Report No.

Brazil Infrastructure Assessment (P174544)

Synthesis Report

June 2022

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Acknowledgments

This report was prepared by Luis A. Andrés (Lead Economist and Water and Infrastructure Program Lead for Brazil), Crystal Fenwick (Consultant), and Dan Biller (Consultant). Additional support was provided by Agne Pupienyte (Consultant), Juan Pablo Brichetti (Consultant), Julio A. Gonzalez (Consultant), Leslie Armijo (Consultant), Mateus De Almeida Maciel (Consultant), and Murilo De Carvalho Marques (Consultant).

The report draws on background papers, case studies, and additional contributions prepared by the Infrastructure and Water teams, including from the Energy team: Megan Meyer, Carlos Costa, Pierre Audinet, Guido Couto Penido Guimaraes, Mumba Ngulube, and Takeshi Mori with contributions from Rafael Kelman, Luana Gaspar, Mateus Cavaliere, and Mario Pereira (PSR Consulting); from the Water and Sanitation team: Juliana Menezes Garrido, Paula Pedreira De Freitas De Oliveira, Viviane Virgolim Zamian, Tatiana Teles, Midori Makino, and Christian Borja-Vega with contributions from Rui Cunha Marques; from the Transport team: Georges Bianco Darido, Edpo Covalciuk Silva, Carlos Bellas Lamas, Ana Waksberg Guerrini, Tais Fonseca, and Xavier Espinet with contributions from Amy Schweikert, Mark Deinert and Guilherme Lher (Colorado School Of Mines), Leise de Oliveira (University of Minas Gerais), Thiago Guilherme Péra, Fernando Vinicius da Rocha, Daniela Bacchi Bartholomeu, José Vicente Caixeta-Filho, Everton Lima Costa, Fernando Pauli de Bastiani, Lavinia Bettoni, Sarah Barbosa da Silva, José Caxieta, Daniela Bonato, Lucas Melo (University of São Paulo), and Andy Ricover (Consultant); from the Digital Development team: Julian Najles, Axel Rifon Perez, and Estefania Belen Vergara Cobos; and from the Infrastructure Finance, PPPs, and Guarantees team: Luciana Guimaraes Drummond E Silva, Philippe Neves, and Patrice Caporossi.

A peer review was conducted by Vivien Foster (Chief Economist, INFCE), Paul Procee (Operational Manager, LCC7C), Stephane Hallegatte (Lead Economist, SCCDR), and David Groves (Senior Climate Change Specialist, SCCDR)

Insightful and helpful advice and comments were received from Satoshi Ogita, Rui Cunha Marques (Universidade de Lisboa). Finally, the report benefited greatly from the strategic guidance and general direction provided by Paloma Anos Caseros (Brazil Country Director) and Franz Drees-Gross (LAC Infrastructure Regional Director). Administrative support was provided by Carla Zardo and editorial services by Fayre Makeig.

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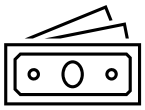
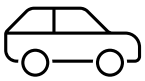
Brazil's Infrastructure at a Glance

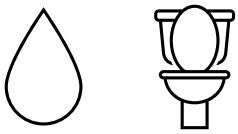


- Brazil must invest **US$778 billion** (or **3.7% of GDP** per year) to bridge the infrastructure gap **by 2030**



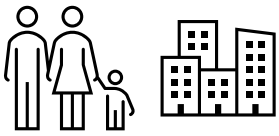
- **53%** of Brazil's investment gap is needed for **transport**
- Only **12%** of Brazil's **roads** are **paved** and this figure has barely changed since 2001
- **23%** of all of Brazil's **roads** are in **bad** or **very bad** condition

- **24%** of Brazil's investment gap is needed for **energy**
- Almost **all Brazilians** (99.8%) now have **access to electricity**
- Brazil is home to some of the **highest electricity tariffs** in the region, yet Brazilians suffer **longer electricity outages** than most other Latin Americans

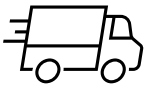


- **12%** of Brazil's investment gap is needed for **water and sanitation**
- **Most Brazilians** (98.2%) now have **access to improved water** but **only 66%** have **access to improved sanitation**
- On average, almost **one-third** of all **water** produced in Brazil **is lost**

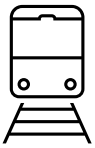
- **11%** of Brazil's investment gap is needed for **digital development**
- A fixed-line monthly **broadband** subscription **costs** about **2.4%** of the average per-capita **monthly income**
- A **mobile** monthly broadband subscription **costs 4%**, double the industry's affordability target



- Access to basic infrastructure services is a function of **geography** and **ethnicity**
- By head count, **most people** who **lack access** live in **urban** areas



- Brazil's **modal split** is **unsuitable** for a country of its size
- **Logistics costs** in Brazil have **improved** significantly **but still lag** major agricultural export competitor, **the United States**
- Combined, **operational inefficiencies** in the transport and water and sanitation sectors **cost** around **1.4 percent of GDP**



- Brazil's **railroad density** of 3.61 km/1,000 km^2 **is less than half that of similarly sized countries** such as Canada and the United States

- Brazil's **waterway density** of 2.3 km/1,000 km^2 **is less than half that of countries with a similar length of navigable waterways**, such as China

Abstract

Leveraging Infrastructure to Improve Productivity and Secure Long Term Growth in Brazil: 50 Years of Progress in a 5-year Term

Brazil's industrialization agenda that started in the 1950s under newly elected President Juscelino Kubitschek's slogan "50 years of progress in a 5-year term" led to impressive gains in access to basic infrastructure services. Over time Brazil's economy transitioned away from a dependency on commodity exports and the country became increasingly urbanized. Today, almost all Brazilians have access to electricity and improved drinking water at home. Meanwhile, hydropower expansion has given rise to one of the world's largest hydropower sectors and with a natural endowment in renewable energy potential, Brazil could reach net zero greenhouse gas (GHG) emissions by 2050.

Brazil's relatively steady—albeit uneven—infrastructure development all but came to a halt during the 1980s debt crisis. During successive periods of high inflation, Brazil saw its investments in productive capacity, particularly infrastructure, dwindle. This ushered in an era of chronic underinvestment and created a maintenance backlog resulting in low-quality, highly vulnerable infrastructure stocks that are now limiting inclusion and productivity, and threatening the country's long term economic growth and competitiveness. Furthermore, recent trends show Brazil's economy has reverted to its earlier dependency on commodity exports and rather than boosting productivity to compete, Brazil is exhausting its natural capital creating a vicious, and unsustainable, cycle of growth.

From Vicious to Virtuous

Investing proceeds from growth wisely will be critical to securing productivity and alleviating poverty. Otherwise, the country will continue its cycle of low productivity growth, while other emerging economies become increasingly more competitive, including in agriculture and extractives, sectors that were largely responsible for Brazil's growth in the first place. Taking the virtuous path means confronting the substantial infrastructure gap currently facing Brazil's economy. Long-term economic growth in Brazil can be achieved through increased investments in high-quality, resilient infrastructure. This will require increasing investments, greater spending efficiency, and enhanced governance, especially to facilitate private sector participation.

This synthesis report presents a summary of analytical work undertaken to explore areas that significantly impact the infrastructure sector's performance and sustainability but which are often overlooked in conventional analyses. For example, understanding the effects of different public investment multipliers on growth, the political economy driving investment decisions, and decarbonizing infrastructure. These topics were addressed through novel economic models and supported by more traditional assessments. Critical cross-cutting themes such governance were woven into the fabric of several analytical pieces. The results of these individual activities informed a broader analytical framework that sought to understand the relationship between infrastructure and productivity, inclusion, and climate change, in the Brazilian context. Combined, the results of these efforts have been used to formulate core policy recommendations to stimulate long-term economic growth in Brazil.

Core Messages

We first propose a core set of overarching measures intended to assist Brazil on the path towards securing long run, climate resilient, socially progressive, and productive economic growth, before diving into more detailed subsector recommendations. Key findings and core messages can be summarized as follows:

1. **Reorient fiscal policy and increase public investments in infrastructure to stimulate the economy.** A minimum of 3.7 percent of GDP per year will be needed through 2030 to ensure Brazil meets its infrastructure-related SDGs. Private investment will of course be needed to achieve this ambitious goal, but public investment is imperative. The good news is new research suggests the multiplier effect on Brazil's economy from public investment by the federal government is at least twice as high as that for public consumption and the effect may carry through at subnational levels of government as well. Reorienting spending to enable increased public investment in infrastructure by the federal government would stimulate the economy and lead to long term growth.

2. **Establish a set of strategic investment and policy priorities to yield cost savings, and increase the country's productivity and global competitiveness.** Identifying and prioritizing key areas in need of urgent attention, such as the maintenance of existing road infrastructure, will lead to future cost savings and, when combined with the sustainable expansion of rail and waterways, strengthen Brazil's position as one of the world's top agricultural producers and exporters. Meanwhile, investing in universal access to basic services and building resilient infrastructure as part of a broader disaster prevention and management program will help address Brazil's inequalities while safeguarding the country's future labor force.

3. **Develop and implement a comprehensive infrastructure governance strategy that focuses on increasing technical capacity at subnational levels to increase private participation.** Brazil has one of the highest degrees of fiscal decentralization and strongest public-private investment (PPI) frameworks among Latin American countries. However, planning capacity in Brazil, especially at the subnational level, is comparatively weak and concentrated in a select few states and municipalities. The success of Brazil's reform process therefore hinges on developing restructured infrastructure governance strategy supported by an intensive capacity building program specially to develop planning and structuring competencies at the subnational level.

Concluding Remarks

Increasing public investment in infrastructure, spending more wisely and efficiently, and building capacity to increase private participation will support Brazil in its efforts to eradicate poverty and increase growth. This is all the more urgent in the context of Brazil's extreme climate variability. The need to increase public investment in infrastructure is critical, yet insufficient without addressing the most important factor that has historically limited the infrastructure sector's progress: technical capacity. No amount of financing will resolve Brazil's infrastructure challenges without a substantial investment in capacity building, especially at the subnational level. This will require strong political will, coordination and rigor across all levels of government with a particular emphasis on bottom-up approaches and a long-term outlook.

Executive Summary

Current State of Infrastructure in Brazil

It is widely accepted that infrastructure development is positively associated with social progress and economic growth. Access to basic infrastructure services has increased significantly in Brazil since the 1950s and almost all Brazilians now have access to electricity and improved drinking water. The country's energy matrix is relatively green and, endowed with an abundance of renewable energy sources[1], Brazil has the potential to reach net zero greenhouse gas (GHG) emissions by 2050.

Before the debt crisis of the 1980s, Brazil was one of the fastest growing economies in the World.[2] With the debt crisis and successive periods of high inflation, public investments in Brazil dwindled significantly. This ushered in an era of chronic underinvestment in infrastructure that created a maintenance backlog resulting in low-quality, highly vulnerable infrastructure stocks that are now limiting inclusion and productivity, and threatening the country's long-term economic growth. Recent events, such as the COVID-19 pandemic, as well as the ongoing effects of climate change have underscored the importance of infrastructure to Brazil's economy.

Planning, funding, building, and maintaining large infrastructure brings political economy challenges for any government. However, Brazilian policymakers encounter additional country-specific impediments to budgeting and allocating infrastructure spending. The federal budget process is profoundly rigid. After transfers to subnational governments, the federal government is left with slightly more than half of all taxes (Dillinger and Webb, 1999), more than 80 percent of which is earmarked for mandated spending (Bonomo et al. 2021). Various laws forbidding specific work-arounds introduce further rigidities. Combined with Brazil's recent history of structural and fiscal vulnerabilities, this makes the road to recovery especially challenging; still, investing in infrastructure can help change these patterns.

Levels of infrastructure investment in Brazil have steadily declined over the past 40 years and hit a near all-time low in 2020, when only 1.6 percent of gross domestic product (GDP) was invested in transportation, electricity, water and sanitation, and telecommunications combined (figure 1): one-third less than the most recent "peak" of 2.34 percent in 2013 and well below the heydays of the 1980s, when levels averaged 5.0 percent.

Brazil's infrastructure financing gap is fast approaching US$800 billion (or 3.7 percent of GDP per year through 2030). Our estimates indicate that almost half (44 percent) of all investment needs correspond to maintenance and the replacement of assets reaching the end of their service life[3] (table 1). The remainder represents the construction of new assets needed to achieve universal access to basic

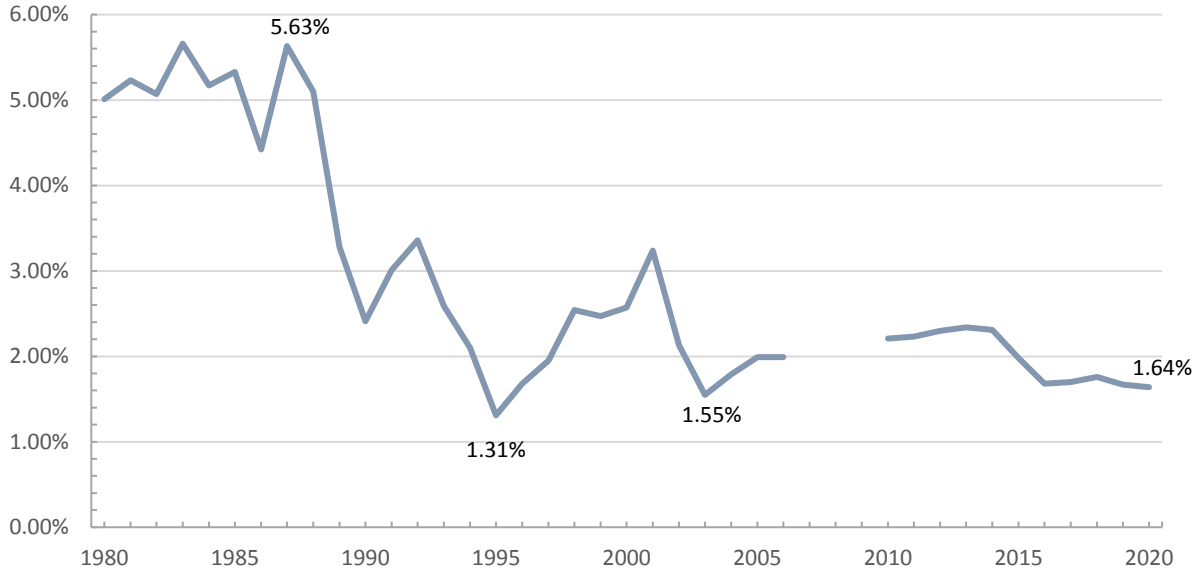
[1] Brazil's total hydropower installed capacity of 109GW is the second highest in the world (IHA, 2022).

[2] Castelar et. al, 2004. "Brazilian Economic Growth, 1900 – 2000: Lessons and Policy Implications," IADB: https://publications.iadb.org/publications/english/document/Brazilian-Economic-Growth-1900-2000-Lessons-and-Policy-Implications.pdf

[3] In some cases, such as electricity distribution and water connections, maintenance and the replacement of existing assets represent up to 75 percent of total investment needs.

infrastructure services, and otherwise meet the country's infrastructure-related commitments to the Sustainable Development Goals (SDGs)[4].

Figure ES1 Total investment in infrastructure in Brazil as a percentage of GDP (1980–2020)



Source: ABDIB and World Bank WDI, 2021.

There are important subsectoral differences and transportation has the largest, single financing gap. More than half (53 percent) of the country's financing gap corresponds to transport, of which 43 percent is needed for maintenance and the replacement of existing assets. To achieve the SDGs by 2030, Brazil needs to invest 2 percent of its GDP in transport annually, yet in 2019 the country invested only 0.34 percent. This level of investment fails to cover the basic financing needed for the maintenance and replacement of existing assets, contributing to the deteriorating performance of logistics that are crucial for Brazil to compete globally. Though the financing gap is smaller in the remaining sectors, Brazil still needs to increase the level of investment in water and sanitation from 0.20 to 0.44 percent, and from 0.43 to 0.46 percent in telecommunications. The level of investment in electricity would need to increase from 0.73 to 0.90 percent.

Table ES1 Estimated Financing (in $USB) Needed to Achieve the SDGs in Brazil by Subsector

Subsector	Maintenance	Replacement of existing assets	Construction of New Assets	Total	Share (%)
Digital Development	13,859	46,197	28,557	88,613	11
Energy	9,122	64,432	116,378	189,932	24
Transport	70,114	108,887	239,326	418,327	12
Water & Sanitation	12,251	20,418	56,588	89,257	53
Total	105,346	239,934	440,849	786,129	100

Source: World Bank, 2021.

[4] For digital development, Target 9.C; for energy, Targets 7.1-2; for transport, Targets 9.1 and 11.2; and for water and sanitation, targets 6.1-3. See: https://datatopics.worldbank.org/sdgatlas/targets/.

Not included in these estimates is the cost of adapting to climate change by building resilient infrastructure while responding to the country's commitment to reduce total net greenhouse gas emissions by 37 percent in 2025 and 43 percent in 2030 (Ministry of Foreign Affairs 2020).[5] Investment needs for climate action in infrastructure represent around 0.5 percent of GDP per year through 2030, which is relatively small when compared with the size of the overall infrastructure financing gap. Once again, these investment needs are largely driven by transport, to finance the infrastructure needed to support a modal shift away from road transportation, and partially compensated through savings gained from lower energy costs in transport and industry, and reduced congestion and air pollution.[6]

Brazil's infrastructure currently lacks the resilience needed to withstand and adapt to changing conditions, while maintaining structural integrity and continuing to provide basic services. This is especially relevant in the context of Brazil's ever-evolving climate, weather patterns, and hydrological systems. Resilient infrastructure systems should be designed in harmony with interconnected ecosystems and the social systems they support. They should withstand potential impacts associated with major weather events while responding to associated changes in demand, for example, surges in electricity during heat waves, enhanced water storage and demand management strategies to cope with droughts, and improved floodplain management to mitigate risks associated with heavy rainfall. This need for better resource management creates additional pressure for greater efficiency, especially for water and energy (Fay et al. 2017).

This synthesis report presents a brief summary of analytical work undertaken to explore areas that significantly impact the infrastructure sector's performance and sustainability but which are often overlooked in conventional analyses. For example, understanding the effects of different public investment multipliers on growth, the political economy driving investment decisions, and decarbonizing infrastructure. These topics were addressed through novel economic models supported by more traditional assessments. Critical cross-cutting themes such governance were woven into the fabric of several analytical pieces. The results of these individual activities informed a broader analytical framework that sought to understand the relationship between infrastructure and productivity, inclusion, and climate change, in the Brazilian context. Combined, the results of these efforts have been used to formulate core policy recommendations to stimulate long-term economic growth in Brazil.

Core Policy Recommendations

Some organizations have been advocating for Brazil to "reduce budget rigidities to create space for public investment"[7] and ensure the country's long-term economic growth. This report puts forward additional evidence that suggests long-term economic growth in Brazil can be achieved through increased strategic investments in high-quality, resilient infrastructure. This will broadly require increased investments, greater spending efficiency, and enhanced governance, especially to increase private sector participation.

[5] https://www.gov.br/mre/en/contact-us/press-area/press-releases/brazil-submits-its-nationally-determined-contribution-under-the-paris-agreement

[6] Overall, total economic costs of the resilience and net zero pathway proposed in the Brazil Climate Change Development Report (CCDR) are around 0.5 percent of GDP, without accounting for avoided climate change impacts (which would depend on action in the rest of the world).

[7] "Directors agreed that fiscal policy should focus on rebuilding buffers and reducing budget rigidities to create space for public investment and a stronger social safety net." (IMF, 2021).

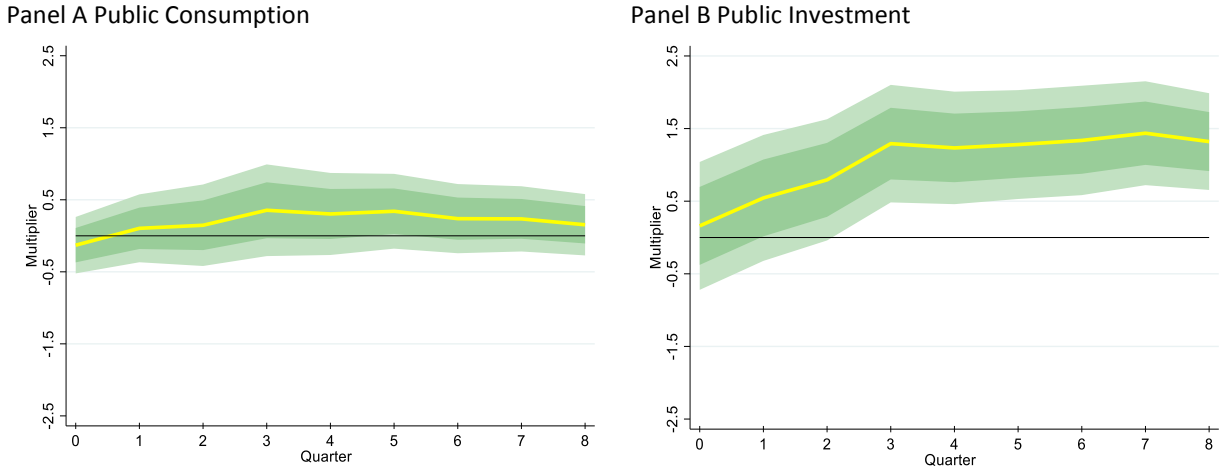
1. Reorient fiscal policy and increase public investments in infrastructure to stimulate the economy.

Our estimates suggest a minimum of 3.7 percent of GDP per year will be needed through 2030 to ensure Brazil meets its infrastructure-related SDGs. Additional investments will be needed to keep pace with Brazil's climate of extremes and support the economy's transition to sustainable power generation. While private investment will of course be needed to achieve this ambitious goal, public investment is imperative.

New research conducted for this report suggests the multiplier effect on Brazil's economy from public investment by the federal government is at least twice as high as that for public consumption (figure 4). Although the evidence is currently less robust, the effect would appear to carry through at subnational levels of government.

The policy implication is clear: reorienting spending to enable increased public investment in infrastructure by the federal government would stimulate the economy and lead to long term growth.

Figure ES2 Government Spending Multipliers in Brazil: Public Consumption vs Public Investment



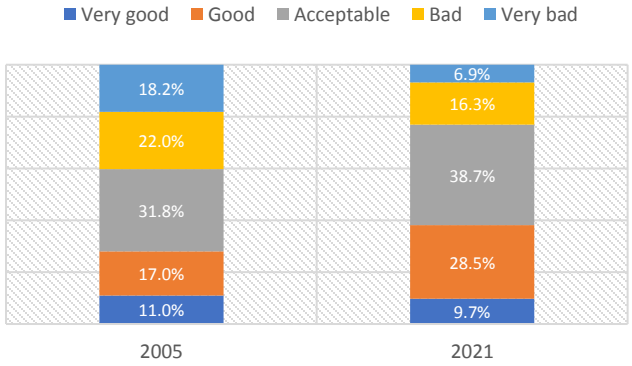
Source: World Bank, 2022. Based on IBGE, Orair (2016) and SNT. Note: Quarter = 0 denotes the year of fiscal shock. Dark green areas denote a confidence interval at 68 percent (1 se), while light green areas denote 90 percent confidence intervals (1.64 se).

2. Establish a set of strategic investment and policy priorities to yield cost savings, and increase the country's productivity and global competitiveness.

Recent economic trends underscore Brazil's dependency on natural resources. Investing proceeds from finite resources, such as minerals and fossil fuels, into renewable resources, human capital and technology, such as sustainable agriculture and forestry, education and innovation, can support Brazil's eventual transition to a more productive and sustainable economy. In addition, identifying and prioritizing key areas in need of urgent attention, such as the maintenance of existing road infrastructure, will lead to future cost savings and when combined with the sustainable expansion of rail and waterways will strengthen Brazil's position as one of the world's top agricultural producers and exporters. Meanwhile, investing in universal access to basic services and building resilient infrastructure as part of a broader disaster prevention and management program will help address Brazil's inequalities while safeguarding the country's future labor force.

a) Brazil's road network is unevenly distributed and its quality is highly variable. Only 12.4 percent of Brazil's roads are paved, a figure that has remained relatively static since 2001 (CNT, 2021). About a third of all roads (38.2 percent) are considered to be in "good" or "very good" condition but about 20 percent are considered to be in "bad" or "very bad" condition (figure 4). Repairs are often only undertaken once conditions have deteriorated to the point of impassibility, significantly increasing the costs of repair. Furthermore, Brazil's road infrastructure is ill-prepared for extreme weather events, exacerbating the extent of disrepair. Adopting a more proactive approach to road maintenance will lead to future cost savings.

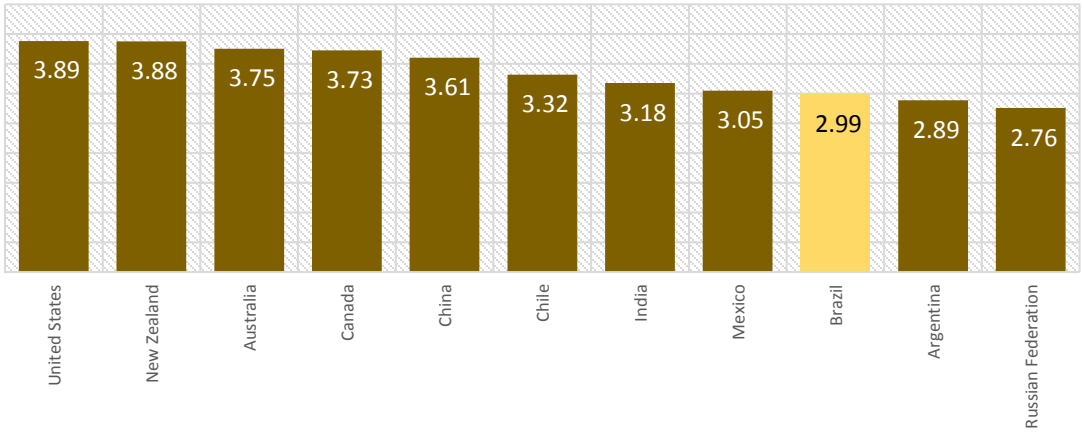
Figure ES4 Changes in Perception of Road Quality in Brazil (2005-21)



Source: CNT, 2021 (Road Surveys Results).

b) Brazil currently ranks 56 out of 161 countries on the Logistics Performance Index (LPI), lagging Mexico, India, China, Canada, and the United States (figure 5). Dropping 15 places since 2010, Brazil is the only BRIC country whose performance decreased. Brazil's vast dimensions, high heterogeneity of transport infrastructure, widespread distances between producing and consuming regions, and a transport matrix that is highly dependent on roads make for a complex logistics and freight system. This implies a number of economic, social, and environmental distortions, such as low fuel-efficiency, and high transport costs and emissions. Sustainably expanding Brazil's rail and waterways will strengthen its position as one of the world's top agricultural producers and exporters.

Figure ES5 Logistics Performance Index (2018)



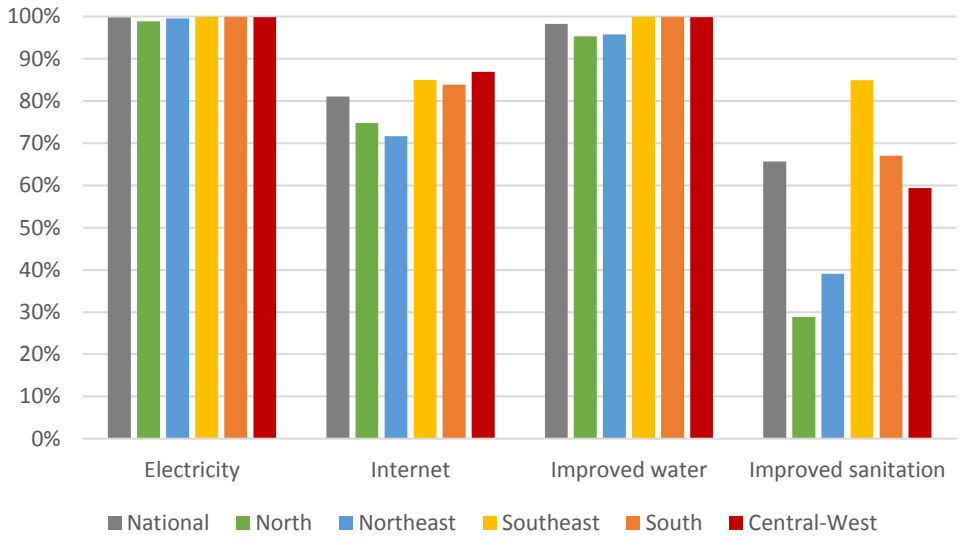
Source: World Bank, 2022.

c) Brazil has achieved near universal access to several key infrastructure services. Notably, almost all Brazilians now have access to electricity and improved drinking water (figure 6). However, progress has been uneven and access to improved sanitation and adequate sewage treatment is significantly lagging. Access to high-quality infrastructure services is a function of income and geography and poor Brazilians (especially those living on the urban fringe) and indigenous peoples are disproportionately affected, jeopardizing the health and wellbeing of millions of Brazilians, and impacting the country's aspirations for an inclusive society. Allocating adequate resources to ensure universal access to affordable and reliable infrastructure services by 2030 will help Brazil address its longstanding battle to eradicate poverty.

Brazil frequently experiences extreme rains, flooding, severe droughts, and other weather-related disasters that affect the country's economic growth, infrastructure, ecosystems and social development. Land use planning in Brazil has not kept pace with the rapid urbanization that has led to millions of Brazilians living in precarious environments and from 1991 to 2010, flash floods and induced mudslides accounted for 74 percent of all weather-related deaths in Brazil. Meanwhile, Brazilian firms lose approximately US$22 billion (1.27 percent of GDP) every year because of infrastructure-related disruptions. The majority (55 percent) are caused by failures to transport infrastructure followed by power (44 percent) and water (two percent). There is a clear need for resilient infrastructure as part of a broader disaster prevention and management program in Brazil that will require a concerted effort across all levels of government.

Investing in universal access to basic services and building resilient infrastructure as part of a broader disaster prevention and management program will help address Brazil's inequalities while safeguarding the country's future labor force.

Figure ES6 Access to basic infrastructure services by region (2021)



Source: World Bank, 2022.

The policy implication is clear: establishing a set of strategic investment priorities that focuses initially on road maintenance, multimodal logistics, and universal access to high-quality infrastructure services and disaster risk management planning will yield long term savings, and increase productivity and long-term economic growth.

3. **Develop and implement a comprehensive infrastructure governance strategy that focuses on increasing technical capacity at subnational levels to increase private participation.**

Brazil has one of the highest degrees of fiscal decentralization and strongest public-private investment (PPI) frameworks among Latin American countries. Some states have implemented significant private-public partnerships (PPP), indicating that subnational governments are critical to both public and private infrastructure investment. However, planning capacity in Brazil, especially at the subnational level, is comparatively weak and concentrated in a select few states and municipalities. Consequently, many states remain caught in a perpetual cycle of impoverishment given the lack of (i) good-quality, reliable infrastructure; and (ii) capacity to secure and regulate resources needed to expand access to, and maintain, new infrastructure. This is a key component of Brazil's legacy of inequality and a major hurdle to increased productivity and competitiveness that warrants the government's full attention.

Certain skills and structural bottlenecks are unique to PPI, for example, project structuring and financial instruments. Targeted support to low-capacity municipalities and states, including alternative financial instruments will help create a more robust PPP pipeline while ensuring wider participation by local governments.

While overall capacity is without a doubt a major harbinger of success, small changes in governance and capacity building efforts targeting key areas, such as regulation, can also go a long way to increasing sector performance. Policies requiring, for example, climate resilient infrastructure are simple, yet effective ways to effect rapid change. Likewise, addressing regulatory uncertainties to limit political influence can boost confidence and improve perceptions of risk, attracting much-needed private investment; for example, identifying and addressing principal-agent problems, whether between agencies or between service providers and customers. Additionally, clearly articulated standards and performance indicators encourage the participation of civil society, which promotes accountability and safeguards transparency.

Governance, capacity building, and transparency are generally ubiquitous in policy recommendations outlined by development institutions. History has shown that without a solid governance framework, and a political commitment to capacity building, most other recommendations are likely to fail.

The policy implication is clear: the success of Brazil's reform process hinges on developing restructured infrastructure governance strategy supported by an intensive capacity building program specially to develop planning and structuring competencies at the subnational level.

Key Subsector Recommendations

A review of subsectors found most suffer from similar challenges: chronic underinvestment and an overemphasis on capital infrastructure to the detriment of maintenance programs; limited and/or skewed accessibility impacting opportunities and access to services; weak institutional strength, especially subsectors with programs that are regulated and/or implemented at the subnational level; and limited, or in the case of guarantees, thwarted, opportunities for private sector investment. Finally, all subsectors experience challenges related to the limited vertical integration of planning and programming and would

benefit immensely from capacity building efforts and increased inter-agency coordination if not collaboration, especially between federal and subnational governments. Below is a snapshot of some of the most pressing challenges and recommendations faced by Brazil's infrastructure subsectors.

Transport and Logistics

Insufficient attention is given to routine road maintenance and Brazil's road network is suffering from accelerated degradation. Specific policy recommendations include adopting and implementing the Proactive and Resilient Investment and Maintenance Program to address fundamental challenges, increase resilience to climate change, and prepare road infrastructure for the implementation of intelligent transport systems. As maintenance begins to improve, consider preparing the road network for future fleet electrification and hydrogenation.

Improving the integration of Brazil's roads into a comprehensive, multimodal transport system will support efforts to improve logistics and increase future productivity while strengthening global competitiveness. Specific recommendations to encourage a more balanced logistics network include: (i) sustainably expanding the country's rail and waterways by increasing network densities and the number of multimodal terminals; (ii) revising policies to reduce market concentration and discourage oligopolies; (iii) integrating the road freight tax system to discourage the use of less efficient routes; and (iv) ensuring new investments target greater synergies with return cargo operations.

The private sector has played a key role in financing, delivering and efficiently operating rail infrastructure since the network's privatization in the 1990's. Nevertheless, unaddressed gaps in the accounting framework prevent the use of guarantees, encouraging costly alternatives and holding back significant infrastructure development. The lack of standardization strongly contributes to lower operational efficiency of Brazil's rail system. Brazil should advance technical standards for railways to better integrate its logistics system. A simplified granting modality was recently sanctioned and there is a need to establish clear definitions regarding the authorization regime, to safeguard trunk corridors and limit space for policy-driven decision-making. With respect to commuter rail and metro systems, less than half of Brazil's states have rail-based transit systems. Brazil's commuter rail and metros are mostly operated by public companies, yet private sector participation has steadily grown. A lack of regulation has held back new private investments in passenger railway systems, particularly in smaller states.

