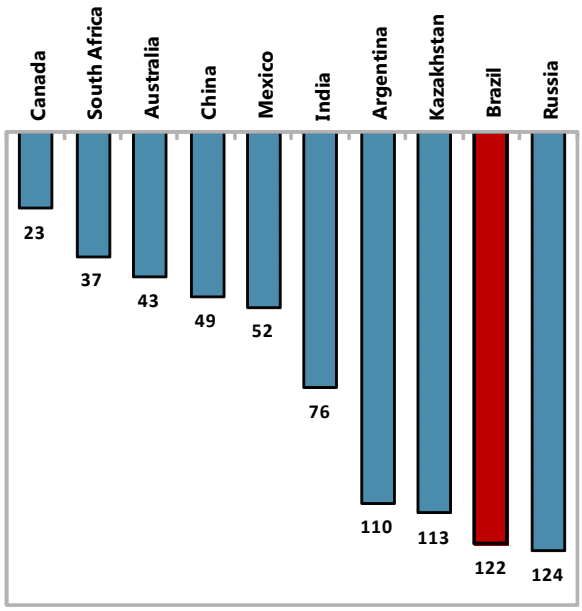
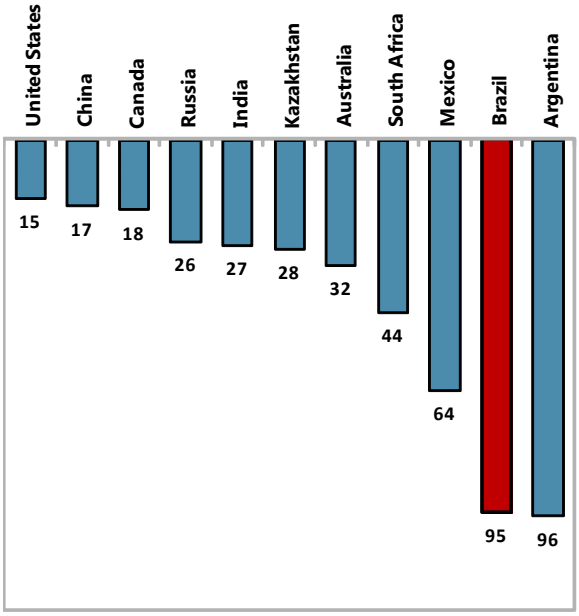
Figure 2. Transport Infrastructure Quality Indicators

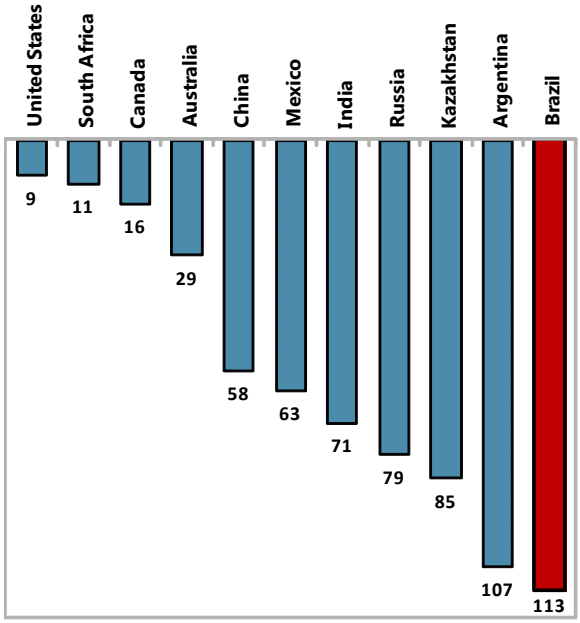
Quality of Roads Infrastructure
(1 = best; 144 = worst)



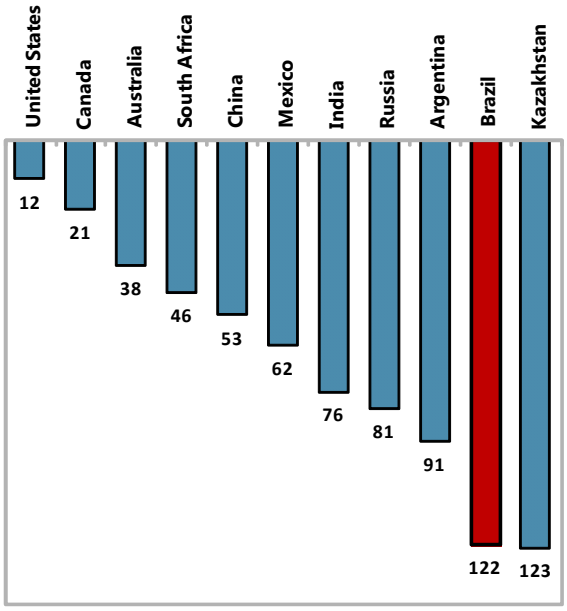
Quality of Railroad Infrastructure
(1 = best; 144 = worst)



