IRIBA Working Paper: 10

Infrastructure and its role in Brazil's Development Process

Edmund Amann[1], Werner Baer[2], Thomas Trebat[3] and Juan M. Villa[4]

July 2014

---

[1]The University of Manchester
[2] The University of Illinois
[3] Columbia University
[4] The University of Manchester

ISBN 978-1-910502-09-9

International Research Initiative on Brazil and Africa (IRIBA)
School of Environment, Education and Development, The University of Manchester, Oxford Rd, Manchester, M13 9PL

iriba@manchester.ac.uk

www.brazil4africa.org

Acknowledgement

This document is an output from a project funded by the UK Aid from the Department for International Development (DFID) for the benefit of developing countries. However, the views expressed and information contained in it are not necessarily those of or endorsed by DFID, which can accept no responsibility for such views or information or for any reliance placed on them.

We thank Donald Coes for many helpful suggestions.

Introduction

The recovery in fortunes of the Brazilian economy since the middle of the 1990s encompasses a number of positive dimensions. Unlike in previous epochs, Brazil's creditable growth performance has been associated with prolonged price stability and the avoidance of excessive accumulation of international debt. Perhaps more significantly still, the growth realized has been broadly pro-poor, thanks in part to its non-inflationary character, but also to a fast-emerging constellation of social policies, in particular Conditional Cash Transfer programs, including the iconic Bolsa Familia program. Brazil's rise to prominence has also featured an unprecedented surge in outward foreign direct investment and an expanding range of home-grown multinational corporations. Still, whatever the scale of these accomplishments, it is painfully evident that Brazil's economic transition from middle-income status is still very much a work in progress.

Nowhere is this more apparent than in the field of infrastructure, the problems relating to which have drawn unfavorable attention from domestic and foreign investors, policymakers and commentators. The infrastructural challenges facing Brazil are epitomized in the well documented difficulties surrounding the construction of facilities for the 2014 FIFA World Cup and the 2016 Rio Olympics. However, the infrastructural issue runs far deeper than these heavily publicized cases, extending across transportation, energy, telecommunications, sanitation and housing. Indeed, as this paper will argue, infrastructural problems lie at the heart of Brazil's growth constraint and go some way to explaining why that growth has failed to keep pace with that generated by other large emerging market economies, notably China.

Not surprisingly, the infrastructural issue has moved to the very heart of the policy agenda in Brazil. Since 2007, the authorities have been attempting to engineer a step change in the scale and quality of infrastructure across a range of strategic sectors. This effort, labeled the Growth Acceleration Program (or PAC, to use the Portuguese acronym) envisages significantly raised investments in highways, railways, energy, air transportation, telecommunications, housing, water and sanitation. However, for reasons that will be made clear, the ambitions embraced by the PAC have been far from fully realized and Brazil remains subject to significant supply side constraints.

These challenges form both the background and stimulus for this paper. To set them in longer term context, this paper opens with a brief historical review of infrastructure in Brazil (Section 1), beginning with the 19^{th} Century and the rise of concession contracts and the subsequent decision to nationalize infrastructure and administer the sector through state enterprises throughout most of the 20^{th} century. The analysis then focuses on the reversal of this policy in the late 20th and early 21st century and the decision to grant the private sector, through concession contracts and Public Private Partnerships, a major role in the development of new infrastructural projects and the takeover of existing assets.

Following this overview, Section 2 examines contemporary infrastructure challenges facing Brazil and the success of attempts to address them. The first component of the section comprises an econometric analysis of the relationship between growth and infrastructural spending. The analysis hints at the constraints implied by recent patterns of infrastructural investment (in 2012-13, investment in infrastructure was only about 2% of GDP). The second component of this section sets the current infrastructural challenge in slightly broader context, taking into account issues such as quality and reliability of infrastructure. This section also considers the implications of relying on concession contracts to deal with infrastructure needs.

Next, Section 3 reviews the implications of the PAC infrastructure investment program launched under the Lula administration, and continued under its successor, the Rousseff administration. Our general aim here will be to highlight the constraints – institutional, regulatory, financial and political - which have shaped the PAC's evolution and which have, we argue, prevented it from living fully up to expectations. As Section 3 will reveal, the drivers of supply (as well as demand) for infrastructure are very complex and quite sector-specific. Bearing this in mind Section 4 aims to add depth to the analysis by reviewing in more detail the experiences of the urban transportation sector. The choice of this sector for enhanced focus stems in part from the strong relevance which, we feel, it has for other developing or emerging economies, notably in Africa. In addition, the social unrest which initiated in Brazil in mid-2013 has had, as its focus, concerns centering on urban transportation issues. The broader international relevance of Brazil's experience – especially from an African perspective – forms the basis for the conclusions, set out in Section 5.

1. Brazil's infrastructural experience in brief historical perspective

Initial developments

The allocation of a growing role for the private sector has characterized the authorities' more recent attempts to accelerate infrastructural investment across a range of sectors. This process began with a wave of privatizations in the public utilities sectors in the 1990s (Baer, 2014) and has continued with the granting of concession contracts and the establishment of Public Private Partnership (PPP) arrangements. In longer term historical perspective these developments embody a surprising degree of continuity. During the 19th century, following independence, the Brazilian state adopted policies of relative openness to trade and foreign direct investment

(Abreu, 1990). Faced with thin domestic capital markets and a narrow tax base, policy makers were obliged to draw heavily on inward foreign direct investment (FDI) in order to meet Brazil's fast expanding infrastructural requirements. These had become very pressing in the light of an upswing in the commodities cycle and the resultant "coffee boom" which triggered significant expansion, immigration and, ultimately, urbanization and industrialization in Brazil's South and South East .

As a result, the early Brazilian railroad, urban transportation (tramways) and electricity supply infrastructure was developed and instituted by foreign investors working under concession contracts with state and municipal governments. Not only was the involvement of foreign enterprise essential given the shortage of domestic capital: the emergence of new electricity-based technologies required technical and innovative capacity which Brazil clearly lacked. Thus, for example, a Canadian enterprise came to build and operate (under concession) the electricity network in the city of Rio de Janeiro. As in the case of neighboring Argentina, early railroads were financed by foreign investors, among them the British, who received concession contracts from the state governments. The earnings from these investments were high enough to attract such capital, as most railroads were guaranteed a rate of return by the states (Summerhill, 1998).

The early installation of tramways and electricity in some of the major cities was financed by both local and foreign groups under concession contracts with municipalities. Regulation of such contracts occurred within the context of local monopolies which were regulated by sub-national governments (Baer and McDonald, 1998). For a while the development of these infrastructure projects seemed to have been satisfactory from both the investors' and recipients' points of view. The regulation of these local monopolies was relatively lax, ensuring a favorable rate of return to the private (mainly foreign) investors (ibid.). While local monopolies prevailed[1] the infrastructure market could be said to have been fragmented, given the great number of enterprises involved in operating these concessions. However, as time wore on, increasing consolidation of the infrastructure providers resulted in a more concentrated picture (ibid.).

Until the 1930s the involvement of the federal government with infrastructure projects was almost non-existent. However, things soon began to change. In the case of railroads, there was a decline in the earnings of the sector and an initial disinclination of the state to subsidize them.

---

[1] According to Baer and McDonald "(a)lthough Light dominated the electric power supply in Sao Paulo and Rio de Janeiro other cities were supplied by locally owned firms and by 1920 343 electric power firms were operating in Brazil were operating on a concession basis with municipalities. Their owners were usually local owners or landowners who owned local concessions." (1998: 506)

As individual railroads hit crisis point they were progressively taken over by the federal government (Baer and Sirohi, 2013). In the case of electric energy Brazil's federal government intervened very little until 1930. In 1904, the government issued a decree (no. 5407) establishing rules for concessionary contracts for firms using hydroelectric sources. In 1931, the government introduced a new system of rules which restricted the frequency with which tariffs could be readjusted (Tendler, 1968: 48-9). In 1934, a new decree – the *Codigo das Aguas* (the Water Code) - set out new rules for the regulation of the water supply and hydro power sectors (Ferreira, 2009: 49). The Water Code would prove to be highly influential in governing the future evolution of the regulatory structure governing infrastructure, not only in the electricity sector but also in other public utility sectors.

The critical departure from earlier arrangements here was that concessions were now granted mainly by the federal government, and then for a minimum period of 30 years. The *Codigo das Aguas* laid down more exacting conditions than previous concession contracts, not only in terms of tariff levels but also in regard to quality of service. As such, this new regulatory framework became a template on which future concession arrangements (and consequent investment in infrastructure) would be based (Baer and McDonald, 1998). As Brazil moved into the 1940s and 1950s, and as its program of import substitution industrialization gathered pace, so did the state take an increasing role as a direct provider of infrastructure, whether in the transportation, power generation and distribution or water and sanitation sectors.

In the case of railroads many private companies began to run up operational losses which led them to the brink of bankruptcy (Ferreira, 2009). Rather than see lines close, a process of nationalization began with the creation of the Federal Railroad Corporation (RFSSA) in 1957. This subsequently incorporated a vast range of formerly privately-owned lines (Baer, 2014: 221). It was also the case that the federal government became more directly involved in electricity, especially in generation. Regarding distribution, many privately held entities – for example Rio de Janeiro's Canadian-owned Light – were transferred to state government ownership. The progressive transfer of infrastructure to public ownership not only reflected the need to inject investment resources where the private sector had been unable or unwilling to do so[2] but also an ideological shift which overtook Brazilian economic affairs from the Vargas years onwards. The centerpiece of this, of course, was the creation of the state owned oil company Petrobras in 1953.

[2] Very often because the tariffs set in compliance with toughened regulatory frameworks would not provide the resources or incentives for such investments.

The import substitution period: the state as a provider of infrastructure

From the early post-World War II period to the late 1970s the import substitution model of economic development was dominant in Brazil. During that time the country relied to a large extent on foreign direct investment to develop new industries (Baer, 2014). Infrastructure, however, was in the hands of the state at various levels of government (Ferreira, 2009).

The ability of the state to furnish resources to meet Brazil's fast-expanding infrastructure needs considerably exceeded that which existed in the 19th century. By the 1950s and 1960s, the state's capacity to raise taxation had greatly increased and it was also the case that, thanks to the post 1944 Bretton Woods arrangements, Brazil was able to draw on special infrastructural lines of credit supplied by the International Bank for Reconstruction and Development, later the World Bank. Such sources of finance were vital in building up Brazil's network of hydro-electric generating stations, for example. Although much was accomplished in terms of building power generating facilities and some highways, other infrastructure such as railroads was largely neglected. As viable enterprises, government infrastructure enterprises, however, operated in such a way as to create substantial distortions in the economy. For instance, the state tried to use its enterprises, including infrastructure enterprises, as instruments of macroeconomic policy. In the midst of many periods of high inflation, the tariffs charged by such enterprises were not allowed to accompany rising costs. This created substantial losses for individual state-owned infrastructure enterprises and resulted in a need for subsidization which contributed to further bouts of inflation (Baer, 2014: chapters 6 and 11).

During the "lost decade" of the 1980s, when Brazil underwent a serious debt crisis, investments in infrastructure were neglected. With the arrival of a new era of a neo-liberal development model by the early 1990s, Brazil faced the necessity of substantially modernizing its infrastructure sector (Amann and Baer, 2002). However, its state enterprises had no means to finance such investments given a crisis-induced decline in tax revenues and a much more restricted access to international credit be it from official sources or private capital markets. By the second half of the 1990s and into the first decade of the 21st century Brazil's policymakers were forced to confront the fact that the only way to deal with the need for infrastructure investment was to revert to the old model of appealing to the private sector through concession contracts (Ferreira, 2009).

2. The contemporary infrastructure challenges facing Brazil

Infrastructure and economic growth

Methodological approach

One of the hardest causality relations to assess in macroeconomics is that between infrastructure and economic growth. Economic growth feeds investment in infrastructure, and the resulting infrastructure accumulation impacts economic growth. The evident endogeneity between these two variables can confound the analysis, to the extent that authors have implemented a significant number of identification strategies to obtain reliable results (Straub, 2008). The availability of data determines the method to tackle or mitigate the endogeneity. The inconsistency of long-term time series data in developing countries at national and sub-national levels has deterred the implementation of dynamic models. In the particular case of Brazil, the existing literature has been based on the estimation of co-integration models between the 1960s and 2000s (Ferreira, 2007). A reliable time series estimation would require more than 100 periods or observations (Box and Jenkins, 1976). Alternatively, cross sectional analysis could be a suitable solution. Nonetheless in a context of one single country with limited information at sub-national levels, cross section analysis, similar to time series, fails to provide trustworthy results.

An alternative to cross section and time series analysis could a combination of both through panel data analysis. For Brazil data are available at state level relating to public spending on infrastructure between 1992 and 2010. With 26 states and one federal district, the potential dataset could be composed of roughly 500 observations, suitable for the implementation of random or fixed effects models. The assumptions behind random and fixed effects models are essential for accounting for endogeneity. Both models can deal with the fact that spending on infrastructure is endogenous to regional economic growth, with the inclusion of instrumental variables approaches. The employment of random effects models would be suitable in this case, as they assume that the state-level effect (or the selection of states) is uncorrelated with the set of explanatory variables. States are not selected on a random basis; therefore, random effects violate the identification strategy. As fixed effects can eliminate time-invariant heterogeneity that may confound the analysis (Wooldridge, 2010), in an ideal world fixed effects combined with an instrumental variable setting would mitigate the endogeneity that arises between spending on infrastructure and growth.

Results from fixed effects models are dependent on the availability of time varying variables, since the mean differencing that their estimation implies eliminates the effects of time-invariant variables. In addition, the traditional instrumental variable model requires an exogenous factor that may be correlated with state-level spending on infrastructure (first stage) but uncorrelated with the error terms of the reduced form. Exogenous time-varying characteristics are difficult to obtain with the aim of instrumenting spending on infrastructure. Intuitively, spending on infrastructure is shaped by the physical conditions of the terrain (Freeman and Warner, 2001). Time-invariant characteristics have limitations for explaining growth (Cohen and Easterly, 2009) but could be essential to determine how infrastructure is shaped. For instance, spending on infrastructure could be determined by distance of the municipalities to the state capital, elevation from the sea level and latitude with reference to the equator which determines precipitation rates and other characteristics of the weather. Natural disasters which result in the demand for restoration of roads or general infrastructure are more likely to occur in mountainous states with high rates of precipitation, predominant in tropical areas. Physical characteristics of the places where infrastructure takes place are exogenously fixed and barely change over time, which implies additional challenges to the ideal setting of a fixed effect model with instrumental variables.