Brazil is a highly urbanized country with 85 percent of its population living in cities mainly located along its vast coastline. Mass transit systems have seen a steady decrease in ridership over the last decade, a trend that was reinforced with the recent mobility restrictions arising from COVID-19. Brazil's cities have limited financial and technical resources for transport infrastructure/ Electromobility is still in its early stages and expected to evolve gradually and heterogeneously in the coming decades. Some areas for policy attention include: (i) reforming the regulatory framework to support municipalities to receive alternative revenues to support transit systems, (ii) promoting the use of electric vehicles for public transportation through financial and non-financial incentives to support energy transition to sustainable mobility, and (iii) supporting metropolitan authorities to integrate and monitor intermodal and metropolitan transport, including increased monitoring capacity with technology and innovation, fare integration and mobile payment, etc.

Energy

Brazil's power system can fully decarbonize without increasing costs when compared with the current business-as-usual (BAU) scenario providing an opportunity for the transport and industry sectors to decarbonize at minimal cost, thanks to electrification and green hydrogen. Going beyond the decarbonization of electricity generation, Brazil's power system can be used to efficiently decarbonize harder-to-abate sectors of transport and industry. Brazil's current thermal expansion plan is associated with significant financial and economic costs for the power system and economy overall. A net-zero scenario could be more resilient by replacing the 8GW of new gas with increased renewable energy capacity and storage to ensure security of the supply at a low additional net cost. Given Brazil's competitive advantages in renewable energy, the country could become a leading producer of green hydrogen. Brazil has exceptional prospects to produce, consume and/or export green hydrogen, which can help accelerate energy transition while diversifying exports and attracting investment.

Specific policy recommendations include: (i) leveraging offshore wind policies, deploying green and blue hydrogen infrastructure for domestic use and exports (incl. steel, etc.), and diversifying the ethanol market to maximize the long-term benefits and increased competitiveness of innovative, renewable electricity and frontier energies, (ii) developing Brazil's carbon market to reduce the costs of climate inaction, and mitigate the risk of re-carbonizing the electricity sector, and stranded assets, (iii) repowering hydro, and increasing hydropower resilience as well as the electricity system's flexibility (e.g. transmission, storage, forecast, hydro hybridization) to manage electricity supply risks, and (iv) increasing the financial efficiency and stability of electricity distribution through, for example, net billing, time-of-use tariffs, improved cost management, non-traditional business models, and enhanced consumer protection.

Water and Sanitation

Brazil's institutional framework governing the water supply and sanitation sector is complex and fragmented. A new legal framework, approved in 2020, provides greater legal clarity especially for private operators, but its successful implementation, which is ongoing, could still be challenging. The new legal framework creates a more robust role for the national regulator, who is tasked with establishing national guidelines for the provision of WSS services. This is expected to resolve the country's long-standing problem whereby countless regulatory agencies with insufficient financial resources and structural capacity to enact and enforce local and state regulations, results in weak or even non-existent regulatory oversight that is subject to local political interference. The new framework also promotes competition between public and private companies, ensuring services are provided by the operator most capable of delivering on the terms of the contract. The federal government can help ensure the success of the new legal framework by coordinating its implementation and providing incentives for service providers and municipalities to align themselves with national guidelines. Alternative financing instruments for operators will be crucial to speed up the sector's expansion and ensure universal access, especially to adequate sanitation. Specific recommendations include: (i) developing and implementing a strategic plan, including models, to rapidly expand access in under-served areas, ensuring its integration with policies and investments for land use planning and social housing, and (ii) supporting a water secure future, adopt and implement an integrated water resources management strategy for planning and use that include resilient infrastructure.

Digital Development

The number of Brazilians using the internet rose from less than 3 percent of the total population in 2000 to over 70 percent in 2018 and Brazil has excellent first and middle-mile connectivity. Still, the number of households with a fixed broadband subscription remains relatively low (less than 50 percent), limiting opportunities. These indicators are well below the OECD average and partially reflect the relatively high cost of subscription charges. The quality of services is subpar and although Brazil has a good fiber optic network, fixed broadband speeds are below all benchmarks, including LAC. While 3G and 4G coverage are comparable to OECD and high-income benchmarks, 5G is just emerging. Consequently, its deployment is below all benchmarks, except within LAC. Brazil's infrastructure, colocation market, and cloud services are exceptional, though mostly concentrated in the southern regions.

Some potential policy recommendations include i) Enhancing co-ordination among federal, state and municipal levels to promote deployment, and the quality and reliability of services; ii) Initiating the implementation of projects funded by the universal service fund (FUST) to improve connectivity, including connecting schools and support for the newly created Group for Monitoring the Costing of School Connectivity Projects; and iii) Implementing the National Cybersecurity Strategy by establishing a wide community of digital security leaders from the public and private sectors.

Concluding Remarks

Increasing public investment in infrastructure, spending more wisely and efficiently, and building capacity to increase private participation will support Brazil in its efforts to eradicate poverty and increase growth. This is all the more urgent in the context of Brazil's extreme climate variability. The need to increase public investment in infrastructure is critical, yet insufficient without addressing the most important factor that has historically limited the infrastructure sector's progress: technical capacity. No amount of financing will resolve Brazil's infrastructure challenges without a substantial investment in capacity building, especially at the subnational level. This will require strong political will, coordination and rigor across all levels of government with a particular emphasis on bottom-up approaches and a long-term outlook.

1. THE IMPORTANCE OF INFRASTRUCTURE TO LONG-TERM GROWTH IN BRAZIL

Statement of Problem

Brazil's path to economic recovery will be challenging given the country's legacy of structural and fiscal vulnerabilities. Brazil had yet to recover from its most recent recession when COVID-19 struck, exposing the country to unprecedented economic, health, and social challenges and leading to a 4.1 percent decline in gross domestic product (GDP) in 2020. An emerging recovery in domestic and external demand and a pick-up in commodity prices are expected to push GDP growth toward 5.3 percent for 2021. However, the path to a full recovery in the medium term remains steep given Brazil's preexisting structural and fiscal vulnerabilities and the impact of inflationary pressures on the economy.[8]

Infrastructure[9] development will be key to the country's recovery efforts and long-term, sustainable growth. The pandemic exacerbated years of chronic underinvestment that deteriorated Brazil's infrastructure stocks and compromised their services, particularly in transport. Limited investment in road maintenance and multimodal transportation is predicted to impact productivity growth. Overall, the country remains below its peers in infrastructure stock (Raiser et al. 2017). At a time when resources were already constrained, COVID-19 underscored the urgency of ensuring access to safe drinking water while expanding access to sanitation services. Digital development proved to be central to the country's pandemic response, supporting public health, business continuity, remote schooling, and public service delivery, and highlighting the need for continued expansion and, importantly, universal access to digital services for all Brazilians.

Policy reforms in the infrastructure sector have resulted in diminished investments. The trajectory of Brazil's infrastructure sector mirrors that of the region as a whole. During the 1990s, most countries in Latin America and the Caribbean (LAC) implemented substantial reforms to improve economic regulation, increase private sector participation, and promote competition to enhance the quality, accessibility, and efficiency of services. Though some reforms were successful, most were not, resulting in new challenges, and by the late 1990s and early 2000s, the region faced a series of financial and economic crises and corporate scandals. These challenges led to a significant decline in private investment—that had failed to fill the gap created by diminished public sector investments in Brazil in the 1980s—an increase in political opposition, and disillusionment with privatization and liberalization policies.

Persistently low levels of investment have depleted Brazil's infrastructure stock. Unsuccessful reforms and chronic underinvestment have depleted Brazil's infrastructure stock, compromised services, and created an infrastructure investment gap in need of urgent attention. Now more than ever, reorienting public expenditure in a way that supports job creation, service delivery, and infrastructure development will be critical to Brazil's progress.

Brazil's fiscal space is heavily constrained by a constitutional commitment to health and education. Brazil's Constitution stipulates that a significant share of revenues and transfers from the central

[8] For a complete overview and to learn more about how the World Bank Group is supporting Brazil's recovery efforts, see https://www.worldbank.org/en/country/brazil/overview#1.

[9] Unless otherwise indicated, infrastructure refers collectively to digital development, energy, transport, and water and sanitation.

government be allocated to health and education (Presidência da República, Casa Civil [2020] as in OECD [2021]). This overriding commitment to these sectors leaves little fiscal maneuverability to fulfill the country's infrastructure-related commitments to the Sustainable Development Goals (SDGs) and international climate goals.

Public investments must be designed to maximize net benefits. Simply increasing the level of investment is insufficient to respond to the infrastructure sector's many challenges. Instead, investments must be spent wisely and efficiently. This requires a greater understanding of *which* infrastructure subsectors succeed in providing broad coverage and high-quality services that successfully connect people to opportunities, firms to markets, and lagging regions to economic centers. Understanding which subsectors provide direct benefits to households or to society at large is equally critical. For individuals, the key questions are whether access to infrastructure is affordable and whether it provides meaningful and quality connectivity to relevant economic and social opportunities. For firms, the key question is whether infrastructure services enhance their productivity and competitiveness, while providing reliable and affordable access to national and international markets. For society as a whole, the question is which infrastructure services maximize well-being.

Climate Change, Inclusion, and Productivity: An Analytical Framework for Long-term Economic Growth in Brazil

Measures of income, such as GDP, provide only a partial picture of a country's economic development. More comprehensive measures of wealth point to the value of a country's underlying assets (World Bank 2021a)—that is, *produced*, *human,* and *natural* capital—as key to evaluating and understanding the sustainability of a country's economic development long-term.

Different forms of capital are highly interrelated, and maximizing a country's total wealth means facilitating and fostering sustainable interactions between them. However, although complementary, they are not necessarily interchangeable. For example, natural capital (e.g., forests) can be used to make physical capital (e.g., houses). An important question then arises: does this transformation increase a country's inclusive wealth or merely substitute more or less tangible forms of capital? Prioritizing one form of capital over another in a bid to increase inclusive wealth generation after generation is a messy problem that has challenged governments throughout time and across the globe.

Productivity growth is key to determining a country's future success and its ability to improve living standards for its population. Labor productivity can be measured as GDP growth per hour worked. Sustained labor productivity growth can indicate major structural changes in the economy, particularly as it may reflect greater and better use of capital (including physical capital such as infrastructure), changes in the labor force exhibited through higher skills, and/or general efficiency gains and technological advancement.

Economists and politicians often focus on human capital aspects of productivity growth but this focus is only partial. Education, and to a lesser extent health, are commonly prioritized over infrastructure when contemplating mechanisms to boost productivity growth. The importance of technological change as a means to increasing efficiency of capital utilization thereby boosting productivity is also commonly underscored. The importance of physical capital in this process is often unappreciated but the quantity and quality of infrastructure can play a major role in enabling productivity growth.

Sustained productivity growth related to human and physical capital depends on continuous, long-term investments. The returns associated with investments in each of these areas may arrive at very different times, especially when different infrastructure subsectors are considered. For example, given the time it takes to complete the education cycle, investments in education typically yield market returns via skilled labor only after a generation or so. Some infrastructure subsectors follow a similar pattern—for example, gains in labor productivity realized through improved health during childhood derived from access to water and sanitation. These factors are highly interrelated, and access to water and sanitation is arguably a necessary precursor to realizing returns on investments in education. Simply put, the lack of clean water and adequate sanitation can significant undermine educational outcomes. Conversely, some subsectors may produce returns much sooner. For example, investing in the operation and maintenance of infrastructure can diminish input and output losses, which translates into quick gains in efficiency.

Choosing the most appropriate, long-term investments depends on multiple factors. Whether to prioritize the highest or quickest returns or not, in terms of boosting productivity growth, will depend on a country's stage of development, initial endowments, and budget constraints. Rather than merely substituting one form of capital for another in a resource extractive manner, policy makers should actively look for opportunities to reinvest finite natural resource rents into renewable activities that can yield sustained returns over the long term. Renewable resources such as land, water, and forestry, should not be treated as exhaustible, promoting their overuse through either pollution or overextraction.

The current state of infrastructure does not characterize the totality of Brazil's historical trajectory. As infrastructure investments are long-run investments, it would be misleading to consider Brazil's current situation as historically representative. Brazil has witnessed significant improvements in infrastructure stock yet progress has been uneven in terms of quality, particularly between infrastructure subsectors. For example, while Brazil has achieved near-universal access to water and electricity, access to sanitation and the Internet lags significantly.

Significant progress made in the second half of the twentieth century was halted by the debt crisis of the 1980s. Throughout its post–World War II history, Brazil strived to undertake the transformation from a resource-dependent to a diversified, productive economy. Initially, it engaged in import substitution industrialization policies aimed at boosting the domestic production of manufactured goods and diminishing economic dependency on a select few natural resource/agricultural commodities. Later, given successive economic crises, Brazil attempted to diversify its export base. At the same time, and to facilitate this economic transformation, significant improvements were made to address infrastructure bottlenecks, including connectivity (such as roads) and welfare-related infrastructure (such as access to piped water). Human capital also experienced a boost. Yet, since the debt crisis of the 1980s, this process appears to have slowed significantly and, comparatively, could even be said to have stagnated.

Investing in infrastructure is key to boosting Brazil's long-term productivity. If the country's policy makers hope to increase Brazil's ability to compete in international markets in the foreseeable future while simultaneously improving living standards, Brazil must invest more heavily in infrastructure. As these investments are long term in nature, the trade-offs between short-term gains and more sustainable long-term returns must be carefully evaluated. This is especially important given the increase in frequency and intensity of climate-related impacts expected for Brazil.

The middle-income trap has characterized Brazil's economy over the past 40 years. The country has failed to experience significant, sustained economic growth; most growth peaks have been driven

primarily by the demand of raw materials from countries such as China. Such resource-dependent growth is not bad in itself; however, Brazil has used the proceeds from this resource dependency poorly, ultimately jeopardizing prospects for long-term economic growth. In effect, after growth peaked at 7.5 percent in 2010 (levels that, over the past 40 years, were experienced only briefly, in the mid-1980s), the country's economy experienced three years of negative growth.

To escape the middle-income trap, Brazil must shift to high-productivity growth bolstered by innovation. Over the past decade, economic growth in Brazil has been timid at best. To sustain long-term economic growth and escape the middle-income trap, Brazil would need to move from resource-driven growth to a growth based on high productivity and innovation. This would require investments in infrastructure and education—areas that have not fared well in the past 40 years. Public expenditure in Brazil has been characterized as excessive and of poor quality. The result is that productivity in Brazil has fallen behind, even in sectors where the country remains competitive in exports (World Bank 2017; Veloso 2018).

The quest of attaining long-term economic growth is further complicated by climate change. The failure to adequately maintain existing infrastructure stocks or invest in new stocks has augmented the negative impacts of weather-related events. For example, droughts have severely threatened energy security for at least the past 20 years, given Brazil's high dependency on hydropower. Meanwhile, the poorly maintained highway system is in constant need of repair due to flooding and landslides caused by heavy rains that usually occur at the end of the Brazilian summer. These events have even been memorialized by Antônio Carlos ("Tom") Jobim in a well-known Bossa Nova song, "Águas de Março" ("Waters of March"). While floods and landslides are typically considered "natural" disasters, their frequency means they have become a known quantity, and associated impacts on infrastructure stocks are generally the result of poor planning, design, maintenance, and preparation.

Inadequate climate change adaptation within the infrastructure sector directly impacts Brazil's productivity. Brazil's prospects for long-term, sustained economic growth are hampered by the lack of a comprehensive approach to climate change adaptation, including sufficient investments, an implementation strategy, and accountability for the infrastructure sector. This nexus of inadequate climate change adaptation and low-quality infrastructure indirectly aggravates the long-term prospects of Brazil's economy by impacting the welfare of its labor force through, for example, increased air pollution and inadequate sanitation. Absent or poorly implemented policies have led to a significant loss of life and environmental damage (Box 1.1).

Box 1.1 Preventable Accidents Cause Significant Loss of Life and Environmental Damage

In January 2019, the Vale ore mine tailing dam, located in Brumadinho, Minas Gerais, in southeast Brazil burst, engulfing a cafeteria, offices, and farms, and killing 270 people. Disaster victims were awarded US$7 billion in compensation, which according to the state represents only an initial estimate of damages. Meanwhile, senior staff are facing murder charges in what has been described as intentional homicide (BBC 2021).

Four years earlier, in November 2015, a similar accident occurred less than 120 kilometers away in the same state, killing 19 people (BBC 2019). At the time, it was considered the country's worst environmental disaster, wiping out two villages and polluting important waterways over 650 kilometers away.

Environmental experts suggested both accidents could have been avoided while a local anthropologist argued such disasters are "political-institutional failures" and that "economics have been placed too far ahead of human life and environmental issues" (*National Geographic* 2019).

Low productivity weighs down a country's ability to promote investments and economic growth. In effect, the economy's poor productivity is arguably the most significant challenge to long-term economic growth. Produced capital such as infrastructure can impact productivity directly and indirectly. For example, improving connectivity in the transport sector frees up labor resources for other tasks, improving the sector's efficiency through labor use. Meanwhile, increasing access to high-quality water and sanitation services can improve well-being, leading to a healthier, more productive workforce.

Labor productivity in Brazil is low compared with both developed and developing economies. Over time, labor productivity in emerging economies has begun to exceed that of Brazil. Productivity growth been modest since 1980, further increasing the distance between Brazil and other countries.

Developed economies are overwhelmingly more productive than Brazil across all sectors. This is true even in a sector like agriculture, where Brazil is often praised for its ability to compete internationally (table 1.1). While this finding is not especially surprising, some lower-middle-income countries, such as India, also surpass Brazil in services. China, an upper-middle-income country like Brazil, and a major importer of Brazilian commodities, has a similar level of productivity in agriculture but surpasses Brazil in manufacturing and services. In all sectors, Mexico significantly surpasses Brazil.

Table 1.1 Productivity of Select Countries by Sector

Country	Total	Agriculture	Manufacturing	Services
United States	89.318	66.271	109.937	85.647
Ireland	84.949	27.976	114.873	80.397
Australia	67.555	65.469	88.358	61.589
France	66.488	50.027	64.056	69.225
Japan	64.967	18.102	70.607	65.400
United Kingdom	56.729	25.184	70.852	54.643
Korea, Rep.	52.503	24.290	74.759	44.429
Mexico	25.260	6.109	31.423	27.836
China	14.792	3.599	25.661	18.549
Brazil	14.689	4.779	19.389	15.814
India	8.423	2.224	11.984	17.307

Source: Veloso, Matos, Ferreira, and Coelho 2016.
Note: Productivity data are expressed in US$ purchasing power parity, using aggregated purchasing power parity. Countries are ranked in descending order by total productivity.

Unfettered land use changes create a vicious cycle of low productivity. Resource-based economic growth could enable sustained growth if proceeds are invested in activities that foster productivity and climate resilience. Historically, haphazard and unplanned land use changes have translated to even more unsustainable behavior, further promoted by perverse incentives such as direct subsidies for land occupation, indirect incentives to build roads in new areas, and a general lack of enforcement of laws preventing these behaviors. Land clearing, usually via slash and burn techniques, effectively treats land, soil, and even water as exhaustible resources. This generates a vicious cycle given that the land's productivity is limited, prompting further expansion when incentives are present.

Long-term productivity growth is further threatened by climate change. Disasters such as floods, landslides, and ecosystem fires affect infrastructure (e.g., destroying roads and bridges, building up silt behind water dams), further diminishing productivity. Climate change exacerbates these disasters, but ironically this type of economic growth strategy (i.e., haphazard land use) also contributes to climate change via increased greenhouse gas (GHG) emissions.

An absence of appropriate coping strategies mean climate change impacts are more likely to affect the poor. Most of Brazil's poor live in urban and rural fringes, which are much more susceptible to climate-related disasters, in part because of poor planning, siting, and zoning. Favelas and village outskirts bear the brunt of droughts, floods, and mudslides. Their inhabitants often lose hard-earned assets acquired through a lifetime of work to weather-related events and slide further into poverty, increasing inequality in the country. The associated rise in morbidity, mortality, and absence from school ultimately impacts productivity.

Infrastructure is one of the most important forces driving poverty reduction. Transport infrastructure (such as rural roads, highways, railways, and ports) spurs economic development through reductions in transport and trade costs, which leads to improved access to input and output markets and to enhanced access to social services, such as health and education. Reliable water and sanitation can reduce the risks of water-borne illnesses that cause child mortality and morbidity and generally hamper quality of life through coping costs and reduced productivity. Likewise, modern energy infrastructure services such as street lighting affect economic productivity and improve quality of life through increased accessibility and safety. Infrastructure services enhance inclusion in the following unique ways (Andrés et al. 2013):

- **Transport.** Evidence from recent impact evaluations strongly suggests significant increases in income for households and businesses associated with adequate transport infrastructure. Examining the channels for this effect indicates rural roads facilitate the transition to nonagricultural employment through reduction in transport costs. Quasi-experimental studies on highways and railroads show that on balance businesses benefit through a reduction in trade costs and the exploitation of gains from trade due to comparative advantage. These effects are robust across settings. Further bolstering of this evidence, which has generally lacked clear sources of exogenous variation, will require more rigorous nonexperimental designs, and perhaps, some experimental approaches, if they are allowed by the project settings. Income benefits at the household level, however, appear to be moderated by levels of human capital. Recent impact evaluations found that literate and relatively educated households more readily exploit business opportunities and employment in the nonagricultural sector. Regarding education, in contexts with costly travel to schools, rural roads are likely to increase school attendance and educational attendance.

- **Water supply and sanitation.** Evidence from recent impact evaluations on hygiene and point-of-use water quality interventions strongly indicate their efficacy in substantially reducing diarrhea incidence among children, in the order of 20 to 50 percent. The evidence suggests source water quality and sanitation interventions are less effective than hygiene and point-of-use water quality at reducing child diarrhea on average. Water quantity interventions are generally found to be the least effective, with reviewed studies finding no effects on reducing diarrhea incidence.

- **Energy sector.** Evidence from recent impact evaluations on electrification suggests a significant causal effect of electrification on household economic welfare. While none of the reviewed studies adopted randomized controlled trial designs, the use of strong quasi-experimental designs and detailed data on intermediate indicators provide compelling evidence for benefits to household income and employment from electrification. Electrification is found to render home production as well as home-based businesses and microenterprises more productive. For firms, manufacturing output is also likely to increase from either greater productivity of existing firms, as well as entry by new firms adopting electrification. Evaluations also suggest benefits to

educational attainment due to electrification. These improvements appear to result in part due to increased study time for children from greater and more affordable lighting, although further study of the mechanism is necessary. Greater incentives for educational attainment due to increases in the returns to education as a result of electrification remain an underexplored question.

Development Objective

This diagnostic applied cutting-edge analytics to generate innovative insights and new knowledge on the policy reforms needed to stimulate and sustain infrastructure development and to strategically inform and scale up policy dialogue with the Government of Brazil. It centers on the following development objective:

To develop innovative and thought-provoking policy advice designed to stimulate infrastructure development in Brazil while supporting the country's COVID-19 recovery process and promoting long-term, sustainable, and equitable growth.

Efforts are intended to emphasize the importance of developing a resilient, sustainable, and inclusive response to Brazil's recovery process. Adopting a multiyear, programmatic approach, this analysis deployed a series of novel and thought-provoking policy recommendations underpinned by robust quantitative and qualitative assessments of Brazil's infrastructure sector.

The effort generated two key outputs:

1. This diagnostic report based on a series of policy and research papers comprising deep dives into a select number of priority areas.
2. A policy reform framework to stimulate and sustain infrastructure development while supporting Brazil's recovery process and promoting long-term, equitable, and sustainable growth.

This findings within this report contribute to: (i) informing the government's strategic planning process for infrastructure; (ii) identifying investment challenges and service delivery shortfalls; and (iii) assessing policy gaps and weaknesses in institutional strength and regulatory frameworks. This assessment was also designed to help coordinate ongoing (and future) trust fund activities while aspiring to contribute to the Bank's country policy matrix, development policy lending, and the Systematic Country Diagnostic and Country Partnership Framework processes, as applicable.

The report's main argument is developed in six steps. First, a bottom-up approach is used to establish the size and significance of Brazil's infrastructure gap. Second, the potential contribution that infrastructure investment could have on the country's growth rate is assessed by estimating the public investment fiscal multiplier. Third, sector-level evidence is used to examine Brazil's physical infrastructure needs, and the technical and managerial inefficiencies impacting them. Fourth, the driving forces behind the limited consideration for infrastructure are examined through a political economy lens. Fifth, five key factors impacting sector performance—namely, regulatory governance, financing and funding, capacity, fiscal risks, and climate change—are explored through a series of analytical case studies and literature reviews. Finally, these analyses inform a series of key recommendations that together offer a reform framework focused on increasing the inefficiency and effectiveness of Brazil's infrastructure sector.

Report Outline

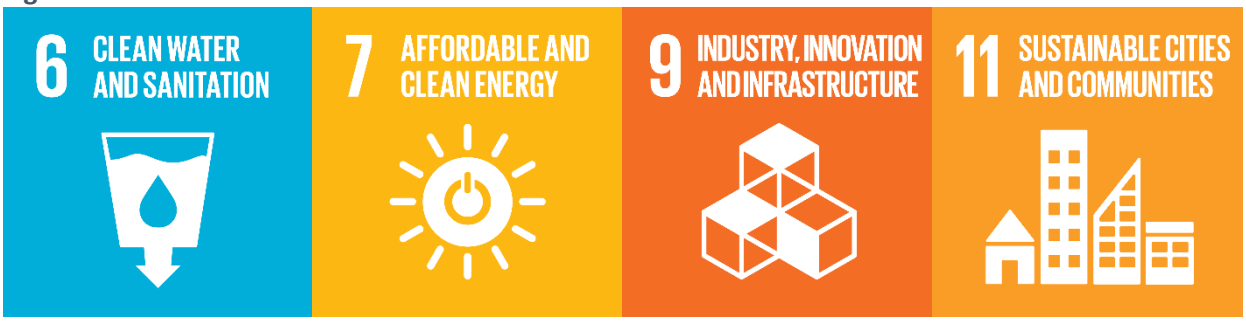
The evidence supporting this five-step reform process has been carefully synthesized in within the pages of this report, which has been divided into four chapters. Chapter 1 describes the importance of infrastructure to long-term growth in Brazil, by first articulating the problem before outlining the analytical framework underpinning the report's central hypothesis—that long-term economic growth is a function of climate, inclusion, and productivity. Chapter 2 presents summaries of each of the analytical activities undertaken and includes the estimated level of investment needed to bridge Brazil's infrastructure gap; a detailed review of Brazil's logistics system; an assessment of access to infrastructure services in Brazil with complementary evidence exploring the quality, efficiency, and affordability of services; an estimate of fiscal multipliers at the federal and subnational levels; and, finally, a qualitative assessment of Brazil's political economy. Chapter 3 presents a series of qualitative and quantitative assessments that seek to addresses the key factors affecting sector performance, including a case study of Brazil's water and sanitation sector and detailed reviews of Brazil's public planning process and private sector engagement. Key recommendations are described in chapter 4, while detailed policy recommendations for each subsector are included in appendix A.

2. DIAGNOSING BRAZIL'S AILING INFRASTRUCTURE SECTOR

Estimating the Level of Investment Needed to Bridge Brazil's Infrastructure Gap

The level of investment needed to bridge the infrastructure gap and achieve the SDGs is often significantly underestimated. Assessing a country's progress toward the infrastructure-related SDGs (figure 2.1) provides a useful benchmark and valuable insight into the impacts of chronic underinvestment. Achieving the SDGs and closing the infrastructure gap in Brazil will require a substantial level of financial investment. While most governments adopt a life-cycle approach to infrastructure asset management, many fail to consider their whole-life cost. For example, the less predictable nature of maintenance and limited capacity, especially at lower levels of government, means estimating maintenance costs is a complex process that frequently results in gross errors or leads to the exclusion of such costs. Consequently, the level of investment needed to bridge the infrastructure gap and achieve the SDGs is often significantly underestimated. Moreover, while bridging the infrastructure gap speaks to the financial investment needed to achieve universal access to water and sanitation, energy, and digital services, as well as robust transport infrastructure networks, it does not speak to the affordability of the services.

Figure 2.1 Infrastructure-Related SDGs



Source: United Nations 2022.

Actual investments are likely to be higher than estimated. To estimate the level of investment needed to close the infrastructure gap, a modular, bottom-up approach was used to quantify access gaps and, where applicable, the quality of Brazil's infrastructure services. Final estimates include the whole-life cost of assets, such as the costs of maintaining existing infrastructure in proper working order and the costs of replacing assets that reach the end of their service life.[10] These estimates represent the minimum level of investment needed. Actual investments are likely to be higher, for a number of reasons:

1. **Infrastructure services are indirectly related to other SDGs.** The estimates in this report were designed to be directly linked to a specific SDG. However, infrastructure services are indirectly related to other SDGs, for example, those related to climate change. Achieving those goals would likely require additional investments that have not been considered here. However, given the modular nature of the methodology, the investments required to achieve goals other than those explicitly described in this report can be similarly estimated and incorporated using the current

[10] For the purposes of this report, maintenance is calculated as a percentage of the estimated existing infrastructure stock valued consistently with the cost information retrieved for assessing new investments. Maintenance estimates cover expenditures related to the rehabilitation of assets, and also activities relate to capital expenditure, but exclude regular works which, by their nature, should be considered part of operating expenses.

estimates as a base. It is, of course, crucial to avoid double counting. In sum, it would be possible to incorporate costs, such as those related to climate change resilience, or other investments in future iterations.

2. **Estimates assume public investments are efficiently spent.** These calculations do not include delays and cost overruns, that is, they rely on the assumption of efficiency. Unfortunately, all too often, infrastructure projects in Brazil and elsewhere suffer from unexpected delays due to project and institutional-related problems such as poor planning, limited preinvestment activities, or procurement challenges exceeding budgets. Recent estimates indicate that in LAC these failures increase the cost of building infrastructure by about 35 percent on average (Serebrisky et al. 2017).

3. **Estimating maintenance costs depends on the quality of information available.** Investments in maintenance can be estimated only when information on existing infrastructure stocks is available. For some sectors (e.g., aviation), estimates were limited by a lack of information. These limitations also tend to underestimate the true costs.

Nevertheless, these estimates are consistent with the estimates produced by the Government of Brazil in 2021 (CIP-INFRA 2021). After making adjustments to render the estimates comparable, both fell within a relatively narrow range of US$475 billion to US$550 billion. The difference between the two estimates can be explained by the difference in road infrastructure investments and the time frames used to close the gaps (in particular, for sanitation and urban mobility). A sector-by-sector breakdown of variations has been included in appendix B.

Brazil's Infrastructure Gap by Subsector

Brazil must invest US$778 billion (or 3.7 percent of GDP per year) to bridge its infrastructure gap by the SDG deadline of 2030. Maintenance and the replacement of assets represent almost half[11] (US$345.3 billion) of total infrastructure investment needs. Given Brazil's heavy reliance on road infrastructure, it is hardly surprising that the transport sector represents more than 50 percent of the total investment needed (table 2.1; figure 2.2).

Declining infrastructure investments mean achieving the infrastructure-related SDGs will be extremely challenging. Since peaking at 2.34 percent of GDP in 2013, infrastructure investments have declined steadily, averaging only 1.69 percent of GDP from 2016 to 2020, and hitting a 10-year low of 1.64 percent of GDP in 2020 (figure 2.3). These figures compare poorly with the 4.8 percent of GDP per year committed during the 1980s and the estimated 3.8 percent of GDP needed to close the gap. Still, a productive, sustainable, and inclusive future for Brazil depends on it and the bottom line is clear: to close the infrastructure gap by 2030, Brazil will need to significantly increase its investments in infrastructure.

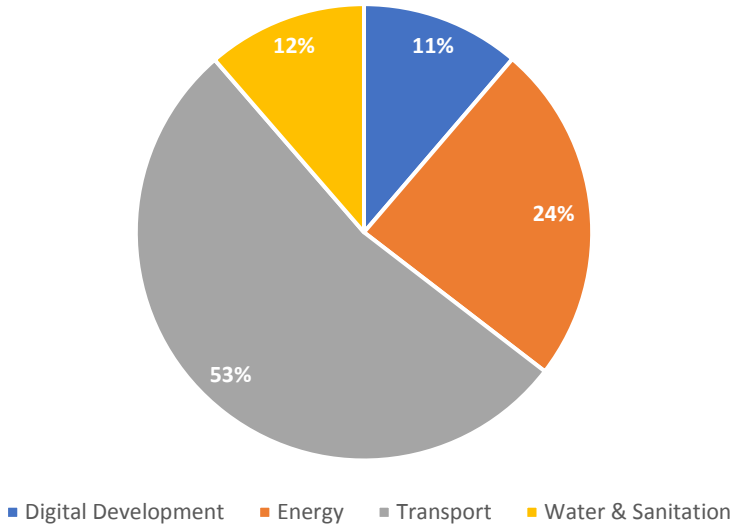
[11] In some aspects, such as electricity distribution and water connections, maintenance and the replacement of existing assets represent up to 75 percent of total investment needs.

Table 2.1 SDG Infrastructure Investment Needs for Brazil by SDG Target and Sector (US$, millions)

Target	Objective	Investment in New Assets	Maintenance	Replacement of Existing Assets	Total
Target 6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all	17,471	5,732	9,553	32,756
Target 6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	31,568	6,519	10,865	48,952
Target 6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	7,549			7,549
Water and Sanitation		56,588	12,251	20,418	89,257
Target 7.1	By 2030, ensure universal access to affordable, reliable, and modern energy services	116,378	9,122	64,432	189,932
Target 7.2	By 2030, increase substantially the share of renewable energy in the global energy mix				
Energy		116,378	9,122	64,432	189,932
Target 9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	158,884	70,114	108,887	337,885
Target 11.2	By 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons	80,442	N/A	N/A	80,442
Transportation		239,326	70,114	108,887	418,327
Target 9.C	Significantly increase access to information and communications technology and strive to provide universal and affordable access to the internet in least-developed countries by 2020	28,557	13,859	46,197	88,613
Digital Development		28,557	13,589	46,179	88,613
Total		440,849	105,346	239,934	786,129

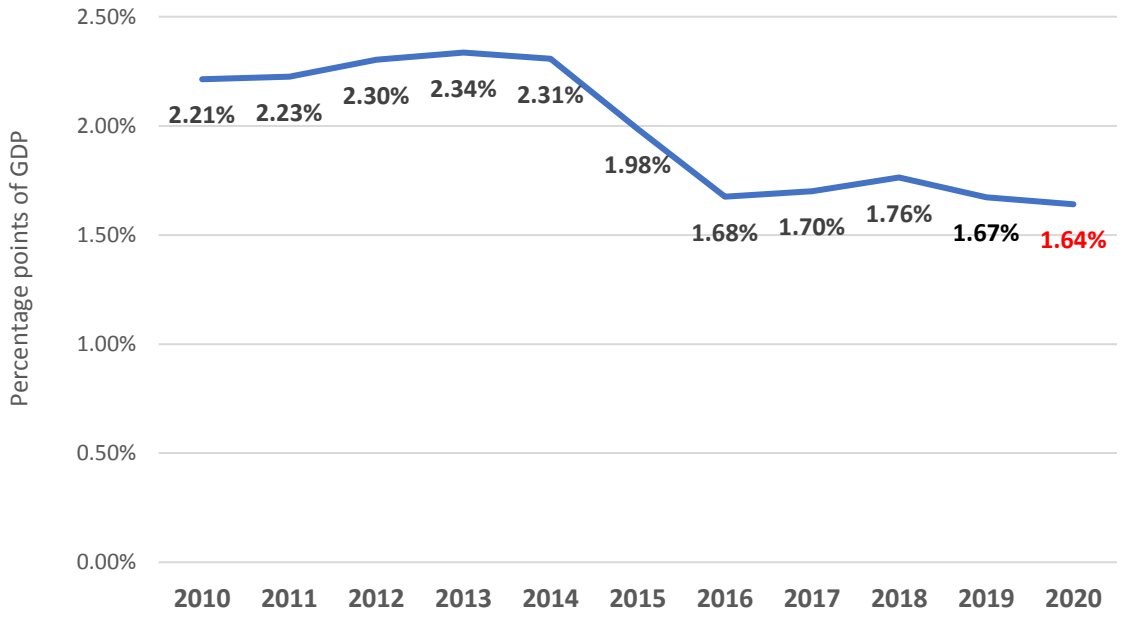
Source: Own elaboration.