Quality of Air Transport Infrastructure
(1 = best; 144 = worst)



Quality of Port Infrastructure
(1 = best; 144 = worst)



Source: World Economic Forum

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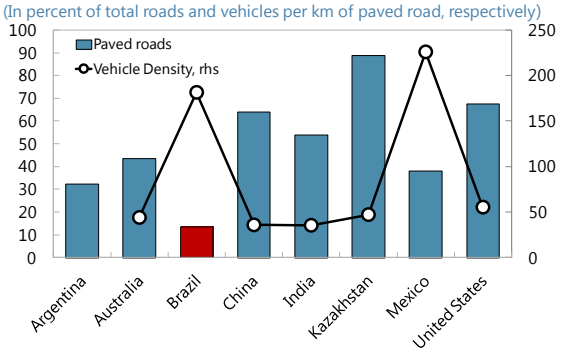
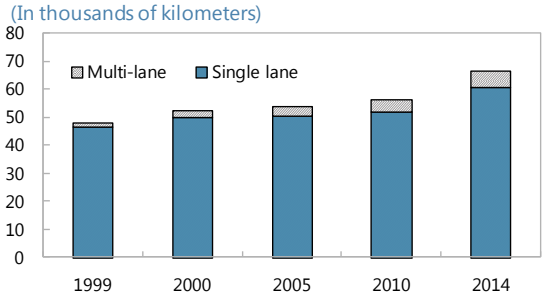
11. Quantitative indicators of infrastructure also paint a grim picture (Box 2). Less than 15 percent of Brazil's roads are paved and congestion is a concern; the estimated number of vehicles per km of road was 25 in 2008 and this number has likely increased in the wake of the recent boom in auto loans as vehicle sales have more than doubled over the past ten years.[7] As a share of paved roads, congestion levels are among the highest against comparators. Moreover, multi-lane roads are still relatively rare in Brazil, although they have doubled over the past half decade.

Paved roads and Vehicle Density
(In percent of total roads and vehicles per km of paved road, respectively)



Source: World Development Indicators, The World Bank.

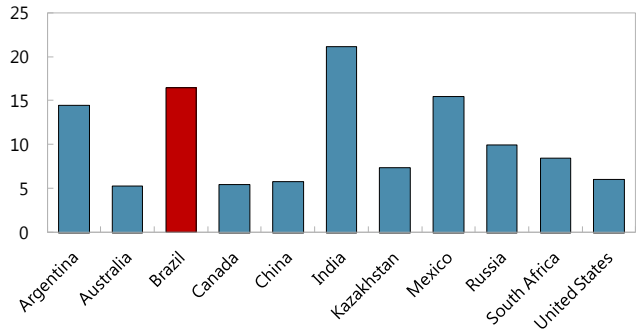
Federal paved roads
(In thousands of kilometers)



Source: Departamento Nacional de Infrastructura de Transportes (DNIT) and Fund staff calculations.

12. Energy indicators are less unfavorable.[8] Per capita electricity generation and consumption have more than doubled since the 1980s and coverage is near universal. However, electric power transmission and distribution losses have increased and now exceed 15 percent of electricity output. Moreover, the recent draught has underscored vulnerabilities from the high dependence on hydropower for electricity generation (Box 3).

Electric power transmission and distribution losses
(In percent of output) 1/



1/ Electric power transmission and distribution losses include losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage.
Source: World Development Indicators, The World Bank.

[7] It is estimated that some 20 million of new vehicles were sold in Brazil since 2008.

[8] Doing Business ranks Brazil in the top 20 based on affordability and the number of procedures and days it takes to obtain electricity.

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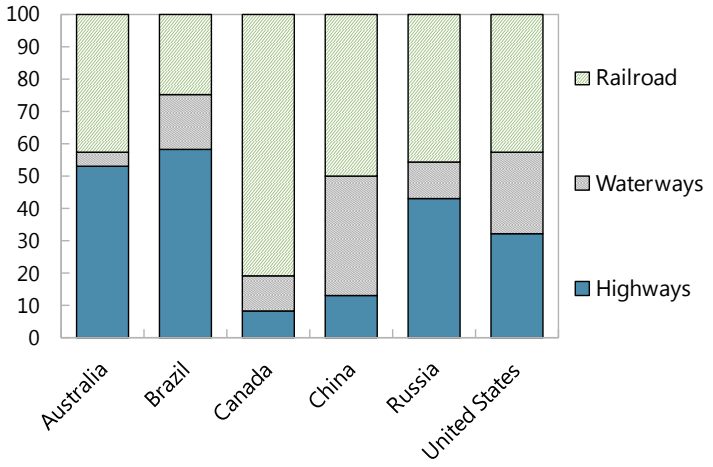
13. Infrastructure gaps in transport appear more dramatic when quality and quantity indicators are coupled with Brazil's transportation mix. Brazil's competitors rely more on rail for moving goods, which is better suited to high-volume, low-value-added commodities. In Brazil, 60 percent of agricultural commodities are transported by highways, while most of the iron ore exported travels by rail (Credit Suisse, 2013). Coupled with the poor state of roads, this transportation mix appears to be a constraint on exports and competitiveness.