Hausman and Taylor (1981) (HT henceforth) offer a solution to the inclusion of time invariant variables in the estimation of panel data models with endogenous covariates (Baltagi et al., 2003).[3] Unlike fixed effects models, HT assume that some of the explanatory variables, the exogenous variables, are uncorrelated with the state-level fixed effects but none of the explanatory variables are correlated with the idiosyncratic error term. In formal terms, we may define the following stochastic equation:

$$y_{it} = x_{1it}\beta_1 + x_{2it}\beta_2 + z_i\gamma + \alpha_i + e_{it} \qquad (1)$$

Starting from the error terms, for each state i in year t, the idiosyncratic error, e_{it}, is assumed orthogonal to the columns of explanatory variables irrespectively whether they are endogenous or exogenous. The state-level time-invariant effect, α_i, is assumed to be randomly distributed across states and orthogonal to exogenous explanatory variables but correlated to the endogenous variable. In other words, x_{1it} is a column of exogenous time-varying (TV) variables that are assumed to be uncorrelated with the errors α_i and e_{it}. Example of TV variables in our setting are population size, number of municipalities, and number of federal deputies, which we consider un correlated to the error terms. x_{2it} is also a TV variable which is endogenous to α_i. In fact, in our context spending on infrastructure is denoted by x_{2it}. z_i is a column of exogenous time-invariant (TI) variables, such as the physical characteristics shaping each state.[4] We instrument x_{2it} with x_{1it} and z_i to mitigate the endogeneity with α_i and also assuming that

[3] Djiofack-Zebaze and Keck (2009) undertake a similar analysis with HT in the telecommunications sector.

[4] See also Egger and Pfaffermayr (2004) for a similar HT setting on direct foreign investment, an endogenous TV, instrumented with distance, a TI exogenous variable.

spending on infrastructure affects growth through the exogenous variables. β_1, β_2 and γ are parameters to be estimated.[5]

In sum, according to HT, when time-varying exogenous characteristics, x_{1it} and z_i, are assumed to be uncorrelated with state-effects, they can play two different roles. First they can provide unbiased estimation of the β_1 parameter and, second, they can be used as instruments for the endogenous variable, namely, spending on infrastructure, that is assumed to be correlated with α_i.

HT offer an example of the application of this method that may help one to understand its main insight. They attempt to estimate the returns to education, arguing that existing ordinary least square (OLS) approaches tend to underestimate this relation. They consider two main variables, years of schooling and experience or age (time-varying). The first is endogenous with respect to earned wages and the other is clearly exogenous. They also add some other exogenous time invariant covariates, such as race, marital status and health status in the last year. Finally, they estimate consistent returns to schooling compared to previous findings based on cross sectional data accounting for parental background and intelligence quotient.

Data and results

The main data source for the estimation of the HT model is provided by the IPEAData service.[6] This collects several sources of public domain data, including regional and municipal information on several topics recorded during the last century. As for the regional information, the variables of interest, real public spending on infrastructure and GDP growth, are provided by the annual reports of each state collected at the national level by the Federal Treasury (Ministerio da Fazenda). Similarly, some other variables were obtained at the municipality level, in particular those time-invariant physical characteristics that may drive spending on infrastructure.

To check the consistency of our results, we rely on an alternative measure of economic activity. In this regard, we make use of luminosity data recorded by satellites that orbit the earth. This has been increasingly widely used since the 1990s, especially when measuring economic growth at the sub-national level (Henderson et al., 2011). This open data is available at the National Oceanic and Atmospheric Administration (NOAA) after being collected by the Defense Meteorological Satellite Program (DMSP) over the period between 1992 and 2012. The DMSP observes the earth from space every night between 8-10pm and records the luminosity activity,

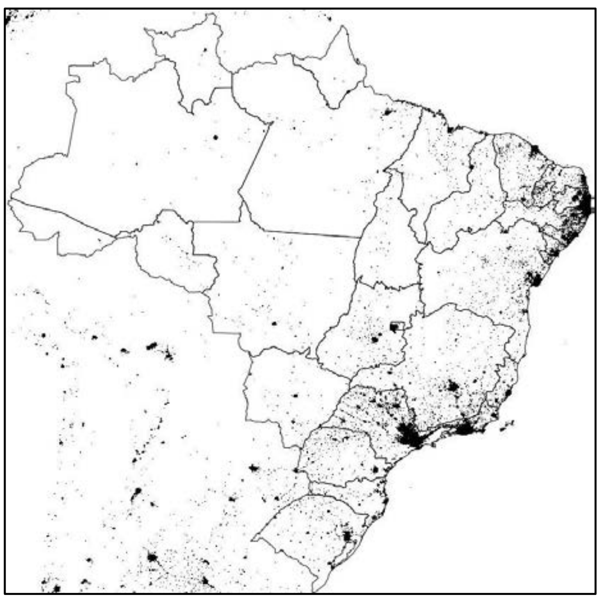
[5] These characteristics are assumed to be exogenous to spending on infrastructure and economic growth.

[6] See http://ipeadata.gov.br (accessed April 2014).

filtering potential contamination from clouds, fires, northern lights or moon cycles (Chen and Nordhaus, 2011). Several authors have validated the use of the luminosity data as a proxy for economic growth (Elvidge et al., 2009; Henderson et al., 2012; Pinkovskiy and Sala-i-Martin, 2014).

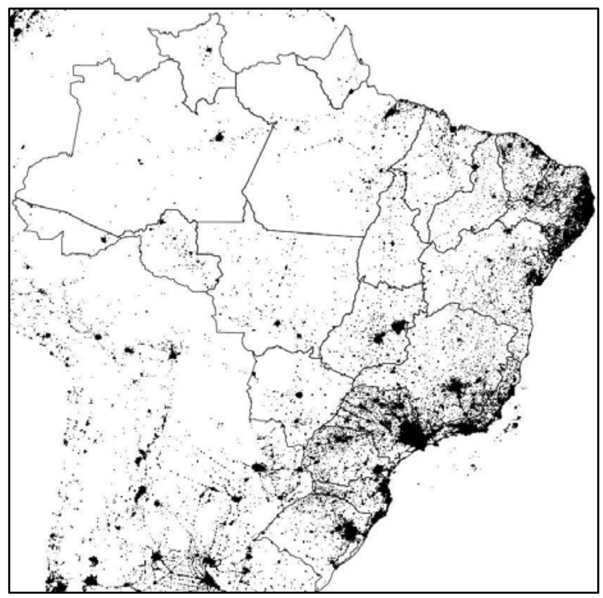
As an illustration, figures 1 and 2 below show the luminosity data generated over Brazil between 1992 and 2012 (with an inverted scale). It is clear that significant changes in luminosity emission have occurred over 20 years with a notable concentration in the south of the country and some areas of the north east:

Figure 1. Luminosity data recorded over Brazil in 1992



Source: NOAA.

Figure 2. Luminosity data recorded over Brazil in 2012



Source: NOAA.

Table A1 in the appendix shows the descriptive statistics of the variables taken into consideration. The first group of variables relates to the outcomes considered for the estimation of the effects of spending on infrastructure on growth. Instead of focusing on the variables' absolute values, we have considered them in logarithmic terms. GDP and GDP per capita at 2000 prices were obtained from national accounts, while alternative luminosity data is obtained independently from NOAA. The number of observations was fixed at 513 as some missing values on growth emerged during the data mining process. There are 27 units of observation, composed of 26 states and 1 federal district. The time length is set at 19 years over the period between 1993 and 2012. The main independent variable, real spending on infrastructure, is defined as the natural logarithm of the sum of the state-level recorded spending on communications, energy and transportation at 2000 prices. This accounts for new telecommunication networks, electricity provision, roads as well as their operation and replacement of depreciated capital. The three components of total spending on infrastructure are also analyzed separately with logarithmic transformation.

Starting with exogenous covariates, population size at the state level is considered, with an average of 6.3 million inhabitants in each state. The physical characteristics that may drive public spending on infrastructure are included in the analysis (Block, 2008; Freeman and Warner, 2001; Henderson, 1999; Koetse and Rietveld, 2009). The number of municipalities is considered as an indication of the dispersion of the demand to the state-level for more spending on infrastructure. Coefficient of variations (standard deviation-mean ratio) of municipal elevation, distance of each municipality to the state capital, geographic latitude and seasonal precipitation are the time-invariant characteristics considered as determinants of spending on infrastructure. The fact that these physical characteristics are time-invariant is reflected by the within zero variance. Finally, the number of federal deputies was taken into account as a political factor that may also shape the spending on infrastructure (Besley and Coate, 2003; Cusack, 1997; Milesi-Ferretti et al., 2002). The representation of each state at the national level may influence the available resources for the state-level budget.

Turning now to the results, Table A2 in the appendix shows the outputs of the estimation of Eq. 1 with the HT method.[7] Dependent and main explanatory variables are transformed into natural logarithms, so the interpretation of the coefficients is made in terms of elasticity estimates. Columns 1-3 report the single OLS estimation for the natural logarithm of GDP, luminosity and GDP per capita. At a glance, it seem that total spending on infrastructure is not statistically significant with respect to GDP, while there are negative effects with respect to the luminosity indicator. Columns 4-6 show the estimation results of a random effects model, where spending on infrastructure is instrumented with exogenous covariates. It yields significant results, but the random effects hypothesis may not be reliable in this context as discussed above. Columns 7-9 present the results of the HT method. The (Hausman, 1978) specification test was conducted for the HT against the random effects model, yielding a positive result for the HT (Chi2(3) = 0.17; Prob>Chi2 = 0.982). In addition, the Sargan-Hansen test for over-identifying restrictions is presented with the estimation results, indicating that the all regressors in the HT models are uncorrelated with the idiosyncratic error and that the exogenous variables are uncorrelated with the fixed effect (Baum et al., 2003). The estimations reported positive results of the latter.

[7] Time effects were included but not reported. Effects of lagged spending on infrastructure were considered but given the nature of this variable, which includes investment, operation and other contingencies.

The results of the HT analysis indicate that spending on infrastructure has a positive effect on growth and per capita growth. Signs for GDP and luminosity data coincide and, although it is not reported, their confidence intervals overlap.[8] This result holds even though the luminosity data contains two more years of information (over the period 1993-2012). Thus, we can rely on the fact that these are robust and unbiased estimates. The scale of the effects of an additional Real spent on infrastructure on economic output is promising. If the states increase their spending in one percentage point, then the regional GDP growth rate would increase by 0.11 percentage points per year, while the GDP per capita growth rate would respond with an increase of 7.2 percent per year. The effects of infrastructure spending on GDP are halved when economic activity is measured by luminosity data.

Columns 10-18 in the second part of Table A2 present the same type of estimation results for the components of total spending on infrastructure, understood as the sum of spending on communications, energy and transportation. This exercise allows us to identify which factor is driving the results. Spending on communications yielded a low effect on GDP and GDP per capita growth rates, with a coefficient of 2.3 and 1.4 percent, respectively. Economic activity measured with luminosity data has a higher response to communications, with a coefficient of 4 percent. Spending on energy infrastructure reported the lowest effect on growth and growth per capita, with coefficients of 1.9 and 1.4 percent respectively. Finally, spending on transportation seems to report the higher coefficient, which we identify as the driver of the general result. The estimated coefficient is 10.3 percent for GDP growth and 6.6 for GDP per capita growth.[9] The coefficient reported by the luminosity data indicates that these effects are also positive but not as strong as it is showed with the national accounts data.

To sum up, the unavailability of data and the impossibility of obtaining results from an ideal fixed effect model with instrumental variables have given us the opportunity to run estimates using the HT method. The data is composed of state-level public spending on three items of infrastructure (communications, energy and transportation) and physical and political characteristics that may drive spending on infrastructure. Luminosity data was considered as alternative to national accounts at the sub-national level. The results indicate that an elasticity of 11 and 7.2 percent respectively is obtained from the relation between GDP and GDP per capita with respect to spending on infrastructure. Spending on transportation drives the overall result among all the studied components of total spending on infrastructure. These results were confirmed to be unbiased compared to OLS and random effects models, and robust with respect to the use of an alternative measure of economic activity.

---

[8] [95% CI: 0.067 - 0.123] for GDP and [95% CI: 0. 038- 0. 073] for luminosity.

[9] This result is consistent with the fact that spending on transportation comprises 87 percent of total spending in infrastructure over the period of analysis.

The infrastructure challenge in broader context

The previous section highlighted the considerable extent to accelerated expenditure in infrastructure could have real and strongly positive growth impacts. However, such a ramping up of spending has not taken place and, given the current stock of infrastructure, the attainment of Chinese-style rates of growth is out of the question. However, deficiencies in the field of infrastructure have broader consequences, the nature of which have received intense international exposure as a result of the 2014 FIFA World Cup and the Summer Olympics of 2016 (Morgan Stanley, 2010: 5). The issues here fall into two broad categories; those centering on the quality of infrastructure and the other revolving around its physical extent or reach across different socio-economic groups.

Perhaps the best known international comparative indicator of infrastructural quality is provided by the World Economic Forum (2013). In its most recent global rankings of infrastructure, Brazil's overall standing was at 114th place. The quality of its roads was ranked in 120th place, its railroads at 103rd, its ports at 131st, its air transport at 123rd, and its electricity supply in 76th place. A more thorough grasp of the issues can be gleaned by examining data on a sector by sector basis.