Figure 2.2 Brazil's Infrastructure Gap



Source: Own elaboration.

Figure 2.3 Total Infrastructure Investments as a Percentage of GDP



Source: ABDIB and World Bank's World Development Indicators 2021.

Estimating the water and sanitation gap

To achieve universal access to safely managed drinking water and sanitation[12] by 2030 (SDG 6), Brazil will need to invest approximately US$89 billion (or 4.75 percent of GDP[13]) (table 2.2). This estimate includes: investing in new infrastructure (US$57 billion); maintenance of existing infrastructure (US$12 billion); and replacement costs for infrastructure that reaches the end of its service life before 2030 (US$20 billion). Universal access to safely managed sanitation accounts for 63 percent of the total water and sanitation infrastructure gap (including 8 percent to expand wastewater treatment in urban areas). Universal access to safely managed drinking water represents 37 percent.

Table 2.2 Investment Needs to Achieve SDG 6 (US$, billions)

Target	Objective	Investment in New Assets	Maintenance	Replacement of Existing Assets	Total
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all	17,471	5,732	9,553	32,756
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	31,568	6,519	10,865	48,952
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	7,549			7,549
Water and sanitation subtotal		56,588	12,251	20,418	89,257

Source: Own elaboration.

Estimating the energy gap

Overall, Brazil will need to invest US$190 billion (or 10 percent of GDP) to achieve universal access to electricity[14] by 2030 (table 2.3). Estimating the level of investment needed to achieve universal access to

[12] Insufficient data exist to estimate the hygiene gap; however, the figure is expected to be marginal when compared to the total investment needs for the sector.

[13] These estimates assume Brazil's economy fully recovered to its 2019 GDP level of US$1.88 trillion by 2021 (World Bank's World Development Indicators). At the time of writing, the latest available data from the Brazilian Institute of Geography and Statistics (IBGE) indicate that Brazil's 2021 GDP was R$8.7 trillion, which, using the yearly average exchange rate, is approximately US$1.6 billion.

[14] Electricity supplied must be sufficient to meet demand, and increasingly generated from renewable resources (Target 7.2). Incorporating renewables into the electricity generation matrix could be problematic given that renewable sources such as solar and wind are intermittent. As a result, it's not possible to extrapolate the investment required to achieve marginal increases in the generation with renewables given the impacts over the operating cost of the electricity network may be not linear. To counter this constraint, the estimates generated for this report rely on the expansion plans announced by the Empresa de Pesquisa Energética (EPE 2021) in Plano Decenal de Expansão de Energia 2031, a document commissioned by the Ministry of Mines and Energy. This expansion plan fulfills the requirement to increase the renewable share in the generation matrix and also incorporate technical feasibility constraints, enabling an estimate of the number of plants (and which type) that should be constructed to satisfy the expected electricity demand.

electricity comprises two components: (i) the infrastructure needed to generate electricity,[15] and (ii) the infrastructure needed to distribute electricity. To generate adequate electricity to meet the country's demands, Brazil will need to invest US$157 billion. About two-thirds will be needed to develop new generation capacity. The remaining third will be needed to replace generation infrastructure that reaches its end of service life before 2030. Comparatively, Brazil must invest approximately US$32 billion in distribution and transmission. Given the already high coverage rate, three-fourths of this investment should be directed to the maintenance and replacement of existing assets that reach the end of their service life before 2030. The level of investment needed for new infrastructure, corresponding to population growth and to reach the "last mile," is estimated to be US$8 billion.

Table 2.3 Investment Needs to Achieve SDG 7 (US$, billions)

Target	Objective	Investment in New Assets	Maintenance	Replacement of Existing Assets	Total
7.1 7.2	By 2030, ensure universal access to affordable, reliable and modern energy services By 2030, increase substantially the share of renewable energy in the global energy mix	116,378	9,122	64,432	189,932
Energy subtotal		116,378	9,122	64,432	189,932

Source: Own elaboration.

Estimating the digital development gap

To achieve coverage parity with the OECD median,[16] Brazil should invest US$89 billion (or 4.75 of GDP) (table 2.4). Telecommunications infrastructure is key to digitalizing production and improving household well-being. Improving broadband access represents 53 percent of the total investment and increasing 4G connectivity represents the remainder. Approximately one-third of the total investment (31 percent) should be devoted to new infrastructure, 15 percent to maintain networks already deployed, and 54 percent to replace existing infrastructure, to keep pace in an environment of rapid technological change.

Table 2.4 Investment Needs in Digital Infrastructure to Partially Achieve SDG 9 (US$, billions)

Target	Objective	Investment in New Assets	Maintenance	Replacement of Existing Assets	Total
9.C	Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	28,557	13,859	46,197	88,613
Digital development subtotal		28,557	13,859	46,197	88,613

[15] Defining actual investment needs for generating electricity requires establishing the cost per megawatt (MW) of installed capacity of different technologies. This can be undertaken using the Model for Electricity Technology Assessment (META) developed by the World Bank's Energy Sector Management Assistance Program. META provides cost and performance data for different generation, transmission, and distribution technologies, taking into account market trends and the latest technological developments.

[16] In the absence of a quantitative indicator, the median coverage for broadband and 4G connections of countries of the Organisation for Economic Co-operation and Development (OECD) is used as a benchmark.

Source: Own elaboration.

Estimating the transportation gap

Brazil must invest a total of US$418 billion (or 17.8 percent of GDP) in transportation infrastructure to meet the transport-related SDGs by 2030. Of this, 43 percent is needed for maintenance and the replacement of assets (table 2.5). The transport-related SDGs comprise two separate goals and three indicators: (i) the proportion of the rural population that lives within 2 kilometers of an all-season road (also known as the Rural Accessibility Index or RAI)[17]; (ii) increased passenger and freight volumes by mode of transportation; and (iii) access to safe, affordable, accessible, and sustainable transport systems for all and improve[d] road safety, in particular by expanding public transport, paying special attention to the needs of people in vulnerable situations, women, children, people with disabilities, and the elderly (in urban environments).[18] To meet the first indicator (the RAI), Brazil must invest $155 billion in new infrastructure, US$70 billion to maintain the existing network, and US$108 billion to replace assets that reach the end of their service life before 2030 represents. Additionally, to achieve the level of transport coverage of the best performing cities in LAC in each of Brazil's cities with more than 500,000 inhabitants by 2030, Brazil needs to invest US$80 billion in new mass transit infrastructure.[19] The remaining $5 billion must be invested in airports (box 2.1).

Table 2.5 Investment Needs in Transportation Infrastructure to Partially Achieve SDG 9 and SDG 11 (US$, billions)

Target	Objective	Investment in New Assets	Maintenance	Replacement of Existing Assets	Total
9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	158,884	70,114	108,887	337,885
11.2	By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	80,442	N/A	N/A	80,442
Transportation subtotal		239,326	70,114	108,887	418,327

[17] Although a specific goal was not defined for this indicator, the spirit of the target suggests the need to achieve universal access. Unfortunately, given Brazil's size and anticipated environmental impacts, achieving universal access in rural areas is fiscally unfeasible. However, including tertiary road networks (typically excluded from the RAI) was shown to increase Brazil's RAI from 35 to 65 percent. Thus, a more achievable goal with the potential to significantly impact Brazil's RAI would be to extend maintenance (and reconstruction) programs to the country's tertiary road networks.

[18] As a specific target has not been established, this report defines the urban mobility infrastructure gap as the investment needed for Brazil's cities with more than 500,000 inhabitants to achieve parity with the top-performing cities in LAC.

[19] Under a cost-effective scenario that assumes increases in mass transit infrastructure are reached using a combination of bus rapid transit systems (75 percent), surface rail (10 percent), and subways (15 percent). These estimates will significantly increase if OECD cities are used as the benchmark or if rail solutions are used to solve existing deficits.

Source: Own elaboration.

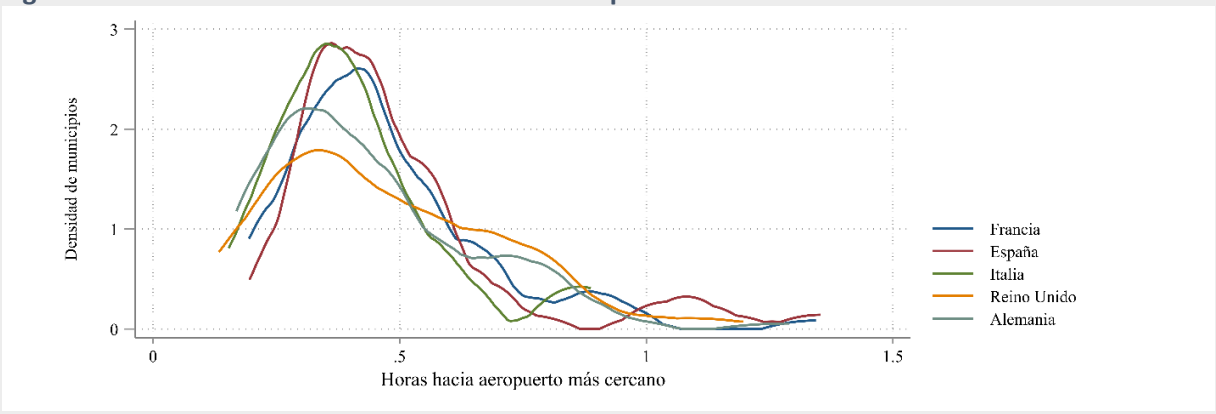
Building and maintaining a reliable road network is insufficient to support the multimodal transportation solutions needed to make Brazil more competitive. Ports, railways, and airports are indispensable to improving logistics, achieving the SDGs, and supporting Brazil's productivity and growth long term. Calculating the level of investment needed to bridge the transportation infrastructure gap beyond Brazil's road network is complex. Recent attempts suggest that private investments will be key to bridging this gap and hinge upon the successful development and implementation of policies and strategies designed to attract private investors.

Box 2.1 Assessing Investment Needs Beyond Brazil's Road Infrastructure

Determining the size of Brazil's infrastructure gaps for ports and airports is not an easy task due to the complexity of technical aspects and the network effects involved, with huge impacts on the total cost of building. Nonetheless, the Development Bank of Latin America (CAF 2016) estimates the total investment needed for Brazil's port infrastructure is US$6.5 billion, including expanding capacity and dredging activities.

Meanwhile, Brichetti et al. (2021) estimate the total investment necessary to guarantee access to airport infrastructure for populations living in urban centers with more than 100,000 inhabitants is at least US$4.5 billion, 28 percent of the total investment needs for Latin America and the Caribbean. The estimate was based on a spatial exercise that determined the urban population of the region that lacks access to an airport less than an hour away from the town or city where it lives. The accessibility criterion was determined taking into account the access time in countries where the air market is highly developed (e.g., Western Europe and the United States; figure B2.1.1). This investment will need to be complemented by other investments directed at expanding existing airports.

Figure B2.1.1 Distribution of Travel Times from Populated Centers

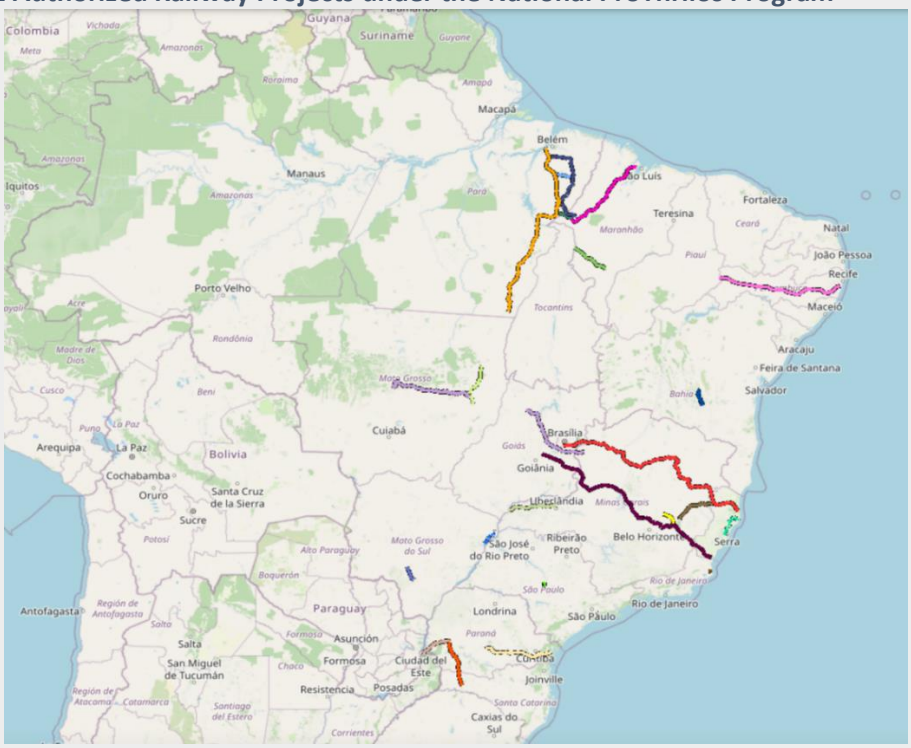


Source: Brichetti et al. 2021.
Note: Travel times are from centers with more than 100,000 inhabitants to the nearest airport by country.

Private investment will be critical to this process and is contingent upon the successful development and implementation of policies designed to attract private investors. The federal government has recently attempted to make strides within the country's railway sector, launching the Programa de Autorizações Ferroviárias (ProTrilhos). Created in August 2021 under MP No. 1.065/21 and awaiting congressional ratification, the program is focused on attracting private investment to both greenfield and brownfield railway projects by streamlining and simplifying the concession process and incentivizing private investment by reducing the number of authorizations needed to proceed. Following privatization of Brazil's railway system in the late 1990s, several significant investments—mostly focused on improving operational performance—were made. Since then, however, its extension has stalled. The ProTrilhos initiative is intended to reverse this trend by encouraging

investment in expanding the current network and developing new services, enhancing competition, and improving productivity within the sector.

Figure B2.1.2 Authorized Railway Projects under the National ProThrilos Program



Source: MINFRA 2022.
Note: As of May 2022.

Beyond Allegory: How an Underdeveloped Multimodal Transport System Presents a Real Bottleneck to Productivity in Brazil

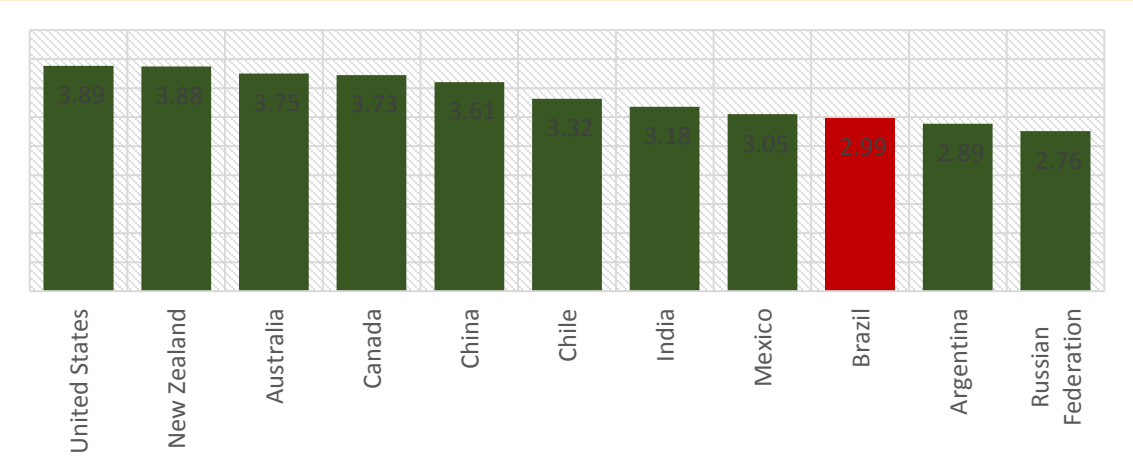
Brazil's complex logistics system is a key limiting factor to the country's future productivity. The country's vast overall dimensions, high heterogeneity of transport infrastructure, widespread distances between producing and consuming regions, and a transport matrix that is highly dependent on roads make for a complex logistics and freight system. In practice, this implies a number of economic, social, and environmental distortions, such as low fuel efficiency and high transport costs and emissions. An unbalanced transportation matrix, a road network in desperate need of maintenance, and limited investment in transport infrastructure are just some of the factors impacting Brazil's competitiveness today (box 2.2).

Box 2.2 Logistics Performance: How Does Brazil Stack Up?

Determining logistics comparators for Brazil is an exercise in its own right. Given its location, Brazil is often compared with other Latin American countries, yet in terms of overall size this would seem inappropriate. More realistic comparators based on size alone might include Canada and the United States, yet given economic disparities this would also seem inappropriate. This leaves the major, emerging economies of Brazil, Russia, India, China, and South Africa, known as BRICS, which are of similar geographic and economic size.

Brazil currently ranks 56 out of 161 countries on the Logistics Performance Index, lagging behind Mexico, India, China, Canada, and the United States (figure B2.2.1). Dropping 15 places since 2010, it was the only BRICS member whose logistics performance decreased. In a category-by-category breakdown, Brazil fared slightly better than Russia in all categories except customs, and otherwise ranked behind China and India on all other measures (table B2.2.1).

Figure B2.2.1 Logistics Performance Index, 2018



Source: World Bank 2022a.

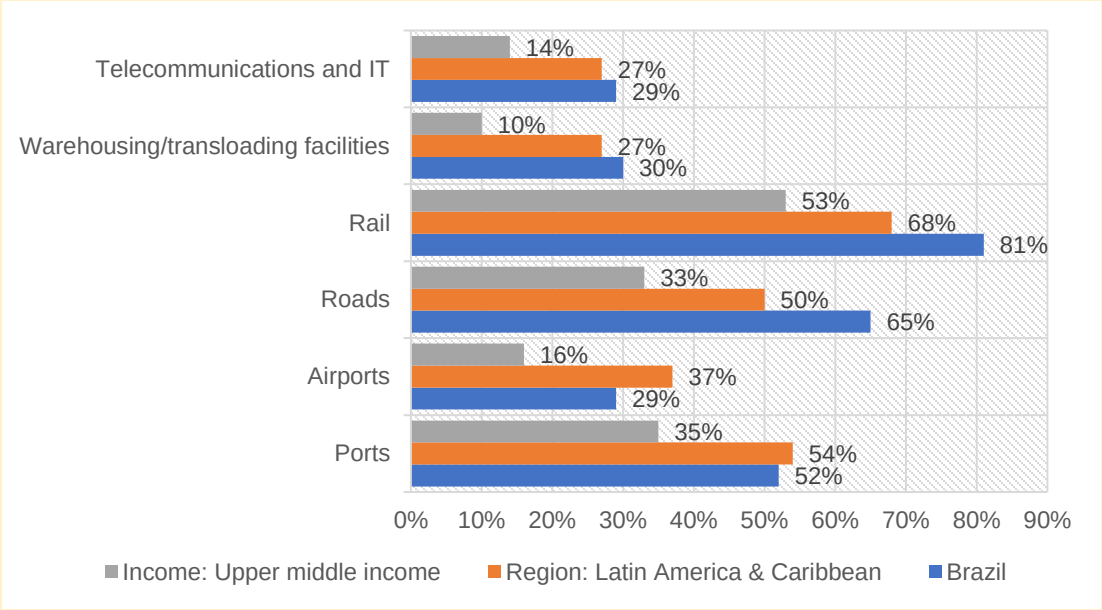
Table B2.2.1 Logistics Performance Index by Category and Country, 2018

Country	Customs	Infrastructure	International Shipments	Logistics Quality and Competence	Tracking and Tracing	Timeliness
Brazil	2.41	2.93	2.88	3.09	3.11	3.51
China	3.29	3.75	3.54	3.59	3.65	3.84
India	2.96	2.91	3.21	3.13	3.32	3.50
Russian Federation	2.42	2.78	2.64	2.75	2.65	3.31

Source: World Bank 2022a.

Regionally, Brazil's fees and charges are perceived as substantially higher than other upper-middle-income countries in Latin America and the Caribbean (LAC) and, with the exception of ports and airports, Brazil's infrastructure is perceived to be of lower quality than the region as a whole, especially roads and railways (figure B2.2.2). Similarly, the competence and quality of services, and efficiency of processes, are deemed much lower than other upper-middle-income countries in LAC. Finally, the perception of the evolution of the logistics environment in Brazil since 2015 is also considered poor. In sum, Brazil is perceived as worse than all other upper-middle-income countries in LAC on virtually every logistics indicator.

Figure B2.2.2 Quality of Infrastructure (share of respondents answering low/very low)



Source: World Bank 2022a.

Exports are growing at a faster pace than the supply of transport infrastructure creating an imbalance in supply and demand. Increases in production (mainly of agricultural and mineral commodities) and in domestic and international consumption have begun to surpass the capacity of the country's transport infrastructure. Despite being one of the world's largest producers of sugar, coffee, orange juice, animal products, ethanol, and soy, Brazil's reliance on a poorly maintained road system to haul freight over long distances will eventually limit export capacity and erode recent gains in competitiveness without a focused effort to increase the modal mix, especially given the low levels of investment in recent years (Péra, Caixeta-Filho, and Salin 2021). For example, in 2016–17, the country produced 200 million tons of soybeans and corn, a figure that is expected to exceed 300 million tons by 2030 (MAPA 2020).

Logistics solutions have been designed primarily to meet the needs of the country's agribusiness sector. Parts of the country have seen a recent increase in both freight volumes and logistics providers. However, demands for more competitive transport solutions are dominated by the agribusiness sector, while the needs of other sectors go unaddressed. Multimodal transport by rail and waterway remains underexplored especially for general cargo. The limited supply of rail and waterway infrastructure helps fuel the country's reliance on roads, exacerbating existing deficiencies in both the extension and quality of the country's road network. This creates a vicious cycle that translates to increased congestion, shipping delays, and higher operating costs, among other problems, ultimately leading to a loss of productivity.

Distances between origin and export terminals are relatively high. Despite some expansion of the country's rail and waterway networks, network density remains low and the number of multimodal terminals in Brazil is small, even in the central cargo regions, leading to a mismatch between capacity and demand. Freight must travel long distances by road before reaching rail and waterways. Poor conditions

along several important road segments in Brazil often cause stoppages and weather-related delays that result in increased costs for shippers. This reduces the potential economic benefits of multimodal transport operations.

Logistics infrastructure, and multimodal transportation solutions in particular, have suffered from a lack of public investment. The current state of Brazil's transport sector is, in large part, a result of the country's historical economic development, the lack of adequate and sustained long-term and systematic planning, and lower than necessary investments that characterize the infrastructure sector as a whole. Increasing the level of public investments is essential, but not the only way to drive change.

Brazil has been slow to improve the business environment needed to render the sector more attractive to private investors. Despite the government's recent efforts to increase private participation, planning, institutional coordination, and the sector's overall inefficiency remain significant hurdles. Different projects have invariably been discussed by the Brazilian government and the private sector. Several investment plans have been launched, but the amount invested has been insufficient to foster more competitive solutions and achieve real change. Improving the business environment could attract larger private investments that would help offset limited public resources, while increased political will could help enhance the pace and performance of public-private partnerships (PPPs).

Brazil's tax arrangements disincentivize a more integrated logistics system. The ICMS (Imposto Sobre Circulação de Mercadorias e Prestação de Serviço) is a highly cited tax when it comes to transportation problems. It varies by state, incentivizing shippers to avoid states with higher taxes and instead use less efficient routes and modal combinations.

Better policies are needed to increase competition in the country's rail and waterway segments. Brazil's rail and waterway freight markets are highly concentrated, leading to reduced competition that gives a market advantage to logistics providers and, in the case of the railway sector, has encouraged oligopolies to emerge. Providers use road freight costs as the benchmark for pricing services, meaning the cost structure of rail and waterway operations is not representative. Reduced competition means providers are not incentivized to pass on savings that would help grow markets and attract more investments.

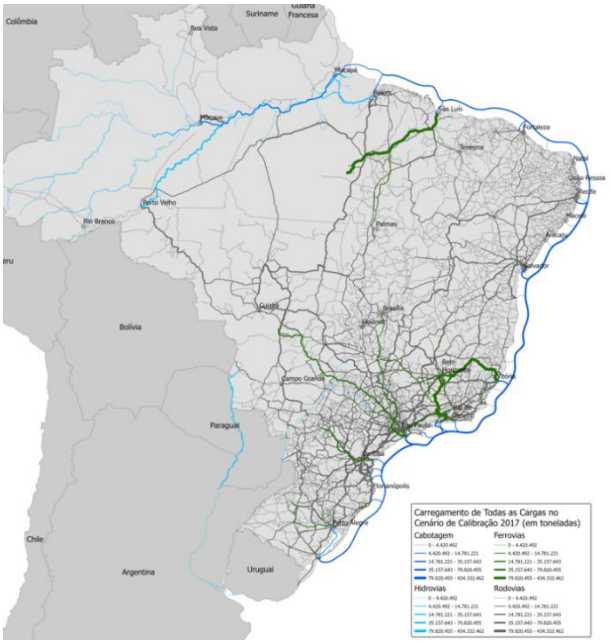
Roads

Brazil's logistics sector is characterized by an extensive road network that dwarfs all other modes of transport (figures 2.4 and 2.5). Extending approximately 1.7 million kilometers, only 12.4 percent (213,452 km) of Brazil's roads are paved. Although the share of paved roads rose from 170,902 km in 2001 to approximately 213,453 km in 2021—an increase of almost 25 percent—the total extension of paved roads has remained relatively static since 2001 (CNT 2021).

Brazil's road network is critical to logistics, yet unevenly distributed and of highly variable quality. Most of Brazil's roads are concentrated in the eastern part of the country, where major urban settlements and industrial activities are located. The southeast region has around 31.0 percent of the total road network, followed by the northeast and south regions with 25.9 and 22.6 percent, respectively. About one-third (38.2 percent) of roads are perceived to be in good or very good condition, up from 28 percent in 2015

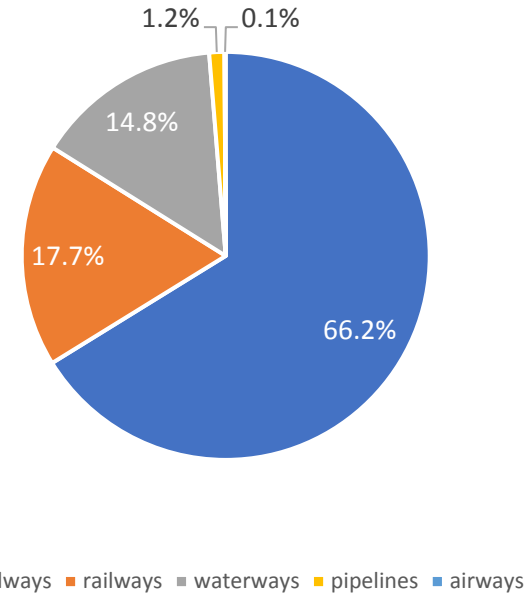
(figure 2.6**Error! Reference source not found.**). Conversely, one-fifth are deemed to be in bad or very bad condition.

Figure 2.4 Main Transport Axes of Brazil



Source: EPL 2021.

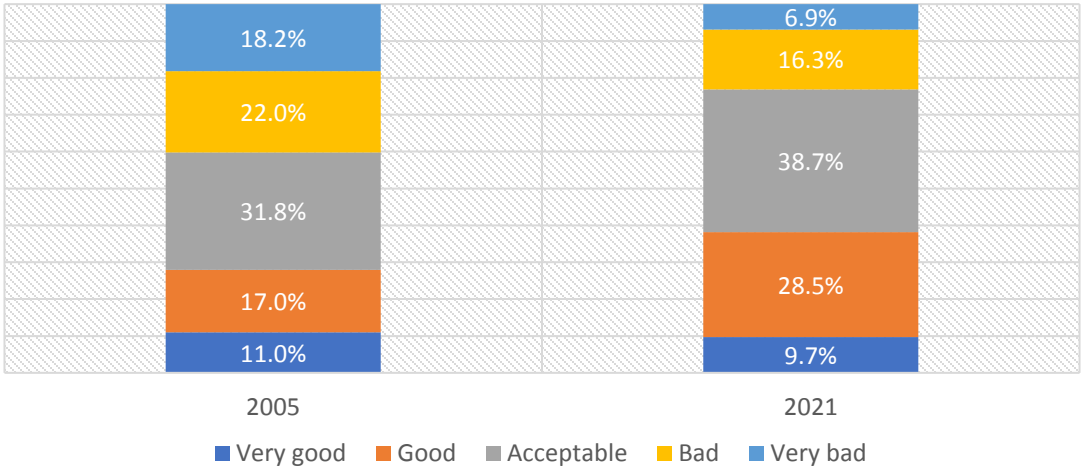
Figure 2.5 Share of Cargo in Brazil by Mode of Transport, 2021



Source: EPL 2021, using estimates from the National Logistics Plan.

Brazil's heavy-duty trucks are a major contributing factor to diminished road quality. Brazil has some of the largest and heaviest trucks in the world. More than 100 different combinations of trucks were already permitted to circulate in Brazil—ranging from 2 to 9 axles, gross weights of between 12 and 74 tons, and lengths of up to 30 meters (DENATRAN 2009)—when the rules were recently updated. Larger, heavier trucks, weighing up to 91 tons, are now permitted but only with a Special Transit Authorization (MINFRA 2022). This regulation mainly favors the transport of sugarcane. Arguably such a weight would have a measurable impact on the quality of Brazil's roads, which would require a commensurate uptick in maintenance investments. By comparison, the maximum allowable weight in Canada and Australia, where a performance-based approach is applied, is 62.5 and 77.5 tons respectively (box 2.3).

Figure 2.6 Changes in Perception of Brazilian Road Quality, 2005–21



Source: CNT 2021 (Road Surveys Results).

Box 2.3 Maximum Allowable Weights around the Globe

Gross vehicle weight (GVW) commonly varies by vehicle configuration. For example, in the United States, where the federal government regulates the system of interstate highways, the maximum allowable weight limit is 36.3 tons. This, however, rises to 58.5 tons inside several states. In Canada, considered a "pioneer in performance-based standards" and where larger semi-trailer trucks are in circulation, the maximum allowable weight is 62.5 tons. The maximum allowable weight for cross-border transport in Europe is currently 40–44 tons, although longer and heavier vehicles, known as "mega" rigs or trailers that measure up to 25.25 meters with a maximum weight of 60 tons, are being considered. In Australia, the most common maximum allowable weight is 44 tons. However, larger trucks measuring up to 30 meters and a maximum allowable weight of 77.5 tons have been tested in the State of Victoria in recent years. In most countries, larger trucks, such as those with a maximum GVW of >70 tons, require special permits to circulate.

In Latin America and the Caribbean, weight limits are highly variable. For example, the maximum weight limit in Chile is 45 tons; however, this can be extended under special circumstances. In Mexico and Argentina, the maximum weight limits are 75.5 and 74 tons, respectively.

In countries with less sophisticated transport systems, excessive weights and a lack of monitoring have been cited as the cause of road damage. Such is the case in Mexico, where the Secretary of Transport estimates 14 percent of all cargo trucks exceed allowable weights.

Sources: US Department of Transportation n.d.; Government of Argentina 2018; *Mexico News Daily* 2021.

Brazil's Aging Truck Fleet

Brazil's truck fleet exceeds 2 million vehicles and has an average age of almost 15 years. More than half (53 percent) are owned by cargo trucking companies and 46 percent are independently owned, which highlights the significance of self-employed drivers to Brazil's freight and logistics market (ANTT 2022). Transport cooperatives own around 1 percent of the fleet (table 2.6). This distribution leads to high competition and low marginal profitability, forcing truck drivers to cut down on maintenance, overload their vehicles, and drive longer hours. The age of a vehicle is crucial for fuel economy, since older vehicles

are typically less efficient and more polluting. With an average age of almost 15 years (ANTT 2022), about 6.1 percent of Brazil's truck fleet is over 30 years old. Trucks belonging to individual owners have an even higher overall average age of about 21.6 years (ANTT 2022).

Table 2.6 Brazilian Trucking Fleet Ownership

Type	Fleet	Share (%)	Average Age of Fleet (years)
Self-employed driver	750,606	46	21.6
Cargo transport company	856,266	53	10.6
Cargo transport cooperative	17,759	1	14.9
Total	1,624,631	-	14.7

Source: ANTT 2022.

Railways

Despite a general overreliance on roads, the concentration of cargo movement in Brazil's rail system increased between 2010 and 2020. Close to 74 percent of all rail freight is iron ore (ANTT 2022), followed by soy, sugar, corn, cellulose, and mineral coal. Corn and soybean travel the highest average distance by train—a function of the cargo movements in Mato Grosso State. Brazil's railway network extends a total of 31,299 km, of which only 10,000 km are used for commercial operations. The country's fleet comprises 98,097 wagons and 2,988 locomotives. At 3.61 km of railway per 1,000 km² of area, Brazil has a comparatively low railroad density compared to other countries of a similar size (table 2.7).

Table 2.7 Railroads (km) and Railroad Density (km/1,000 km²) in Select Countries

Country	Area (millions of km²)	Railroads (thousand km)	Density (km/thousand km²)
Russian Federation	17.10	87.15	5.10
Canada	9.98	77.93	7.81
United States	9.83	293.56	29.86
China	9.60	131.00	13.65
Brazil	8.52	30.75	3.61
Australia	7.74	33.34	4.31
India	3.29	68.52	20.83
Argentina	2.78	36.91	13.28
Mexico	1.96	20.82	10.62
South Africa	1.22	20.98	17.20

Source: ANTT 2022.

Infrastructure is not keeping pace with agricultural exports in Brazil. Between 2010 and 2020, railway transport in Brazil grew by 12.4 percent; however, exports increased by 34.2 percent over the same period. The growth dynamics of railway movements in Brazil have been driven by the demand of the leading agribusiness sectors. In 2021, transportation of grains and sugar represented 17.9 percent of the entire volume moved by rail in Brazil, an increase from 9.1 percent in 2010.