Share of Goods Transport
(in percent)



Source: Credit Suisse based on World Bank data, 2013

Box 2. Infrastructure Adequacy Indicators

Infrastructure gaps are usually quantified by estimating the existing capital stock and comparing it to a benchmark, typically based on the country's development level. This method can take into account evolving infrastructure needs along different stages of development and can provide an estimate of underinvestment in a sector. Other quantitative indicators generally measure outputs, such as electricity generation, available km of roads, railroads, or waterways, or airline passenger traffic. These indicators are valuable but they may be difficult to compare across countries.

In practice, the information content of quantitative indicators is partial for a variety of reasons. For instance, the indicator "share of paved roads in total roads" fails to take account of the state of road support services (gas stations, emergency equipment), how well roads connect main business centers, and how many lanes each road has. Maintenance is also an important unknown. Because obsolete infrastructure cannot adequately support production, qualitative indicators should be used to complement the analysis, ideally along with more detailed, sector-specific surveys. Such an approach may shed light on infrastructure quality and its suitability to meet the evolving needs of its users.

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14. Ports and airports are also constrained. Only one of Brazil's ports—the port of Santos (Sao Paulo) —was in the top 100 list of best ports in the world in 2013, occupying the 41st position, thanks to a 6.2 percent rise in throughput in 2012 (Containerisation International). Anecdotal evidence of bottlenecks in Brazilian ports is easy to find; for example, Credit Suisse (2013) notes "10-mile line of trucks waiting at gates to unload the crop and 200 ships waiting to load the cargo". While part of the growing infrastructure gap may be due to inadequate maintenance and intensification of use, the largest share of the gap is most likely due to a prolonged period of underinvestment in relative to other countries.[9]

15. Brazil's infrastructure quality is also below the average in countries with similar income levels. Over 2005−10, the overall infrastructure quality score for Brazil was lower than an average constructed using the distribution of GDP per capita across countries (PPP, constant 2005 international $). Among Brazil's export competitors, the distance from the average was larger only for Argentina. However, the overall result masks differences across sectors. Brazil's electricity supply and telecommunication infrastructure score relatively high. In contrast, the quality of roads, railroads, ports and airports was significantly below average with the largest gaps in road and port infrastructure.

[9] Sector-specific gaps can accrue also as a result of changing production patterns, technological change, energy costs, and changes in income distribution, among other factors.

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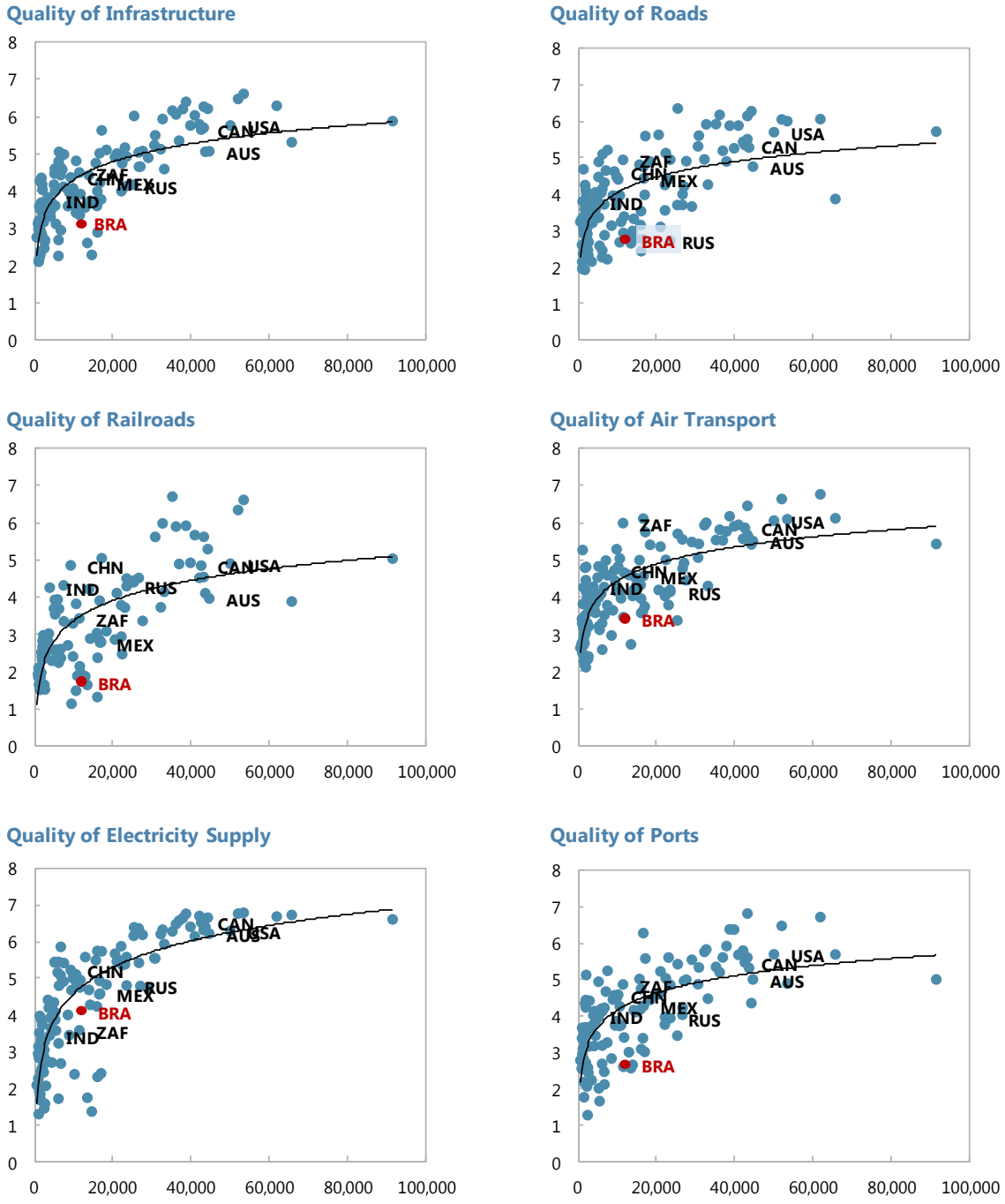
Figure 3. Infrastructure Quality and Income