1) **Highways:** By 2011, although Brazil had the world's 4th largest road network, there remained significant quality issues associated with it. According to a 2012 World Bank study, of 1.75 million kilometers of highways, only 18 percent were paved. This represents an especially significant deficiency bearing in mind that 60 percent of Brazil's freight moves by road. Moreover, in relation to optimal levels, the authorities have been spending far too little on highway maintenance. In the budget for 2011-14 less than 1 percent of GDP per annum has been set aside for such spending when, according to the World Bank, 6 percent of GDP would be necessary to catch up with advanced industrial countries. It is also important to note that the quality of highway infrastructure is heavily differentiated by region. While the South and South East are comparatively well served with divided multilane paved highways, the same is not true in some of the less developed regions of the country, notably the North, the North East and the Centre West. Even the capital Brasilía remains to be connected to the South's multi-lane "interstate" system. Partly for this reason, transportation costs are notoriously high in Brazil: spending on logistics represents 15.4 percent of Brazil's GDP. In advanced countries this is typically closer to 8-10 percent (The World Bank 2012).

2) **Railways:** As is the case in most economies, the extent of the railway network is substantially smaller than that for paved roads in Brazil (five times smaller in fact) (The

World Bank, 2012: 78). If one sums up the paved and non-paved road network then the rail network is no less than 50 times smaller. Unlike in other key emerging market economies – China and India for example – rail transportation is almost exclusively the preserve of freight, the latter being heavily dominated by iron ore (which accounts for no less than 79 percent of total rail cargo). Brazil possesses just 3.4 km of rail per 1000 square km compared with 14.7km in the United States (The World Bank, 2012: 79). Another curious feature of the Brazilian rail network is that it possesses, rather as Australia did, a significant narrow gauge as well as standard gauge element. Such a feature poses a major challenge to network inter-operability. As indicated, the relative absence of an extensive passenger rail system is another peculiar feature of Brazil, passenger rail being the almost exclusive preserve of a small network of commuter lines around Rio de Janeiro and São Paulo (Da Silva Campos, et al., 2010). The ending of long distance passenger service accompanied the financial crisis and nationalization of the railways following WW II. Unlike in Europe, or even the USA, no meaningful steps were taken to provide a publically subsidized long distance service. Partly as a result of this, today's highway and airport infrastructure has come under acute pressure, especially in the heavily trafficked corridors between Curitiba, São Paulo, Rio de Janeiro and Belo Horizonte. While plans for a high speed line between Rio and São Paulo have been announced, financial constraints and delays in the planning process have impeded progress.

3) **Ports:** For an economy heavily dependent on exports of natural resources-based products Brazil suffers to a surprising extent from quality and capacity limitations in its port infrastructure. Despite limited privatization and accompanying investment in the sector, turn of the 20th century inefficiencies remained. According to Micco and Perez (2002) "tariffs were three to six times higher than the international average, with long waiting times for ships" (p. 27). The authors further establish that in "1998 the average cost of handling a 10-foot container in Buenos Aires was US$ 180.-, while in Santos, Brazil, it was US$ 350. At that time 50 workers were required to handle a cargo ship in Santos, compared to only 14 in Buenos Aires" (Micco and Perez, 2002: 28). Things did not improve by the second decade of the 21st century. According to one report: "while Brazilian ports handle on average 34 containers per hour per ship, ports such as Hamburg handle 66 containers and Singapore 100 containers; and berthing wait times are high and space is insufficient. For example, at the port of Santos, in the first 23 weeks of 2008, over one third of ships waited over half a day to dock, while one sixth of them waited for over 24 hours". *(Freight Logistics*, p. 56) Unless capacity is significantly increased the problems here are only likely to intensify given the increasing size of vessels, in particular the growing prevalence of Post Panamax

container vessels[10]. The problems surrounding Santos, Brazil's biggest port, have spread out onto Brazil's hard-pressed highway infrastructure. Delays in loading/unloading and in customs clearance frequently mean trucks spending hours (sometimes days) queuing outside the port with consequent impacts on exporters and, in the case of imports, on the domestic production chain. The fact that Brazilian ports handle 95 percent of the country's trade by volume and 85 percent by value underlines the scale of the problem and its broader ramifications. By common consent, a modernization of ports is crucial to the future trade prospects of the country.

4) **Water and Sanitation:** According to Mourougane and Pisu "water and sanitation is the sector where investment is probably most needed" in Brazil (2011: 25). In 2008, according to the World Bank Development Indicators, 80 percent of Brazil's population had access to 'improved sanitation facilities' compared with 96 percent in Chile (a regional leader), 83 percent in South America overall and 97.5 percent for the OECD countries as a whole. More strikingly only 47 percent of Brazil's population is provided with sewage collection of which only 20 percent is treated (ibid.). There are also strong inter-regional variations in access to water and sanitation services as Table 1 reveals.

Table 1: Coverage indicators for the water and sanitation sector in %

Region	Coverage)	Coverage	Coverage	Coverage (	Treatment of Sewage Collected
	Water Total	Water Urban	Sewage Collection Total	Sewage Collection Urban	Total
North	57.5	71.8	81.0	100.0	22.4
Northeast	68.1	87.1	19.6	26.1	32.0
Southeast	91.3	96.6	71.8	76.9	40.8
South	84.9	96.0	34.3	39.9	33.4
Center-West	86.2	95.3	46.0	50.5	43.1
BRAZIL	**81.1**	**92.5**	**46.2**	**53.5**	**37.9**

Source: SNIS, 2010.

[10] Post Panamax vessels are those too large to fit through the locks of the Panama Canal.

A major enduring characteristic of the water and sanitation sector in Brazil is its decentralization. Until 1968 water and sanitation services were the sole responsibility of municipalities. However, as urbanization accelerated the federal government became more proactive in driving up infrastructure provision. In 1968, with the establishment of the National Water Supply and Sanitation System (PLANASA), the government attempted to bring strategic direction and enhanced investment to bear on a sector badly in need of upgrade and reform. Other initiatives and regulatory structures followed, with the current framework being introduced in 2007. Rather than adopting the centralizing approach embodied in PLANASA, the current framework allows for a more decentralized approach, placing the municipalities at the heart of service provision but granting state governments a role in larger urban areas and the federal government an overall coordinating function. Despite these reforms, which allow for municipalities to outsource water and sanitation activities to the private sector, the sector remains both highly public sector-dominated and decentralized.

Despite the instability of the policy environment surrounding the sector, it is important to note that over the long term there have been notable improvements. Whereas in 1970 a mere 12.4 percent of Brazil's population had access to piped water and 6.4 percent to sewerage services, by 1991 these percentages rose to 50.2 percent and 19.2 percent respectively. As can be seen in Table 1, by 2010 water coverage was widely - though far from universally - available, particularly in urban areas. Sanitation coverage, however, was rather thinner. Aside from the regulatory complexities affecting investment in this sector it is important to note that it has been especially exposed to financing challenges stemming from changes in the fiscal policy arena. Following the implementation of the Law of Fiscal Responsibility in the 1990s (see Afonso et al., 2014) the ability of sub-national governments – in this case municipalities – to borrow to finance capital spending has been severely curtailed. Given the failure of the private sector to compensate fully via accelerated investment, it is little surprise that the sector has struggled to meet its challenges surrounding improving the quality and scope of service.

5) **Airports:** The physical scale of Brazil, the absence of long distance rail services and the poor quality of highways infrastructure outside the South and South East mean that Brazil is highly reliant on air transportation. Here, as elsewhere, the infrastructure is associated with a legacy of under-investment and poor connectivity, placing Brazil at a disadvantage in terms of international trade, investment and tourism. Brazil's two most significant international airports, São Paulo's Guarulhos and Rio de Janeiro's Galeão date respectively from the 1980s and 1970s and their capacity (at least in terms of terminal

rather than runway) is now severely strained (Da Silva Campos, 2010) something which is likely to become more acute in the wake of the Rio Olympics in 2016 and the FIFA World Cup in 2014. At the same time none of Rio or São Paulo's airports are served by rail or metro links, highly unusual for cities of such size and international standing. Size restrictions at these and other airports (notably São Paulo's Congonhas) together with limited capacity at the military-run national air traffic control system result in frequent delays and costs which are passed on to passengers. In an attempt to overcome some of these issues, operating concessions were granted to private sector consortia across a range of key airports (including Guarulhos and Galeão) in 2012 and 2013. The impact of these on Brazil's strained airport capacity issues remains to be seen but the indications so far are that the improvement work has got off to a slow start (Financial Times, 10 September 2013).

3. Contemporary policy responses:
The role of the private sector and the Growth Acceleration Program (PAC)

By the time of President Lula's second mandate (2007-2011) a firm national consensus had developed around the necessity to tackle the infrastructural deficiencies and bottlenecks retarding growth and, by extension, the further alleviation of poverty. As in the case of earlier efforts to tackle inflation (see Amann and Barrientos, 2014) business groupings (such as the National Confederation of Industry), trade unions and civil society were in broad agreement over the need to tackle a serious structural issue, while the government proved more than willing to step forward with a pragmatic solution embracing elements of market liberalization and state-directed investment. The resulting program, known as the PAC (Programa de Aceleração de Crescimento – Growth Acceleration Program) (Morgan Stanley, 2010: 55) was introduced in 2007 at the beginning of President Lula's second term. The PAC has divided into two phases, the first (PAC 1) running from 2007 to 1010 and the second (PAC 2), under the administration of Dilma Rousseff, from 2010 to 2014. They consist mainly of projects to increase infrastructure spending in critical, growth-sensitive areas (see Table 2). In terms of PAC 2, investments fall under six key initiatives: My House, My Life (housing), Water and Light for All (water, sanitation and electricity), Bringing Citizenship to the Community (safety and social inclusion), Better Cities (urban infrastructure), Transportation (railroads, highways and airports) and Energy (renewable, oil and gas).

PAC I envisaged spending of R$ 503.9 bn over its four year period while the more ambitious PAC 2 proposes spending of R$ 958.9 bn over its lifespan (around 2.7 percent of 2010 GDP per year), with a further R$631.6bn of investments planned beyond 2014. Whether these post PAC

2 investments take place as scheduled (or at all) will depend on the outcome of the October 2014 presidential elections though, with a victory for the incumbent President likely, it seems probable that elements of the plan, at least, will be followed[11]. The PAC, recognizing the limitations of previous spurts in infrastructural spending (notably the Second National Development Plan of the 1970s) also aims to address issues of infrastructural quality and durability by increasing public resources targeted at operation and maintenance.

Table 2: Brazil: PAC Investments by sector in %

Sectors	**2007-10**	**After 2010**	**Total**
Logistics	14.9	7.2	11.5
Energy	45.7	92.4	66.1
Social and Urban	39.5	0.4	22.2
Total	*100.0*	*100.0*	*100.0*

Source: PAC, Morgan Stanley LatAm Economics

Both phases of the PAC program have involved a central role for the Federal Government whose key strategic function embraces the selection of projects and the design of incentive mechanisms to encourage private, as well as public investments. However, the program has come under criticism for not delivering on its ambitious targets sufficiently rapidly. A brief review of the data suggests that these concerns may be – in the aggregate – overblown. Between the beginning of 2007 and the end of 2010, 82 percent of planned PAC 1 projects were completed with public investment rising to 3.2 percent of GDP compared with around 2 percent prior to the program's launch (Mourougane and Pisu, 2011: 10). It will be noted from Table 2 that there was a significant concentration of investment in PAC 1 located in social and urban infrastructure (mainly housing): this decline significantly in PAC 2. In Section 4 we shall see how this changing emphasis led to the rise in public protest, as it showed for a while that such problems as urban congestion were going to be sidelined.

Data released in February 2014 show that 82.3 percent of PAC 2's projects had been completed by the end of 2013 with accumulated spending reaching R$773.4bn, or 76.1 percent of the program's total budget[12]. Despite the scale of the program's achievements in overall terms, it remains true that investment in certain critical subsectors – notably urban transportation and sanitation - have met with significant delay. In the area of sanitation, for example, by the end of

[11] For more detail regarding spending priorities embodied in the PAC please see the PAC website http://www.pac.gov.br/sobre-o-pac/divulgacao-do-balanco

[12] Investorideas.com, 20th February 2014 http://www.investorideas.com/news/2014/international/02204.asp

2013, out of a total of 4128 sanitation projects scheduled to go ahead as part of PAC 2 only 54 percent have been granted formal approval and, of these, many have not reached the construction phase. A number of reasons explain the delays highlighted here; these will be analyzed in the next but one subsection and subsequent case study on urban mobility. Before discussing these issues it is worth reviewing the critical role of the private sector in driving PAC investments and infrastructural improvements more generally.

Regulation, PPPs and the concession contract-based model of infrastructural development

With the policy decision to tackle Brazil's legacy of ingrained under spending on infrastructure two things became obvious; first that the state did not have the technical or managerial means to accomplish these projects by itself, and, second, that it did not have the financial wherewithal to see these projects through to completion. It was thus decided to turn to two models; the Public Private Partnership (PPP) and the longer-established model of concession contracts. According to Spilki (2012: 5) the PPP concept "is not a precisely defined term and represents a variation of concepts and possible structures". In the Brazilian context these structures – or modalities of PPP – have included Build Own-Operate, Build Operate Transfer and Build Own Operate Transfer formats[13].

However, their common feature, as established under a 2004 law, is that they envisage an injection of public sector resources to support the private sector's investment activity (Mourougane and Pisu, 2011: 14). Concession contracts, by contrast, under the terms of the law, require no such public funding and should be able to sustain themselves by the levying of (regulated) user charges alone. The PPP approach was pioneered in the highways sector in the 1990s and has continued to be applied in that area with 17,904 km of roads under private sector operation by late 2013, compared with 15365 km by the end of 2010 (*O Globo*, 2013: 49).

During the Rouseff administration – whether through PPPs or concessions – the private sector became increasingly involved not only in the construction and maintenance of highways, but also in the construction, expansion and maintenance of railroads, the modernization of ports, the expansion of power generation, and the modernization of airports. This experience stands in some contrast to the generalized perception that under Lula and Rousseff, the approach to management of the economy has become more "statist". Faced with continuing fiscal restraint (see Afonso et al., 2014) the major factor driving the progressive introduction of both PPPs and the concessions was the lack of public funds to fully underwrite the infrastructure projects from

[13] For a full discussion of these concepts please see the World Bank PPP in Infrastructure Resource Center at: http://ppp.worldbank.org/public-private-partnership/agreements/concessions-bots-dbos

the public sector, and the perception that the private sector would be able to deliver infrastructure-based services in a more efficient manner than its public sector counterpart (Calderón and Servén, 2012). What are the implications of this model?