Brazil's railway network remains insufficient, especially in regions characterized as agricultural frontiers. There are only a few multimodal transshipment terminals in the central regions and with the limited advance of investments in multimodal transport infrastructure, the number of transshipment terminals available overall is small. In addition to this limited capacity, the problem of long distances to

access railways (and waterways) is significant. For example, Sorriso and Lucas do Rio Verde, both situated in Mato Grosso, are 618 and 550 km, respectively, from the Rondonópolis Railway Terminal, the country's main railway terminal. By contrast, the Itaituba Waterway Terminal in Pará is 1,081 km from Sorriso. The average distance from agricultural production regions to multimodal terminals around the country by road is 700 km (Péra, Caixeta-Filho, and Salin 2021). High road freights are thus characteristic of Brazilian multimodal transport in the central agricultural regions.

Brazil's railway logistics market is characterized by low competitiveness. The limited number of options for existing railway operators in the Brazilian market is reflected in the number of concessionaires, currently 16, ranging in size from 164.1 km up to 7,856.8 km (ANTT 2022). In Brazil, railway concessions are mainly vertical: railway companies are responsible for managing the infrastructure and providing services, requiring high investments. A lack of public policies governing railway transport development, low levels of public investment in infrastructure, and risks felt by the private sector regarding investments in railroads (such as the dependency on access to the rail network and the lack of idle capacity), have all contributed to the sector's characterization of low competitiveness.

Reduced competition in the rail market gives market advantages to the logistics provider when pricing services. Rail providers do not use the cost reduction potential of these modes in the logistics chains. Road freight is used as a benchmark for the prices charged for rail transport operations instead; that is, rail freight prices depend on (and are proportional to) road freight pricing.

Greater synergy with return cargo operations could enhance pricing and increase returns on investment. In Brazil, few attempts have been made to explore return cargo operations from ports to production centers. For Brazilian agribusiness, the most common return loads are fertilizers; indeed, Brazil is the world's top importer of fertilizer. In addition to the potential reduction in transport costs by shippers, coordinating exports with return cargo operations makes better use of investments (in infrastructure and rolling assets).

Ports

Ports are vital to Brazil's logistics system and serve one of the longest coastlines in the world (figure 2.7). The Port of Santos (São Paulo State) is the most economically important given its freight handling capacity and influence on the national economy. There are seven other ports of major importance across the country: São Luís (MA) port terminals, Rio de Janeiro (RJ) port terminals, Vitória (ES) port terminals, the São Sebastião (SP) port terminal, the Port of Paranaguá (PR), the Port of Suape (PE), and the Port of Rio Grande (RS).

Port activity has increased substantially in recent years. Total port activity increased at a rate of around 3.4 percent per year to 44.5 percent between 2010 and 2021. In 2021 Brazilian ports moved 1.21 billion tons of cargo compared to 840 million in 2010 (ANTAQ 2022). Solid bulk cargo represents around 58.1 percent (707 million tons) of total cargo, followed by liquid bulk (315 million tons in 2021), containers (113 million tons), and general cargo (60 million tons) (figure 2.8). Long haul activities represent almost 75.0 percent of total port activities, cabotage 17.6 percent, and inland waterway transport operations 9.7 percent. Since 2010, all three have experienced substantial increases, ranging from 38 percent for long haul to 62 percent for cabotage to 44 percent for inland waterway transport (ANTAQ 2022).

Figure 2.7 Main Ports of Brazil

Source: ESALQ-LOG 2022 (based on data from ANTAQ 2022).

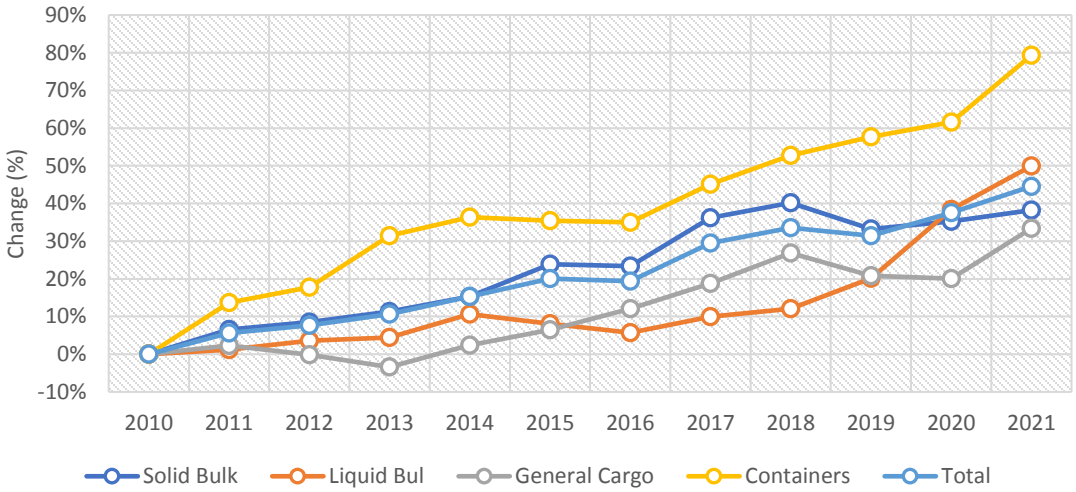
Brazil's port system is becoming increasingly geographically diverse, in part bolstered by a change in regulation in 2013 permitting the construction of private port terminals. This initiative led to an increase in the number of terminals for private use, encouraging the development of logistics corridors in some areas of the country. The increase in port operations has been felt countrywide and from 2010 to 2020, 46 new port facilities (ports, port terminals, and waterway transshipment terminals) were added to Brazil's logistics system. The southeast region experienced an increase in total volume of 13.0 percent between 2010 and 2020. The northeast experienced the most significant increase in volume, up 78.3 percent (146.5 million tons). The south and north regions also had important gains of over 50 million tons each.

The current port administration model suffers from inefficiency. Despite the recent increase in port infrastructure and its growing diversity, Brazil's port system still suffers from several critical problems. One notable challenge to port system development in Brazil is an inefficient port administration model. The country's main ports are managed by the federal government. Terminals can be privately operated, but run by directors who have been appointed by the federal government (or the state administration in some cases). This has led to persistent underinvestment while bureaucracy has hampered modernization efforts, making Brazil's ports uncompetitive at the global level.

An absence of professional port management presents another bottleneck. The salaries paid by the government are insufficient to attract the type of talent that a private sector concessionaire would draw, and port directors are often political appointees who lack the experience required to run these complex

nodes of the logistics chain. Moreover, the sector lacks a sound regulatory framework to promote competition between ports. Greater competition would lower costs and promote more efficient use of resources. Finally, the lack of harbor capacity is also a key constraint in Brazil and capsize vessels are limited to only a few ports with adequate loading capacity.

Figure 2.8 Evolution of Brazil's Port Activities by Cargo Type



Source: ANTAQ 2022.

Waterways

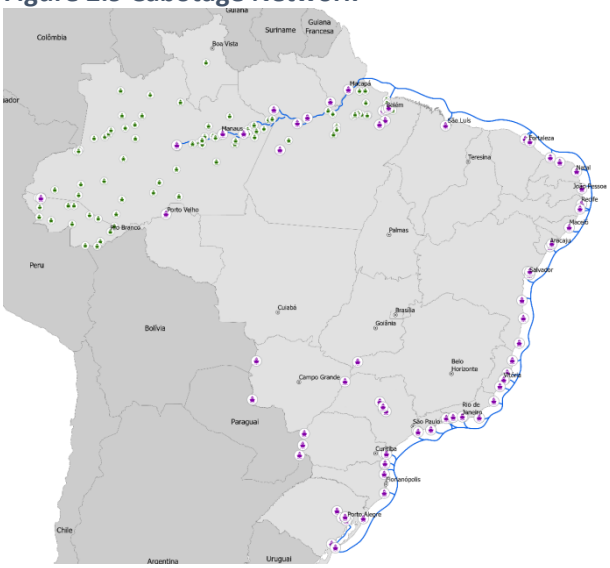
Cost competitiveness and growth potential are driving efforts to increase cabotage for transport between Brazilian cities and regions. Brazil's cabotage fleet consists of about 406 vessels (4.7 million deadweight tons) (CNT 2021). In 2021, 206.9 million tons were transported by cabotage in Brazil, up from 136.1 million tons in 2011. Mineral fuels and derived products represented 76.5 percent of the total volume of cabotage (158.3 million tons), followed by minerals (around 9.9 percent) and containers (9.0 percent).

Historical restrictions on cabotage activities have been lifted in a bid to increase supply and competition. Cabotage activities were historically restricted to domestic flag vessels operated by a Brazilian individual or one of Brazil's shipping companies (known as EBNs). Recent regulatory efforts have been made to increase cabotage supply and the sector's competition, under Law 14.301/2022 ("BR do Mar"), by: (i) creating new ways to charter foreign vessels as a way to increase the operating fleet; and (ii) encouraging the development of the naval industry to reduce the dependence of EBNs on foreign shipyards. This public policy has been seen as an essential effort to increase cabotage transport in Brazil.

Inland waterway operations increased by a third over the last decade, but lack density and are poorly distributed. Most inland waterways are in the country's northern region, where the local economy is still not generating sufficiently high volumes of freight. About 22,000 km of waterways from a total of 63,000 km of rivers and lakes are economically navigable in Brazil (figures 2.9 and 2.10). Still, inland waterway transport operations moved 108.4 million tons in 2021, up 33.1 million tons from 2011. Amazônica and Tocantins-Araguaia are the two main hydropower basins in Brazil and are responsible for 55.8 and 32.7

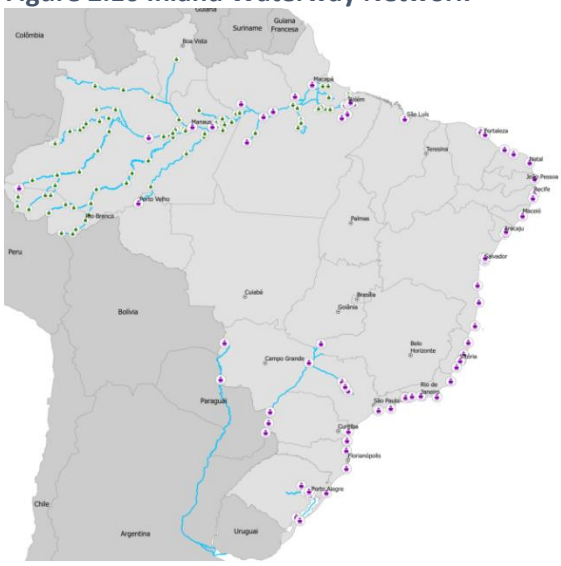
percent of waterway operations, respectively. Brazil's waterway density is about 2.3 km/1,000 km², compared to 13.2 km/1,000 km² in China. In 2021, Brazil's inland waterway fleet was 3,425 vessels (3.8 million deadweight tons) (CNT 2021). This represents an increase of 129.3 percent compared to the number of ships in 2010 (220.6 percent of growth when comparing deadweight tons).

Figure 2.9 Cabotage Network



Source: EPL 2021.

Figure 2.10 Inland Waterway Network



Source: EPL 2021.

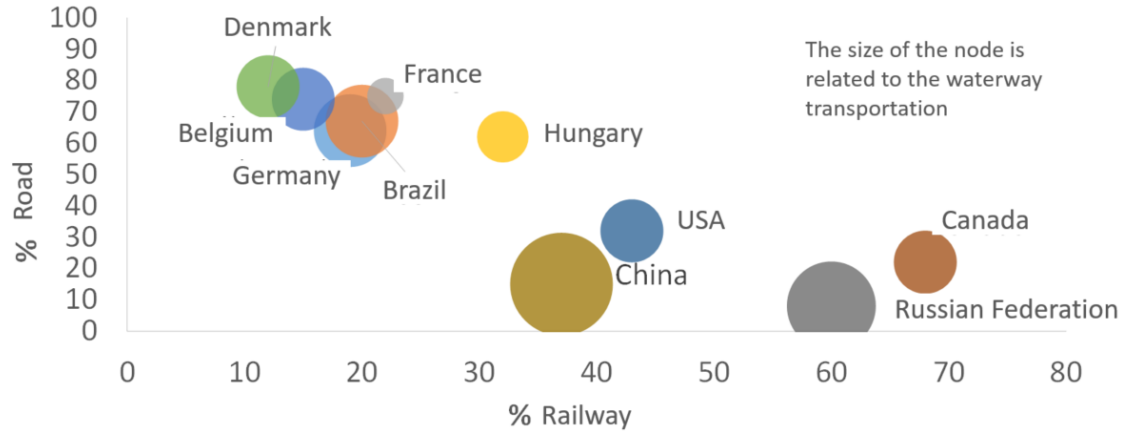
With few exceptions, river transport in Brazil continues to rely on low-quality infrastructure and facilities. Some of the main challenges facing waterborne transport are the lack of harbor facilities capable of handling large cargo volumes. Another problem is the limited accessibility to waterway terminals, especially given the low-quality road network in certain parts of the country. Finally, in some regions, rainfall seasonality and the impacts of drought, including the need to conserve water for power generation, can drastically affect the navigability of rivers. For example, in 2021, at the height of the country's worst drought (box 2.5), the government announced it would reduce large drafts in the Parana river basin, disrupting cargo movements along the Tietê-Paraná Waterway. Shipments to and from farm states like Goias, Minas Gerais, Sao Paulo, Parana, and Mato Grosso do Sullonger would be significantly impacted. In these scenarios, shippers would be forced to transport goods by road, increasing costs, impacting road quality, and exacerbating climate impacts (Viga Gaier and Mano 2021). Little attention is paid to the Brazilian waterway system by the public and private sectors, resulting in inadequate investments. Yet the sophisticated transshipment facilities required for modern waterway movement require substantial investment. Greater use of inland waterways will be conditioned to the economic activities of their respective areas of influence.

Transport Modal Split: How Does Brazil Stack Up?

Road transport will always be critical to Brazil's logistics network, but is it cost-inefficient for long-haul transport? Brazil's modal split compares to countries like Germany, France, and Belgium (figure 2.11), whose smaller size justifies their greater dependence on roads. Brazil's vast expanses and the

predominance of bulk and heavy commodities such as mineral ores and grain justify greater railroad and waterway transport. Larger countries such as the United States, China, Canada, and Russia rely more heavily on railways and might serve as benchmarks for Brazil.

Figure 2.11 Transport Modal Split by Country



Source: CNT 2021.

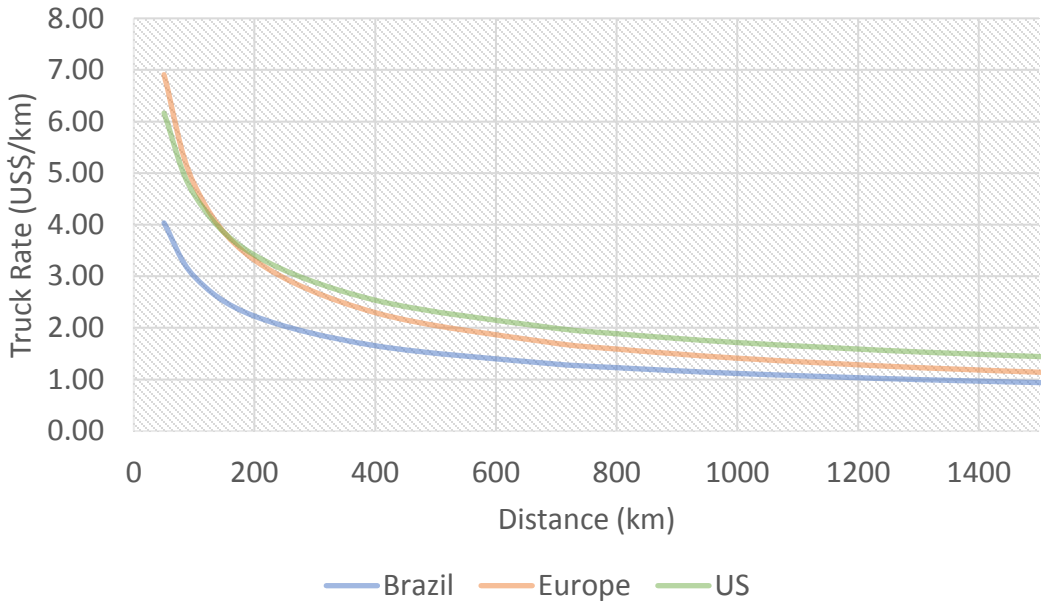
Brazil's heavy reliance on roads is driven partially by an unevenly distributed rail network. The limited paved road network is about 6.9 times longer than the railway network (and the combined paved and nonpaved road network is almost 51 times longer). The unbalanced development of these two transport modes represents an impediment to rail becoming a truly viable alternative to road transport. Brazil's railway density (3.6 km/km²) is one-eighth that of the United States (19.8 km/km²). Although comparing densities between countries is imperfect, it's clear that in Brazil, railways do not meet the demands of the primary commodity-producing regions.

Brazil's inland waterways are underutilized primarily because of the lack of essential infrastructure. Waterways are used even less than railways because of the lack of appropriate infrastructure needed for longer river convoys, which are fundamental for transporting grain and mineral ores. Brazil uses fewer waterways than other large countries with similar water geographies, such as China (figure 2.11). Despite the increase in operations observed in recent years, there are still very few transshipment terminals that allow for the quick and efficient transfer of freight from water to road and rail. The largest volume of transport via waterways is in the northern region. Interestingly, this has evolved partially in response to passenger transport stemming from the disconnected road network in some areas.

Logistics Costs

Brazil's freight market for agricultural cargo is highly competitive.[20] The self-employed driver is a price taker in this market, which is characterized by: (i) low differentiation of equipment, (ii) high number of agents offering and demanding transport services, and (iii) low or zero barriers to entry and exit from markets. Truck freight rates in Brazil ($4.03/km) are much more competitive than the United States ($4.58/km) and Europe ($4.78/km) across shorter distances, but this competitive advantage begins to shrink across longer distances ($0.91/km, $1.40/km, and $1.10/km, respectively) (figure 2.12).

Figure 2.12 Comparison of Truck Freight Rates (US$/km) for Different Regions, 2020



Source: ESALQ-LOG 2022.

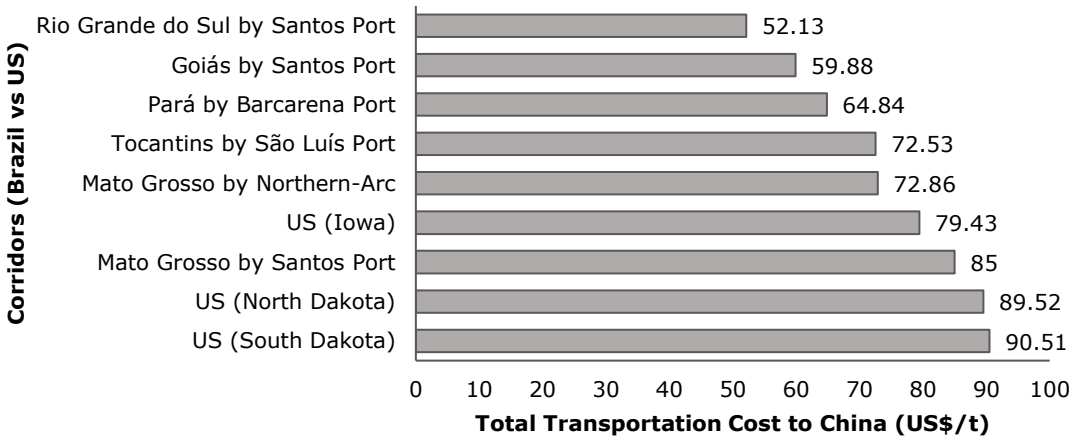
Brazil largely undersells the United States for key export commodities such as soybeans. The largest consumer and client of Brazilian agricultural products in the grain sector is China. Interestingly, certain Brazilian corridors are more competitive in supplying the Chinese market than important US corridors, such as Iowa, North Dakota, and South Dakota. Even Mato Grosso, a state within Brazil's Central region that is far from any ports, is becoming more competitive than US corridors (figure 2.13).

Though logistics costs in Brazil have improved in some areas, they still lag the United States overall. In 2007, logistics costs in Brazil were approximately 15.4 percent of gross national product, twice as high as the United States (World Bank 2007). More recent estimates suggest that logistics costs were around 12.1 percent of gross national product in 2020 compared with 7.6 percent for the United States (ILOS 2021).

[20] The behavior of freight prices depends on several factors, including (i) the distance travelled; (ii) the specificity and quantity of the filler; (iii) the seasonality of demand and supply for transport; (iv) regional peculiarities in origin and destination; (v) the possibility of return freight with some secondary cargo; (vi) competition or complementarity with other modes of transport; (vii) the state of conservation of the roads; (viii) the existence of tolls and scales along the roads; (ix) delivery times; (x) competition with other products in the region; and (xi) the level of storage capacity in the region of origin (Péra et al. 2018).

While this shows a marked improvement, Brazil's limited transportation matrix remains an important impediment to reducing costs further. For example, most grain handled on railways and waterways in Brazil is for export. Considering the vast volumes being exported, the diversification of the transport matrix in recent years has been inadequate. For diversification to occur, the supply of infrastructure must grow at a higher rate than exports (Péra, Caixeta-Filho, and Salin 2021). Furthermore, because of the country's low rail density and reduced number of multimodal terminals, the average distance from farm to rail, or waterway terminal, in Brazil is around 700 km. By contrast, in the United States, soybean exports are predominantly transported by waterways (54 percent compared to only 30 percent by railways) and the average transport distance from farm to terminal (elevators) is 150 km (Salin 2021). In Mato Grosso, the largest grain-producing state in Brazil, given the long distances between farms and terminals, multimodality would have an economic advantage of 7 to 12 percent compared to road transport (Salin 2021).

Figure 2.13 Total Costs (US$/ton) of Transporting Soybeans to China through Various US and Brazilian Corridors, 2020



Source: ESALQ-LOG 2022.

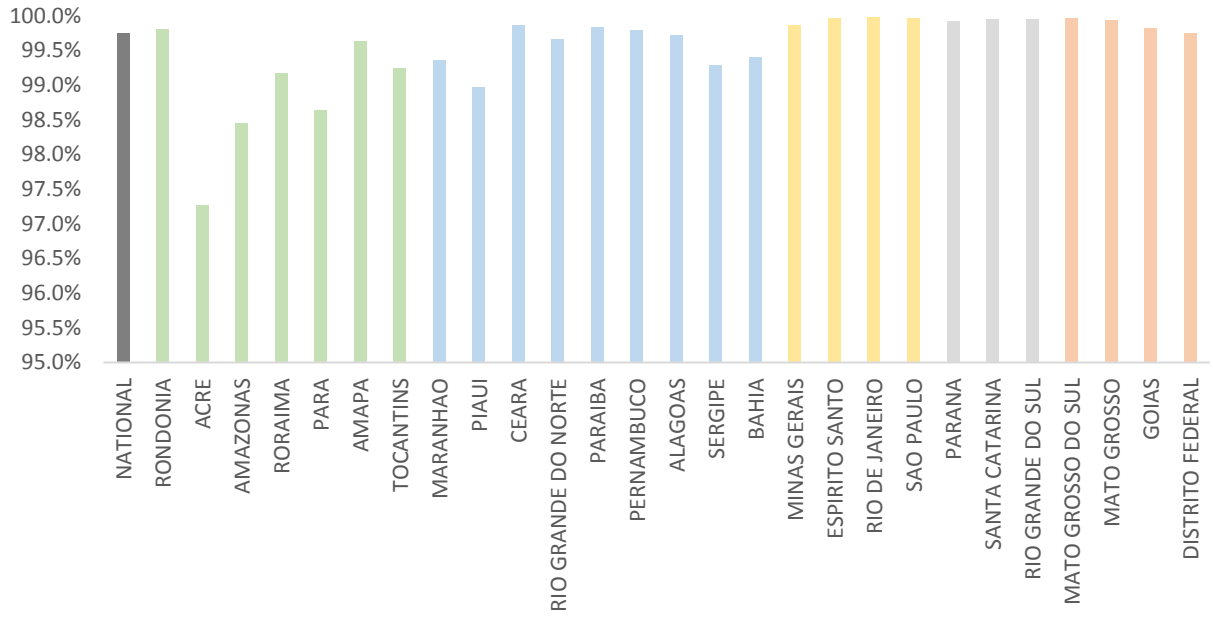
Access to Basic Infrastructure Services Across Brazil

In recent decades, Brazil has achieved near universal access to several key infrastructure services, but progress has been uneven. Notably, almost all Brazilians now have access to electricity (figure 2.14) and water (figure 2.15) at home. However, progress has been uneven between infrastructure subsectors. Some, such as sanitation, lag significantly (figure 2.16). Meanwhile, although access to the internet has increased substantially in recent years (figure 2.17), not all homes have the means to capitalize on what has become a critical service. For example, nearly 60 percent of Brazilians do not have a computer at home (figure 2.18). By contrast, at least one person in most homes has a cell phone (figure 2.19).

Access varies dramatically by region: the north and northeast regions are home to the lowest rates of access, while the southeast is home to the highest. The largest single gap is in access to improved sanitation between Piaui (7 percent) and Sao Paulo (92 percent). Interestingly, in Piaui, there are more homes with a computer (24 percent) and internet (65 percent) than improved sanitation. It is also worth

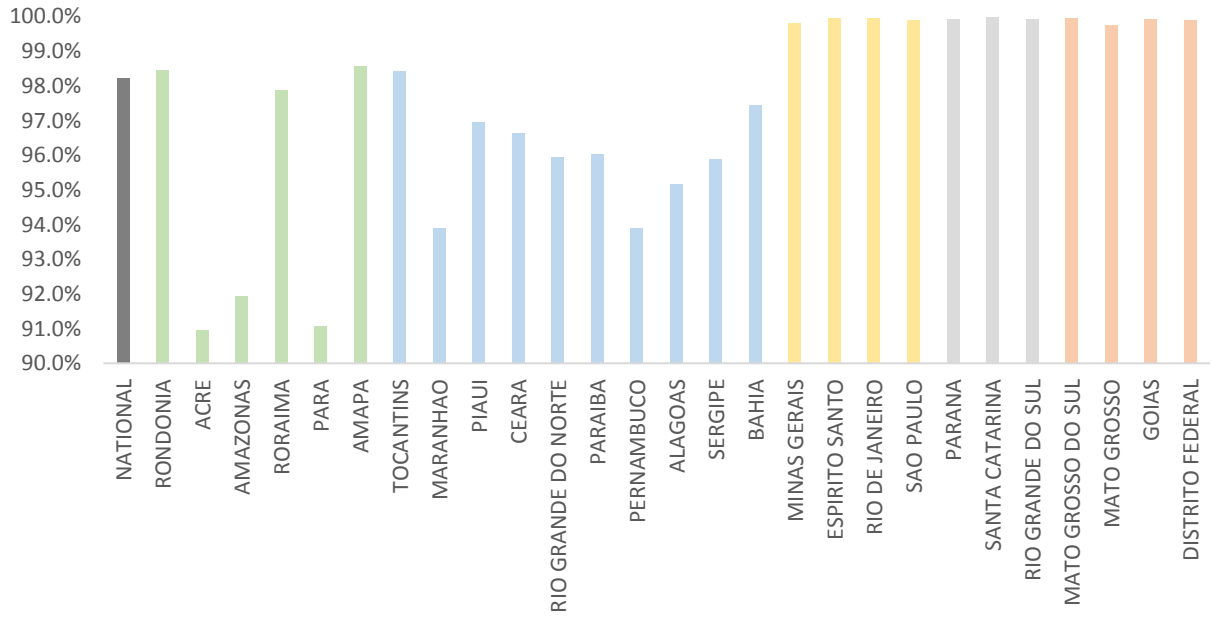
highlighting that less than half of all homes in the north region, across all states, have access to improved sanitation.

Figure 2.14 Household-Level Access to Electricity in Brazil, by State, 2021



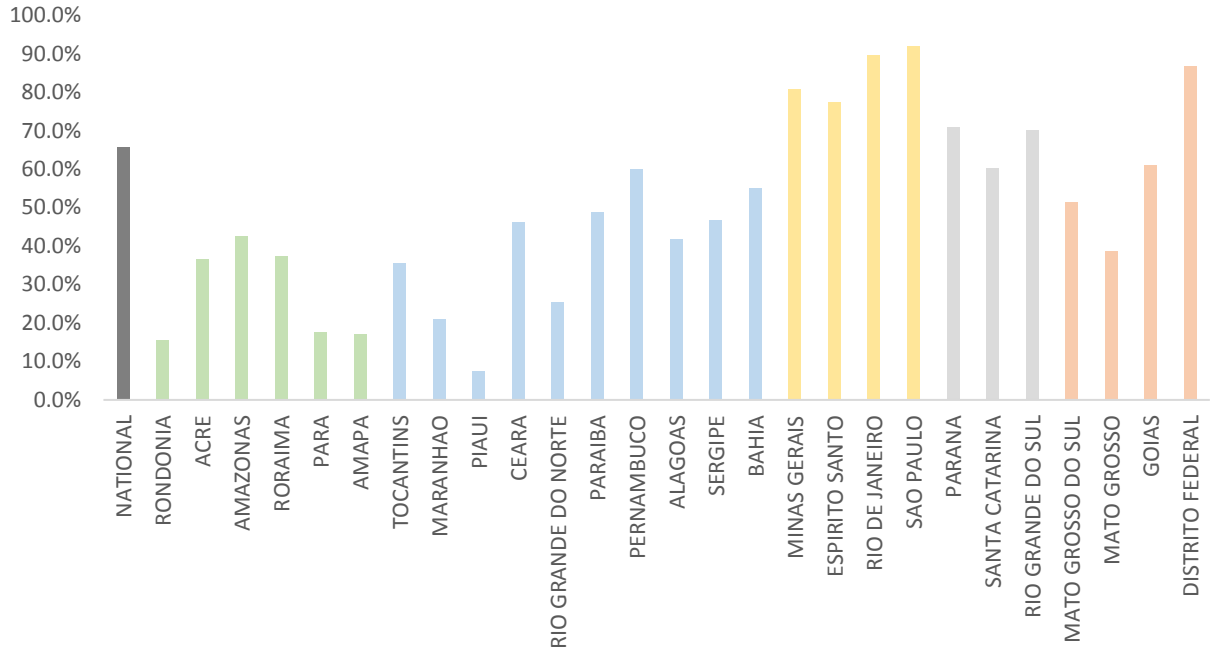
Source: Own elaboration (using data from IBGE 2021).
Note: The states are color-coded by region as follows. Green = north; blue = northeast; yellow = southeast; grey = south; orange = central-west.

Figure 2.15 Household-Level Access to Improved Water in Brazil, by State, 2021



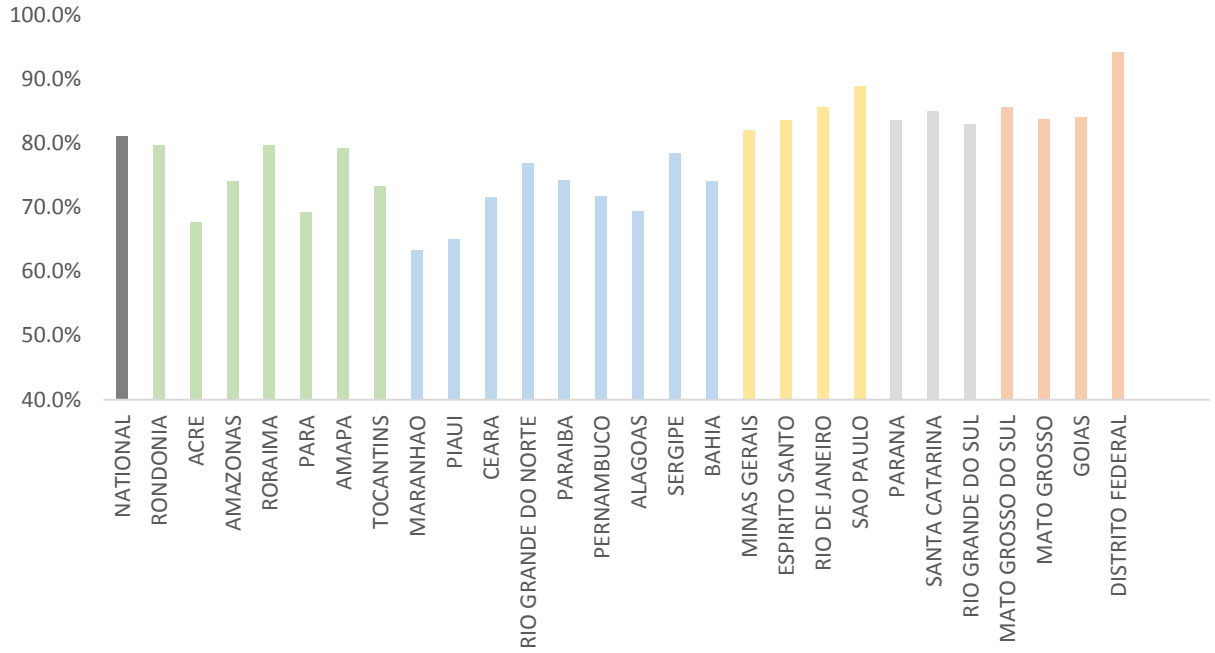
Source: Own elaboration (using data from IBGE 2021).
Note: The states are color-coded by region as follows. Green = north; blue = northeast; yellow = southeast; grey = south; orange = central-west. green = north; blue = northeast; yellow = southeast; grey = south; orange = central-west.