(y-axis: quality of infrastructure, 2014, 10 = best; x-axis: GDP per capita, PPP dollars, 2012)



Sources: World Bank WDI; and WEF; and Fund staff estimates.

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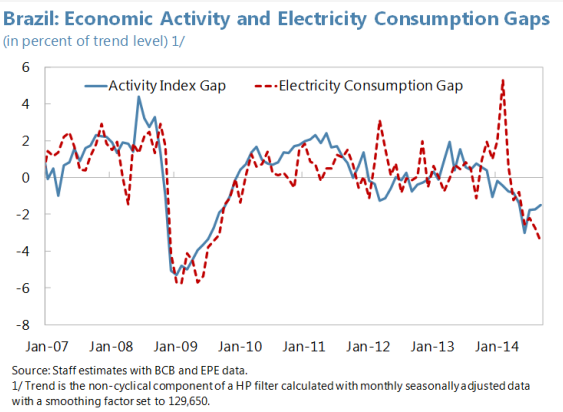
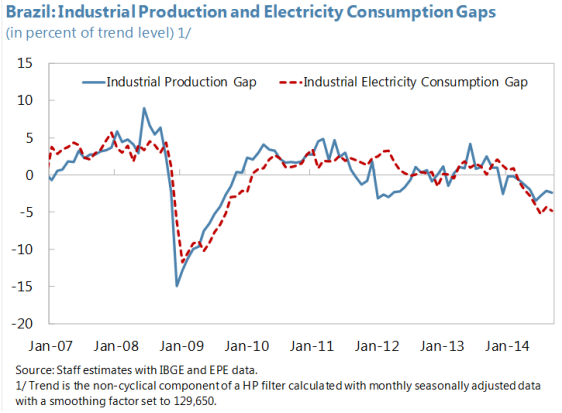
Box 3. Electricity Sector Woes

Several years of low rainfall and increasing demand have strained water reservoir levels that are approaching historical minimums. With still vivid memories of the 2001 nationwide mandatory rationing episode[1], the Southeast region, constituting almost ⅔ of total generation and consumption of electricity, has entered the rainy season with exceptionally low reservoir levels. While rainfall and natural hydropower—the capacity to transform rainfall into power—have been at or slightly above the 10-year median level and the level recorded in 2001 in the North and South, these regions account for only 12 percent of national capacity.

Demand for electricity was boosted by improved credit availability over recent years and raising incomes. Increasing electricity demand since 2009, mostly in residential consumption, was driven by the boom in the acquisition of households appliances. Moreover, increasing average temperature levels, in particular during the recent drought period, also called for more elevated electricity consumption on air conditioning, putting further pressure on energy supply. Nevertheless, some relief may be coming from the demand side in the period ahead with the recent widening of the industrial production gap and the general slowdown in activity in 2014 that are strongly correlated with electricity consumption. Lower cost of running thermal power due to lower international fuel prices may also provide a needed temporary cushion.





In the face of demand pressures, hydropower supply is constrained by storage capacity and challenges related to transmission costs. Down from 80 percent in 2001, hydropower still constitutes a very large share of total generation, despite some scaling up of investment in thermal and wind energy in recent years. However, while total electricity generation nearly doubled over this period, the last investment in hydropower storage capacity took place in the distant 1990. Moreover, because many of Brazil's hydropower generating facilities are located far away from the main demand centers, transmission and distribution losses are high and accounted for 16 percent of power output loss in 2011. Investments directed towards the electricity sector in the government's concession program focus mainly on upgrading distribution capacity and logistics, with no regard to the need for greater storage space, highlighting the trade-off dictated by limited availability of projects.