In order to attract sufficient private sector bids for infrastructure projects, the rate of return (based on tariffs and/or tolls) could not be at an artificially repressed level. The reason for instead accepting a more "market-based" rate of return for projects was that it was the only means to attract the necessary financing and the technological and managerial input which the project required (ibid.). Thus, in this sense, reliance on the private sector may imply accepting a situation which in the short run may contribute to the worsening of the distribution of income, as higher tariffs and tolls usually fall more heavily on lower income groups. Also, concession contracts are long term commitments as most of them have a duration of 25-30 years. Since, during the contract period there will be several changes in government it is conceivable that new policymakers – perhaps embracing a populist agenda - may be less favorably disposed towards the private sector. Thus, the model of concessions in Brazil could potentially lead to eventual conflicts between the state and concessionaires over tariff levels which were originally set at a level consistent with attracting accelerated investment.

A potential advantage of the concession and PPP models has to do with maintenance. The long term Brazilian experience suggests that when the state is directly in charge of infrastructure, its bias is to be concerned with opening up new projects and to neglect maintenance. However, the new concession and PPP contracts usually contain clauses that oblige the private sector operator to maintain the infrastructure to a carefully specified standard. Under public ownership in Brazil, especially during the 1980s and 1990s, maintenance of infrastructure suffered as subsequent governments deferred spending due to fiscal crisis or, in better times, in favor of spending on new, politically higher profile projects (Baer, 2014). However, the state has to establish a careful method of monitoring not only the maintenance, but the adherence of the operator to other terms of its contract which would typically include quality of service provisions, universal service (in some cases), interconnection arrangements[14] and other important stipulations whose precise nature would depend upon the sector in question. In order to facilitate this, appropriate regulatory arrangements need to be established and this requires the creation of sufficient technical and legal capacity to carry out the necessary functions.

[14] Interconnection arrangements refer to where comprehensive networks are created by linking the infrastructural assets of different providers. The most prominent example may be found in telecommunications where most regulatory structures mandate the interconnection of rival operators' networks in the interests of the consumer.

Brazil during the 1990s saw the creation of a range of sector-specific regulatory agencies, for example, ANATEL (for telecommunications), ANEEL (for electricity) and ATT (for ground transportation) (Pires and Goldstein, 2001). The challenge here – quite apart from the technical and legal demands – is to ensure that the regulatory bodies remain free from undue outside influence and capture by those they seek to regulate.

Regulatory issues and other factors driving delays in infrastructural investment

A characteristic to date of infrastructure investments in Brazil has been the comparative slowness with which they have been rolled out. The delays in implementation affecting the PAC, in particular, have been blamed on the complicated bureaucratic mechanism which has grown over many generations governing the release of public funds and the very cautious approach of the authorities in running bidding competitions, especially in the field of the novel PPP contracts. Perhaps the most glaring obstacle to accelerated process has centered on the delayed issue of environmental permits by IBAMA and state-level bodies. The delays here have largely concerned the slow operation of dispute resolution procedures and the licensing mechanisms rather than the environmental regulatory provisions themselves (Mourougane and Pisu, 2011: 17).

Brazil's environmental licensing procedure involve a three stage process involving the issue of Preliminary, Installation and Operating licenses, each of which requires its own procedures and creates separate scope for the generation of disputes and appeals. This stands in marked contrast to the more streamlined processes which are typically found in other emerging and developed economies. According to a recent World Bank study, no less than 15-20 percent of the budgets of hydroelectric projects in Brazil are accounted for by environmental licensing costs (The World Bank, 2008). Easily the most celebrated case in this regard has been the Belo Monte dam project, which, in the wake of environmental disputes, has met with repeated delays and budget overruns.

Although issues around environmental licensing have attracted most attention, investment continues to be inhibited by other regulatory problems, not least changes in the long term approach surrounding the setting of tariffs. A good case in point here concerns the highways sector. Under the government of Fernando Henrique Cardoso in the 1990s, road tolls were set at a sufficiently high level to encourage private sector operators to enter what was then a very new market. This policy did lead to a rapid upsurge of private sector investment in the motorway network of the South and South East. However, the high level of tolls provoked popular opposition and the decision of some users to abandon the newly improved infrastructure for more congested – and dilapidated - public sector highways.

Presidents Lula and Rousseff, appealing to their political support base, changed the regulatory model for new highway concessions, selecting winning bidders on the basis of those able to offer the lowest tolls rather than on the basis of track record or capacity to deliver. Correspondingly, the pace of private sector-driven upgrading of the highway network has lagged behind schedule while there are curiously high disparities in toll levels between highways governed by Cardoso-era and Lula/Rousseff era contracts. As a result, tolls now vary between R$1.99 and R$18.56 per 100km (*O Globo,* 8 December 2013). Similarly, the need to rein in tariffs underpins at least in part, the failure of much needed additional power generation and distribution capacity to be put in place in the urbanized South and South East. Stemming from this, power outages are by no means an infrequent occurrence in these economically critical regions.

While public attention has been focused on the role of regulatory obstacles to accelerated infrastructural investment it is important to recognize the role of two other critical factors: access to long term finance and technical capacity. For reasons which are made clear in an accompanying paper on fiscal policy (Afonso and Araújo, 2014), since the 1980s the capacity of both the federal and sub-national governments to expand the scope of discretionary spending in the field of capital investment has been severely restricted. As a result, and as already made clear, the private sector has been expected to fill the breach. However, at least as far as the domestic private sector is concerned and unlike its counterpart in high-investing China, its ability to perform this function has been severely constrained by the comparative shallowness and illiquidity of domestic capital markets (see Torres et al., 2014). At the same time, and, again in telling contrast to China, base real interest rates have been maintained at among the highest levels in the emerging market world as part of the authorities' counter inflationary strategy.

Consequently, for potential domestic private sector infrastructure operators, the provision of capital has become a binding constraint with the only viable sources being retained earnings, or, more usually, subsidized credit from official sources such as Brazil's BNDES development bank or the International Finance Corporation. The BNDES has played a very active role in supporting the provision of infrastructural provision through the extension of long term credit. Still, the scale of the investment challenges involved will require additional sources of capital if growth constraints are to be alleviated. Foreign investors have, and will continue to play an important role. However, following a burst of foreign participation in infrastructure projects following major privatizations in the 1990s (notably in the telecommunications sector), the surge of foreign infrastructural investment has slowed largely as a result of a less favorable regulatory climate. This has been an especially important factor in two critical sectors: electricity and oil and gas. In the former, following its adjustment under President Lula, the tariff regime on offer has not proven sufficiently attractive to draw in required investment. In the latter, local content requirements and the National Oil Company (NOC) – Petrobrás centered – regulatory framework surrounding the development of new offshore oil reserves has also served to deter strongly accelerated investment.

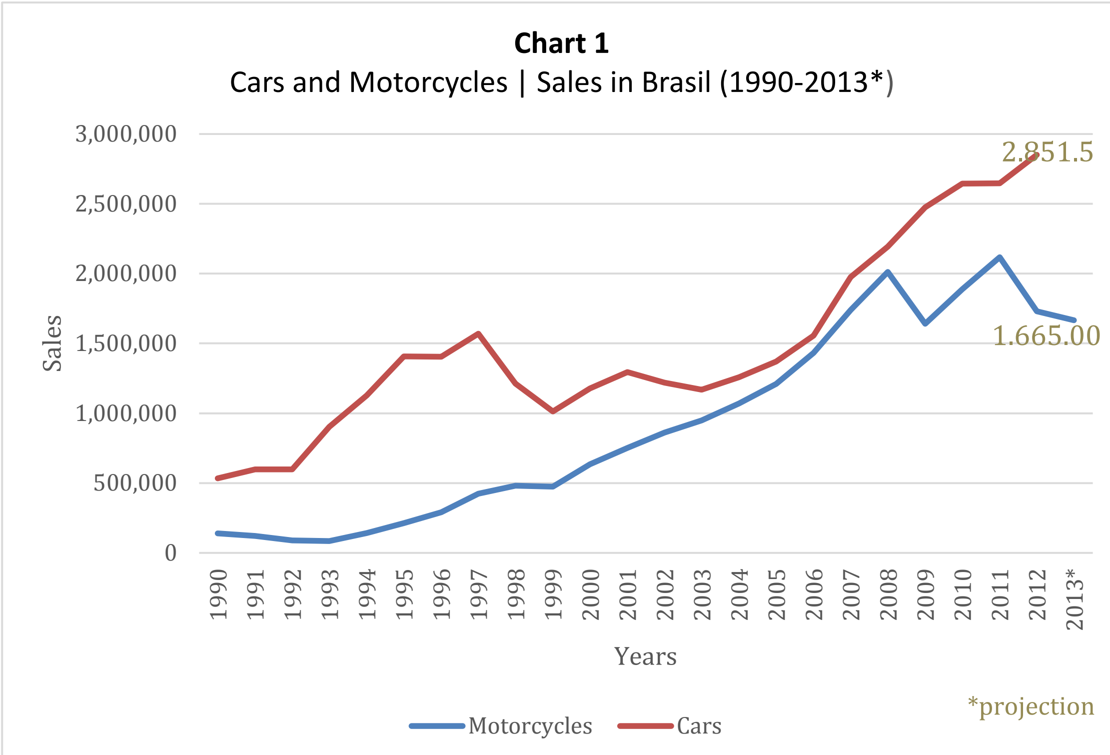
The role of technical capacity should not be underestimated in considering the challenges that Brazil faces in trying to ramp up spending on complex and technologically demanding infrastructure projects. Brazil possesses world class technical expertise and home grown infrastructure project specialist multinationals such as Odebrecht and Camargo Corrêa. Such capacity stems from a long tradition of civil engineering and infrastructure organization, dating back at least to the Barão de Mauá in the nineteenth century. This provided Brazil with the pool of expertise and human capital stock necessary to build up infrastructure.

However, a legacy of under-investment in human capital born of the 1980s and 1990s infrastructure squeeze, means that this expertise is now very thinly spread. Although this technical capacity constraint is being alleviated through a renewed commitment to training and investment within the construction and other relevant sectors, there are considerable lags involved. In the absence of increased foreign participation in Brazil's infrastructural investment, these constraints will continue to bite in the short and medium term.

Although it is not our aim to get into details, our survey of Brazil's infrastructure would not be complete without mentioning the problems of corruption that it entails. A FIESP study, the São Paulo-based industrial association, estimated that with the money lost to corruption in the first stage of the PAC between 2007 and 2010, 124 percent more roads and 525 percent more railways could have been built. (for details, see: Ojo and Everhardt, 2013).

4. Case study: urban transportation

Brazilian cities are among the most car-dependent in the world (Biderman et al., 2009). Automobile production has grown from less than one million vehicles per year in the early 1990s to about 3.5 million in 2011. Domestic sales of autos have doubled in the 2005-2012 period and motorcycle sales also have shown dynamic growth (Chart 1).



Sources:
ANFAVEA Annual Report- Anuário da Indústria Automobilística Brasileira 2013 (http://www.anfavea.com.br/anuario2013/anfavea2013.zip)
ABRACICLO - Associação Brasileira dos Fabricantes de Motocicletas, Ciclomotores, Motonetas e Similares (http://www.abraciclo.com.br/images/stories/dados_setor/motocicletas/retrospectiva/2013_retrospecto_setor_motociclos1.pdf)

Automobiles are near the intersection of big business and big government in Brazil. The country hosts more than 20 private companies producing vehicles in at least 53 plants; new entrants into this market appear regularly. The industry generates more than 150,000 jobs directly and many more indirectly through networks of suppliers, retailers, and providers of support services. Automobile sales generate significant tax revenues for the government with something on the order of 30 percent of the final consumer automobile price comprised of various federal, state, and municipal levies.

Car ownership in Brazil as a whole is still relatively limited by international standards. The ratio of inhabitants per automobile in the United States, for example, is 1.2; this same ratio is 3.5 in Mexico, a middle-income society comparable to Brazil. In Brazil, the ratio is much higher – six residents per vehicle (ANFAVEA, 2013). Between 2008 and 2012, years of rapid economic growth in Brazil, the percentage of Brazilian homes with either an automobile or motorcycle increased by nine percentage points from 45 percent to 54 percent of all households.[15] In some of the wealthier states in the south of Brazil, these ownership rates can be as high as 75 percent of households with access to a vehicle (IPEA, 2012b.)

While individual motorized transport expands relentlessly, Brazil's system of public transportation – buses, suburban railroads, subways, ferries, and so forth – is, for the most part, a study in decline. In Chart 2 below, the main ridership trends can be seen using long-term data from Rio. Cars are now the dominant mode of transport, surpassing and competing for urban space with public buses which is the only other important mode of transportation in the city. Streetcars have disappeared with no light rail systems built to replace them. [16] Commuter rail usage, even including subways, has barely increased. Most public transportation (on the order of 90 percent of all trips taken on public transportation) occurs on buses and related informal modes of transport, such as private vans. Rio has only 40 kilometers of subway lines.[17] Bus Rapid Transit (BRT) construction, a cheaper alternative to subways, is accelerating in advance of the 2014 World Cup and 2016 Olympic Games; 160 kilometers of such dedicated lanes are under construction.[18]

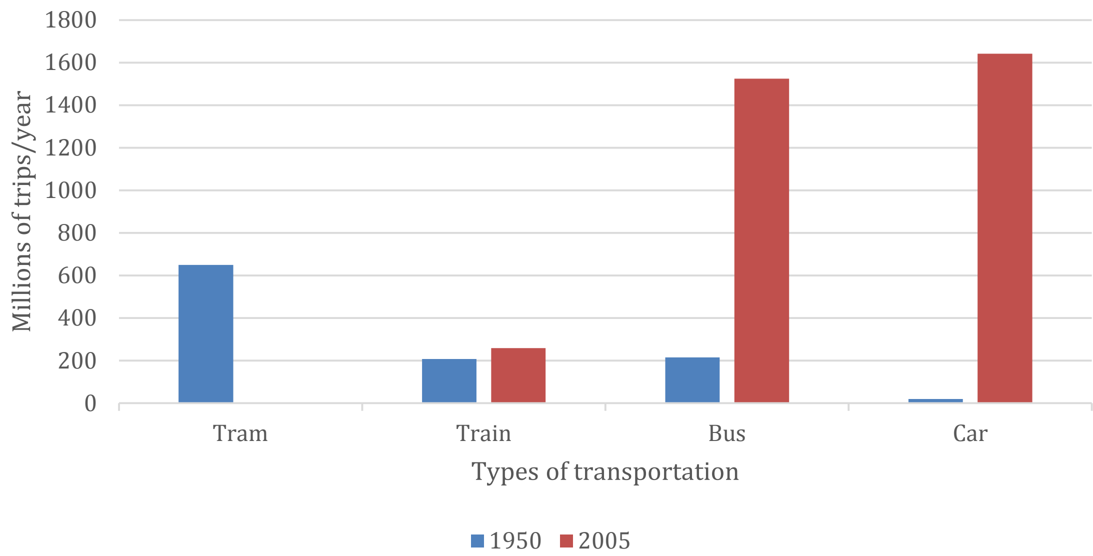
[15] Amplifying this point, the same IPEA (IPEA 2012b) study showed that only 28 percent of the poorest households in Brazil in 2012 had an automobile whereas 88 percent of the richest households owned at least one car.