Figure 2.16 Household-Level Access to Improved Sanitation in Brazil, by State



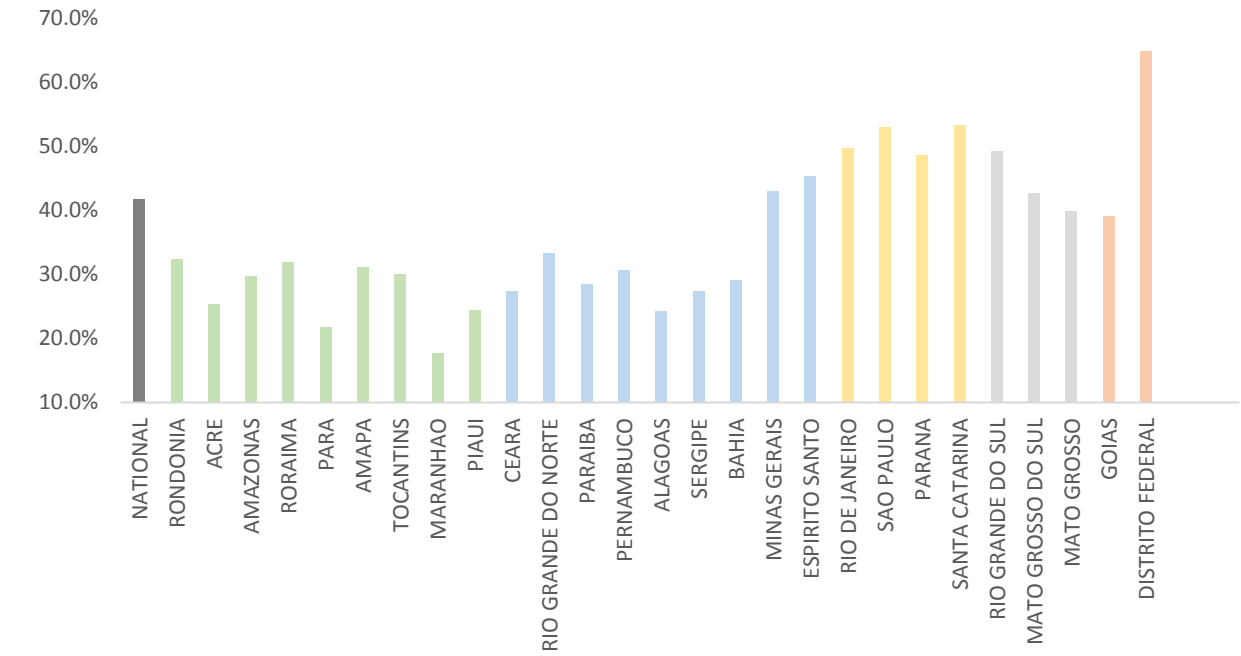
Source: Own elaboration (using data from IBGE 2021).
Note: The states are color-coded by region as follows. Green = north; blue = northeast; yellow = southeast; grey = south; orange = central-west.

Figure 2.17 Household-Level Access to the Internet in Brazil, by State, 2021



Source: Own elaboration (using data from IBGE 2021).
Note: The states are color-coded by region as follows. Green = north; blue = northeast; yellow = southeast; grey = south; orange = central-west.

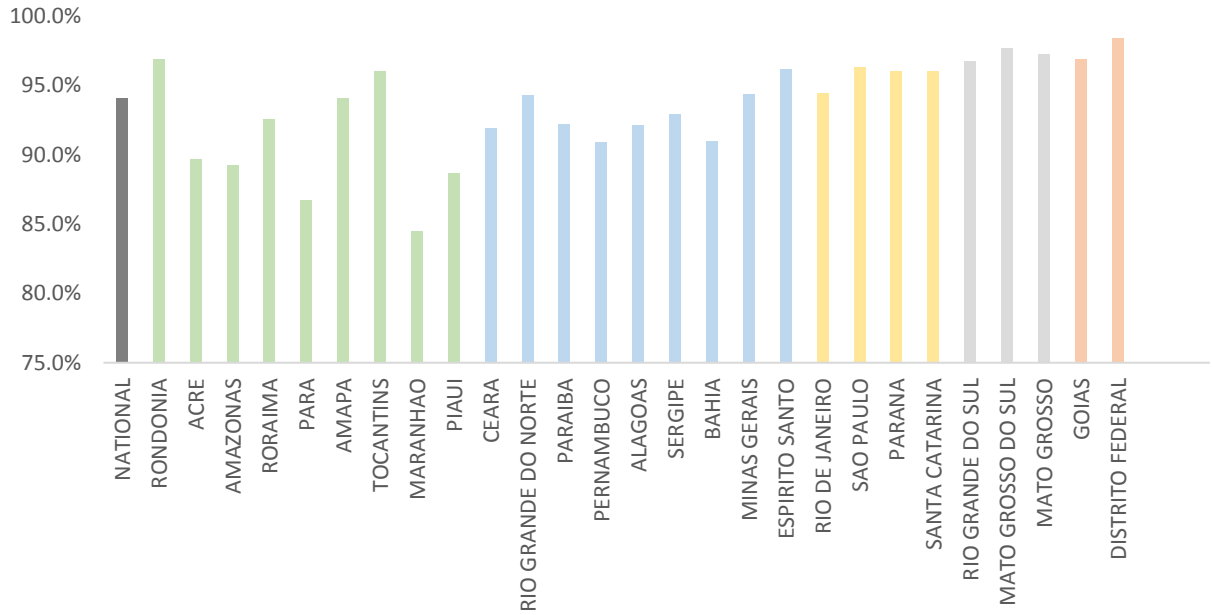
Figure 2.18 Household-Level Access to a Computer in Brazil, by State, 2021



Source: Own elaboration (using data from IBGE 2021).

Note: The states are color-coded by region as follows. Green = north; blue = northeast; yellow = southeast; grey = south; orange = central-west.

Figure 2.19 Household-Level Access to a Cell Phone by State, 2021



Source: Own elaboration (using data from IBGE 2021).
Note: The states are color-coded by region as follows. Green = north; blue = northeast; yellow = southeast; grey = south; orange = central-west.

The Inequality Gap

Though overall welfare has improved in Brazil, inequality remains pervasive and certain population groups continue to be overly affected. Almost 3 in 10 poor Brazilians are Afrodescendant women living in urban areas, and three-quarters of all children living in rural areas are considered poor (World Bank 2022c). Not surprisingly, then, access to basic infrastructure services reflects Brazil's reputation as a country of many different "countries," and long-standing geographical and socioeconomic disparities persist.

Access to infrastructure lags in rural areas. In rural areas, 3 percent of rural Brazilians lack access to clean drinking water, 37.1 percent lack access to improved sanitation (including 2.35 percent who continue to practice open defecation), 48.4 percent lack access to the internet, 86.3 percent don't have a computer at home, and 16.9 percent don't have a cell phone (figure 2.20).

Figure 2.20 Access to Basic Infrastructure Services in Brazil: The Urban-Rural Divide, 2020–21

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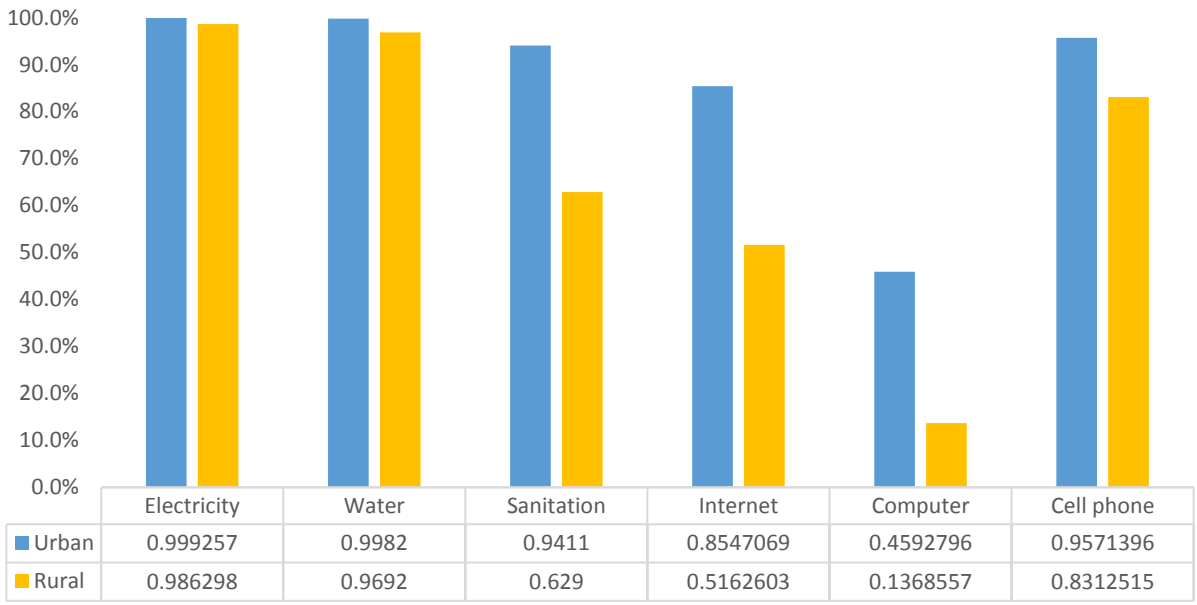


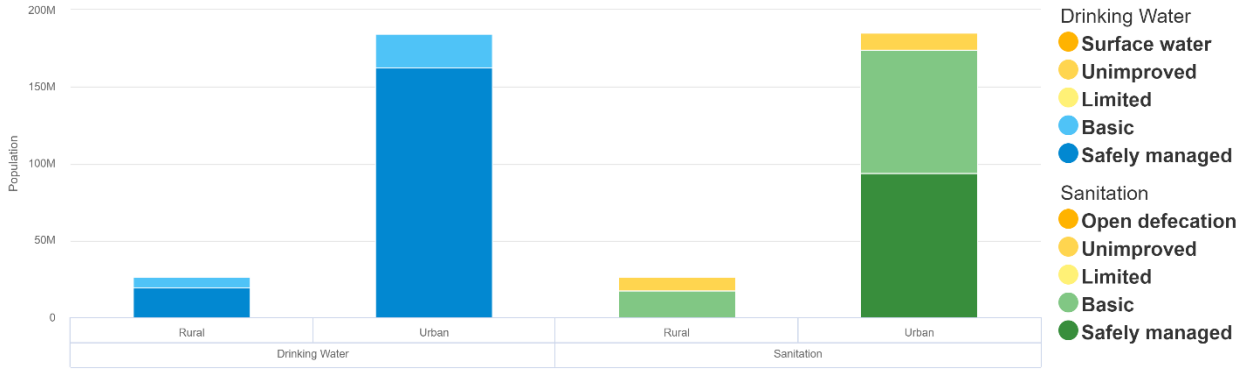
	Electricity	Water	Sanitation	Internet	Computer	Cell phone
Urban	0.999257	0.9982	0.9411	0.8547069	0.4592796	0.9571396
Rural	0.986298	0.9692	0.629	0.5162603	0.1368557	0.8312515

Source: Own elaboration (using data from IBGE 2021 for all indicators except water and sanitation, which were sourced from WHO-UNICEF [2022a; 2022b] for the year 2020).
Note: Urban = blue; Rural = yellow.

Rates of access as a percentage of the population do not always reflect actual need, especially in highly populated areas. Brazil's immense urban population means that in many cases, there are greater numbers of affected people living in urban areas than in rural. Considering absolute headcounts, the 36.4 percent rural gap in access to improved sanitation translates to approximately 9.3 million people. By contrast, the 5.9 percent urban sanitation gap translates to approximately 10.9 million people (figure 2.21). Notwithstanding, the highest level of sanitation available to rural Brazilians is considered "basic"—that is, no Brazilians living in rural areas have access to safely managed sanitation[21] compared to half of all Brazilians living in urban areas. All Brazilians living in urban areas have access to improved water, while about 3.1 percent of rural Brazilians lack access, which translates to approximately 850,000 people. However, when considering the highest level of drinking water services attainable—that is, safely managed water[22]—coverage rates once again mask actual need. So, while the rural gap stands at 28.2 percent in rural areas, or approximately 7.9 million Brazilians, the urban gap of 12.2 percent, or some 22.6 million Brazilians, is actually much larger.

[21] Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or removed and treated off-site. By comparison, "improved sanitation" means those facilities that are designed to hygienically separate excreta from human contact, and include: flush/pour flush toilets connected to piped sewer systems, septic tanks or pit latrines, pit latrines with slabs (including ventilated pit latrines), and composting toilets (WHO-UNICEF 2022a).
[22] This is defined as drinking water from an improved water source that is accessible on premises, available when needed, and free from faecal and priority chemical contamination. By comparison, the more general term "improved water" are those sources that have the potential to deliver safe water by nature of their design and construction, and include: piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater, and packaged or delivered water (WHO-UNICEF 2022b).

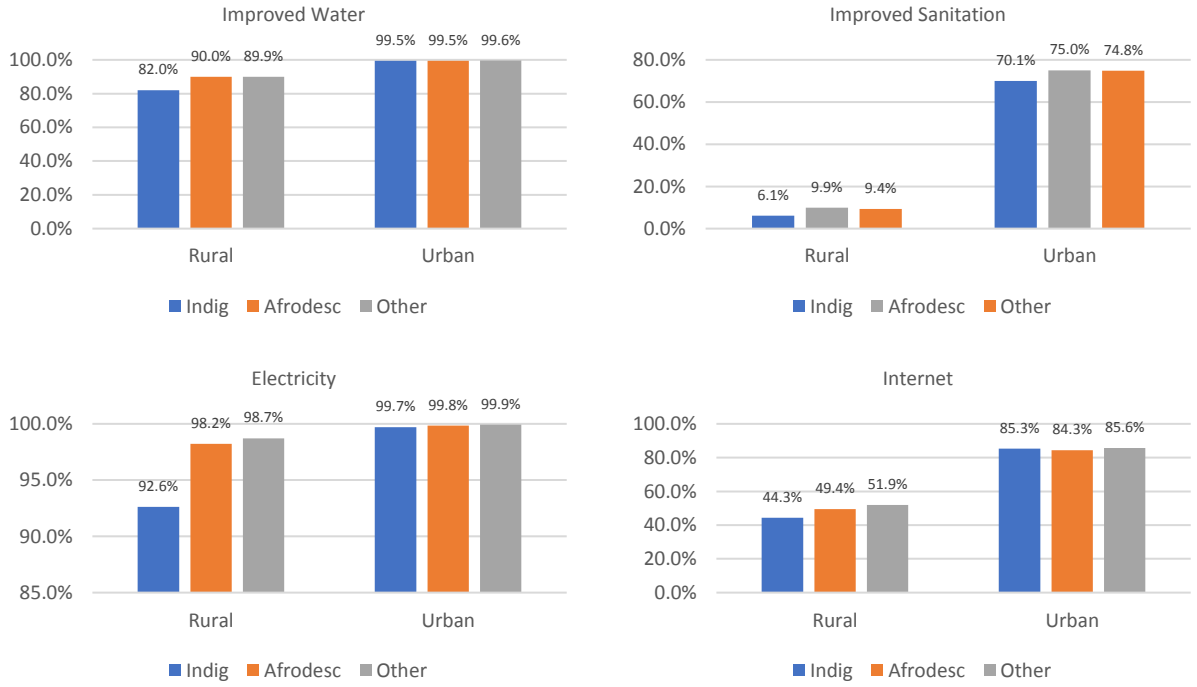
Figure 2.21 Access to Water and Sanitation in Brazil, by Area and as a Function of Total Head Count, 2020

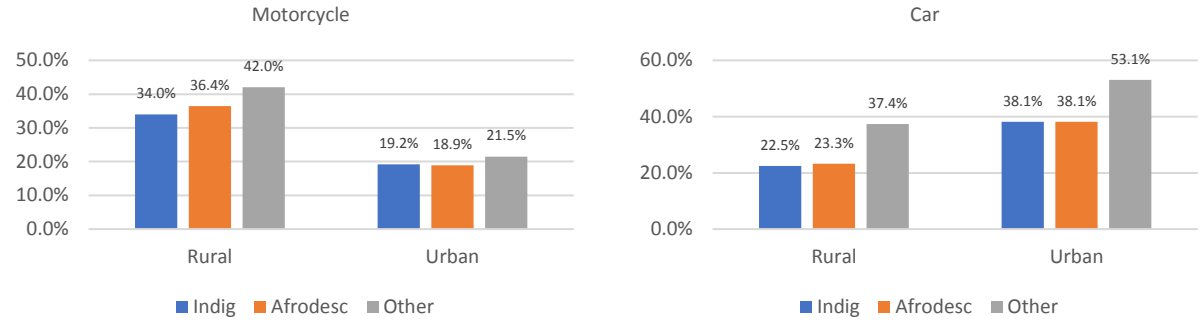


Source: WHO-UNICEF 2021a, 2021b.

Indigenous peoples are more likely than other demographics to lack access to basic infrastructure. Generally speaking, where there's a gap in access to basic infrastructure services for the population as a whole, indigenous peoples are more likely than all other Brazilians to lack access—a trend that applies to both urban and rural areas, but is more pronounced in rural areas, where most of Brazil's indigenous population resides (figure 2.22 and box 2.4).

Figure 2.22 Access to Basic Infrastructure Services in Brazil as a Function of Ethnicity and Geography, 2021





Source: Own elaboration (using data from IBGE 2021). **[[expand Indig and Afrodesc in legend]]**

Box 2.4 Indigenous Peoples and Quilombola Territories

A complete view of the welfare status of Brazil's traditional communities is missing. Evidence indicates their monetary and nonmonetary levels of deprivation are high. Coming from traditionally marginalized communities, indigenous peoples (IPs) and the quilombola are not included in official Brazilian national surveys. In past years, this statistical blind spot was partially illuminated by the inclusion of these peoples in the Cadastro Unico (CadUnico).

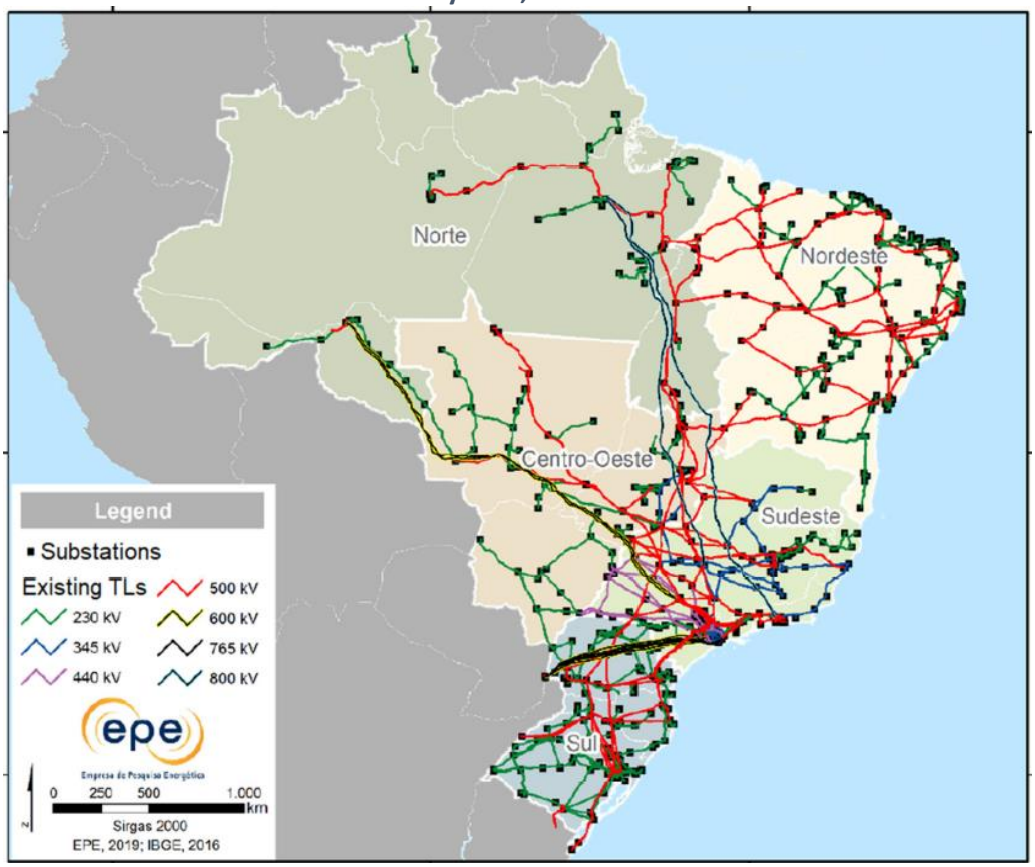
In addition to the estimated high rates of poverty among vulnerable families already included in CadUnico, 96 percent of IPs and 91 percent of quilombolas are rendered even more fragile because of a lack of access to basic infrastructure services. Close to one-third of IPs and 8 percent of quilombolas lack access to electricity, many more than the rural poor as a whole (2 percent). While this missing infrastructure can compromise the integration of these families into economic chains, the needs are broader and even more basic. Roughly 51 percent of IPs and 42 percent of quilombola households have no water supply, negatively impacting their health and human capital. The upcoming 2022 National Census marks the first time the quilombola identity will be recorded.

Source: Adapted from World Bank (2022c).

Quality of Infrastructure Services: A Limited Study of Brazil's Electricity Sector

Brazil has a well-developed National Interconnected System (NIS) to ensure the availability of electricity, but more can be done to improve its reliability. Brazil's national grid comprises over 140,000 km of high voltage transmission lines made up of four subsystems: southern, southeast and central west, northeast, and most of the northern region, designed to offset significant hydrological variations between the various regions (figure 2.23). The NIS is also interconnected with Argentina, Uruguay, and Paraguay. All of Brazil's large hydropower plants (HPPs) are thus interconnected with each other and with consumer markets. As of 2020, Brazil has 9,012 power stations, of which 222 are HPPs and 1,290 smaller HPPs (Péra et al. 2021). The NIS allows the exchange of energy between regions. Thus, regions with better river affluence and higher levels of water storage in their reservoirs can generate and send energy to regions undergoing drier periods. In this way, the NIS seeks to minimize supply failures by increasing reliability. The NIS serves about 99 percent of all electricity demand. In 2020, 85 percent of Brazil's power was renewable, mainly hydropower. Only about 1 percent of the power system is not integrated into the NIS; these are small isolated systems in the north (especially the Amazon). Isolated power systems use diesel as their main source of electricity generation.

Figure 2.23 Brazil's National Interconnected System, 2019

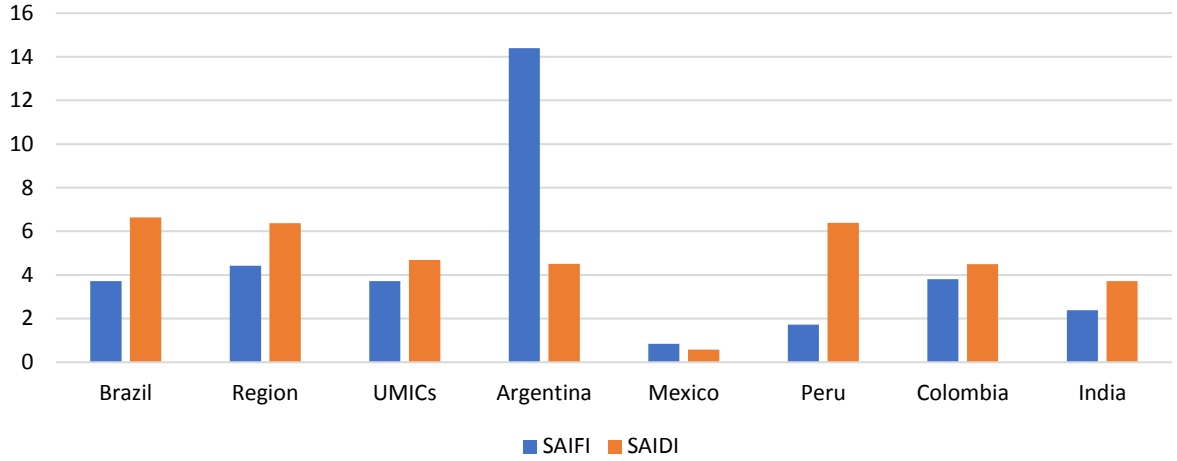


Source: EPE 2019–20; IBGE 2016.
Note: TL = transmission line; kV = kilovolt.

Brazil lags in standard metrics of quality for electricity services when compared to Mexico and India (figure 2.24). In Brazil, SAIDI[23] (6.64) is higher than SAIFI[24] (3.8) just like its comparators, except Argentina. A longer duration of electricity interruption per customer indicates insufficient and poor-quality technical service provision. In terms of SAIDI, Brazil performs poorly when compared to its comparators. In terms of SAIFI, Brazil is comparable to peers in its income group, but underperforms when compared to Mexico (0.85), Peru (1.73), and India (2.38). In 2021, the duration of interruption per consumer (DEC) and the frequency of interruption per consumer (FEC) were below the limits set by the ANEEL (Brazil's electricity regulator). Improved performance over the years is as a result of measures implemented by ANEEL, such as the introduction of supply quality rules in concession contracts for distributors, results plans for distributors with poor performance, financial compensation to consumers, inspections by the agency, and the reduction of interruption limits.

[23] The System Average Interruption Duration Index (SAIDI) is a metric used to measure the reliability of electric utilities that measures the total time an average customer experiences a nonmomentary power interruption in a one-year period (US EIA 2020).
[24] The System Average Interruption Frequency Index (SAIFI) measures the frequency of interruptions.

Figure 2.24 Electricity Reliability Metrics for Brazil and Its Comparators, 2020



Source: World Bank Global Infrastructure Map.

Brazil is highly dependent on hydropower generation, which is extremely vulnerable to droughts and rising temperatures, posing a risk to the country's long-term electricity supply. The Brazilian hydroelectric potential is estimated at 172 gigawatts, of which more than 60 percent has already been used. Between 2001 and 2002, Brazil suffered one of the worst droughts on record. The government had to implement a strict rationing program for nine months to reduce the power load in 80 percent of the country by 20 percent (World Bank 2020). Since 2012, several droughts have periodically affected areas of the country that represent 86 percent of stored hydro capacity. This has led in the short run to a considerable increase in the use of costly thermal energy, and hence a spike in the cost of electricity (World Bank 2020). Meanwhile, droughts between 2012 and 2015 led to an increase in emissions due to the increased use of thermal power generation (Lima et al. 2020).

Box 2.5 Brazil's Hydrological Crisis

Sometimes, the worst-case scenarios of probabilistic simulations arise; this is what happened in 2021 when Brazil experienced its worst drought in 91 years. Brazil's hydrological regime is highly variable. Severe droughts are becoming more plausible than the models currently used by Brazilian decision makers predict. More robust models indicate key important changes: "(i) areas under drought have increased, reaching about 70% during the 2012–2015 period; (ii) droughts in Amazon and humid regions are less frequent but with higher durations; and (iii) drought variability and its occurrence are relatively higher in the extreme north, north-east" (Ndehedehe et al. 2020). This has a significant impact on existing storage, for example, the maximum energy storage in the southeast region's reservoir is expected to be reduced to between 10 percent and 22 percent of its historical maximum.

What went wrong?

a. **Overreliance on hydropower and lack of diversification in the electricity mix.** In spite of Brazil's impressive efforts to increase the penetration of variable renewables resources, the country still largely depends on energy storage at the reservoirs and appears to lack resilience criteria in power system planning, which includes generation and transmission. Hydrology conditions are simulated using long-term time series data that may not fully incorporate the impacts of climate change, and the models used for plan efficiency may underestimate the efficiency losses of hydro equipment over time.
b. **Governance and coordination failures.** For example, the governance of water use and its economic value for different uses is fundamental. Improvements in these areas could help redefine the water availability currently considered by the electricity sector, which is critical for planning.
c. **Lack of mechanisms for demand-side management.** The government recently put forward an ordinance (Portaria 22/2021) to support the Voluntary Reduction of Electricity Demand (RVD) to supply the National Interconnected System, and two days later the Minister of Energy and Mining announced a voluntary reduction program aimed specifically at residential consumers (to take effect that September 1). However, these measures are only temporary (lasting until April 2022), and a broader demand-response program that reaches all consumers is needed to prevent future crises.

The government's response is currently focused on the short term and does not address the underlying root causes of the crisis. Potential support to the Ministry of Energy includes the following.

- *For the short-term response:* (i) crisis management advice by experts in hydro crisis management; (ii) outage risk analysis for the next 18 months; and (iii) communication advice, through support in the design of a communication campaign to convey the issues and proposed solutions to the population at large.
- *For longer-term resilience building:* (a) better planning, including modeling tools that fully incorporate the probability of severe climate events; (b) increased governance/institutional coordination across relevant authorities on the most sustainable use of water; and (c) broadening demand-response programs that reach all consumers, such as payment for a voluntary reduction in demand by any consumer over a given period.

Reports by the Operador Nacional do Sistema do Electricidad (ONS) indicate the hydropower crisis is over, but caution remains warranted for 2022 and beyond.

Inefficiency of Infrastructure Services: A Costly Pattern of Neglect

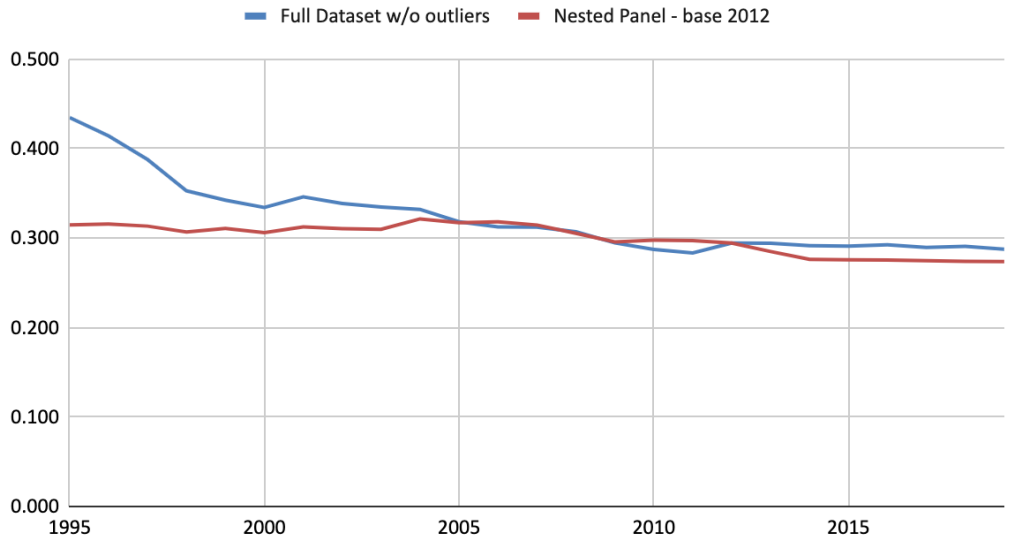
The overreliance on roads to transport freight is extremely expensive. In the transport sector, as discussed, the biggest challenge for domestic connectivity is the modal mix, which remains dominated by roads, giving rise to increased economic and environmental costs. Allocative inefficiencies were estimated by quantifying cost savings to users by switching the transportation of goods from roads to railways

(World Bank 2017). The benefits of using railways over roads quickly accumulates given the volume of freight and distances travelled in Brazil. A rough estimate of the annual savings in the transportation of bulk solid minerals is US$11.8 billion (or 0.5 percent of GDP) with an additional US$4.7 billion for agricultural cargo (0.2 percent of GDP). Most of those benefits are generated in the south for minerals (accounting for more than half of the transport cost savings for all minerals) and in the northeast for agriculture (accounting for 43 percent of the transport cost savings for all agricultural cargo).

Operational inefficiencies in the transport and water and sanitation sectors cost around 1.4 percent of GDP. In the transport sector, operational inefficiencies are directly linked to the diminished quality of services. For example, less than 15 percent of Brazil's roads are paved and close to 0.7 percent of GDP is lost due to poor road quality, underengineering of the network, and congested roads (World Bank 2017). In the water sector, inefficiencies can be mainly traced to underpricing and the poor management of water utilities and also amount to around 0.7 percent of national GDP (World Bank 2017). These inefficiencies lead to overconsumption and the waste of scarce resources. Technical losses are the main source of inefficiencies across utilities, followed by unpaid bills.

In Brazil, almost one-third of all water produced is lost. The average rate of nonrevenue water (NRW) for Brazil's water utilities has decreased only nominally since 1995 and still remains problematic at just under 30 percent (figure 2.25). Although this is in line with Brazil's comparators (table 2.8), such figures are frequently underestimated owing to a lack of data, especially in developing economies, where the capacity and technology needed to estimate NRW are generally limited. In fact, this is an area where very little progress has been made over the past few decades. Municipalities and utilities frequently do not realize the severity of the problem or how much money they are losing (box 2.6). Even when they do, they don't (or can't) prioritize the problem because the upfront investment in technology is seen as a hurdle, not to mention public resistance to metering. Even in advanced economies, such as the United States, NRW is a persistent problem for water utilities. To a certain extent, NRW is the cost of transporting water through underground pipes, and so reducing it is the goal, not eliminating it. Targeting investments for maintenance and replacement of assets, increasing metering coverage, changing collection policies, and encouraging behavioral changes are all essential to reducing overall technical losses and collection inefficiencies.

Figure 2.25 Average Annual Rate of Nonrevenue Water among Brazil's Water Utilities, 1995–2020



Source: Own elaboration.
Note: Nonrevenue water is calculated as (volume of water produced – volume of water billed)/volume of water produced. (unweighted). As different raw data were available for different utilities over the years, a number of iterations were undertaken. Outliers were removed by restricting parameter values to within 3 standard deviations (both ways) of the mean and values under 2 percent or over 70 percent. The final number of observations was around three-quarters of the initial sample.

Table 2.8 A Country Comparison of Average Rates of Nonrevenue Water

Country	Rate (%)	Year
Argentina	42	2014
Brazil	28	2020
Chile	33	2008
China	21	2012
India	41	2009
Latin America (regional average)	43	Varies by country
Mexico	24	2012
Peru	36	2014
Russian Federation	27	2020
United States	14	2020

Source: IBNet 2022.

Box 2.6 The Real Cost of Water and Capacity Building as a Measure to Reduce Nonrevenue Water

With financial support from the Government of the United Kingdom, the World Bank has been working with COMPESA (the state-owned water and sanitation utility, located in Recife, the fourth-largest urban area in Brazil) since 2018 to improve its operational efficiency by reducing water losses. The initial external financial output paved the way for the Smart Water Programme by first assessing water loss management in the Recife Metropolitan Area and then defining potential behavioral interventions to improve water conservation.

Despite a reduction in funding that meant smart nonrevenue water (NRW) equipment could not be acquired, tremendous progress toward reducing water losses has been made, most notably through capacity building and knowledge transfer. Over three years, COMPESA reduced NRW losses by 3.4 percentage points (table B2.6.1). Assuming an equal distribution across all connection categories (e.g., commercial, industrial, public, residential), this translates to an estimated annual cost savings of R$55.4 million (roughly US$11.6 million).

Table B2.6.1 Reduction in NRW Losses over Time (2019–22) at COMPESA

	Mar-19	Mar-20	Mar-21	Jan-22
(%) Nonrevenue water by volume: Percentage of the system input volume that corresponds to nonrevenue water	43.8	42.2	41.9	40.4

Importantly, COMPESA now considers NRW in all of its operational activities and is currently revising all of its strategies and structures to ensure losses are adequately addressed. In addition, a newly defined global indicator for NRW will be used to design a common target, reflecting a shift in corporate strategic thinking.

Although it is difficult to measure direct impacts on the quality of life of the poorest, reducing water losses and managing water resources more efficiently means more water—and more money—are available to expand coverage.

For electricity, total network losses are high in the north and northeast, areas with a low peak demand but that are critical (third and second, respectively) to electricity generation. The main challenges facing the NIS include: (i) high loss of energy due to large distances covered by transmission lines (HPPs are located far from consumers); (ii) high network losses in the north (although they have been stable since 2016) and an increase in losses of 10 percent in the northeast since 2016; (iii) areas with low peak demand that have the highest total network losses; (iv) high maintenance costs; and (v) high investment costs to migrate to a full smart grid transmission system.