In the face of the continuing drought, these factors increase the likelihood of electricity rationing in the near future. In the Southeast, the natural hydropower was about 40 percent below the long-term average and 20 percent below the 2001 level in November this year. With reservoirs at lowest levels, the prospect of energy rationing in 2015 may already be affecting investment decisions and will depend

[1] In response to the 2001 energy crises, the government introduced consumption quotas based on historical and target consumption levels. Bonuses were offered for consumption below the prescribed level and penalties applied for over-consumption. Consumption levels were reduced by 20 percent over eight months. Generators and distributors, however, experienced losses that were eventually covered by increases of tariffs.

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Box 3. Electricity Sector Woes (Concluded)

heavily on the amount of rainfall in the first quarter of next year.[2] The direct effect of a 10 percent energy rationing throughout 2015 is estimated to subtract over 1 percentage point from the annual GDP growth, mainly through a contraction in manufacturing industry and commerce, while the effect on inflation from tariff increases and food prices was estimated at 0.7 percentage points. ("Brazilian Utilities", Credit Suisse Research; November 2014).

Greater investment in the energy sector calls for further liberalizing the regulatory framework. The 2004 reforms increased competition by establishing energy auctions as the main procurement mechanism for distribution companies to acquire energy. The 2012 reform aimed in turn at lowering some taxes affecting the electricity sector companies, decreasing tariffs of regulated consumers by 20 percent, and renewing concessions that were due to expire in 2015 and 2017. The power sector is expected to receive US$73.8 billion of new investment over the next 5 years (R$18 billion in renewable, R13 billion in transmission lines and R$35.8 billion in thermo and hydropower). But to increase private participation in energy investments it will be necessary to promote long-term finance, improve the environmental licensing process, and allow some adjustment in tariffs over time to increase profitability and attractiveness of concessions in the energy sector.

[2] The probability of rationing is very difficult to assess because historical volatility in rainfall is very high—while the median rainfall between 1931 and 2013 was 210 GW, the standard deviation was 49 GW.

D. Infrastructure Investment Trends

16. The infrastructure bottlenecks described above reflect a prolonged period of low infrastructure investment. Infrastructure investment in Brazil has dropped significantly from an average of 5.2 percent of GDP in the early 1980s to an average of 2¼ percent of GDP over the last two decades, and slightly increased to around 2½ percent of GDP in 2013. While good and standardized infrastructure investment data, in particular for cross-country comparison, is not available, different data sources confirm that for a couple of decades Brazil's infrastructure investment has fallen short of the levels observed in other Latin America and emerging market countries, such as Chile, China and India (Calderón and Servén, 2010; Frischtak, 2013). There are also important differences in the investment levels by sector. In particular, the electricity and telecommunications sectors continue to represent the bulk of infrastructure investment in Brazil, reflecting the participation of the private sector under the concessions scheme. In contrast, Chile has invested more in roads and distribution/supply of water and sanitation.

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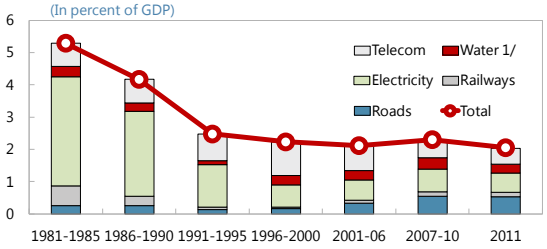
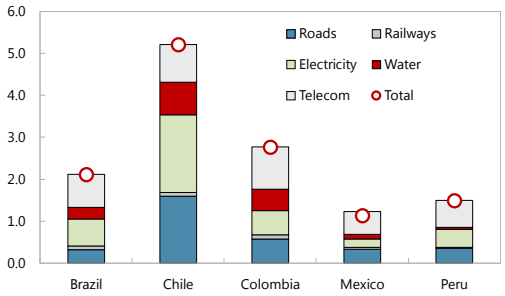
Brazil: Infrastructure Investment
(In percent of GDP)



Sources: The chart shows data till 2006 from Calderón and Servén, 2010; and for the period 2007-2011 from Frischtak, 2013. Differences across data bases are minor: for example, total infrastructure for the period 2001-06 averaged 2.11 percent of GDP in Serven and Calderon's dataset, while it averaged 2.08 percent of GDP in Frischtak's dataset over the same period.
1/ Includes also infrastructure investment in ports and airports.

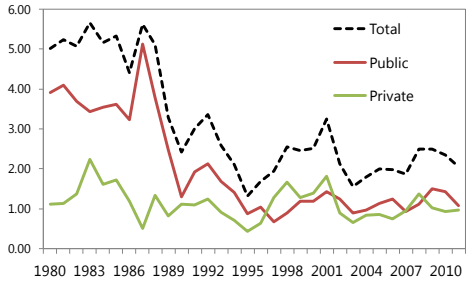
Latin America: Infrastructure Investment, average 2001-06
(In percent of GDP)



Sources: Calderón and Servén, 2010.