[16] Rio is planning to inaugurate by 2016 a new light rail system in its downtown area.

[17] By comparison, Mexico City, which started its system at about the same time, has 177 kilometers. Other systems in wealthier countries typically have more than 200 kilometers and, in the case of London, more than 400 kilometers of subways.

[18] Ironically, BRT systems were pioneered in a Brazilian city – Curitiba in the 1970s. The irony is that no other Brazilian cities have proven to be good imitators of Curitiba's widely heralded success.

Chart 2
Long-term Trends in Mobility in Rio de Janeiro



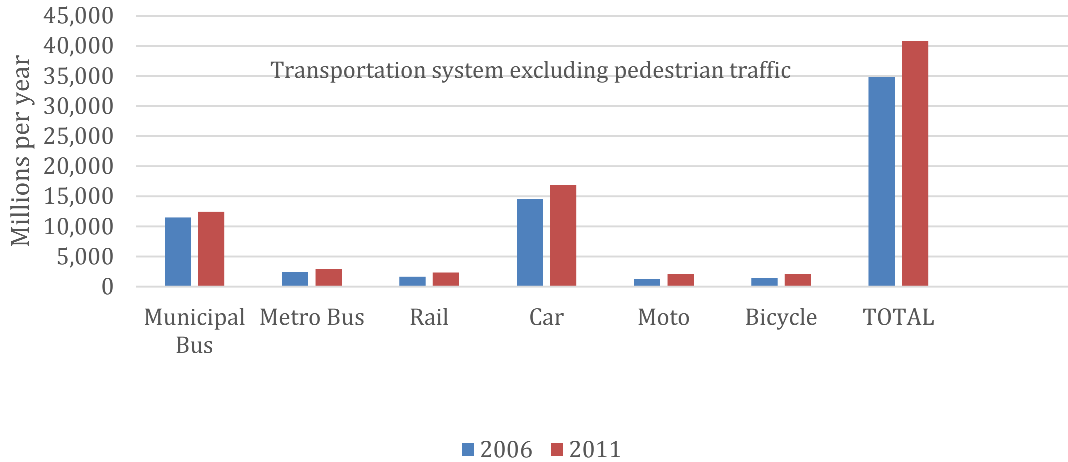
Sources: BNDES (2012: 316).

São Paulo is emblematic of the types of traffic problems that lie in waiting for other Brazilian cities. Some public investment in transport infrastructure is occurring, but it is relatively small. Following years of delay, São Paulo has a subway extension of 60 kilometers and 120 kilometers of BRT corridors. To put these advances in perspective, São Paulo has 17,000 kilometers of roadways, 15,000 buses, 4,300 kilometers of regular bus routes, and 7 million cars with the car fleet growing by 650 new vehicles per day. Traffic backups in São Paulo typically extend to 100 kilometers per day, peaking at between 200 to 300 kilometers (Biderman et al., 2009).

Transportation modes in Rio and São Paulo are typical of other metro areas. Chart 3 shows the relative importance and recent growth of transport modes. Aside from the fact that most trips taken in cities are by pedestrians on foot, the transportation system in urban Brazil is basically bimodal – private autos and municipal buses with growth of the former rapidly exceeding that of the latter. All other modes – subways, commuter rail, metropolitan region buses, etc. – account for very small percentages of rides taken in cities.

Chart 3

Urban Mobility in Brazil: Trips Taken by Mode of Transport



Source: National Association for Public Transportation (ANTP) 2011 and 2006 Annual Report

Most automobile owners in Brazil use vehicles primarily as a means to get to their places of employment. As congestion mounts, commute times are increasing. IPEA data show that the time required to commute one-way in Brazilian cities is already among the highest in the world. (IPEA, 2012b) The average time to commute to work is on the order of 30 minutes but this is increasing and higher in the larger urban areas. 20 percent of urban dwellers spend one hour or more to commute to work; in the two largest cities of São Paulo and Rio, 25 percent of commuters use more than one hour to get to work, especially residents of poorer, outlying districts (Biderman et al., 2009). In addition to the inefficiencies caused by lengthening commute times, other negative externalities are generated by the growing national reliance on cars. Traffic accidents, air pollution, inefficient use of public lands, and a national dependence on fossil fuel are among the additional by-products of dependence on cars.

As Brazilian cities become congested, technical solutions are not at hand. BRT construction may be the most attractive alternative, and it has worked well for the city of Bogotá (whose efficient TransMilenio system carries huge passenger volumes with relative speed and safety) but the experience of other Latin American cities (e.g. Santiago which faced great difficulty and public protests following the roll-out of its "Trans-Santiago" BRT system which became immediately overcrowded) shows that BRTs are not a cure-all. Subway expansion helps and is very popular but the cost per kilometer of subway lines is eight times that of BRTs and constructing subways in the built environment of Brazilian cities adds delays and legal complexities. Other approaches to congestion alleviation do not play well politically in Brazil. Public and businesses do not support restrictions on vehicle use such as congestion charges, street closures, parking fees, circulation restrictions, higher vehicle and gasoline taxes, etc. Left undisturbed, the short-term and long-term trends point to increasing use of the private auto and a relative decline in municipal buses. Seminars are regularly held in both Rio and São Paulo about what to do when these car-clogged cities eventually "stop". The story of how Brazil came to this impasse emerges out of public policy to encourage the use of the automobile combined with a history of neglect of urban transport infrastructure.

Urban Mobility Policy in Historical Perspective

Public urban transportation networks (roadways, buses, etc.) in Brazil have developed in Brazil in response to local development needs. For the most part, public mobility infrastructure today remains the responsibility of municipal governments. The federal constitution of 1988 formally recognized the primacy of local governments in traffic and transportation, albeit without assigning to these units the fiscal resources to carry out what was to become an increasingly complex task.

The federal government has little legal basis to intervene in local transport planning and financing, although, by an accident of history that remains uncorrected, the federal government does own and operate suburban commuter rail tracks. Municipal control has its pitfalls. Many Brazilian municipalities are contiguous urban territories and yet no level of metropolitan government authority has the legal and financial power to coordinate policies within the region. The situation is particularly complex in São Paulo where 38 independent municipalities adjoin one another to form the metropolitan area (IPEA 2013a).

Public-private partnerships have played a minor role in public infrastructure investment in Brazil. Local governments typically arrange for the financing to construct and maintain the main transportation corridors (roadways, rail and subway track, etc.) and then select private concessionaires through open bids who are responsible for the purchase of equipment and operation of the system, plus storage and maintenance of the rolling stock. Given the local emphasis in urban transportation policy, federal government policy toward the urban transportation sector has emerged only fitfully in the modern era (Lima, 2012). Prior to the 1960s, the federal government's role was restricted to the construction and operation of a national highway network linking urban centers. The federal government has become entangled in suburban rail transportation service through its ownership of national railway systems that, while mainly carrying long-haul cargo, also operated passenger train systems.

Modern federal transportation policy dates to planning for the subway systems of São Paulo and Rio which were constructed with federal financing starting in the late 1960s and early

1970s (IPEA 2013d). A seminal moment was the creation in 1965 of the Empresa Brasileira de Planejamento de Transportes (BNDES, 2012) which for the first time established urban transportation as a priority of the federal government. Further institutional development under the aegis of the Ministry of Transportation occurred over the ensuing decade, primarily for the purpose of training transportation specialists and city planners. Other initiatives in the 1970s and 1980s included a fund to finance urban mobility (Fundo de Desenvolvimento de Transportes Urbanos, one of several such funds). The federal railway system spun off a subsidiary, to become known as the Companhia Brasileira de Trens Urbanos (CBTU), to focus on the suburban passenger and urban subway systems.

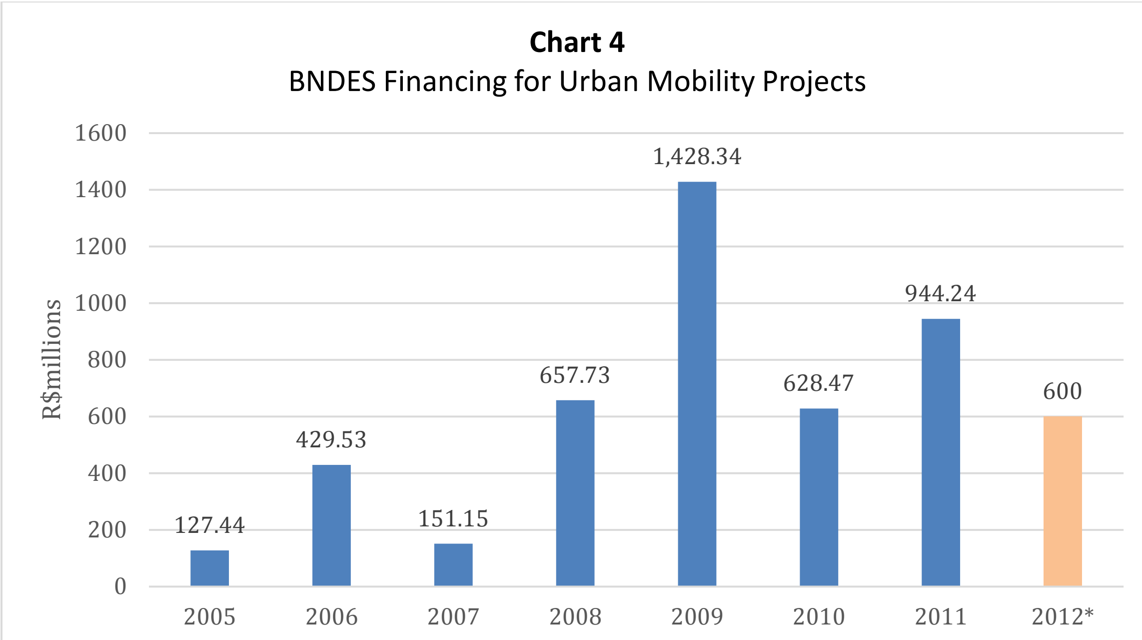
Despite such institutional ferment, federal urban transport policy failed to take root in subsequent decades. Reflecting failures in integrated planning, federal transport policy was not closely aligned with housing policy or employment market trends in the major cities. In any event, Brazil's infamous "lost decade" of financial crisis in the 1980s and early 1990s drained federal coffers of resources for effective investment especially in face of other, more pressing national priorities. Even the subway projects in Rio and São Paulo, launched with great expectations in the 1970s, came to a halt. Suburban rail systems - trains, platforms, tracks, and technology - suffered grave neglect from a distracted federal government working in poor coordination with local transport authorities.

The early 2000s have witnessed a more promising era in federal urban transport policy and in urban policy more generally (IPEA 2012a). A Ministry of Cities was created in 2003 to deal specifically with urban policy concerns, including public transportation.[19] New federal legislation was proposed to set mandatory guidelines for local governments, including universal access to public transportation, enhanced safety standards, and energy efficiency. Final approval of this legislation did not occur until 2012, however, reflecting conflicts between the respective roles of federal and local governments in urban transport policy.

The requirement that cities in excess of 500,000 inhabitants be required to produce integrated urban transportation plans was another sign of the more active federal role in the mid-2000s. To encourage more local mobility projects, the federal government authorized increases in low-cost lending by the National Bank for Economic and Social Development (BNDES). Disbursements, mainly for subway systems, increased significantly in the 2000s, as can be seen below in Chart 4.[20]

[19] Although whether this was a healthy institutional move is open to question given the low profile and relative weakness of this new ministry.

[20] Not all of the proposed urban mobility projects proposed by the federal government are likely to relieve the most severe congestion at the least cost. For example, a hugely expensive, high-speed train



Note: 2012 data is estimated based upon disbursements through June.
Source: BNDES (2012)

Other forms of federal financing also appeared in the early 2000s. The federal government designed a special "Growth Acceleration Program" (PAC) in 2011 to channel funding to urban mobility projects, though again the major emphasis was on subway systems in cities, including Belo Horizonte, Recife, Salvador, and Fortaleza. In the aftermath of the public unrest with the transport system in 2013, the federal government announced additional emphasis on urban mobility programs, though without releasing detailed plans. (While more federal spending through these channels seems likely, a risk exists that such projects could be awarded on the basis of political considerations as mayors and governors lobby federal officials for pet projects. BNDES financing, by contrast, is more likely to be preceded by careful planning and cost-benefit analysis than other units of the federal government, including the Ministry of Cities, are capable of mounting.)

Despite some advances, shortcomings in public transportation policy stand out. The federal government effectively remains on the sidelines of the urban transport debate, limited to project support at the local level, but unsuccessful in such areas as national regulatory standards, dedicated project funds, best management practices, and new technologies that might promote modernization of urban transport infrastructure. These problems related to the federal government's role are particularly significant in view of the financial and human resource limitations of the local municipalities most responsible for urban policy.

---

link between Rio and São Paulo is on the drawing boards, though implementation has been delayed. It is expected that the BNDES would provide up to 70% of the total project cost of approximately $20 billion.