High nontechnical losses underpin the high total network losses in the north, while in the northeast they are driven by high technical losses. Nontechnical losses depend on the management of the concessionaires, and the socioeconomic characteristics and behavioral aspects in each concession area. Nontechnical losses originate from theft, fraud, and measurement and billing errors. A large part of nontechnical losses occurs in the low voltage market. Only 10 of the 32 distribution companies with nontechnical losses above 0.5 percent account for 69 percent of the nontechnical losses in the country. Light and Amazonas Energia account for 30 percent.

Affordability of Basic Infrastructure Services: A Snapshot of Electricity Tariffs in Brazil

Electricity tariffs in Brazil are cost-reflective and reported to be among the highest in the region. Brazil's electricity market is divided in two: (i) the regulated electricity market (ACR) where generators and distributors close bilateral contracts via government auctions; and (2) the free electricity market (ACL)

where eligible large consumers buy energy directly from generators or traders. ANEEL sets the electricity tariff using a complex methodology that accounts for the various costs faced by different service providers. Tariffs paid by consumers in the regulated market include costs for generation, transmission, distribution, sectoral charges (i.e., to subsidize renewable energy, low-income customers, and finance public policy), and state and municipal taxes incorporated separately for each distribution company.

There is considerable variation between the electricity prices paid by end customers in each of the 63 concession areas. Periodic and extraordinary tariff reviews, with dates defined in the concession or permission contracts, are undertaken. Consumers in the free market pay a transmission system usage rate (TUST) and a distribution system usage rate (TUSD). Paradoxically, increasing electricity supply has not translated into lower bills for consumers and businesses. Residential tariffs are high in Brazil (US$0.14/kilowatt-hour) when compared to Mexico and India (US$0.08/kilowatt-hour each). This is despite Brazil having a higher generation capacity per capita of 778 MW in comparison to Mexico (609.12 MW) and India (304.09 MW). Factors contributing to high electricity tariffs include the sector's reliance on hydroelectricity and the use of costly thermoelectricity as a backup. Diversifying and optimizing the energy system and investing in energy efficiency, could help expand Brazil's energy mix, cut grid losses, and potentially lower prices.

Impact of Infrastructure Investment on Economic Growth

During the twenty-first century, Brazil's fiscal policies changed according to the prevailing macroeconomic conditions. From a fiscal policy perspective, at least three different periods can be identified: 2002–08, the commodities boom stage; 2009–14, the post–global financial crisis stage; and 2015–21, the post–fiscal crisis stabilization stage.

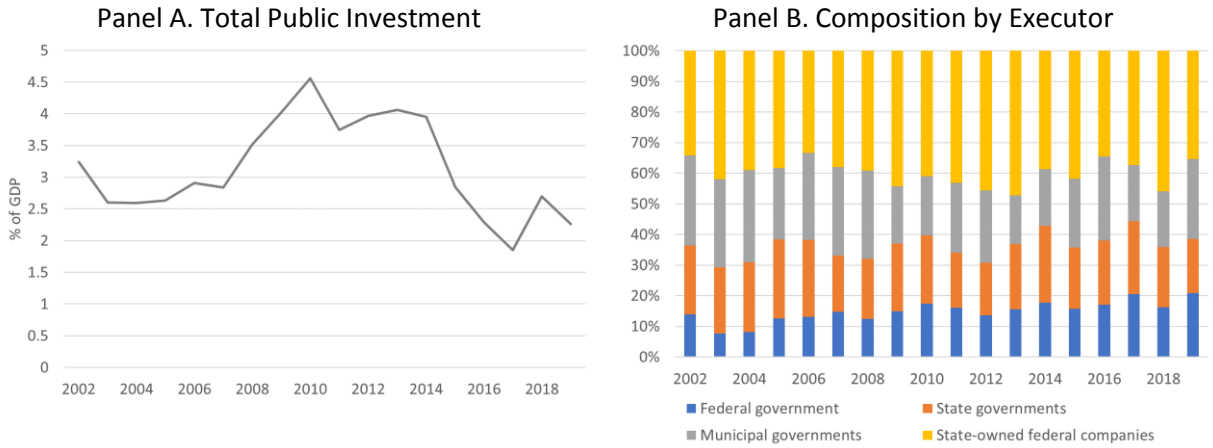
During the first period (2002–08), public expenditures were kept in line with increasing revenues. Brazil adopted responsible fiscal policy behavior, only slightly increasing its public expenditures in line with the increase in revenues generated by the commodities pricing boom and the strong economic growth it engendered. This combination of fiscally restrained policy and strong economic growth enabled a significant reduction in gross public debt: 15 percentage points of GDP for the same period. Moreover, during this period the increased fiscal space allowed for increased public investment, reversing a decreasing trend that had dominated in the previous two decades. This trend became more evident after the Programa de Aceleração do Crescimento (Growth Acceleration Program) launched in 2006, enabling national and subnational governments, including state-owned enterprises (SOEs), to increase their public spending.

This fiscally virtuous period was interrupted by the global financial crisis of 2008–09. Global conditions led to an acute but short economic downturn. The crisis stagnated fiscal revenues while public expenditures continued to increase. This loose, procyclical fiscal policy contributed to a deterioration of primary fiscal balances over time, increasing inflationary pressures and eventually forcing Brazil's Central Bank to tighten its monetary policy, with an impact on the interest bill paid by the Treasury. By 2014, this fiscal scheme proved unsustainable, forcing a fiscal consolidation with severe impacts on economic growth, political stability, and the capability of the government to sustain levels of public investment.

Between 2014 and 2018, Brazil's gross public debt rose rapidly and threatened the country's solvency. The economic recession and the increased interest bill resulted in a rapid increase in the gross public debt of 27 percent of GDP, between 2014 and 2018, that threatened debt solvency. This led to a period of economic stagnation in which efforts to restore a fiscally sound policy were hampered by increases in indexed, mandatory expenditure (mostly focused on personnel, social security, health, and education). To regain fiscal solvency and confidence, in 2016, Brazil adopted a strict expenditure ceiling severely restricting the growth of nominal primary expenditures. The resulting lack of fiscal space led to a sharp reduction in public investments, hurting productivity and reinforcing the procyclical bias of the fiscal policy.

Public investment[25] in Brazil has been mainly procyclical during the twenty-first century, often acting as a buffer to achieve fiscal targets. Public investment rose during the commodities boom phase as macroeconomic conditions allowed for increases in public expenditures, stagnated in the aftermath of the global financial crisis as fiscal space reduced, and finally, collapsed during the fiscal consolidation efforts after the fiscal crisis of 2014–15 (figure 2.26, panel A). Despite huge variations (from a peak of 4.5 percent of GDP in 2014 to a trough of less than 2 percent of GDP in 2017), composition by budget executor remained fairly stable. If anything, municipal governments lost a relatively small share of their total investments to the federal government (figure 2.26, panel B). On average during the whole period, the federal government executed 15 percent of all public investments; state governments, 21 percent; municipal governments, 24 percent; and SOEs, the remaining 40 percent.

Figure 2.26 Total Public Investment in Brazil, 2002–19



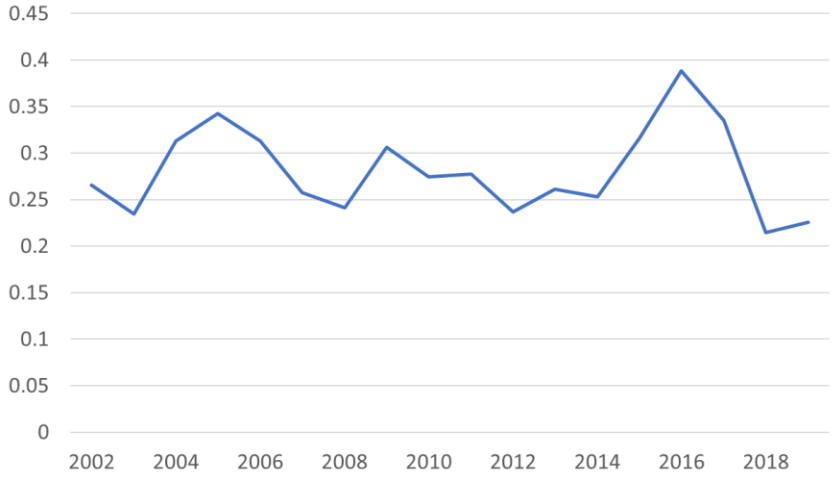
Source: Own elaboration (based on data from Bonomo et al. 2021).

In contrast to overall public investment, economic infrastructure investment is mainly executed at federal and state levels. Until recently, the shares of economic infrastructure investment by both the federal government and the states (including SOEs) were the same, but this behavior started to diverge in 2016, and by 2020 states (and their SOEs for water and, for some states, power) were executing almost

[25] Public investment refers to a wide range of activities from funding and building large engineering works such as dams, power stations, and ports to smaller civil works such as building water connections and housing programs. Moreover, those activities are carried out by federal, state, and municipal governments, as well as SOEs. Hence, the importance of composition and execution.

two-thirds of total public infrastructure investments. Plainly, the reduction in public infrastructure investment that has occurred since 2016 is mainly a result of contraction at the federal level, primarily by federally owned enterprises reeling from poor governance, mismanagement, and corruption scandals (Bonomo et al. 2021). Contraction at the state level was considerably milder (figure 2.27).

Figure 2.27 Public Infrastructure Investment in Brazil as a Share of Total Public Investment, 2002–19



Source: Own elaboration (based on data from Bonomo et al. 2021).

A Primer on Estimating Fiscal Multipliers

One of the main questions guiding future macroeconomic policy in Brazil will be how to undertake fiscal consolidation without hurting economic activity, while maintaining the levels of public spending needed to increase productivity in the long run. Answering this question requires understanding the effects of different fiscal policies on growth, or estimating fiscal multipliers.

Discussions about the size of multipliers have flourished within academic literature alongside a growing effort to estimate precise values. At the theoretical level, multipliers depend on the economic framework. For example, in a neoclassical framework an increase in public spending translates into a negative wealth shock in the short term (given higher taxes in the present or in the future) and the size of the multiplier depends on whether the change in spending is permanent or transitory (Baxter and King 1993). From a Keynesian view, an increase in public spending has positive effects on output depending on the marginal propensity to consume (Galí Lopez Salido and Valles 2007). Importantly, a multiplier lower than one (1) implies crowding-out effects on some other component of aggregate demand. At the empirical level, the fiscal multiplier can be estimated using different methodologies depending on how fiscal shocks are identified.

In a nutshell, pioneering empirical evidence was based on the widely used identification method of Blanchard and Perotti (2002) in the context of structural vector-autoregression models (SVAR) that rely on the existence of a quarter lag between output and fiscal response. This methodology has been called into question by Ramey (2011) on the basis that an orthogonal shock for a SVAR may be different for private forecasters. To remedy this, Barro and Redlick (2011) have suggested the use of a natural experiment approach (e.g., US military buildups) to identify exogenous changes in public spending.

Crucially, the size of the fiscal multipliers depends on the fiscal policies being evaluated and the economic conditions underlying those policies. Academic literature shows that changes in taxes, ceteris paribus, are usually related to smaller multipliers than changes in spending. Furthermore, not all kinds of spending have the same effects: government consumption and transfers may have larger but shorter-lived impacts on growth in the short term versus capital spending (Vagliasindi and Gorgulu 2021). In this regard, understanding the differential impacts of fiscal policies is fundamental to enabling a policy mix that is more likely to achieve what are often conflicting development goals.

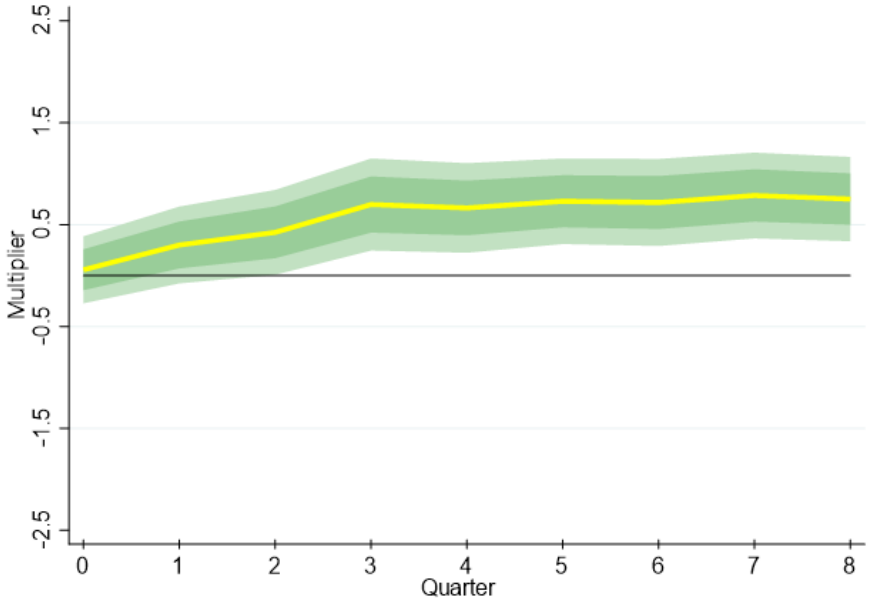
Fiscal Multiplier Estimates for Brazil

This section presents a range of fiscal multiplier estimates based on different public revenue spending and investment scenarios. The overall purpose of this activity is to explore the effects of using different fiscal policy mixes to promote growth in the short and long term and provide useful estimates to guide fiscal policy in Brazil.

National Multipliers

The total spending multiplier represents a useful benchmark to ensure consistency when moving from general to specific estimates. On impact, the total spending multiplier for Brazil is 0.05 (SE=0.20) and grows larger over time until it reaches 0.75 (SE=0.25) three quarters after the initial spending shock, and remains at that level until the end of the two-year period estimated (figure 2.28). However, at 90 percent confidence intervals, the null hypothesis that the spending multiplier will be lower than 1 after two years, cannot be rejected.

Figure 2.28 Baseline Estimate of Government Spending Multiplier in Brazil



Source: Own elaboration (based on IBGE, Orair [2016], and SNT).
Note: Quarter = 0 denotes the year of fiscal shock. Dark green areas denote a confidence interval of 68 percent (SE=1), while light green areas denote 90 percent confidence intervals (SE=1.64).

To check this result, the number of lags are altered using standard criteria (figure 2.29). If five (or three) lags are included instead of four, the spending multiplier remains 0.80 (or 0.70) after two years, having started at zero, the moment of impact. The inclusion of both linear and quadratic trends raises the value of the multiplier to around 1.20. If, in addition to controlling for the tax rate, additional controls, for example, for inflation, are included, the multiplier will be around 0.87 after two years. If all controls are removed, the value of the multiplier dips to 0.77. Again, and in all cases, at 90 percent confidence levels, the null hypothesis that the spending multiplier will be less than 1 after two years cannot be rejected.

Figure 2.29 Robustness Check for the Government Spending Multiplier in Brazil

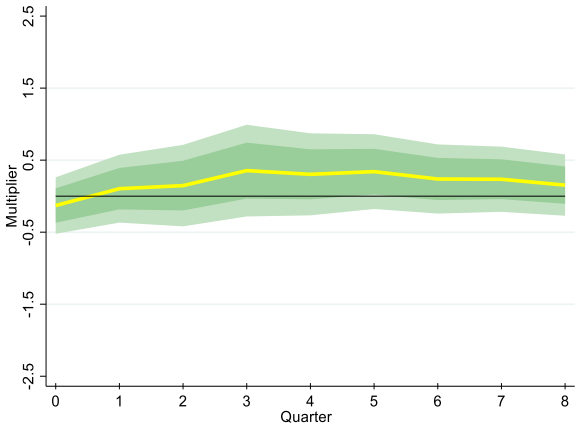
Quarter	5 Lags		3 Lags		Linear Trend		Linear and Quadratic Trends		Additional Controls		No Controls	
	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E
0	0.06	0.21	-0.36	0.17	0.07	0.21	0.06	0.19	0.11	0.20	0.15	0.21
4	0.93	0.26	0.55	0.25	0.96	0.30	0.91	0.28	0.88	0.28	0.71	0.28
8	0.80	0.28	0.70	0.23	1.28	0.31	1.26	0.31	0.87	0.34	0.77	0.24

Source: Own elaboration (based on IBGE, Orair [2016], and SNT).
Note: Quarter = 0 denotes the year of fiscal shock.

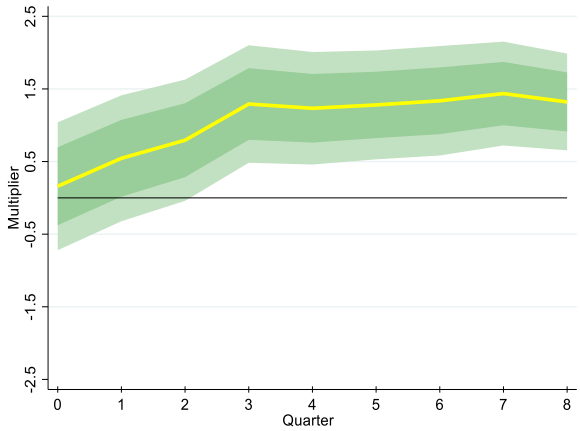
Next, the fiscal multiplier is differentiated by the spending component—that is, the public consumption multiplier vis-à-vis the public investment multiplier. The public consumption multiplier is a small multiplier of less than 0.5 that does not differ statistically from zero at any time (figure 2.30, panel A). The public investment multiplier, which is null at the time of impact, becomes positive and, importantly, statistically significant after three quarters (figure 2.30, panel B). After two years, the public investment multiplier reaches a value of 1.43 (SE=0.43).

Figure 2.30 Government Spending Multipliers in Brazil: Public Consumption vs Public Investment

Panel A. Public Consumption



Panel B. Public Investment



Source: Original elaboration based on IBGE, Orair (2016), and SNT.
Note: Quarter = 0 denotes the year of fiscal shock. Dark green areas denote a confidence interval at 68 percent (SE=1), while light green areas denote 90 percent confidence intervals (SE=1.64).

Critically, the size of the public investment multiplier as well as its spillover effects on the private sector depend on existing public capital stock (Izquierdo et al. 2019; Ramey 2020). When the public capital stock is low, and based on simple first principal arguments, the marginal product of an additional unit of public investment is large and, therefore (coupled with spillovers with private investment) delivers public investment multipliers well above 1. To the contrary, when starting with a high public capital stock, such an impact is small, and the multiplier is well below 1. Future iterations of this analysis therefore aim to study the role of Brazil's initial capital stock on the public investment multiplier. Overall, the results of this analysis hold up against robustness tests similar to those applied to the total expenditure multiplier and align with existing literature (appendix B).

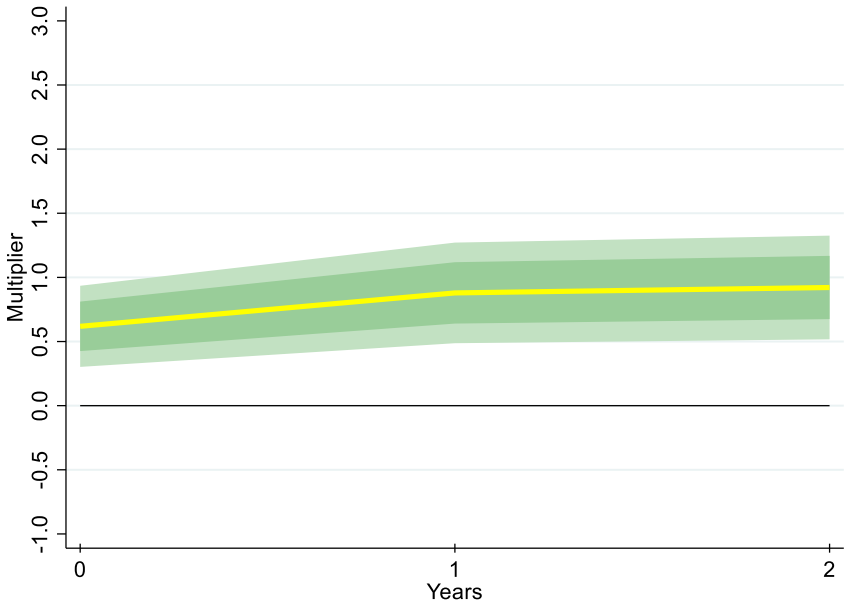
Subnational Multipliers

Given the relative importance of state-level public investments to Brazil's infrastructure program, this exercise was repeated at the subnational level. To conduct this analysis, a subnational-level dataset[26] comprising fiscal information for each of Brazil's 27 states was constructed for the period 2012–20. Quarterly subnational data are not available, a prerequisite of the SVAR model used for the national-level assessment. Instead, the subnational estimates were estimated using panel Ordinary Least Squares (OLS) regression models that lead to biased results under the presence of endogeneity. These results should therefore be interpreted with caution and viewed as a preliminary step to estimating the multipliers using an instrumental variable approach—needed to address potential endogeneity.

The aggregate multiplier for public spending for the period 2002–18 is 0.61 (SE=0.19) on impact and becomes larger over time until it reaches 0.92 (SE=0.25) within two years of the spending shock (figure 2.31). Interestingly, at 90 percent confidence levels, the null hypothesis that the spending multiplier will be lower than 1 after two years cannot be rejected. The result is in line with national estimates.

[26] Main sources of data: IBGE, the Treasury, the Pesquisa Nacional por Amostra de Domicílios, and the Confederação Nacional do Transporte.

Figure 2.31 Subnational Aggregate Public Spending Multiplier Estimate



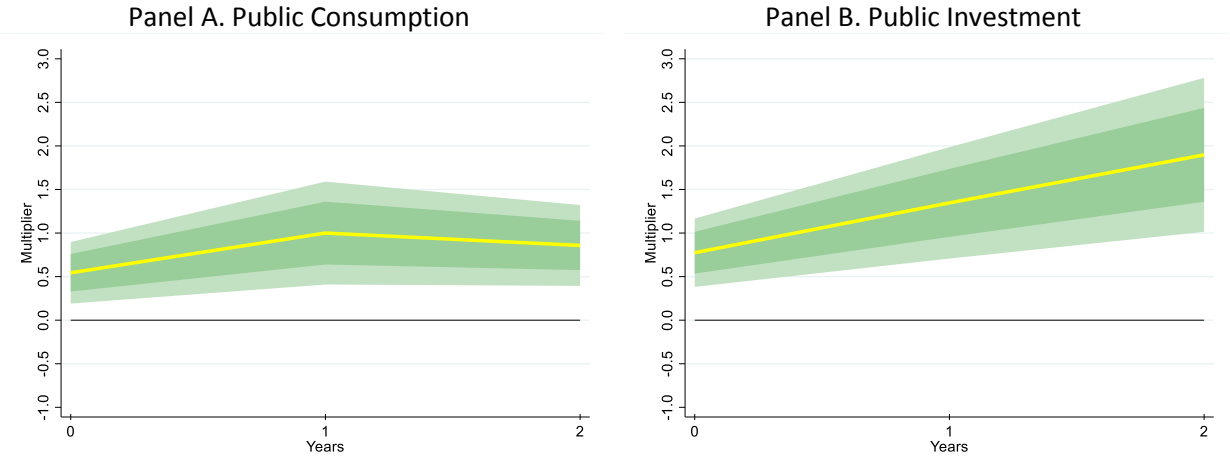
Source: Own elaboration.

When the state-level aggregate fiscal multiplier is decomposed by spending component (public consumption multiplier vis-à-vis the public investment multiplier), the results are consistent with those estimated at the national level. The public consumption multiplier is 0.54 (SE=0.21) on impact and peaks around 0.85 (SE=0.28) after two years (figure 2.32, panel A). This is larger than the national public consumption multiplier of less than 0.5. The state-level public investment multiplier is 0.77 (SE=0.23) on impact and after two years reaches a value of 1.89 (SE=0.53) (figure 2.32, panel B). These results show a different impulse response profile, given the lag between the time of investment and implementation. Nonetheless, they are expected to have longer-lasting effects on growth, especially given public investment promotes growth by increasing demand and also by making more productive assets available, thereby increasing supply and enhancing complementary private investments.

Once the impulse response profiles were determined for the subnational public investment multipliers, a final estimation of the impact of initial infrastructure stocks on the size of the multipliers was calculated.[27] For states characterized as having a high initial level of infrastructure stock (figure 2.33, panel A), the size of public investment multipliers are smaller vis-à-vis the estimates for states with low levels of initial infrastructure stock (figure 2.33, panel B). However, given the large standard errors associated with the change in models, the differences reported are not statistically different in most cases (see appendix B for related robustness checks).

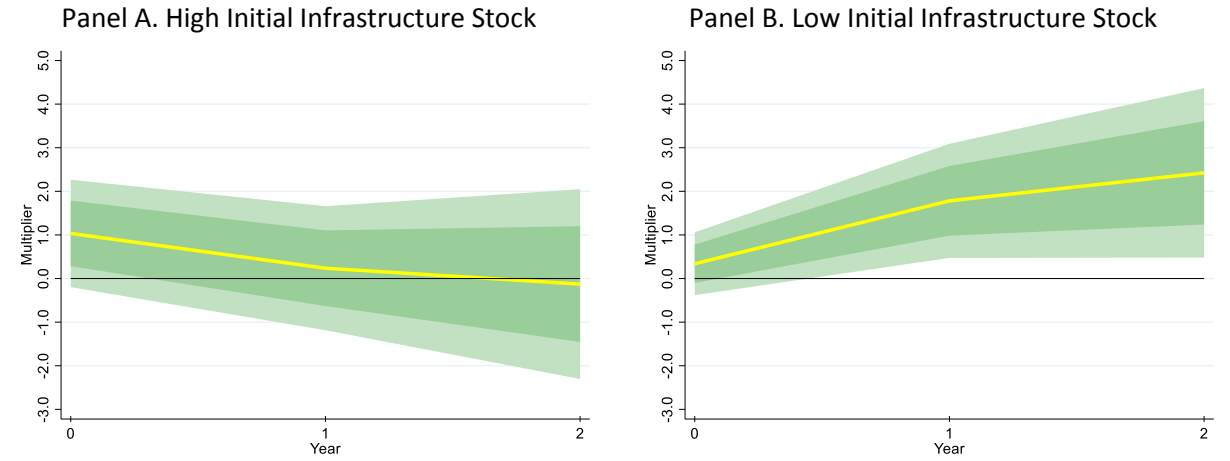
[27] This was done by developing an infrastructure stock index for Brazilian states using information on household services (electricity, water and sanitation, and fixed telephone lines) and telecommunication services (internet and mobile phones) from the Pesquisa Nacional por Amostra de Domicílios and road network information from the Confederação Nacional do Transporte.

Figure 2.32 Decomposed Subnational Public Spending Multiplier Estimate, 2002–18



Source: Own elaboration.

Figure 2.33 Impact of Initial Infrastructure Stock on Subnational Public Investment Multipliers, 2002–18



Source: Own elaboration.

How Did Brazil Get Here? Exploring Brazil's Political Economy Legacy

From 1995 to 2015, Brazil's total public investment averaged only about 2 percent of GDP, compared to 6.4 percent for all emerging markets and 5.5 percent across Latin America as a whole. This period corresponds to the two decades after Brazil finally ended chronic high and very high inflation, which reached an annual level of four digits in 1994—from which public finances have not yet recovered. Consequently, Brazil's capital stock (economic and social infrastructure combined) in 2015 measured only 35 percent of GDP, compared to a mean of 92 percent for all emerging economies and 87 percent for Latin America (IMF 2018).

How did Brazil arrive at such an extreme state of chronic underinvestment? What are the major political economy factors that influence Brazil's ability to provide basic infrastructure services, of a quality and quantity at or above the mean achievements of other upper-middle-income emerging economies?

There are a number of reasons why infrastructure is profoundly challenging to plan, construct, and govern in democratic countries everywhere (box 2.7). Infrastructure projects tend to be technically complex and to involve large budgetary outlays, with substantial sunk costs once begun. Infrastructure is site specific, which means costs depend on the availability and geological characteristics of the land upon which it is built, as well as environmental regulations. Infrastructure investments are typically long lived, which increases uncertainties regarding construction and operation and maintenance costs as well as demand for their services. They are vulnerable to unforeseen exogenous shocks, including business cycles, exchange rate fluctuations, and various types of natural disasters. Infrastructure's inherent complexity and long-term nature greatly complicates forecasting and provisioning.

Box 2.7 General Considerations of Large Infrastructure Investments

- Greenfield infrastructure projects have a long time horizon to completion.
- Large infrastructure projects need continuous technical oversight and maintenance.
- In many cases (e.g., water and sanitation) the social benefits outweigh potential profits, making such infrastructure projects less attractive to private investors. Consequently, the public sector must often assume responsibility for planning, financing, and building infrastructure.
- Large portions of a country's national infrastructure stock constitute natural monopolies, for example, urban water and sanitation systems or a railway connection between two points.
- Negotiation of public-private partnerships is always tricky, as each side would prefer to offload risk (necessarily high in long-term infrastructure provision, even in brownfield projects) onto the other.
- Large greenfield projects, particularly in the transport sector, but also in power generation, require enormous complementary investments made simultaneously, including in physical infrastructure, and also technical education/training, market research and development, and so on.
- Large infrastructure projects, especially greenfield sites for electricity generation and transmission, as well as transportation, for both freight and people, invariably impose both environmental costs and climate-related costs, which are different.

Sources: Roland (2014) and Engel, Fischer, and Galatovic (2014) provide more detailed examples of the types of problems summarized here.

Brazil's Political Institutions: How Coalitional Presidentialism Impacts Public Finance

There are numerous peculiarities within Brazil's configuration of political institutions at the national level that worsen many of these generic infrastructure problems, including:

- Political incentives that make enduring, policy-driven coalitions difficult, even among legislators with similar preferences[28]
- Private infrastructure providers that operate as monopolies or oligopolies

[28] Most democratic politicians everywhere face incentives to go for short-term electoral payoffs, but Brazil's system of open-list proportional representation is especially challenging, as it also undercuts the willingness of federal deputies to cooperate even with members of their own party.

- Generic challenges embedded within the public sector (e.g., patronage, overemployment, inefficiency, etc.) and the private sector (e.g., rent-seeking, pursuit of private profits but socialized losses, etc.)

Brazil's ability to adopt and carry out a new infrastructure initiative or national policy program is differently problematic under governments leaning left or right. Initiatives brought forward by center-left governments typically imply increased direct public spending and therefore are, ceteris paribus, more challenging to execute because financial resources must be found, which may imply an expansion of informal trade-offs. However, programs initiated by center-right governments commonly target increased private investment, which implies the need to alter legal rules and hence are also quite difficult in terms of executive-legislative relations, center-state fiscal relations, and so forth.

The national budget process implies that the interests of social groups unable to elect "their" legislators are shunted aside. Moreover, even being part of an influential national movement is not necessarily helpful for politically less powerful, and usually lower-income, interest groups to gain representation in the Congress. For example, federal deputies are elected in a single statewide district, a system that forces members of the same party to compete with one another and renders them very dependent on powerful governors.

Presidents without access to politically relevant resources to trade with legislators, including but not limited to the offer to campaign for subnational politicians, simply cannot pass major infrastructure bills. Unpopular presidents fare worse, given they typically have few politically relevant resources to trade (box 2.8).

Box 2.8 The Rise and Fall of Brazil's 2015 Logistics Investment Program

In June 2015, six months into her second term, center-left President Dilma Rousseff announced the Logistics Investment Program, intended to attract US$64 billion in private investment, mostly in long-distance freight transportation, as well as regional airports. A year later she had been impeached, and all of the large infrastructure auctions had failed or been indefinitely delayed. This was the political fallout of an enormous cash-for-contracts scandal centered on Brazil's largest state firm, the energy and petrochemicals giant Petrobras, with counterparties mostly in the private construction sector, including Odebrecht. President Michel Temer, Rousseff's "ticket-balancing" vice president from the center right, served out the term, concentrating on modernizing and liberalizing the regulatory framework for private investment, and doing the groundwork for legal changes passed under the current administration in January 2019.

Governors are dependent on the central government for substantial fiscal transfers, a mandated portion of which state governments in turn pass to municipalities. But the careers of national legislators, even those of apparently ideologically opposed political parties, in practice are quite tied to the whims of state governors. The influence of governors over federal legislators ties back to the statewide, and thus very large, electoral districts, in which even candidates from the same party run against one another, so that voters regularly must wade through lists of dozens of candidates for the same office. In this institutional context, name recognition is everything, and governors can either endorse or ignore candidates.

Moreover, and crucially, if infrastructure initiatives are to ultimately be evaluated in terms of their implications for enhanced quantity and quality of infrastructure, as opposed to the numbers of firms

transferred to private owners or revenues raised, then the political economy considerations become in certain respects even more challenging.

In sum, any infrastructure initiative in Brazil, which is assumed to originate within the executive branch (e.g., the president and economic ministers), requires enormous effort and political capital to get the program agreed—and funded—via the national legislature.

Brazil's Economic Ideologies and Presidential Policies

The federal administration determines the thrust of national economic policies, including those for infrastructure. Since the end of the Second World War, national economic policies in Brazil have reflected a rather large degree of consensus—although this is not necessarily recognized by policy makers. Central to this consensus, and thus to the understanding of national infrastructure policy, has been a vision of Brazil's industrial vocation.

This gives rise to several questions. First, does the vision of infrastructure and economic development pursued during the initial three years of the current presidency deviate from the pattern established by previous postwar governments? For many decades, Brazilian presidents and senior policy makers have pursued liberalizing, market-friendly policies, but without yielding the larger goal of Brazil joining the ranks of high-income countries via pursuit of high-value-added industrial or services production and exports. Or does the current administration's vision merely represent the most recent turn in a relatively constant long-term pattern of fluctuating economic ideologies and national policy making?[29] Second, and assuming the pattern promoted by current economic ministers is a deviation from a long-term trend, what caused this shift?

It may be too early to answer either question; but perhaps opportunities for Brazil to become the next Republic of Korea; Taiwan, China; or China have simply passed? Since approximately the opening of the new millennium, the characteristics of Brazil's production profile, trading partners, and export profile have all shifted dramatically. According to a columnist for Valor Econômico, even the majority of exports from the state of São Paulo, Brazil's industrial, financial, and commercial center, are now commodities (Rittner 2022). One option might therefore be for central-government-funded research and development to focus on innovative agro-industry. Vieira Filho and Fishlow (2017) argue that the achievements of Brazil's Institute of Agricultural Research (EMBRAPA) compare favorably to those of industrial champions Petrobras in energy and Embraer in civil aviation.

The Contemporary Politics and Political Economy of Brazilian Infrastructure

The principal commitment of the current administration is to open as much space as possible for the private sector to lead infrastructure development. There are likely two reasons for this. One reason follows from the genuinely economically liberal beliefs and models shaping the policy preferences of the current government. A second reason, however, is entirely pragmatic: it is very hard for federal policy makers to allocate funds to capital expenditures.

[29] That there has been a lot of continuity in Brazilian national economic policies from the early 1990s to the present (or even from the 1950s to the present) is explored in detail in Armijo (2017).