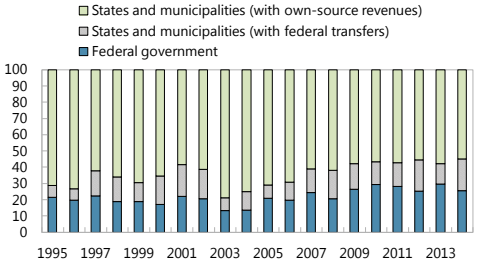
17. The decline in infrastructure investment in Brazil is mostly explained by a reduction in public infrastructure investment. The 1988 Constitution reduced the pool of federal funds available for capital expenditures as it replaced sector-specific federal taxes earmarked to energy, transport, and telecommunications with non-specific state-level ones; raised transfers to sub-national governments; and earmarked revenues to certain current public expenditures. The fiscal adjustment effort carried out from 1999 limited the available fiscal space for public investment, due to the budgetary rigidities and mandatory current primary spending. Consequently, public expenditures allocated for infrastructure investment have remained subdued since then, despite initiatives aimed at prioritizing infrastructure investment such as the *Programa de Aceleração do Crescimento* (PAC), which was launched in 2007 by the Federal government with the goal of accelerating economic growth.[10] At present, about 75 percent of total investment for the general government is being executed at the subnational level.

Brazil: Public and Private Sector Infrastructure Investment
(In percent of GDP)



Source: The chart shows data till 2006 from Calderón and Servén, 2010; and for the period 2007-2011 from Frischtak, 2013.

Brazil: Public Investment by Level of Government 1/ 2/
(In percent of total)



Source: Ministry of Finance.
1/ Excludes public enterprises.
2/ Investment refers to gross capital formation, and therefore, covers not only infrastructure invesment.

18. Meanwhile, private sector investment has not filled the space vacated by the public sector. During the 1990s, privatization and concessions opened up key infrastructure sectors such as

[10] The PAC—excluding allocations to defense, education and the Minha Casa Minha Vida programs—amounted 0.5 percent of GDP in 2013, up from 0.3 percent of GDP in 2007.

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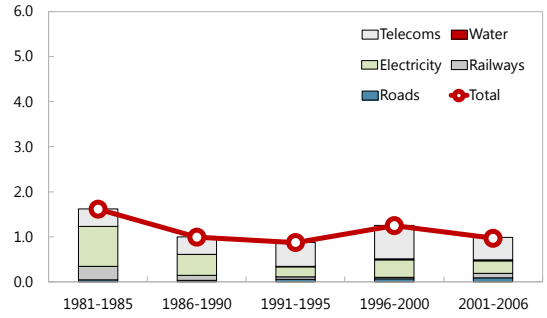
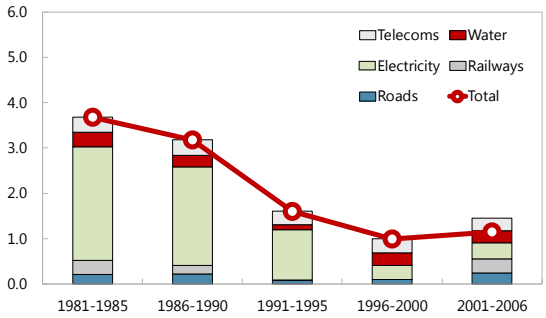
telecommunications, energy, and transport to private investment, but private investments have not been sufficient to compensate for the decline in public investment.[11] Private participation in infrastructure in Brazil has been low in comparison with other Latin America countries, in particular, Chile, corroborating that the investment environment, including investment opportunities, and regulatory and institutional frameworks play a major role in determining overall infrastructure investment levels and therefore tackling the infrastructure gaps.

Brazil: Infrastructure Investment by Private Sector
(In percent of GDP)



Source: Calderón and Servén, 2010.

Brazil: Infrastructure Investment by Public Sector
(In percent of GDP)

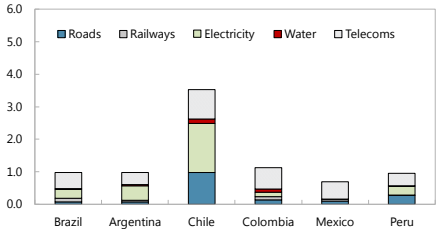


Source: Calderón and Servén, 2010.

E. The Role of the Concession Program

19. Brazil has been pursuing opportunities for concessions with the aim of filling infrastructure gaps. The concessions can bring in private sector expertise and efficiency and also help bypass some of the challenges faced by public investment—such as contracting obstacles—and therefore speed-up the process of investment. A first phase of concessions in Brazil took place during the late 1990s. Through privatization, the private sector became the main operator in telecommunications, electricity and railways. Concessions were also granted for about 5,000 km of federal roads. It is worth noting that private sector investment through concessions in the telecommunications and electricity sectors helped eliminate the infrastructure gaps and improved Brazil's ranking in these areas, as mentioned earlier in the text.