Economics of Urban Public Transportation

Recognizing that a transportation system is a public good that benefits all, global cities assign budget resources so that non-users (e.g. private automobile owners, businesses) share in the costs. In Brazil, however, public transport revenues derive almost entirely from user fees, mainly bus fares paid by passengers. São Paulo does provide about 20 percent of the funds needed for bus and subway transportation through the city budget, but São Paulo's budgetary allotment is smaller than in developed world cities in which public budget support accounts for 40 to 60 percent of mass transit revenues.[21]

As the level of bus fares in urban Brazil was one of the sparks of public dissatisfaction and a daily reminder of government corruption and inefficiency, a closer look at fare setting and its distributional consequences is merited. Regulatory authorities in metropolitan areas, some better staffed and more effective than others, oversee fare setting. The fare is calculated by dividing a broad gauge estimate of operating costs per kilometer by an index of ridership per kilometer (taking into account that not all riders pay the full fare as some groups, including seniors and students, ride for free). The resulting ratio of cost/rider is then used as a baseline in a public bidding process. On top of this baseline, private bus operators compete by adding desired profit margins.[22] Concessions are awarded to the lowest bidders on five-to-seven year terms and are renewable. The larger metropolitan regions typically license between six to eighteen private operators.

While the fare-setting model is competitive – concessionaires are awarded routes on the basis of the lowest bids – it does little in practice to encourage efficiency. If the input prices (mainly salaries and diesel fuel) cause the baseline cost to rise, fares are automatically adjusted upward. Operators have little incentive to reduce costs. (It was just such an automatic adjustment in fares that sparked the mass demonstrations in São Paulo and other cities in 2013.) Moreover, as fares do rise, ridership tends to decline, thus increasing the regulatory body's estimated cost per passenger kilometer. Eventually, this feeds into still further increases in fares in a vicious circle pattern.

Little is known of the actual financial performance of the private bus operators. Realized rate of return data, for example, are not available. Public fear persists that bus owners foster and

[21] Luis dos Santos Senna, *O Transporte Público de Passageiros e Seu Financiamento.* Unpublished presentation, available at: http://www.al.rs.gov.br/FileRepository/repdcp_m505/ComEspMobilidade/Transp_publ_%20L.Afonso_Senna.PDF (accessed January 2014).

[22] Subway charges are then set close to the bus fare, with the difference in operating costs of the subway system made up by state subsidies.

benefit from corruption in city governments and lax regulation. Competition tends to be fiercest on lines that service the center city areas, leading to concentrations of buses that add to congestion and slow travel times in downtown areas. While some cities operate clearinghouse systems to force a sharing of revenues among operators in dense and those in less dense areas of the metropolis, most cities do not. As a result, the peripheral areas of the city tend to be less well served while those in the center of the city endure an excess of competition that probably compresses profit margins.

The weakness of government regulatory bodies (including a lack of qualified inspectors) and the particular business models of the bus operators do little to promote passenger comfort, safety, and satisfaction (BNDES, 2012). For example private operators supplement fare revenues through the purchase and subsequent resale of vehicles to smaller, poorer cities in interior regions of Brazil. This encourages the use of stripped down vehicles, which contributes to poor perceptions of public transit. Typically, municipal buses lack air conditioning, despite Brazil's warm climate, are equipped with motors that are noisy, wasteful of energy, and underpowered, turnstiles that are difficult for passengers to navigate, suspension systems not up to the task, entrances and exits inaccessible to the handicapped, and minimal safety equipment. [23]

On top of these non-fare factors that would explain public dissatisfaction, the relative price of public transportation in Brazil has actually increased substantially in comparison to vehicle ownership (IPEA, 2013a). This is a combination of two factors: a) the pricing model for public transportation that permits fairly automatic pass-through of increases in input prices and little concern for operating efficiency; and b) conscious public policies to encourage the use of individualized motor vehicles through reducing the cost of ownership.

The figures in Chart 5 below illustrate these price dynamics at work (ibid.). During the period 2005 to 2014, Brazil's index of consumer prices (known as the IPCA) increased by 160 percent. During the same interval, retail gasoline prices, which are controlled by the federal government, rose by only 16 percent, reflecting trends both in global oil markets and deliberate government policies to ease the inflationary impact of gasoline prices. Meanwhile, the overall costs of vehicle ownership (including, taxes, maintenance, insurance, registration, etc.) rose by only 7 percent, i.e., far below the average increase in the cost of living. Public transportation prices, measured as average bus fares in six major metropolitan areas, have illustrated a strikingly different pattern during 2005 to 2014, rising by almost 170 percent, some 10 percent above the average increase in consumer prices. This substantial real increase in bus fares, a

[23] While the emphasis here is on public buses, passenger comfort, safety, and satisfaction with suburban train systems (operated and regulated by the federal government) operate at similarly low standards.

pattern that probably has held since at least 2000, fueled the fires of public discontent in Brazil. The decadal increase in bus fares only leveled off after the public protests in 2013.

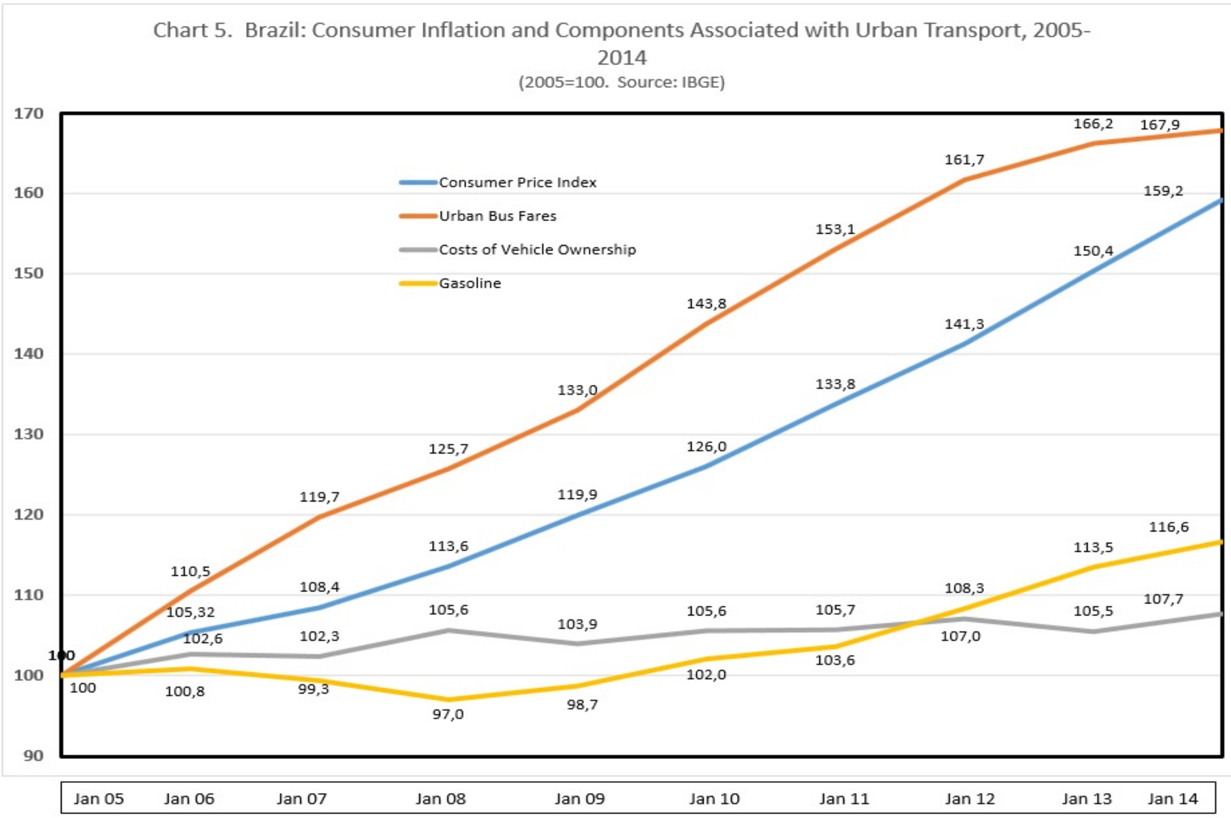


Chart 5. Brazil: Consumer Inflation and Components Associated with Urban Transport, 2005-2014
(2005=100. Source: IBGE)

Source: IBGE http://www.ibge.gov.br (Ipca por subitem), accessed May 2014.

The rising real cost of diesel fuel, an input accounting for at least 20 percent of operational costs, was the most important factor behind the rise in the cost of public transport. Local bus systems are labor-intensive operations with wage costs accounting for 40 percent or more of total costs. Thus, it is noteworthy that the rise in bus fares in the 2000s is not explained by rising wage costs; on the contrary, salaries for drivers and fare collectors have lagged well behind inflation. A possible explanation is that, faced with steep increases in diesel prices, bus operators have compensated by reducing the work force and capping salaries for employees, thereby limiting bus service, undermining employee morale, and diminishing passenger satisfaction.

Other components of the cost of bus operations played a role, for example, government taxes. Typically, 4 to 10 percent of the cost base of public transportation is comprised of various state and municipal levies. While not large in itself, the positive tax burden points to the remarkable fact that in Brazil local authorities actually derive revenues from the public transportation system, a marked contrast with international practice. Moreover, studies suggest that the combined direct and indirect tax burden on public transportation is actually much higher – closer to 30 percent - after taking into account federal, state, and local taxes on inputs such as fuel and salaries (IPEA, 2013a).

In all, the rising price of public transportation relative to vehicle ownership probably accelerated the trend to abandon public transportation in favor of automobiles and motorcycles. This relative price movement should have been expected. A recent IPEA study calculates that 90 percent of all subsidies to urban transportation in Brazil are subsidies to private vehicles, through holding down retail gasoline prices as compared to diesel fuel and by reducing the tax burden on vehicles, especially on smaller vehicles, while taxing public transportation at the same time (IPEA, 2013e).

The distributional consequences of the urban mobility system are alarming. The poor pay relatively much more than the more well-off to use the public transportation system while at the same time having the least access to it. Household survey data show that 15 percent of the income of the poorest 10 percent of the populations in metropolitan regions of Brazil is spent on public transportation versus an average of just 3 percent for all income groups - five times as much. Furthermore, 30 percent of the poorest families in the bottom 10 percent of the income distribution report spending no money at all on public transportation, suggesting their total exclusion from the system meant to serve all. Across Brazil, the household data suggest that as many as 8 million urban dwellers have no access at all to public transport; they simply do not use it.

Lessons from the Brazilian urban mobility experience: involving the private sector

Investment needs in urban mobility in Brazil are large, far beyond the capacity of the public sector to provide or even to plan for. A BNDES report estimated minimal investment requirements for BRTs, subways, railroads, and light rail in 38 Brazilian metropolitan areas. In order to compensate merely for existing deficiencies in service, investment would need to be on the order of at least R$113billion, approximately US$50 billion (BNDES, 2012). This estimate did not take into account future needs to accommodate growth in Brazilian cities. In order to begin to address this gap, new mobility policies and institutional designs are needed to attract private sector investment to this sector.

On the policy front, an absolute priority must be given to public transportation over individual motorized (cars and motorcycles) transport. (Biderman et al., 2009) Politically unpopular measures must be taken to discourage automobile use in major urban areas, including congestion pricing and restrictions on circulation, even before satisfactory public alternatives become available. Some cities, especially Rio and São Paulo, have begun to experiment with such vehicle restrictions.

Regulatory and governance issues must also be addressed. Few, if any, Brazilian municipalities have in place adequately staffed regulatory agencies to apply and review rules for public transportation, monitor performance under contracts, and watch over the economic and financial soundness of the sector. The role of the federal government needs to be strengthened in this regard and a new push may need to be made to empower metropolitan governments to forge regionally coordinated policies. The issue of operation and oversight of suburban rail systems must also be re-examined by extracting the federal government from the operation of this critical sector to permit more integrated mobility planning.

Public policies must channel additional financial resources into the urban mobility sector, including through ordinary budget resources of local governments. Brazil's dependence on fares to generate revenues needs to be changed. The federal government may be able to play a role in assembling a permanent fund for mobility financing through, for example, increased gasoline and vehicle ownership taxes, providing the proceeds of these are clearly set aside and used for urban mobility. Attempts have been made in the past to set up such dedicated funds and even to earmark tax revenues for public transport. For various reasons, these efforts have floundered. The issues need to be revisited and re-addressed with urgency.

Once such policy priorities as those mentioned above are established, Brazil will be in a stronger position to attract private sector financing to public transportation. The present model of public-private partnership is not remotely sufficient to address investment needs. As things stand, the public sector builds the infrastructure and then contracts private operators. These private operators are not providing significant investment resources and are plagued with significant operating problems - a loss of productivity, rising costs, declines in ridership, and a lack of guarantees for target rates of return. On top of these, much of the potential passenger base migrates inexorably toward automobiles while the high level of fares puts service out of reach of many low-income riders who underuse the system.

Attracting private investment to design, build, and operate new systems of public transportation will require legal guarantees of a rate of return for the private firms. Rates of return should not be squeezed to the bare minimum, as is the practice in public-private partnerships in Brazil today, in order for winning bidders to cope with risks inherent in this sector and to gain incentives to seek funding from private sector sources and not solely from the BNDES or the federal government (Senna, 2013).

Finally, it is ironic that Brazil finds itself in an urban mobility dilemma when a Brazilian city, Curitiba, showed the world decades ago a possible path toward relieving congestion through modern design and better technologies for safety, comfort, and efficiency in the system. Cities inspired by Curitiba's example, Bogotá prominently among them, have continued to develop modern transport systems with intelligent use of public-private partnerships. In Bogota's case, these policies have centered on aggressive policy of BRT expansion of a type involving the best technologies leading to much lower travel times and greater passenger safety and satisfaction. For the most part, Brazil's BRT expansions, in São Paulo in particular, have been downgraded variations on the Bogotá experience, clearly inadequate in scope and execution to the task at hand.