There is very little flexibility in Brazil's federal budget. Even within the small share of federal resources allocated to capital investment, both the incentives and the legal tripwires of Brazilian political institutions (known collectively as "coalitional presidentialism") strongly militate against long-term, on-budget infrastructure spending. From the 1950s through the 1980s, a great deal of Brazil's infrastructure and long-term industrial investment was funded through opaque flows within the public sector: (i) SOE budgets; (ii) the central government's share of inflation tax; (iii) various pools of forced public savings for social security, unemployment, and similar social insurance goals, obligatorily invested in low-yielding public sector debt securities; and (iv) a host of informal practices, ranging from the president's privilege of sequestering funds at will from the budget passed by the legislature (now subject to additional constraints, but continuing) to institutionalized patterns of delayed payments to government contractors and suppliers. The process of achieving greater fiscal transparency, the first and most important step of which was the mid-1990s conquest of endemic high to very high inflation, is surely necessary in the long haul, but arguably has made subsequent governing—and particularly funding long-term capital expenditures within the public sector—more difficult.

Moreover, certain types of infrastructure are more easily funded via budgetary allocations than other types, because the former are popular with politicians and the public. For example, virtually every internationally comparative investigation made in the twenty-first century concluded that Brazil's greatest need in terms of growth-promoting infrastructure is in the transport sector, where the "infrastructure deficit" is highest. Moreover, within the category of transportation allocations, intermodal expansion yields cheaper freight costs, especially for bulk cargoes in which Brazil increasingly has specialized, with lesser negative externalities for both the global climate and the local environment, than improving or expanding highways.

Nonetheless, Brazil's most recent long-term planning document makes clear that pursuing the current trajectory over the next 15 years will result in more than half of all transportation investment funds going to highways, about half this amount to rail, a smaller and declining share on waterways, and a tiny share on airports (CIP-INFRA 2021). Chronic underinvestment has left Brazil's roads in an impressive state of disrepair and this report estimates that almost half of all funding destined for roads must be earmarked for operation and maintenance.

Still, it is hard to ignore that roads have always been popular with voters, inter alia, because they serve what has emerged over the past decade as an increasingly important interest group: independent (self-employed) truckers, a core constituency. Brazil's vocal middle class also favors more and better highways, enabling them to travel by private car. Finally, poorer Brazilians, who also need to travel between cities either for employment or occasional visits to rural family homes, will not be traveling by private car or air, even with substantial planned expansion of regional airports. As Brazil ended nearly all interurban passenger rail service decades ago, this constituency travels by bus. There are numerous, politically savvy interest groups (especially long-haul truckers) and/or voters. For the general public, interurban rail expansion is understood correctly, at least in part, as designed to benefit large-scale commercial agriculture. In other words, it is easier to allocate federal on-budget funds to highway improvements, such as creating divided highways to reduce traffic accidents and fatalities, than to build railways serving large agribusiness and commodity export interests.

The larger conclusion here is as follows: in every contemporary democracy, allocating public funds in an open and transparent fashion via the political system to long-term investment uses whose value is not immediately perceived by the general public, is difficult. Building a consensus to fund big infrastructure projects is even harder in presidential democracies, constructed so the executive, charged with long-term strategic thinking across multiple policy domains, is institutionally obliged to battle a separately elected legislature, designed to represent parochial and localized interests at the center. In parliamentary democracies with stronger party discipline (because a party that cannot hold together its legislative coalition necessarily loses control of the executive via a no-confidence vote), constructing strategic policies with legislative support is somewhat easier. These generic truths about presidential versus parliamentary systems are magnified in federal systems with independently elected governors. And contemporary Brazilian political institutions add many further layers of complexity (Taylor 2020). This does not mean it is impossible to convince the public that building big infrastructure is in their interest. However, it is a difficult task, requiring sustained commitment at the center.

Beyond a few major projects, largely designed to respond to the goals of Brazil's private sector, the current administration has left the field open to the creativity of private entrepreneurs, without a great deal of central government imposition—or guidance—on what will be built, serving whom, or where. The strategy includes several components. Permissions granting land will be expedited. The regulations imposed will concern corporate governance ("don't cheat minority investors"), financial transparency ("no bribes for public officials"), and whatever environmental or climate-related restrictions either the Brazilian public or foreign investors or customers—in practice, principally the European Union—insist upon.

The strategy of moving toward greater private sector involvement has three characteristics. The first is to have solid, competent, and independent federal regulatory institutions in place for each infrastructure sector, particularly those in which private participation is set to increase. In most cases, these were created as necessary components of the large-scale privatization process of the 1990s under President Cardoso.

The second component, which also continued under governments leaning both center-right and center-left, but given great emphasis under President Temer and during the current administration, has been to modernize the legal and constitutional framework within which the regulatory institutions, as well as the extensive legal and judicial agencies and enforcement processes of Brazil's federal government, must operate. This includes liberalizing sectors and modalities previously closed to private or foreign investment. New legal frameworks have been established legalizing private, including foreign, investment in telecommunications (late-2019), water and sanitation (mid-2020), natural gas (early 2021), and railroads (late 2021). Other infrastructure sectors were liberalized earlier, notably including the port sector in 2013. Such legislation alters existing law, and must pass through Brazil's national legislature, requiring political coalition building.

In addition, there are now five different legal frameworks for private participation in infrastructure investment. Three pre-date the current administration: (i) full privatization, in which the private investor purchases a controlling share although public entities such as the Brazilian Development Bank (BNDES) often retain significant equity and influence; (ii) licensing ("concession"), via auction, of a service contract

to operate revenue-generating infrastructure for a fixed period, typically 30 years; and (iii) PPPs, for which the legal framework was established but hardly used, and which has now been modernized via the Investment Partnerships Program (PPI) established in 2016 (Law 14.133 of 2021). The current administration has added two further options: (i) early renewal (*prorrogacão*) of existing concessions without a new auction; and (ii) a new framework known as an "authorization" regime, created by the current government by a decree which the administration plans to shepherd through the full legislative process at a future date. In essence, the authorization is a legal procedure permitting faster letting of concessions. In exchange for an expedited license to operate (or build and operate) an infrastructure facility, along with faster access to the necessary permissions, concessionaires assume all of the financial and other risks, as well as the profits. This modality is particularly intended to increase investment in rail transport. The new legal framework for the sector allows companies, usually in the agro-export or commodity export sector, to design and build relatively short-haul private rail segments, primarily for their own use, connecting a private production facility to the market. Similarly, private docks at major ports, first allowed during the Rousseff administration, may be expanded.

The third component is a multiyear planning exercise (Box 2.9 Recent Advances in Brazilian Infrastructure Planning and Governance). On the one hand, these occur frequently in Brazil. On the other hand, some plans are notably more "serious" in terms of their political profile, which typically equates either to significant public funds dedicated to assist in the plan's implementation, or to a significant alteration of the direction of investments or their legal framework. The current plan, the initial framework for which went to Brazil's Congress as a decree in mid-2020, and which has now been published as the Integrated Long-Term Infrastructure Plan (Plano Integrado de Longo Prazo da Infraestrutura, PILPI), version no. 1, appears consequential due to the significant legal changes that have accompanied it, as well as the high level of attention given to it by the economy minister. Of note, is the near absence of any mention of infrastructure meant to serve industry, as well as the apparently low priority given to environmental and related concerns.

Box 2.9 Recent Advances in Brazilian Infrastructure Planning and Governance

Investment planning in the infrastructure sector has seen important improvements in Brazil since the enactment of Decree 10526/2020. With the institutionalization of the Integrated Long-Term Infrastructure Plan (PILPI), the updating of federal plans for transport, energy, water resources, urban mobility, telecommunications, and research and development began to be carried out in a harmonized manner based on uniform and transparent premises. The new governance model instituted by the Interministerial Infrastructure Planning Committee (CIP-INFRA 2021) has promoted the appraisal and prioritization of large-scale projects with upstream levels of planning based on socioeconomic cost-benefit analyses. Significant strides have been also achieved in the dissemination of standardized methods aligned with international best practices for project preparation (Five Case Model Guidance), ex ante appraisals (CBA Guide), and ex post evaluations. A capacity-building program including courses and workshops supported by the World Bank has been recently rolled out to also reach subnational entities involved in infrastructure planning. These advances have been recognized by the Brazilian Federal Court of Accounts as preventive steps to address the root causes of misallocation of resources and promote further transparency and evidence-based decision-making in the infrastructure sector.

Infrastructure and Brazil's International Relations

Two related issues seem likely to become increasingly important going forward: the question of industrial policy and the shape of the twenty-first century global economy and how Brazil might react to its shifting

opportunities and options. The first, again, concerns the implications of Brazil increasingly specializing in commodity exports, albeit possibly ones accompanied by the most advanced, digitally managed transportation facilities. However technologically sophisticated the infrastructure, commodities remain subject to high price volatility, not to mention disruptions in trade. In other words, the core theses of the Latin American structuralist economic tradition would still seem to apply, at least in view of those who accepted this analysis in earlier decades.

The second issue concerns the foreign relations of Brazil, both with its neighbors and with the rest of the world. Clearly, the strongest historical ties, both political and economic, outside the region, are with North America and Europe. However, China is now the major trading partner for Brazil and most of South America, and its state-owned banks are the largest external investors in energy infrastructure in Brazil and most of South America. China is, moreover, the major bilateral provider of finance to emerging markets and developing economies as a whole. Public sector sources of international finance, whether from the West (or global North) or China, tend to come with political strings (Armijo 2020). How will Brazil balance its relations with the United States, the European Union, China, and Russia if the world evolves toward competing trade and financial blocs?

Future Considerations

The types of challenges raised in this exploration of Brazil's political economy are not technical, but also not, at their core, classic challenges of political economy per se (involving, for example, dilemmas of collective action, or time inconsistency). Nor are many of these specific infrastructure challenges—where to site a railroad, for example, and who should bear the costs and risks of constructing it—really a consequence of difficult political institutions that, for example, undermine attempts to follow apparently rational public budgeting procedures. That is, all of these dimensions can be problematic, but they are not ultimately the essential problem.

Because large, infrastructure projects are, inevitably, expensive, risky, and, of greatest importance, with long-lasting legacies, it seems profoundly important to have an open debate about Brazil's national vision of development. For example, Brazilian leaders and intellectuals periodically prioritize continental integration via infrastructure, for example, the Initiative for the Integration of the Regional Infrastructure of South America project, among whose strongest promoters were Presidents Cardoso and Lula da Silva. One might draw an analogy to the vision of President Juscelino Kubitschek in the late 1950s, whose goal in constructing Brasília was to open up Brazil's interior. For contemporary Brazil, becoming gradually untethered, at least economically, from the United States could reinforce drift and a choice, conscious (as for the current administration) or not (for most Brazilians, including most politicians), to leave big, important, national—and regional, that is for South America as a whole—decisions to the private sector. Such a choice may reflect implicit acceptance of the proposition that trying to agree a societal vision for planned infrastructure, especially in the transportation and power sectors, is simply not possible. The other response is to approach the problem of building modern infrastructure as, first and foremost, one of deciding on where one wants to arrive, as a society and a country: that is, to talk about what a corporation might term its mission statement. This may circle back to the problem of social trust, never high in Latin America or Brazil in comparative perspective, and at historic and abysmal lows in Brazil at

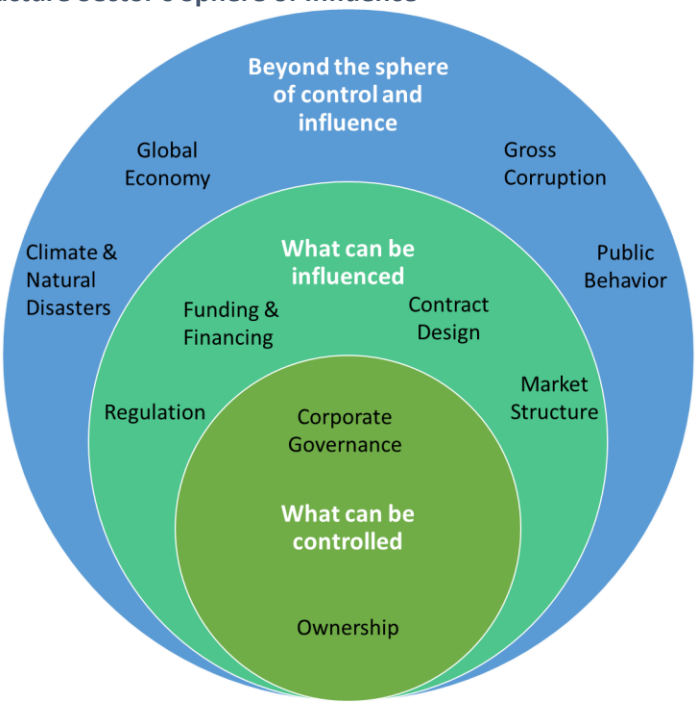
present (Corporación Latinobarómetro 2021) without which, perhaps, heavy infrastructure cannot—although it should—be planned.

3. KEY FACTORS AFFECTING SECTORAL PERFORMANCE

The results are far from homogeneous and access to reliable infrastructure can't be achieved in isolation. Various factors influence the infrastructure sector's overall ability and agility to respond, such as regulatory governance, funding, financing, and even climate. The extent to which these factors affect performance is correlated to the sector's sphere of influence (figure 3.1). Some, such as corporate governance, can be controlled at the company level. Others, such as regulatory governance, private sector participation, contract design, and market structure, are generally beyond the sector's sphere of control, but within its sphere of influence. Impacts related to the degree of decentralization and a government's overall capacity, as well as other factors, such as sovereign risk ratings, gross corruption, consumer behavior, and climate, are generally beyond the sector's sphere of influence. But even in the face of externalities, the ability to prepare and build resilience to mitigate eventual impacts remains within the sector's sphere of control. This is especially relevant in the context of Brazil's climate, which can be characterized as a climate of extremes.

This section relies on select case studies and examples to explore several of the key drivers impacting the performance of Brazil's infrastructure sector: specifically, factors within the sphere of influence, such as regulatory governance and financing and funding, and factors beyond the sphere of influence such as capacity and climate. While not a comprehensive assessment, the results identify several areas of concern that cut across all four infrastructure subsectors evaluated in the context of this report that may warrant a deeper investigation, either thematically or at the subsector level.

Figure 3.1 The Infrastructure Sector's Sphere of Influence



Source: Own elaboration.

Within the Sphere of Influence: Sectoral Conditions Affecting Performance

Regulatory Governance: A Case Study of Brazil's Water and Sanitation Sector

Understanding the various interventions and conditions that explain sector performance is indispensable to reducing a country's infrastructure gap. Until recently, data constraints have forced researchers to rely on small samples of companies or countries and a limited number of indicators. In this case study analysis, large datasets were leveraged to assess the role of regulatory governance in Brazil's water and sanitation sector. Key determinants known to impact sector performance were identified before analyzing longitudinal trends and comparing common features across water and sanitation independent regulatory agencies (IRAs) to better understand the unique drivers of sector performance in the Brazilian context.

The impact of regulatory agencies on sector performance is supported by several empirical studies. Research has associated better sector performance, represented by higher levels of performance indicators, with the governance of regulatory institutions (Stern and Cubbin 2005; Andrés, Guasch, and Azumendi 2009; Andrés, Schwartz, and Guasch 2013). Significant improvement in utility performance occurs as a result of the existence of a regulatory agency, even in the case of SOEs. Thus, the existence of a regulatory agency matters, as does its experience and governance.

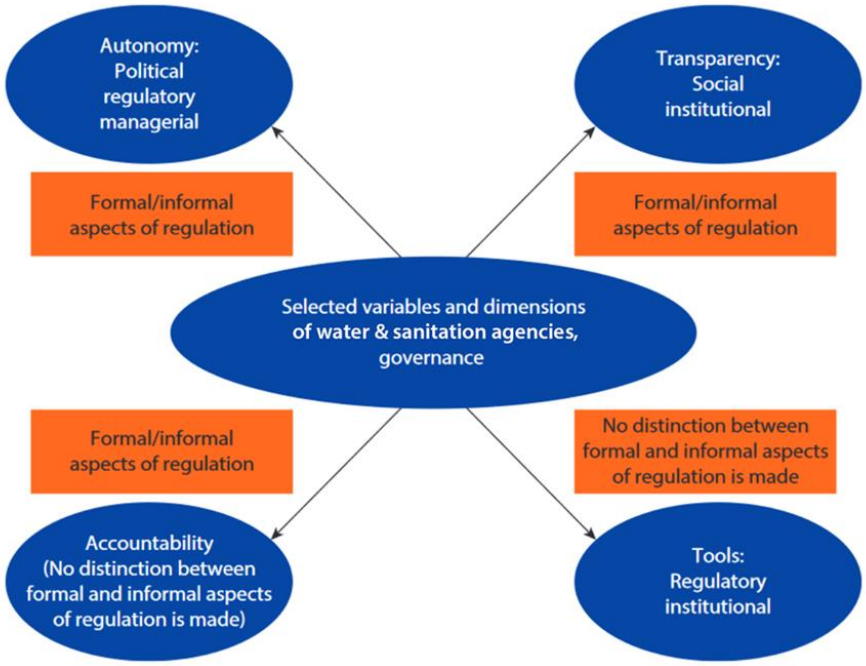
IRAs are more widespread in Latin America and the Caribbean than other developing regions (Sosay and Zenginobuz 2005). Created within the context of wide private sector participation programs, they were the chosen institutional arrangement to insulate decision-making in various economic sectors, including infrastructure, from political intervention (Thatcher 2007). Most literature on the governance of IRAs in LAC has focused on comparing countries in the region in terms of formal attributes of IRAs. Analysis of causality is at best limited. This analysis attempts to determine the inputs or characteristics that contribute to greater autonomy and accountability although their presence or absence does not, of course, guarantee that either improves. In addition, this work involves the application of techniques used in qualitative comparative politics to address issues of causality, sequencing, and complex interaction effects to capture aspects of the governance of IRAs that help assess and better explain their role in policy making (figure 3.2Figure 3.2).

Water Regulatory Governance Index

With more than 100 regulatory agencies in the water and sanitation sector, Brazil presents a wide spectrum of institutional designs. Agencies were grouped into three tiers based on their overall performance ranking. Tier 1 encompasses agencies with conditions conducive to developing good regulatory governance. Tier 2 includes agencies with the minimum conditions needed to implement the benchmark for regulatory governance. Agencies in this tier have fewer responsibilities and lower levels of autonomy than agencies in Tier 1. They also have fewer sophisticated mechanisms for publishing their

decisions and policies. Tier 3 includes agencies that do not meet the minimum conditions needed to implement the benchmark for regulatory governance.[30]

Figure 3.2 Framework for Assessing Governance of Independent Regulatory Agencies



Source: Andrés, Guasch, and Azumendi 2009.

None of the 45 regulatory agencies analyzed met the conditions considered conducive to developing good regulatory governance (figure 3.3Figure 3.3). Just over half (27) fall in Tier 2, meaning they meet the minimum conditions necessary to implement the independent regulator model. Meanwhile, 18 agencies fall in Tier 3, meaning they do not meet the minimum conditions for good regulatory governance. Two of the best-performing IRAs overall, and three of the top five, are consortiums. The third-best-performing IRA is a municipal agency. Of the 18 Tier 3 agencies, 11 are state IRAs, 3 are consortiums, and 4 are municipal. Based on this high-level qualitative assessment, consortium agencies appear to outperform their state and municipal peers. Although none of the water and sanitation IRAs examined in Brazil have the conditions conducive to developing good regulatory governance, almost two-thirds (60 percent) met the minimum conditions considered necessary to implement the independent regulator model.

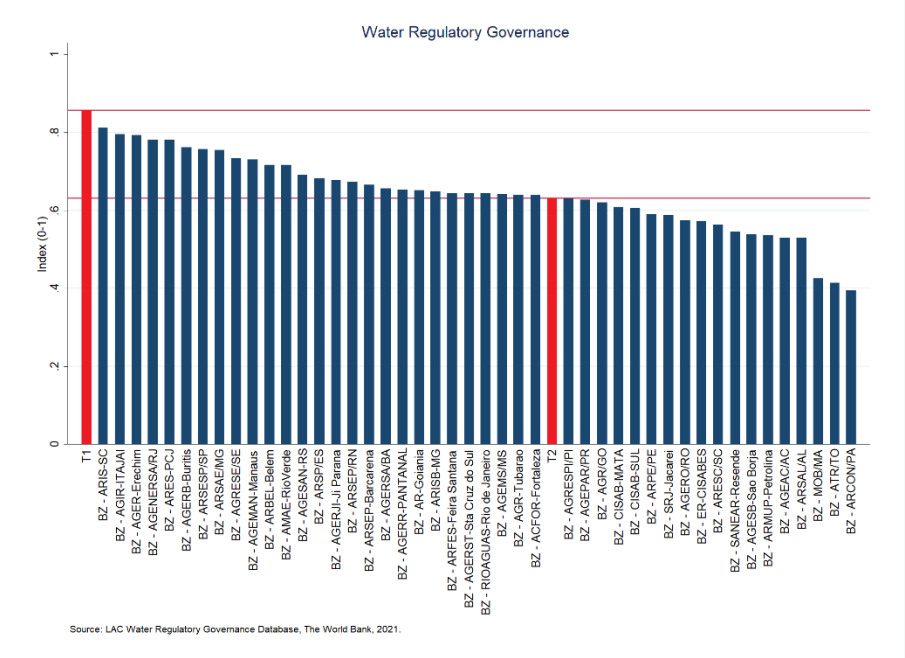
How Does Regulatory Governance Differ between Brazil's Water and Sanitation IRAs?

Overall, agencies performed best on measures of autonomy. This was followed by transparency, tools/capacity, and then accountability. In terms of autonomy, low-performing agencies are less independent, and more likely to suffer from greater political interference than high-performing agencies.

[30] For each subindex generated, there is a Tier 1 benchmark bar (T1) and a Tier 2 benchmark bar (T2). Benchmarks are generated for each individual measure/index according to the particularities of each variable being measured. Therefore, T1 and T2 benchmarks are not equal across the different subindices. In the figures presented in this section, agencies positioned to the left of the T1 bar are considered Tier 1. Agencies positioned between the T1 and T2 bars are considered Tier 2. Agencies situated to the right of the T2 bar are considered Tier 3.

Differences between the best- and worst-performing agencies in terms of transparency were narrower than for other measures. Nevertheless, low-ranking agencies are less likely to publish basic data or perform public consultations. They may have ad hoc advisory committees or no committee at all relying instead on a single decision-making authority, and no cooling-off period is required for departing directors—all areas that can easily be improved. Concerning tools/capacity, low-performing agencies had fewer regulatory instruments, were less likely to use benchmarking techniques, were less effective in enforcing sanctions, and more likely to rely on paper-based mechanisms to register customer complaints. None of the agencies surveyed had a performance-based payment system, a tool that is certainly worth exploring.

Figure 3.3 Water Regulatory Governance Index Rankings for Brazilian IRAs



Overall, agencies performed worst on measures of accountability. This might explain the lack of progress improving institutional quality. With some exceptions, it would appear the process that started with the creation of regulatory agencies in Brazil has not been expanded or significantly improved since. Almost all regulatory agencies in Brazil are accountable to the government (whether state or municipal) and in particular to the executive (and much less to the law-making or representative powers), which might explain these overall low scores. In other words, the main difference between the best and worst performers could be that the worst performers have more formal obligations to the executive. This is compounded by the fact that many agencies lack the ability to appeal their decisions, which would also adversely affect their score. Finally, agencies that lack mechanisms for internal auditing were also negatively impacted. Thus, several of the instruments required for effective accountability are not in place.[31]

[31] Although IRAs in Brazil do not have competency in antitrust matters, this did not have a large impact on overall accountability.

Political and regulatory autonomy are in need of improvement. Disaggregating the four main variables into their different sub-elements sheds light on areas where there is room for improvement. Political autonomy is clearly an area that merits attention, namely, increasing an agency's autonomy from the government and diversifying an agency's budget. Regulatory autonomy also has room for improvement, including strengthening an agency's regulatory prerogatives and the power to enforce regulations.

Political independence is likely a function of regulatory control. The binary distribution of regulatory autonomy scores compared to the more even distribution of political autonomy scores may explain the importance of linking political independence with the expansion of an agency's regulatory powers. An agency can have the highest level of independence from political authorities but no power to regulate the sector, making independence an abstract characteristic of the agency's functioning with no real impact on regulation. In the same way, in theory an agency can have all regulatory powers in place, but if the level of independence from political authorities is limited, the agency will have no real impact on regulation.

Institutional transparency also demands closer attention. Transparency is broken down into *social* and *institutional* transparency. Institutional transparency warrants more attention. Improvements include replacing single decision-making entities with boards composed of a number of directors with varied technical backgrounds that allow for more comprehensive and diverse debates on regulatory topics; publishing information such as job vacancies, annual reports, institutional strategies, and audited accounts in readily accessible formats; and finally, recording the minutes of board meetings, and mandating cooling off periods for departing directors. In general, agencies with good institutional transparency tend to possess characteristics related to administrative modernization.

Brazilian agencies perform better on measures related to regulatory tools. Tools are categorized as *regulatory* and *institutional*. Areas for improvement include: creating and using tools to achieve better standards (i.e., regulatory impact analyses, cost-benefit analyses, and administrative simplification); implementing a structure for staff and salaries; developing and publishing an institutional strategy; facilitating the processing of consumer complaints through electronic means; and creating an employee incentives scheme.

Financing and Funding: Bolstering a Weak Public Planning Process to Harness Private Sector Investment and Know-How

Inherent Fiscal Risks in the Infrastructure Sector

Uncertainty is inherent in infrastructure spending, but public and private provision of infrastructure entail different fiscal risks.[32] Infrastructure spending creates uncertainties, regardless of the quality of government planning and projections. Once these materialize, they can lead to financing pressures on fiscal authorities, that is, contingent liabilities that can lead to fiscal shocks. Public provision of infrastructure gives rise to fiscal risks by creating unanticipated additional expenditures because of cost overruns or asset deterioration. Inadequate maintenance of infrastructure over time (because of insufficient and inefficient spending, and the poor quality of construction) eventually requires additional spending on recurrent and nonrecurrent maintenance to prevent assets from falling into disrepair.

[32] This section is based on Herrera Dappe et al. (2022).

Infrastructure SOEs can create substantial risks for public finances through explicit guarantees and public insurance schemes, such as insurance against disasters and extreme weather events, cashflow, and bailout risks. PPPs entail different fiscal commitments that can also lead to fiscal surprises, such as contingent liabilities from contract renegotiations and early terminations.

State ownership erodes profitability and puts SOEs in a vulnerable position when faced with negative shocks. The volatility in performance and the frequent losses are not only transformed into modest requests of fiscal support on an annual basis, but they can also rapidly erode the capital base of SOEs and thus create a larger request for fiscal support to recapitalize or bailout the companies in question, particularly when hit by a negative shock. Rather than portraying fiscal risk from SOEs as extreme events, evidence shows that fiscal risk usually requires regular fiscal injections that can turn into larger risks during negative shocks (Herrera Dappe et al. 2022). For example, annual fiscal injections to SOEs are, on average, 0.64 points of GDP for power and transportation. Rather than focusing solely on operating subsidies, these estimates of fiscal injections include changes in the stock of government equity (that is, recapitalizations); changes in the loans SOEs receive from the government, and from financial and nonfinancial SOEs; and changes in deferred tax liabilities (that is, when they are used as an instrument to support an SOE), all of which is net of asset increases or as a percentage of GDP.

Comprehensive measures of fiscal injections to SOEs and simple tools from the finance literature can help governments foresee and prevent fiscal risk. Recent evidence suggests that on-budget spending on infrastructure has been procyclical in the 2005–18 period (Foster, Rana, and Gorgulu 2022) suggesting that in times of economic downturn on-budget infrastructure spending is expected to be particularly vulnerable to spending cuts. A significant negative shock leads to a deterioration in an SOE's financial performance, which coupled with the fact that infrastructure SOEs tend to operate with little financial slack, leads the affected SOEs to ask for sizable fiscal injections.

Fiscal risks from PPPs stem from frequent and extreme events. Most countries do not have a robust framework for the fiscal treatment of PPPs—which creates a fertile ground for fiscal risks—and do not follow good practices in the preparation, procurement, and management of PPPs (see Activity E, "Fostering Private Sector Participation in Infrastructure in Brazil," in appendix BAppendix B. Links to Background Papers) The fiscal risks from demand guarantees tend to be small when prudently used; however, if governments pursue infrastructure expansion in a shortsighted manner, based on optimistic expectations of projects, the fiscal costs of guarantees can be sizeable.

Experience shows that PPP contracts are renegotiated too frequently and too early for the observed renegotiations to be justified as an efficient outcome. The average time to first renegotiation in Latin America ranges from 1.0 to 4.3 years among PPPs, depending on the sample. When renegotiations fail, PPPs are terminated early, which can lead to sizable fiscal costs. Like renegotiations, early terminations of PPPs are more likely to happen early in the contract periods. Early terminations are less frequent than renegotiations, but their fiscal costs tend to be larger. The value-at-risk from early termination of active PPPs, over their entire lifetime, as a share of 2020 GDP, is highest in Brazil at approximately 0.9–2.8 percent.

Closing Brazil's infrastructure financing gap requires increasing the efficiency and fiscal sustainability of infrastructure spending. This entails mitigating the fiscal risks from infrastructure to increase the value

for money from existing resources and additional capital that will need to be mobilized to close the gap. A reform agenda to achieve such goals should aim to create the right incentives to root out the sources of fiscal risks specific to different modalities of provision and mitigate risks that cannot be eliminated through integrated fiscal management across the three different channels of infrastructure spending. Creating the right incentives requires transparency, accountability, and adequate capacity in government.

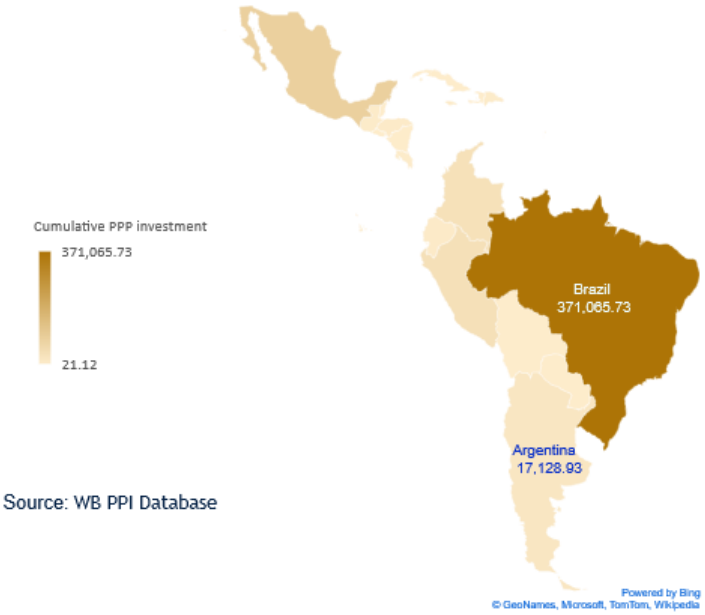
Identifying Critical Constraints within Brazil's Infrastructure Pipeline

Private sector investment in infrastructure is higher both nominally and as a percentage of GDP in LAC than any other region around the world (figure 3.4Figure 3.4). Private sector participation in infrastructure in Brazil dates back to the imperial era;[33] however, it was not until the 1990s that the legal and institutional foundation for the current enabling environment was developed.

From 2015 to 2021, the private sector committed about US$170 billion to infrastructure in LAC, of which 50 percent went to Brazil (figure 3.5Figure 3.5). The energy sector attracted most investments, followed by transport and then water and sanitation. Unlike many World Bank client countries, Brazil's strongest PPP programs have been developed at the state and municipal levels. For example, since 2015, 941 PPP projects have been brought to market. Of these, approximately 78 percent were developed at the municipal level, 16 percent at the state level, and only 6 percent at the federal level.[34] Of those that were procured, 283 reached financial closure.

Figure 3.4 Private Sector Investment by Region, 2001–H1 2021 (US$, percentage of GDP)

Region	2001-2021 in US$ million*	% of Regional 2020 GDP**
LAC	576,160	14.33%
SAR	349,647	9.55%
ECA	195,514	6.03%
SSA	87,594	5.11%
MENA	55,297	4.60%
EAP	419,971	2.34%



Source: WB PPI Database

* 2001-2021 cumulative PPPs are used as most of these contracts are long term (20 years) and earlier PPPs remain relevant as a fiscal risk
**2020 Regional GDP (excluding high income) has been used because it is the latest value available.

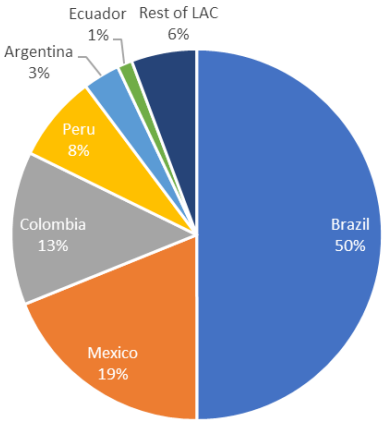
Source: World Bank's Private Participation in Infrastructure Database 2022.

[33] On June 26, 1852, during Brazil's imperial era, the Brazilian emperor enacted Decree 641, authorizing the government to offer railroad concessions: https://www2.camara.leg.br/legin/fed/decret/1824-1899/decreto-641-26-junho-1852-558790-publicacaooriginal-80365-pl.html.

[34] Radar PPP.

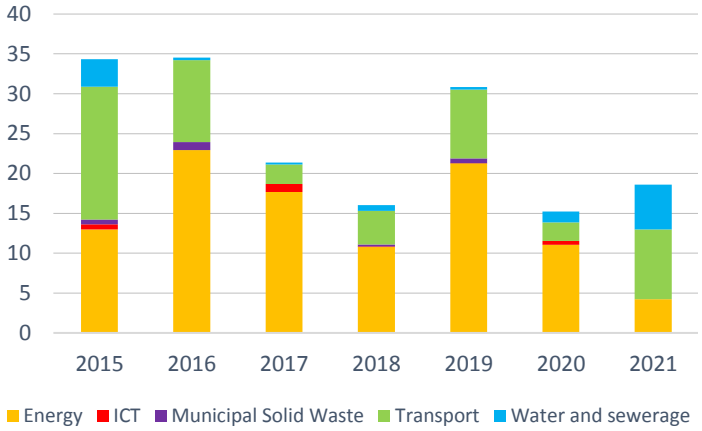
Figure 3.5 Private Investment in Infrastructure in LAC by Country (Panel A) and Sector (Panel B), 2015–21

Panel A



Source: World Bank's Private Participation in Infrastructure Database 2022.
Note: N = US$170 billion.

Panel B



Source: World Bank's Private Participation in Infrastructure Database 2022.
Note: In 2020 US$ billions.