Latin America: Infrastructure Investment by Private Sector, 2001-06
(Average, in percent of GDP)



Source: Calderón and Servén, 2010.

[11] In contrast, in Chile, the private sector more than compensated for the fall in public expenditures since 1989, with a net positive impact on total investments (World Bank, 2007).

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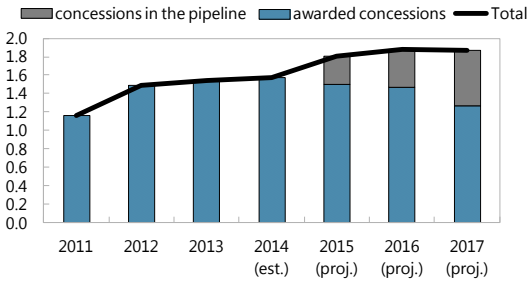
20. The current phase of concessions was launched a few years ago and focuses on projects in critical infrastructure sectors such as roads, ports and airports. During the period 2011–14, concession projects were auctioned in the areas of transport, energy, with an associated total investment estimated at R$183.4 billion, split between airports (R$35.8 billion), ports (R$8.4 billion), roads (R$29.2 billion), urban transportation (R$6.9 billion), power generation and transmission (R$96.7 billion) and telecommunications (R$6.4 billion). The federal government plans include the awarding of projects in the areas of transportation (roads, railways, and ports), power generation and transmission, telecommunications and urban transportation, with estimated total investment of R$109 billion (Secretaria de Acompanhamento Econômico, 2015). The concession period usually ranges from 20 to 35 years, with most of the infrastructure investments taking place during the first five years. Concessions awarded in the past and the ones in the pipeline are expected to add about ¾ percentage points of GDP in infrastructure investment per year over the period 2011–17. Delays in the biddings and changes to the contracts could dilute investments over time. The infrastructure concession program could also be hampered by the probe into corruption concerning Petrobras, as several of the largest construction companies are involved in the investigation and these could see their access to funding diminished.

Brazil: Annual investments through concessions 1/ 2/
(In percent of GDP)



Source: Secretaria de Acompanhamento Economico do Ministerio da Fazenda.
1/ Awarded concessions and concessions in the pipeline as of end-2014.
2/ Excludes investments in new railways, oil, gas and urban transportation.

F. Filling the Gap

21. Brazil's infrastructure gap has become a major obstacle to growth. Brazil's business climate and competitiveness have been suffering in recent years from obstacles related to the complex tax system, administrative hurdles, judicial inefficiencies, red tape, inadequate regulatory framework, that have come to be known under the name "*custo Brasil*". While infrastructure bottlenecks are not considered part of this "soft" burden on business attractiveness, they are believed to be among the main constraints to raising potential growth. Infrastructure is not adequate to support current income levels, foster regional integration, and put Brazil on a more competitive footing against rivals in main export products which include some of the advanced economies.

22. Filling the gap will entail increasing investment, but also stepping up other reforms. The infrastructure gap has grown over time due to low public and stagnating private investment across all sectors over the past decade. The government's concession program has the potential to step up and speed up infrastructure investment; but by itself, it may not be enough to boost potential growth significantly. Other reforms to eliminate "soft" bottlenecks, including reforms to enhance governance standards, will have to accompany efforts to fill the infrastructure gap to make the business environment more attractive to foreign and domestic investments in an environment where regional competition to attract investments is set to intensify.