Brazilian municipalities, by embracing radically pro-public transport policies, must follow this path in the future, thereby heading off catastrophic problems of congestion and other negative externalities which will be caused by the simple extrapolation of today's trends. As Biderman et al. (2009) remind us, public transportation policy in most developing countries, including Brazil, means accommodating more cars. As cities advance toward developed status, public transportation policy must mean something diametrically different – far fewer cars, much more public transportation, especially bus rapid transit systems, and vastly more pedestrian and cycle traffic. Brazil is at this policy crossroads right now, but whether its largest municipalities and the federal government will have the political courage and technical vision to make the right choices remains an open question.

Conclusions

Hirschman (1958) argued that infrastructural investments are very lumpy in nature and therefore, unless there is an acute shortage of capacity, investments tend to be postponed until a crisis situation is reached where political justification for large amounts of investments will be acceptable to society. Leaving infrastructural provision to the private sector, is it the case that such postponements can be avoided? Brazil over the last 25 years offers an interesting case study of an economy where private provision of critical infrastructure has come to rival that of the public sector.

Whether or not this development will allow Brazil to avoid the "the Hirschman trap" depends on a number of factors which we have examined in the course of this paper. These would include the nature of tariff setting arrangements, the types of regulatory frameworks applied to performance factors such as quality and availability of service and, more generally, changes in the political climate that might deter future rounds of private sector investment. The evidence so far provides a mixed picture and it is certainly not the case that present arrangements are generating increases in infrastructural provision sufficient to meet rapidly rising demand and expectations on behalf of the population at large. This complex situation provides important lessons – both positive and negative – for other developing and emerging economies, notably those of Africa.

The first general conclusion to be drawn from the Brazilian experience is that infrastructural spending can be an important driver of GDP growth, both in overall and per capita terms. Our econometric analysis indicates high growth elasticities, especially where investment in transportation infrastructure is concerned. In this sense, it is perhaps surprising that infrastructure investment, notwithstanding the PAC I and II programs, has been so comparatively restricted in recent years. This has created real pinch points and structural bottlenecks as the analysis of the urban transportation sector so clearly reveals. Such a situation is by no means unique to Brazil: fast –growing African economies such as Nigeria and Ghana are also suffering the effects of infrastructural capacity constraints, most especially in regard to urban transportation (as any gridlocked motorist in Accra or Lagos could attest). Given the obvious priority that should be accorded to infrastructure, the question then becomes why has investment in this sector not been higher? This paper points to a number of factors, most of which have clear resonance across other developing and emerging economies. In first place, efforts to drive up infrastructural spending through direct public sector investment have long been limited in Brazil by the necessity for fiscal adjustment and the weight of non-discretionary spending items in the overall budget. This ongoing situation, of course, provides the background and justification for increasing private sector involvement. However, as we have seen, the private sector has been unable to fully take up the slack left by a fiscally constrained public sector. Part of the reason here lies in thin domestic private sector capital markets and associated high interest rates. This, of course, partly explains why foreign direct investors have played such a significant role in private infrastructure provision since the early 1990s.

However, foreign investment flowing from the private concession and PPP arrangements that have dominated the landscape for the past two decades has failed to keep pace with Brazil's fast-expanding infrastructure demands. This paper has argued that a central reason for this lies in the design and implementation of regulatory mechanisms. In having to reconcile their social obligations with the need to attract investment, regulators have increasingly drawn the line in favor of the former, with rates of return on offer insufficient to ignite accelerated private sector participation. At the same time, and in common with many African economies, uncertainty has continued to surround regulatory processes, most of all in the energy sector. The granting of environmental licenses has proven an especially intense source of regulatory uncertainty as the case of oil and hydro projects makes clear. Still, it should not be imagined that regulatory issues are the only non-capital market-related factor holding back investment. This paper argued that the technical capacity to successfully execute projects is in limited supply in relation to the demand that currently exists. In itself this represents a long term structural challenge to policymakers. This finding is of special relevance to African economies where, too, the stock of relevant expertise and experience is in short supply relative to the growing pipeline of infrastructure projects.

Bibliography

Afonso, J. R. and E. C. Araújo (2014) Institutions for Macro Stability in Brazil: Inflation Targets and Fiscal Responsibility, IRIBA working paper 07. Available at: http://www.brazil4africa.org/publications/

Abreu, Marcelo de Paiva (1990), A ordem do progresso: Cem anos de politica economica republicana, 1889 – 1989, Rio de Janeiro: Editora Campus.

Amann, E. and A. Barrientos (2014) Is there a new Brazilian model of development? Main findings from the IRIBA research programme. IRIBA working paper13. Available at: http://www.brazil4africa.org/publications/

ANFAVEA (2013) Annual Report-Anuário da Indústria Automobilística Brasileira 2013. Available at: http://www.anfavea.com.br/anuario2013/anfavea2013.zip

Associação Nacional de Transportes Públicos (2012) Annual Report 2011. Sao Paulo:ANTP.

Associação Nacional de Transportes Públicos (2007) Annual Report 2006. Sao Paulo:ANTP.

Baer, W. (2014) *The Brazilian Economy: Growth and Development*, 7th edition, Lynne Rienner Publishers.

Baer, W. and C. McDonald (1998) A Return to the Past? Brazil's Privatization of Public Utilities: The Case of the Electric Power Sector, *The Quarterly Review of Economics and Finance*, Vol. 38, No. 3, pp. 503-523.

Baer, W. and R. A. Sirohi (2013) Transportation Infrastructure and Economic Development: A comparative Analysis of Brazil and India, unpublished manuscript.

Baltagi, B. H., G. Bresson and A. Pirotte (2003) Fixed effects, random effects or Hausman–Taylor? A pretest estimator, *Economics Letters* 79, pp. 361–369.

Baum, C. F., M. E. Schaffer and S. Stillman (2003) Instrumental variables and GMM: Estimation and testing, *Stata Journal* 3, pp. 1–31.

Besley, T. and S. Coate (2003) Centralized versus decentralized provision of local public goods: a political economy approach, *Journal of Public Economics* 87, pp. 2611–2637.

Biderman, C., et al (2009) Mobility, Integration, and Accessibility – Transport Policies in the São Paulo Metropolitan Region, in: P. Rode, R. Burdett, R. Brown, F. Ramos, K. Kitazawa, A. Paccoud and N. Tesfay (eds.) *Cities and Social Equity: Inequality, Territory, and Urban Form,* Urban Age Programme, London School of Economics, London, chapter 6.

Block, P. J. (2008) An assessment of investments in agricultural and transportation infrastructure, energy, and hydroclimatic forecasting to mitigate the effects of hydrologic variability in Ethiopia (Working Paper), CGIAR Challenge Program on Water and Food, available at: http://www.cgiar.org/

BNDES (2012) Transporte Público: O Papel do BNDES no Apoio da Solução dos Principais Gargalhos de Mobilidade, in: *BNDES 60 anos – perspectivas setoriais*, Vol. 2, pp. 313-348, Rio de Janeiro: BNDES.

Box, G. E. P. and G. M. Jenkins (1976) *Time Series Analysis: Forecasting and Control*. 2nd ed., San Francisco: Holden-Day.

Calderón, C. and L. Servén (2012), "Infrastructure", in J. Ocampo and J. Ros (eds.) *The Oxford Handbook of Latin American Economics.* Oxford: Oxford University Press, pp. 679-684.

Chen, X. and W. D. Nordhaus (2011) Using luminosity data as a proxy for economic statistics. PNAS 108, 8589–8594. doi:10.1073/pnas.1017031108

Cohen, J. and W. Easterly (2009) What Works in Development? Thinking Big and Thinking Small. Washington, D.C: Brookings Institution Press.

Cusack, T. R. (1997) Partisan politics and public finance: Changes in public spending in the industrialized democracies, 1955–1989, *Public Choice* 91, pp. 375–395.

Da Silva Campos, A. N., J. M. Pepino de Paula and H. de Souza (2010) *Rodovias Brasileiras: Políticas Públicas, Investimentos, Concessões e Tarifas de Pedágio,* Texto Para Discussão 1668, Brasilía: IPEA.

Djiofack-Zebaze, C. and A. Keck (2009) Telecommunications Services in Africa: The Impact of WTO Commitments and Unilateral Reform on Sector Performance and Economic Growth. *World Development* 37, pp. 919–940.

Egger, P. and M. Pfaffermayr (2004) Distance, trade and FDI: a Hausman–Taylor SUR approach. *Journal of Applied Economics* 19, pp. 227–246.

Elvidge, C. D., P. C. Sutton, T. Ghosh, B. T. Tuttle, K. E. Baugh, B. Bhaduri, E. Bright (2009) A global poverty map derived from satellite data, *Computers & Geosciences* 35, pp. 1652–1660. doi:10.1016/j.cageo.2009.01.009

Ferreira, P. C. (2007) Growth and Fiscal Effects of Infrastructure Investment in Brazil, mimeo, Fundaão Getúlio Vargas, Rio de Janeiro.

Ferreira, T. T. (2009) *Arranjos Institucionais e Investimento em Infra-Estrutura no Brasil,* São Paulo: USP, Dissertação apresentada ao Departamento de Economia para obtenção de mestre em Economia.

Financial Times (2013) *Brazil: Infrastructure 2013,* 10 September.

Freeman, P. and K. Warner (2001) Vulnerability of Infrastructure to Climate Variability: How Does this Affect Infrastructure Lending Policies? World Bank, Disaster Management Facility, ProVention Consortium.

Hausman, J. A. and W.E. Taylor (1981) Panel Data and Unobservable Individual Effects. *Econometrica*, 49(6), pp. 1377–1398. doi:10.2307/1911406

Henderson, J. V. (1999) Overcoming the Adverse Effects of Geography: Infrastructure, Health, and Agricultural Policies, *International Regional Science Review* 22, pp. 233–237.

Henderson, J. V., A. Storeygard and D. N. Weil (2012) Measuring Economic Growth from Outer Space, *The American Economic Review* 102, pp. 994–1028. doi:10.1257/aer.102.2.994

Henderson, V., A. Storeygard and D.N. Weil (2011) A Bright Idea for Measuring Economic Growth, *The American Economic Review* 101, pp. 194–199. doi:10.1257/aer.101.3.194

Hirschman (1958) *The Strategy of Economic Development.* New Haven: Yale University Press.

IPEA (2013a) *Nota Técnica No. 2 – Tarificação e financiamento do transporte publico urbano.* Brasília: IPEA.

IPEA (2013b) *Territorio metropolitano, politicas municipais.* Brasília: IPEA.

IPEA (2013c) *Nota Técnica No. 4 – Transporte Integrado Social: Uma Proposta para o Pacto da Mobilidade Urbana.* Brasília: IPEA.t

IPEA (2013d) *Comunicado No. 161 – Indicadores da mobilidade urbana da PNAD 2012.* Brasília: IPEA.

IPEA (2013e) *Texto para Discussão No. 34 – Transportes e Mobilidade Urbana.* Brasília: IPEA.

IPEA (2012a) *Comunicado 128: A Nova Lei de Diretrizes da Política Nacional de Mobilidade Urbana.* Brasília: IPEA.

IPEA (2012b) *Sistema de Indicadores de Percepção Social – Mobilidade Urbana.* Brasília: IPEA.

IPEA (2012c) *Comunicado Indicadores de Mobilidade Urbana da Pesquisa Nacional por Amostra de Domicílios 2012.* Brasília: IPEA.

IPEA (2012d) *Transportes e Metrópoles: Um Manifesto pela Integração.* Brasília: IPEA.

Koetse, M. J. and P. Rietveld (2009) The impact of climate change and weather on transport: An overview of empirical findings. Transportation Research Part D, *Transport and Environment* 14, pp. 205–221.

Lima, I. M. de Oliveira (2012) As batalhas para a politica nacional de mobilidade urbana, *Revista dos Transportes Públicos – ANTP*, No.1, pp. 115-123.

Milesi-Ferretti, G.M., R. Perotti and M. Rostagno (2002) Electoral Systems and Public Spending, *The Quarterly Journal of Economics* 117, pp. 609–657.

Morgan Stanley (2010) *Brazil Infrastructure: Paving the Way*. (May 5).

Mourougane, A. and M. Piso (2011) Promoting infrastructure development in Brazil, *OECD Economics Department Working Papers* No. 898, pp. 1-33.

NOAA (2014) DMSP-OLS Nighttime Lights Time Series (No. Version 4). National Oceanic and Atmospheric Administration. Washington, DC.

Ojo, F. and A. Everhardt (2013) Brazilian infrastructure and corruption, *America's Business Intelligence*, Washington D.C., 11th October.

Pinkovskiy, M. and X. Sala-i-Martin (2014) Lights, Camera,... Income!: Estimating Poverty Using National Accounts, Survey Means, and Lights, *Working Paper No. 19831,* National Bureau of Economic Research.

Pires, J. C. and A. Goldstein (2001) Brazilian regulatory agencies: early appraisal and looming challenges in Edmund Amann ed. *Regulating Development: Evidence from Africa and Latin America*. Cheltenham: Edward Elgar, pp. 114-152.

Senna, L. dos Santos (2013) *O Transporte Público de Passageiros e Seu Financiamento,* Universidade Federal do Rio Grande do Sul, unpublished presentation. Available at: http://www.al.rs.gov.br/FileRepository/repdcp_m505/ComEspMobilidade/Transp_publ_%20L.Afonso_Senna.PDF (accessed January 2014).

Spilki, M. (2012) Public-Private Partnerships and the Role of Internal Control in the State of Rio Grande do Sul in Brazil, *The Minerva Program*, The Institute of Brazilian Business and Public Management Issues, The George Washington University.

Straub, S. (2008) Infrastructure and Growth in Developing Countries: Recent Advances and Research Challenges, *ESE Discussion Paper No. 179*, Edinburgh School of Economics, University of Edinburgh.

Summerhill, W.R. (1998) "Market intervention in a backward economy: railway subsidy in Brazil, 1854-1913", The Economic History Review, 51(3), pp. 542-568.

Tendler, J. (1968) *Electric Power in Brazil*, Cambridge, MA: Harvard University Press.

The World Bank (2012) *Brazil - How to decrease freight logistics costs in Brazil*. Transport papers No. 39. Washington, DC: The World Bank.

The World Bank (2008) *Environmental licensing in Brazil: a Contribution to the Debate*. Washington DC: The World Bank, pp. 1-37.