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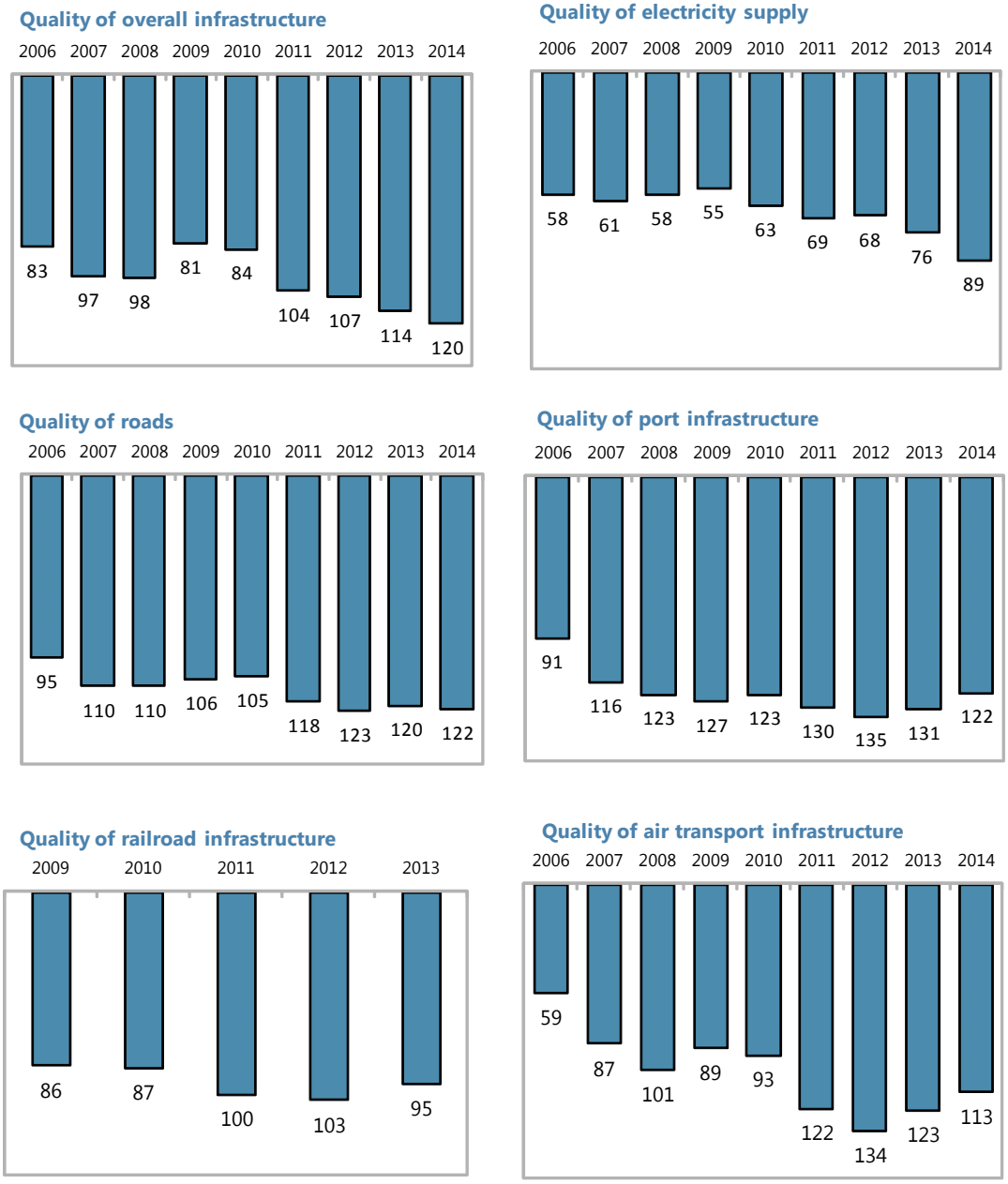
Appendix I. Infrastructure Indicators

Figure 1. Brazil: Infrastructure Quality, 2006-15
(rank out of 144)



Source: The World Competitiveness Report, World Economic Forum.

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Appendix II. Panel Unit Root Methodological Note

We first run individual ADF regressions of the time-effect treated price level ($p^*_{i,t} \equiv p_{i,t} - \bar{p}_t$) for every city i. Lag-lengths K_i are selected using the Akaike Information Criterion and are allowed to be heterogeneous amongst individuals. For those processes which are not explosive, we calculate the half-life (h_i) of the autoregressive parameter from the individual ADF regressions.

(1) $$\Delta p^*_{i,t} = \tilde{c}_i + \sum_{k=1}^{K_i} \phi_{i,k} \Delta p^*_{i,t-k} + (\rho_i - 1) p^*_{i,t-1} + \eta_{i,t}, \quad i = [1, 2, \dots, 11]'$$

(2) $$h_i = {}^{\ln(0.5)}\Big/_{\ln(|\rho_i|)}, \quad |\rho_i| < 1 \; \forall \; i$$

Afterwards, we collect individual t-statistics for i cross sections (t_{iT}) and from their average calculate a panel Z_{t-bar} statistic, which should also be asymptotically normally distributed. $E[t_{iT} | \rho_i = 1]$ and $Var[t_{iT} | \rho_i = 1]$ are obtained by interpolating the values from Im, Pesaran, and Shin (2003) tables.

(3) $$Z_{t-bar} = \frac{\sqrt{N}(N^{-1}\sum_{i=1}^{N} t_{iT} - N^{-1}\sum_{i=1}^{N} E[t_{iT} | \rho_i = 1])}{\sqrt{N^{-1}\sum_{i=1}^{N} Var[t_{iT} | \rho_i = 1]}}, \quad \rho_i(\bar{\rho}, \sigma^2_{\rho_i}).$$

In repeating the exercise using São Paulo rather than national prices, we simply re-set $p^*_{i,t}$ as $p^*_{i,t} \equiv p_{i,t} - p_{jt}$, where p_{jt} stands for prices in São Paulo. This estimates co-integration between each city price levels with São Paulo price levels rather than the national trend. This was necessary to have a travel benchmark between the cities. The baseline model is more informative insofar as it tests for co-integration among all cities. But the alternative model is necessary to assess the association between average half-lives and shipping times.

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