Torres, E., L. Macahyba and R. Zeidan (2014) Restructuring Brazil's National Financial System, IRIBA working paper 06. Available at: http://www.brazil4africa.org/publications/

Wooldridge, J. M. (2010) *Econometric analysis of cross section and panel data*, Cambridge, MA: MIT Press.

World Economic Forum (2013) The Global Competitiveness Report 2013-2014 Full Data Edition, Geneva: World Economic Forum.

Appendix

Table A1: Descriptive statistics

Variable		Mean	Std. Dev.	Min.	Max.	Observations		
Ln(GDP)	Overall	16.74	(1.331)	13.40	20.14	N	=	513
	Between		(1.331)	14.33	19.87	n	=	27
	Within		(0.253)	15.81	17.41	T	=	19
Ln(GDP per capita)	Overall	1.576	(0.548)	0.365	3.262	N	=	513
	Between		(0.518)	0.700	2.792	n	=	27
	Within		(0.204)	0.968	2.220	T	=	19
Ln(Lights)	Overall	11.91	(1.122)	8.732	14.78	N	=	513
	Between		(1.107)	9.712	14.274	n	=	27
	Within		(0.275)	10.83	12.86	T	=	19
Ln(Infrastructure spending)	Overall	1.183	(1.749)	-4.983	5.896	N	=	513
	Between		(1.019)	-0.144	4.369	n	=	27
	Within		(1.434)	-3.800	3.672	T	=	19
Ln(Communications spending)	overall	-1.932	(2.654)	-12.15	1.565	N	=	513
	between		(1.593)	-6.445	0.077	n	=	27
	within		(2.144)	-11.94	4.940	T	=	19
Ln(Energy spending)	overall	-2.214	(2.447)	-10.52	3.720	N	=	513
	between		(1.243)	-4.649	0.875	n	=	27
	within		(2.120)	-10.48	2.435	T	=	19
Ln(Transportation spending)	overall	1.043	(1.821)	-5.509	5.885	N	=	513
	between		(1.059)	-0.529	4.258	n	=	27
	within		(1.494)	-3.938	3.501	T	=	19
Population (x1000)	Overall	6,349	(7,595)	228.7	41,485	N	=	513
	Between		(7,688)	326.2	37,312	n	=	27
	Within		(814.6)	1,164	10,523	T	=	19
State area Km2 (x1000)	Overall	314.9	(368.7)	5.788	1,559	N	=	513
	Between		(375.4)	5.788	1,559	n	=	27
	Within		(0.000)	314.9	314.9	T	=	19
Municipalities	Overall	193.9	(191.3)	1.000	853.0	N	=	513
	Between		(193.3)	1.000	806.9	n	=	27
	Within		(22.94)	76.33	240.0	T	=	19
Coef. Var.: elevation	Overall	0.721	(0.328)	0.000	1.496	N	=	513
	Between		(0.333)	0.000	1.496	n	=	27
	Within		(0.000)	0.721	0.721	T	=	19
Coef. Var.: distance	Overall	0.602	(0.115)	0.410	0.829	N	=	513
	Between		(0.118)	0.410	0.829	n	=	27
	Within		(0.000)	0.602	0.602	T	=	19

Coef. Var.: latitude	Overall	0.186	(0.217)	0.000	0.836	N	=	513
	Between		(0.221)	0.000	0.836	n	=	27
	Within		(0.000)	0.186	0.186	T	=	19
Coef. Var.: winter precip.	Overall	0.455	(0.295)	0.000	1.176	N	=	513
	Between		(0.300)	0.000	1.176	n	=	27
	Within		(0.000)	0.455	0.455	T	=	19
Coef. Var.: fall precip.	Overall	0.043	(0.026)	0.000	0.106	N	=	513
	Between		(0.027)	0.000	0.106	n	=	27
	Within		(0.000)	0.043	0.043	T	=	19
Coef. Var.: spring precip.	Overall	0.043	(0.027)	0.000	0.104	N	=	513
	Between		(0.027)	0.000	0.104	n	=	27
	Within		(0.000)	0.043	0.043	T	=	19
Coef. Var.: summer precip.	Overall	0.035	(0.020)	0.000	0.073	N	=	513
	Between		(0.021)	0.000	0.073	n	=	27
	Within		(0.000)	0.035	0.035	T	=	19
# of federal deputies	Overall	17.60	(15.30)	4.00	70.00	N	=	513
	Between		(15.24)	7.16	65.37	n	=	27
	Within		(3.153)	3.39	22.23	T	=	19

Source: IPEA Data; NOAA (2014).

Notes: (1) Coef. Var. are coefficients of variation of variables at state level generated with municipality data. (2) Precip. is the average yearly rain precipitation at municipality level for the referred season. (3) Time-invariant variables have 0.000 within standard deviation.

Table A2: estimation results

Variables	(1) Ln(GDP)	(2) Ln(luminosity)	(3) Ln(GDP PC)	(4) Ln(GDP)	(5) Ln(luminosity)	(6) Ln(GDP PC)	(7) Ln(GDP)	(8) Ln(luminosity)	(9) Ln(GDP PC)
Endogenous:									
Ln(Infrastructure investment)	0.019	-0.032**	0.092***	0.095***	0.123***	0.058***	0.110***	0.056***	0.072***
	(0.019)	(0.015)	(0.009)	(0.011)	(0.016)	(0.009)	(0.007)	(0.009)	(0.006)
Ln(Communications investment)									
Ln(Energy investment)									
Ln(Transportation investment)									
Exogenous:									
Population (x1,000,000) (TV)	0.058***	0.054***	0.004	0.052***	0.093***	0.026***	0.027**	0.027***	0.088***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
State area in Km2 (x1,000,000) (TI)	0.788***	0.531***	0.139***	0.708	0.411	0.121	0.725*	0.725	0.409
	(0.000)	(0.000)	(0.000)	(0.918)	(2.649)	(0.167)	(0.402)	(0.402)	(0.403)
# of municipalities (TV)	-0.001***	0.000*	-0.001***	0.001**	0.001	0.000	0.000	0.002***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Coef. Var.: elevation (TI)	-0.901***	-0.288**	-0.659***	-0.562	-0.049	-0.407	-0.699	0.210	-0.468
	(0.148)	(0.123)	(0.072)	(1.537)	(1.187)	(0.288)	(0.678)	(0.685)	(0.313)
Coef. Var.: distance (TI)	0.152	-0.736***	0.240*	1.150	-0.769	0.324	1.066	-0.496	0.302
	(0.275)	(0.228)	(0.134)	(2.924)	(2.253)	(0.542)	(1.287)	(1.297)	(0.591)
Coef. Var.: latitude (TI)	-0.939***	-1.408***	0.235*	-1.276	-1.457	-0.001	-1.155	-1.763	0.053
	(0.256)	(0.213)	(0.125)	(2.812)	(2.162)	(0.516)	(1.234)	(1.241)	(0.563)
Coef. Var.: winter precip. (TI)	-0.358***	0.286***	-0.862***	-0.253	0.537	-1.064***	-0.164	0.310	-1.016***
	(0.101)	(0.083)	(0.049)	(1.031)	(0.796)	(0.193)	(0.454)	(0.458)	(0.209)
Coef. Var.: fall precip. (TI)	-136.694***	-63.913**	-100.489***	-95.462	-97.275	-119.564**	-85.303	-101.914	-111.719*
	(29.814)	(24.733)	(14.539)	(327.433)	(251.682)	(60.127)	(143.764)	(144.474)	(65.649)
Coef. Var.: spring precip. (TI)	136.390***	57.183**	112.631***	93.377	81.754	127.537**	85.805	82.881	121.423*
	(31.114)	(25.815)	(15.173)	(343.310)	(263.787)	(62.880)	(150.637)	(151.314)	(68.682)
Coef. Var.: summer precip. (TI)	12.172**	15.969***	-7.416***	22.416	19.988	-11.801	22.984	16.113	-11.939

	(4.849)	(4.028)	(2.365)	(52.299)	(40.204)	(9.602)	(22.951)	(23.067)	(10.477)
# of federal deputies (TV)	-0.034***	-0.071***	0.014***				0.013***	0.003	0.009***
	(0.009)	(0.007)	(0.004)				(0.003)	(0.005)	(0.003)
Constant	15.247***	10.484***	1.986***	15.264***	11.475***	1.949***	15.250***	11.358***	1.906***
	(0.219)	(0.182)	(0.107)	(2.277)	(1.755)	(0.424)	(1.003)	(1.012)	(0.462)
Observations	513	567	513	513	567	513	513	567	513
Number of states				27	27	27	27	27	27
Sargan-Hansen (Chi-sq)				17.57	3.18	8.48	4.59	3.45	2.74
P-value				0.000	0.0744	0.003	0.205	0.327	0.433

Source: IPEA Data; NOAA (2014).

Notes: (1) Standard errors in parentheses. (2) TV: time varying variables; TI: time-invariant variables. (3) Coef. Var. are coefficients of variation of variables at state level generated with municipality data. (4) Precip. is the average yearly rain precipitation at municipality level for the referred season. (5) Columns 1-3 are estimated by ordinary least squares. (6) Columns 4-6 estimated by random effects with instrumental variables (Number of federal deputies used as instrument). (7) Columns 7-18 estimated by the Hausman-Taylor instrumental variable approach. (8) Time specific effects included but not reported given space limitations. (9) Inference: *** significant at 1%; ** significant at 5%, * significant at 10%.

Table A2 (continuation): estimation results

Variables	(10) Ln(GDP)	(11) Ln(luminosity)	(12) Ln(GDP PC)	(13) Ln(GDP)	(14) Ln(luminosity)	(15) Ln(GDP PC)	(16) Ln(GDP)	(17) Ln(luminosity)	(18) Ln(GDP PC)
Endogenous:									
Ln(Infrastructure investment)									
Ln(Communications investment)	0.023***	0.040***	0.014***						
	(0.005)	(0.006)	(0.004)						
Ln(Energy investment)				0.019***	0.042***	0.014***			
				(0.005)	(0.005)	(0.004)			
Ln(Transportation investment)							0.103***	0.057***	0.066***
							(0.007)	(0.009)	(0.006)
Exogenous:									
Population (x1,000,000) (TV)	0.074***	0.075***	0.037***	0.085***	0.088***	0.043***	0.031**	0.087***	0.009
	(0.014)	(0.000)	(0.000)	(0.000)	(0.015)	(0.000)	(0.012)	(0.000)	(0.010)
State area in Km2 (x1,000,000) (TI)	0.650	0.350	0.080	0.699	0.435	0.112	0.732*	0.415	0.134
	(0.427)	(0.365)	(0.301)	(0.442)	(0.439)	(0.325)	(0.400)	(0.396)	(0.189)
# of municipalities (TV)	0.002***	0.003***	0.001***	0.003***	0.003***	0.002***	0.000	0.002***	-0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Coef. Var.: elevation (TI)	-0.297	0.162	-0.169	-0.143	0.406	-0.067	-0.671	0.199	-0.440
	(0.720)	(0.621)	(0.510)	(0.745)	(0.743)	(0.549)	(0.674)	(0.673)	(0.324)
Coef. Var.: distance (TI)	1.305	-0.010	0.481	1.169	-0.185	0.412	1.073	-0.487	0.316
	(1.368)	(1.176)	(0.968)	(1.416)	(1.410)	(1.043)	(1.280)	(1.275)	(0.612)
Coef. Var.: latitude (TI)	-1.528	-1.733	-0.225	-1.721	-2.055	-0.356	-1.172	-1.749	0.032
	(1.310)	(1.123)	(0.926)	(1.356)	(1.349)	(0.998)	(1.227)	(1.219)	(0.584)
Coef. Var.: winter precip. (TI)	-0.561	0.243	-1.295***	-0.621	0.150	-1.335***	-0.166	0.329	-1.025***
	(0.482)	(0.414)	(0.341)	(0.498)	(0.497)	(0.367)	(0.451)	(0.450)	(0.217)
Coef. Var.: fall precip. (TI)	-121.030	-69.941	-135.860	-142.476	-100.569	-148.528	-86.405	-99.217	-112.727*
	(152.730)	(130.860)	(107.948)	(158.036)	(157.222)	(116.317)	(142.965)	(142.009)	(68.027)
Coef. Var.: spring precip. (TI)	110.385	50.398	138.048	130.461	79.236	149.885	87.217	80.958	122.493*
	(159.997)	(137.004)	(113.042)	(165.592)	(164.701)	(121.849)	(149.795)	(148.726)	(71.172)
Coef. Var.: summer precip. (TI)	18.229	22.144	-15.715	12.673	13.220	-19.310	22.120	16.187	-12.620
	(24.390)	(20.906)	(17.240)	(25.225)	(25.097)	(18.564)	(22.822)	(22.672)	(10.855)

# of federal deputies (TV)	0.003	-0.001	0.002	0.004	0.003	0.004	0.012***	0.002	0.008***
	(0.004)	(0.005)	(0.003)	(0.004)	(0.005)	(0.003)	(0.003)	(0.005)	(0.003)
Constant	15.404***	11.152***	1.988***	15.511***	11.304***	2.049**	15.257***	11.345***	1.908***
	(1.067)	(0.917)	(0.755)	(1.104)	(1.100)	(0.814)	(0.998)	(0.995)	(0.478)
Observations	513	567	513	513	567	513	513	567	513
Number of states	27	27	27	27	27	27	27	27	27
Sargan-Hansen (Chi-sq)	2.64	3.011	1.66	8.047	1.73	2.91	4.41	4.33	5.82
P-value	0.450	0.390	0.646	0.0450	0.630	0.406	0.220	0.228	0.121

Source: IPEA Data; NOAA (2014).

Notes: (1) Standard errors in parentheses. (2) TV: time varying variables; TI: time-invariant variables. (3) Coef. Var. are coefficients of variation of variables at state level generated with municipality data. (4) Precip. is the average yearly rain precipitation at municipality level for the referred season. (5) Columns 1-3 are estimated by ordinary least squares. (6) Columns 4-6 estimated by random effects with instrumental variables (Number of federal deputies used as instrument). (7) Columns 7-18 estimated by the Hausman-Taylor instrumental variable approach. (8) Time specific effects included but not reported given space limitations. (9) Inference: *** significant at 1%; ** significant at 5%, * significant at 10%.