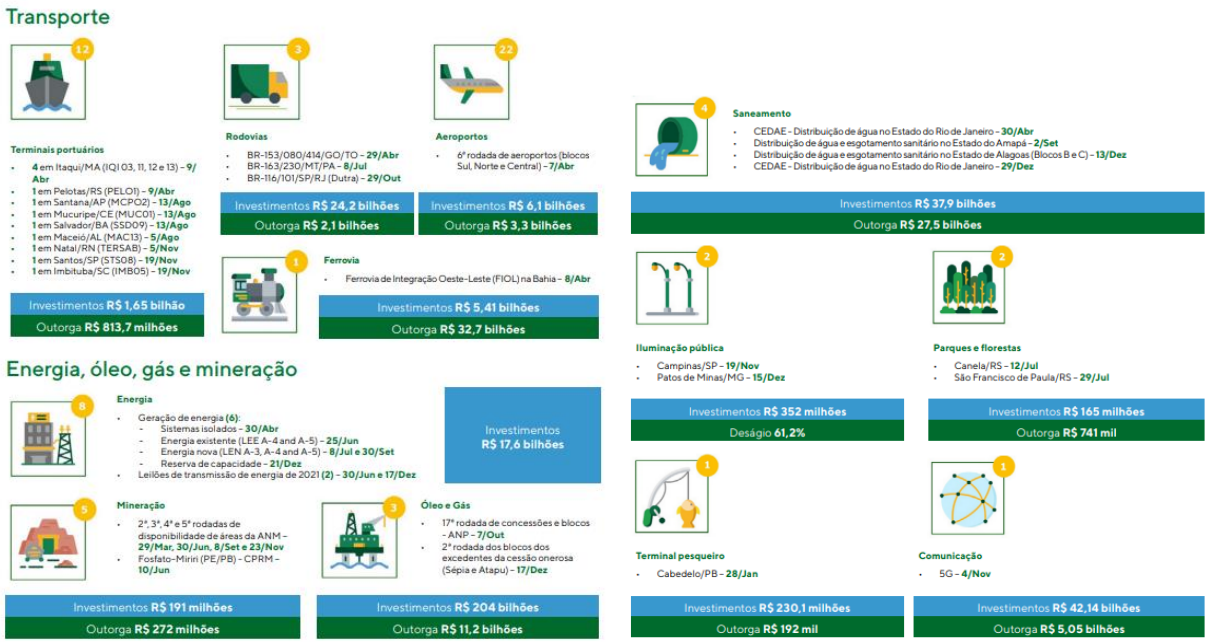
In 2016, the government stimulated a new wave of private sector participation in infrastructure. In 2016, the federal government created the Investment Partnerships Program (PPI) dedicated to expanding and strengthening interactions between public and private entities. The program's purpose was to reduce the state's level of involvement and create a more dynamic economy by removing barriers to competition, increasing transparency, and organizing/centralizing the country's infrastructure pipeline. The PPI Secretariat (created under Law 13.334 in 2016) functions similar to a PPP unit, and has the mandate of supporting different stakeholders involved in the development and implementation of the PPI. It therefore has an important role in increasing private sector participation in infrastructure, namely coordinating and monitoring the bidding process to ensure legal stability and predictability—including minimizing state intervention, evaluating the process to promote competition, and finally, conducting supervision and oversight. Since its inception, 201 assets have been procured totaling US$28.2 billion that are expected to generate US$144.5 billion in investments throughout the life of their contracts. Of these, 92 were awarded to foreign firms/consortiums (figure 3.6**Error! Reference source not found.**), a testament to the quality of Brazil's pipeline.

Despite COVID-19, the government managed to award US$9.6 billion in infrastructure projects in 2020 and liquidated three SOEs.[35] In 2021, 66 projects worth approximately US$10.4 billion were awarded, estimated to generate over US$71.4 billion in investments (figure 3.6Figure 3.6). Several important assets were taken to market, including 5G infrastructure, the Nova Dutra road connecting São Paulo to Rio de

[35] The three SOEs that were liquidated were: CASEMG (Companhia de Armazens e Silos do Estados de MG), CODOMAR (Companhia Docas Maranhao), and CEITEC (Centro Nacional de Tecnologia Eletronica Avancada).

Janeiro, CEDAE (the water and sanitation SOE in Rio de Janeiro), and FIOL (the railway connecting the east and west regions). The government plans to auction an additional 152 assets in 2022. These include several projects that are key to Brazil's economic development such as the Santos Dumont and Congonhas Airports (the main domestic airports in Rio de Janeiro and São Paulo, respectively), and two railway lines, among others (figures 3.7 and 3.8Figure 3.7). The list of projects to be divested is also robust and is expected to attract international attention. SOEs such as Eletrobras (responsible for the generation and transmission of energy in Brazil) and Correios (post office services), and Santos Port (including the port operator, CODESA) are expected to bring substantive investments to the country.

Figure 3.6 Projects Successfully Taken to Market in 2021



Source: Presidência da República do Brasil 2022.

Figure 3.7 Brazil's Federal Pipeline for 2022

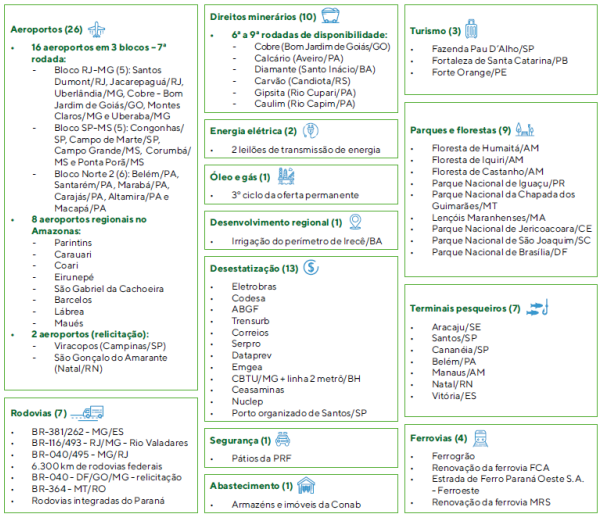
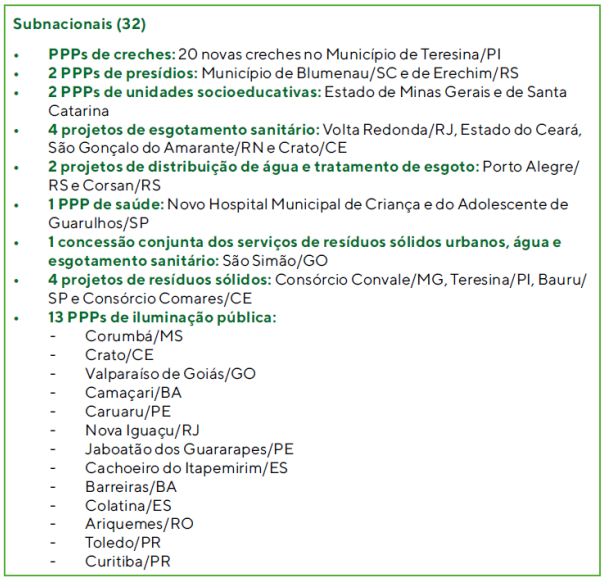


Figure 3.8 Brazil's Subnational Pipeline for 2022



Source: Presidência da República do Brasil 2022.

Brazil still faces certain structural challenges to reducing its infrastructure gap and improving the country's competitiveness. Challenges include project prioritization, screening, and selection; project structuring; and the limitation of the use of public guarantees, all within the context of reduced fiscal space.

Project Prioritization, Screening, and Selection

Well-informed decisions are crucial to achieving any government's goals. Governments around the world face the similar challenge of allocating limited resources to infrastructure development. In a context of limited—and in the case of Brazil, legally capped—public resources, deciding which project/sector to prioritize is rarely straightforward especially when more than one sector needs urgent attention. Robust project selection methods[36] can increase transparency and are less susceptible to political pressure, a particularly pressing problem within the Brazilian context.

Brazil's initially well-prepared planning exercise falters during implementation. Pluriannual and annual plans and national/sectoral strategies are poorly implemented, leading to an ineffective prioritization of projects. The country's cumbersome and complex political economy, described in detail in previous sections, frequently results in unrealistic costs, multiple congressional amendments to the budgets, an unrealistic volume of projects, and an overall lack of institutional coordination. These aspects are even more apparent in the current context of shrinking fiscal space, with too much to do and too little money to do it.

Strategic guidance and a standardized approach are needed to improve Brazil's planning process. The lack of clear strategic guidance for public investment combined with the absence of proper, standardized

[36] For more details on this subject, see Raiser et al. (2017).

methodologies for project prioritization and screening have made it nearly impossible for the government to consolidate and structure a robust long-term infrastructure investment program. Although the creation of the PPI has reinforced coordination and centralized the capacity for PPPs and concession project preparation, projects are mostly selected based on their potential for attracting private sector interest, and not after carefully conducted project analyses.

The lack of a rigorous, standardized approach leaves planning processes subject to political influence. While some spending ministries undertake some financial and/or economic analyses, this is far from systematic and there are no centralized procedures in place requiring the spending ministry to appraise projects financially or economically as part of project preparation. There is no guidance on standard methodologies for value-for-money and cost-benefit analyses regarding funding modalities, that is, PPPs, concessions, or public procurement. Each line ministry has its own set of criteria for selecting major projects for pipeline approval, and the quality and comprehensiveness of these varies across ministries. Similarly, there are no standardized project selection criteria for the Ministry of Economy. In practice, the ministry does not play the role of gatekeeper regarding projects to be included in the budget. Selection is mostly based on the information provided by line ministries and a superficial evaluation by the Ministry of Economy. Consequently, the current list of projects significantly exceeds the fiscal space available to finance/fund the pipeline, let alone manage them. Furthermore, Congress can propose amendments to budgetary plans and request the inclusion of projects without adequate studies to justify their inclusion. This political interference makes it even harder for the ministry to consolidate Brazil's infrastructure pipeline.

Project Structuring

Project structuring reforms are persistently hamstrung by low technical capacity. In Brazil, the high number of projects and limited capacity of the government to meet the demand of different agencies makes project structuring another key challenge for developing a healthy infrastructure pipeline. There are four main challenges related to the project appraisal process in Brazil:[37]

i. There is a lack of capacity to develop technical and financial studies.
ii. Consultants are normally selected based on the lower cost option instead of quality.
iii. Numerous audits and controls slow down the process and/or lead to the cancellation of the bidding process, often without justification.
iv. The lack of a well-structured PPP program, and consequently, designated budget for proper project structuring.

To solve these challenges and render project structuring more agile, the federal government created the PMI process[38] under which the private sector is allowed to submit proposals for which it is reimbursed by the winning bidder. By law, the government is not obliged to procure any of the projects received through the PMI, so although the PMI has worked well for some sectors, notably airport concessions, the uncertainty regarding selection is a disincentive for private firms to participate in the process.

[37] Based on a preliminary desk review and interviews with relevant actors.
[38] Procedimento de Manifestação de Interesse.

More technical capacity is needed to ensure the success of recently created project structuring units. Given the size of Brazil's pipeline, in May 2021, a provisional measure (MP) 1.052/2021 was enacted[39] allowing the federal government to create a new fund that aims to support the development and implementation of the PPP project cycle, including developing technical and financial studies, at all three levels of government. The government will be able to participate in this fund with an investment of up to US$2.14 billion. This new fund will be created by restructuring the Infrastructure Guarantee Fund (FGIE).[40] Similarly, some line ministries have created their own project structuring units: the Ministry of Energy and Mining created the Energy Research Office (EPE); the Ministry of Transports (now Ministry of Infrastructure) created the Planning and Logistics Company (EPL) and restructured Valec, a company originally created to oversee the construction of railways and which is now allowed to conduct project-structuring-related activities. While these agencies have been supporting their related ministries with structuring and prioritizing their pipelines, their capacity is limited and their role normally restricted to the structuring of a few select projects.

Efforts to improve institutional coordination also risk being undermined without additional technical support. In an attempt to address these pervasive challenges, the current administration is trying to improve institutional arrangements to promote efficiency and the delivery of US$73 billion[41] in procured infrastructure projects. The Brazilian Development Bank (BNDES) and the state-owned Brazilian financial services company (Caixa Economic Federal, CEF), the main public federal entities with the best capacity to structure PPPs, and the Secretariat for infrastructure Development, under the Ministry of Economy (SDI)[42] are working together to better organize Brazil's infrastructure pipeline. Ideally, SDI will work as a coordinator of the country's infrastructure pipeline, the PPI will act to ensure better infrastructure governance, and BNDES and CEF will support these projects through financing and technical assistance. Still, given the magnitude of the task, the government is openly seeking technical support and innovative ideas that would resolve all of the challenges once and for all.

Reduced Fiscal Space and Limitations on the Use of Public Guarantees

Federal guarantees have historically been constrained by the lack of fiscal space. Brazil's PPP Law[43] establishes the types of guarantees[44] that can be used in a PPP contract, which aims to cover the availability payments of a given PPP contract. In an attempt to incentivize the use of PPPs, the law also established the Federal PPP Guarantee Fund (FGP). The FGP was a much-needed resource especially for governmental entities that lacked a tradition in developing PPPs and/or did not have an investment-grade rating. However, due to the lack of fiscal space, there has always been a preference for concessions[45] in Brazil (100 percent user-fee projects), and therefore, FGP has never provided a guarantee to any project. Consequently, the fund's resources were drastically reduced, from over R$469 million in 2012 to R$21 million in 2016.

[39] The MP modifies the Law 12.712/2012.
[40] More information on the FGIE will be provided in the following section.
[41] Exchange rate of R$1 = US$0.21.
[42] Secretaria de Desenvolvimento da Infraestructura.
[43] Law 11.079 from 2004.
[44] Including: (i) earmarking of public revenues, (ii) the use or creation of specialized funds, (iii) private insurance, (iv) IFI guarantees, (v) guarantor funds, and (vi) other mechanisms allowed under the law.
[45] The preference for concessions also explains the focus on economic infrastructure.

Brazil's fiscal ceiling challenges efforts to increase PPPs and restricts access to guarantees at the state level. As part of the measures to increase private investment in infrastructure, another fund was created, the Infrastructure Guarantee Fund (FGIE), established with the goal of providing guarantees to cover political, economic, credit, and contractual risks. The use of these resources is limited by the Fiscal Responsibility Law in conjunction with the PPP Law. The latter established the fiscal ceiling that a federal entity can spend on PPPs, which significantly limits the involvement of the federal government in the implementation of PPPs.[46] Hence, states and municipalities with an active PPP portfolio in Brazil, include only those with a portfolio below the fiscal ceiling established by the law. Although establishing a fiscal ceiling for PPPs is important, it has created a barrier to subnational entities with small economies developing their own PPP pipelines and portfolios. To the contrary, given this structure, only very experienced and rich subnational governments are capable of receiving guarantees and transfers for the implementation of their PPP program.

Beyond the Sphere of Influence: External Conditions Affecting Performance

Capacity: Limitations of Subnational Governments

Although Brazil has one of the highest degrees of fiscal decentralization among Latin American countries, subnational capacity is extremely weak. Given Brazil's strongest PPP programs have been developed at the state and municipal levels, this is critical to both public and private investment. At the subnational level, capital spending is financed by the states and municipalities through borrowing and federal government transfers, both automatic and discretionary. Federal discretionary grants finance a wide set of activities at the subnational level and use a variety of design, management, and monitoring arrangements. Each ministry uses its own methodologies for assigning grants and monitoring their execution. In the current framework, there are three types of discretionary transfers. Voluntary transfers through which a federal agency (usually a ministry) funds projects or activities by states and municipalities. The second mode is the grant or covenant, which the federal government uses to transfer funds and monitor the entire cycle of the program or activity financed through the grant. In general, this role has been fulfilled by CEF. Almost all capital transfers currently use this modality. The third is the partnership agreement initially restricted to civil society organizations.

Activities financed through voluntary transfers are explicitly identified and allocated in the federal budget. Each ministry distributes resources through their decentralized programs. Such programs are generally designed to solve externalities, economies of scale, and technical capacity deficiencies. However, during the budget process, legislators can introduce amendments that, if approved, change the resource allocation proposed by the executive. Once the budget is approved by Congress and sanctioned by the president, each ministry chooses the most relevant programs and annually publishes a call for states or municipalities to submit proposals. Alternatively, a ministry can identify specific local needs and

[46] The PPP Law establishes that the federal government can only procure a new PPP project if the total amount of existing PPPs are not higher than the equivalent of 1 percent of the current year's net revenues, and the total amount of debt for the next 10 years of the PPP portfolio is not higher than 1 percent of the net revenues estimated for the following decade. Furthermore, the PPP Law forbids the federal government from providing guarantees and/or transfers to states, the federal district, and municipalities, if the total amount of liabilities of these federal entities is not higher than 5 percent of the public net revenues, or if the projected amount of liabilities for the following 10 years is also superior to 5 percent of the net revenue of the present fiscal year.

provide resources for the development of a program in the municipalities of a region or a group of states that has been prioritized.

Granting ministries are responsible for guiding, monitoring, and evaluating the implementation of the program. The granting agency is also in charge of signing agreements and issuing norms and guidelines for the release of financial resources. These responsibilities even include verifying that the procurement legislation is applied adequately. Given the wide geographical spread of grant agreements, monitoring, controlling, and certifying compliance is far from trivial. For the beneficiaries of grant agreements, although they receive technical assistance from the ministries and CEF, preparing the proposals and fulfilling all obligations during the execution of the project can be very challenging, especially for smaller recipients with low technical capacity (International Monetary Fund, PIMA).

In Brazil, discretionary capital transfers are made through *convênios* (grant agreements) on a project-by-project basis, and usually monitored from beginning to end by CEF. Multiple convênios can sometimes be concluded for a single investment project, creating a fragmented system difficult for spending ministries to manage. In addition, subnational governments may not have sufficient capacity to properly prepare and execute projects, which creates an additional hurdle to the grantor ministry, which must find a way to support these municipalities to improve their project management capacity.

Brazil's large number of municipalities poses a real challenge to providing much-needed technical support. With over 5,500 municipalities, most needing to improve the delivery, quality, and reliability of infrastructure services, the federal government faces a real challenge to support even a reduced pool of municipalities. Neither BNDES nor CEF nor EPL, etc. have the capacity to fulfill this demand. Consequently, municipalities with at least some capacity are commonly prioritized. To add to this scenario's complexity, lenders typically select projects that have a higher chance of success, reducing the pool of candidates and projects further. CEF has adopted a more aggressive posture and is trying to establish itself as the go-to lender for municipalities seeking support with PPPs. Nevertheless, PPPs are a new business line for CEF and it may struggle to support low-capacity clients.

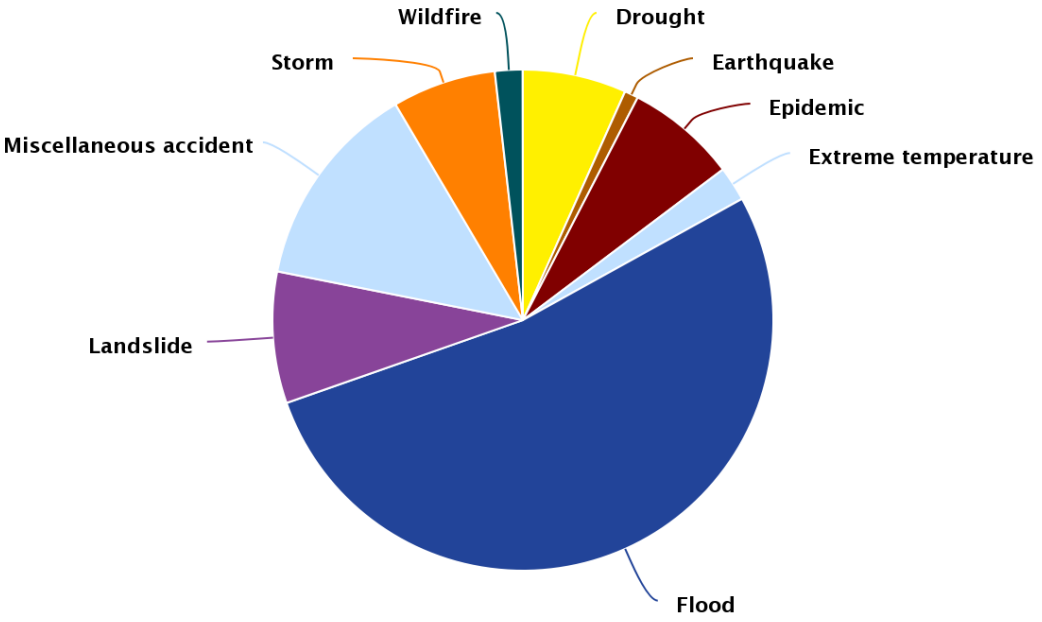
Climate Change: At the Confluence of Infrastructure and Productivity

Brazil is highly susceptible to climate hazards. Brazil frequently experiences extreme temperatures, flooding, severe droughts, and other weather-related disasters affecting the country's economic growth, infrastructure, ecosystems, and social development. Flooding is by far the most common disaster to affect Brazil (figure 3.9Figure 3.9). From 1900 to 2016, Brazil experienced 142 flood events resulting in a cumulative economic loss of more than US$6.1 billion. Over the same period, Brazil experienced 18 droughts causing more than $11.2 billion in economic damages and affecting almost 80 million people (World Bank 2021b).[47] Flash floods and induced mudslides are primarily responsible for deaths from extreme weather events, accounting for 74 percent of all weather-related deaths in Brazil from 1991 to 2010. Every year, Brazilian firms lose approximately US$22 billion (1.27 percent of GDP) due to infrastructure disruptions. The majority (55 percent) are caused by failures to transport infrastructure

[47] Given modern technologies for data collection, for example, remote sensing, are more accurate than historical techniques, and data gaps in historical records, these data may be underreported.

followed by power (44 percent) and water (2 percent). Vulnerability to climate-change-related shocks is a reality for one in every five Brazilians. Under the different climate scenarios, the number of days of extreme heat are expected to increase (World Bank 2022b). In 2021, a record drought led at least 53 cities in five states to ration their water supply. Aggravated by the chronic underinvestment in infrastructure, Brazil's climate change needs are complex and often competing.

Figure 3.9 Average Annual Natural Hazard Occurrence for Brazil, 1980–2020



Source: World Bank 2022b.

Vulnerable groups in urban areas are disproportionately affected by the impacts of climate change and extreme weather. Rapid urbanization over the past five decades has led people to build on unsafe areas such as floodplains and steep terrain, making them especially vulnerable to heavy rainfall and the flooding and landslides that ensue. Between 2009 and 2014, almost every highly populated municipality in Brazil was affected by flooding and about 50,000 low-income homes were destroyed (Debortoil et al. 2017). In 2011, floods, landslides, and mudslides in Rio de Janeiro claimed the lives of roughly 1,000 people and led to economic losses totaling 1.35 percent of the state's GDP (World Bank 2021b).[48] There is no shortage of weather-related disasters in Brazil.

The impacts of climate change and extreme weather are highly correlated to infrastructure planning. Without a robust mitigation strategy, the impacts of climate change and extreme weather events will continue to wreak havoc on the country's population, economy, and ecosystems. Adaptation and resilience are key to overcoming the anticipated rise in frequency and intensity of extreme weather events. The role of infrastructure is fundamental to mitigating impacts and increasing overall resilience,

[48] Given that modern technologies for data collection (e.g., remote sensing) are more accurate than historical techniques, and data gaps in historical records are not uncommon, these data are likely to be underreported.

especially in urban areas. A key goal of infrastructure planning must therefore be to secure economic growth while improving welfare.

Brazil's GHG emissions profile is different from that of most large GHG emitters. Brazil is the sixth-largest emitter of GHGs, primarily stemming from forestry and land use changes rather than energy (bolstered significantly by its reliance on hydropower). Still, emissions generated by the transport sector have important consequences, particularly given the proliferation of, and preference for, car ownership in Brazil's cities, where air pollution is a major problem. Furthermore, if the impact of infrastructure planning on land use changes is taken into account, infrastructure investments may have a significant, albeit indirect, impact on emissions.

Adaptation

The impacts of climate change on human and social capital, including poverty and labor productivity, predominantly affect Brazil's coastal cities. More than 85 percent of the country's population resides in urban areas and 25 of the largest urban areas generate 63 percent of the country's GDP. One-quarter of Brazil's population lives in coastal cities that are often flanked by large escarpments created by mountain ranges like the Serra do Mar rising steeply from a narrow coastal plain. These series of mountain ranges run parallel to the Atlantic coast from the southern part of the country's northeast down to the northern part of the southernmost state. This topography and geology facilitate weather-related disasters such as landslides caused by frequent torrential downpours in the rainy season. This is further aggravated by rampant deforestation and land use changes caused by urban encroachment and agriculture in areas unfit for human occupation like the urban fringe.[49] As climate change worsens, the frequency and strength of storms are likely to increase further aggravating these disasters.

Population growth patterns in Brazil have changed over the past 30 years, shifting to secondary cities. Since the enactment of the 1988 constitution, which further decentralized federalism in Brazil, urban population growth has gradually shifted toward secondary cities and smaller state capitals rather than major hubs like São Paulo or Rio de Janeiro. These smaller cities have limited capacity to manage urbanization and deliver urban services (World Bank 2022b). Urban infrastructure services, particularly when provided by municipalities, are often associated with market failures such as local public goods (e.g., flood control, land slide abatement efforts, street maintenance, etc.) and thus are lacking. Climate change impacts are augmented by this lack of infrastructure; the greater vulnerability of the poor, who inhabit the urban fringe and have less capacity to cope; and the increased propensity of disasters in these landscapes. Major disasters can be expected at the end of the rainy season in March and April. This year has witnessed major floods and landslides coupled with rapid infrastructure degradation and unfortunate loss of lives in populous states of the south and southeast of the country.

Regional and national infrastructure also needs to adapt to climate change and extreme weather-related events. While the national transport subsector is often subject to the impact of landslides during rainy seasons, the energy subsector gains from additional rains. Brazil's power sector is heavily reliant on hydropower as an energy source. This has clear advantages in terms of GHG emissions but makes the

[49] The urban fringe is defined as areas subject to urban expansion on the edge of cities and environmentally fragile urban areas (e.g., riverbanks, steep hills, canal edges, and floodplains). They are often unstable and unfit for occupation (Biller 2007).

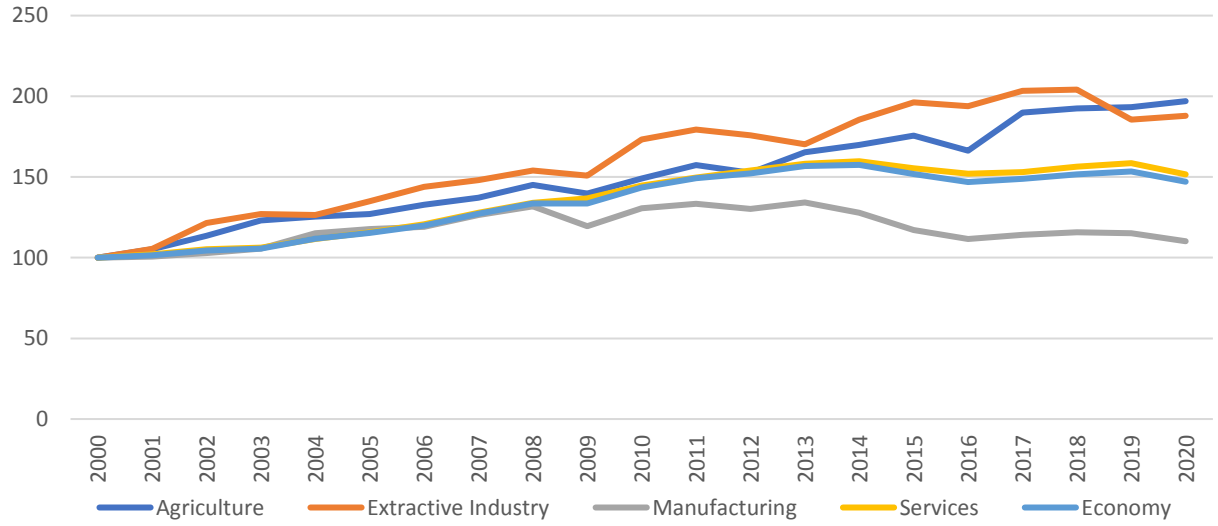
power sector vulnerable to extreme droughts, which are becoming more prevalent in the country. Essentially, hydropower dams act as batteries, and droughts deplete the energy stored in them. Alternative energy sources need to be connected to the grid so as to avoid blackouts, which increases the costs of provision. Depending on the energy source, it may also increase GHG emissions.

Outcomes are well understood and illustrate the significance of climate change impacts on infrastructure and productivity. While significant uncertainty is connected with the future intensity and frequency of weather-related events, historical outcomes demonstrate how infrastructure planning, designing, financing, managing, and regulating have been largely deficient across the country. The quality and gains made in the provisioning of certain services, like electricity and piped water, for which close to universal access has been achieved, is now threatened. Moreover, the amelioration and expansion of other services such as those linked to connectivity and/or to environment-related market failures (e.g., sanitation and sewage treatment) have been slow at best. This weighs down current and future productivity growth by increasing losses related to trade and diminishing access to education via health and other impacts.

Mitigation

Discussing climate change mitigation in Brazil means understanding how the country invests the proceeds of its recent natural-resource-dependent economic growth. Most of Brazil's GHG emissions come from land use changes, agriculture, and forestry (CAIT WRI data for 2016). Over the past 20 years, Brazil's agricultural and extractive sectors have experienced significant growth (97 and 88 percent, respectively), almost double that of manufacturing (figure 3.10Figure 3.10). This implies that the quality of growth matters: how a country reinvests the proceeds of this growth matters even more in determining its sustainability.

Figure 3.10 Growth of Gross Domestic Product by Sector (2000 = 100)



Source: System of National Accounts (IBGE).

Brazilian infrastructure investments have partially fostered unsustainable growth. Using natural capital to improve human, physical, and social capital, is not necessarily bad if sustainability is part of the decision-making process. Hartwick's Rule expresses the need to invest the proceeds of declining exhaustible resource stocks into renewable activities like produced capital augmentation, innovation, and factors that boost productivity (Hartwick 1977). While natural resources such as ecosystems, soil, and water, among others, have the capacity to regenerate, overexploitation can lead to extinction and market failures that may further constrain future growth once the resource is exhausted.

Land use change in Brazil, particularly in fragile ecosystems, suggests proceeds from the exploitation of exhaustible resources have been poorly used. Rather than experiencing a boost of productivity in different "renewable" sectors, Brazil seems to be falling behind countries that previously were less productive (table 1.1Table 1). Moreover, in order to continue to grow, Brazil has been engaging in increasingly unsustainable behavior such as the pattern of converting fragile ecosystems into productive lands and the occupation of unsafe, marginal lands. This ultimately drains scarce fiscal resources and degrades natural capital and deteriorates social capital. Additionally, as occupation mostly occurs on marginal land of lesser quality, the production potential is limited in time and scope requiring further expansion. The creation of new roads in rural areas and new streets in urban areas greatly contribute to this process by lowering the costs of land use changes. Since they are mostly publicly financed,[50] this is an additional example of fiscal waste.

While infrastructure-related sectors comprise about 30 percent of direct GHG emissions, indirectly some infrastructure may be contributing more to climate change. Any infrastructure investment that facilitates deforestation via the burning of forests and land expansion of the agricultural frontier is indirectly contributing to the increase of GHG emissions. By lowering transportation costs, new transport infrastructure such as roads enables the occupation of natural ecosystems and thus land use changes. Since the share of GHGs coming from land use changes, agriculture, and forestry is significantly larger than that of infrastructure and new road expansion, particularly in the Amazon region, it is important to diminish the costs of occupying primary forest land. The indirect effect on GHG emissions could be significant. Related efforts not only have consequences for global climate change, but also for air pollution in urban areas and loss of biodiversity. In the dry season, the consequences of ecosystem fires in the center-west impacted cities as far as São Paulo. Large urban areas of the country's north and center-west are also directly impacted. This has obvious consequences on welfare via health impacts among others and may impact GDP growth as well, given that most of the country's GDP is in urban areas.

By contributing to air pollution, ecosystem burning adds to the impacts of vehicles and point source urban emissions. Rising air pollution increases respiratory ailments, which decreases labor productivity. In effect, it trades off long-run production via productivity for increased production in the short run. Moreover, this agricultural expansion does not incentivize an increase in the productivity of existing agricultural land. A better use of fiscal resources could be diverting expenditures to operation and maintenance of existing transportation infrastructure, thereby limiting losses and improving efficiency.

[50] They can also be privately financed such as in the case of illegal logging and land grabbing.

The focus would be on increasing the productivity of existing factor inputs rather than expanding the agricultural frontier to marginal, less-productive land to secure higher short-run production.

Box 3.1 Decarbonizing Brazil's Transport Sector by Adopting the Avoid-Shift-Improve (ASI) Planning Framework

Decarbonizing Brazil's transport sector requires reconciling the population's growing mobility needs against the imperative of climate action and improved resilience. Transport has a central role in the development agenda, facilitating access to opportunities and services, and connecting local, regional, and global markets. Brazil's infrastructure investment needs are significant; however, investment decisions must avoid locking the country into an unsustainable, and costly to reverse, path. Approaches that reduce the dependence on roads and fossil fuels, without inhibiting growing mobility needs, can deliver immediate positive environmental, local economic, and welfare benefits. These strategies can be best achieved by adopting the so-called Avoid-Shift-Improve (ASI) planning framework, while enhancing resilience, which combines measures aimed at: (i) avoiding or reducing motorized kilometers traveled by efficiently integrating land use and transport, reducing unnecessary trips, and improving logistics; (ii) shifting travel to the most efficient modes (typically nonmotorized and public transport for passengers; rail, inland waterways, and well-run trucking and intermodal logistics services for freight transport) by strengthening the attractiveness and viability of these modes of travel and discouraging less efficient modes; (iii) improving existing forms of motorized transport through technological improvements and transport system management to improve freight logistics systems; and (iv) enhancing the resilience of transport systems, which demands a life-cycle approach that spans from system planning to engineering and design passing through operations and maintenance, contingency programming, institutional capacity, and reducing disaster risk mechanisms.

In this context, the risks, trade-offs, and economic impacts associated with the transition to a green transport sector were analyzed. The analysis focused on four main problems: (i) assessment of strategies to **avoid** motorized transport where possible through policies to shorten or reduce the frequency of trips, through "transit-oriented development"; (ii) strategies to **shift** transport demand to less-emission-intensive modes of transport; (iii) assessment of opportunities to **improve** the emissions performance of transport; and (iv) climate vulnerability assessment of the multimodal national transport network (including road, rail, waterway, and air transport).

Trade and logistics, primarily freight transport, play a vital role in economic development while at the same time representing a major source of greenhouse gas emissions in the transport sector. As a first-order issue in fostering Brazil's transport decarbonization, a significant change in the transport modal split could lead to a more environmentally friendly transport operation. Railways are a relatively fuel- and energy-efficient mode and they provide an attractive and economical alternative to other modes. However, considering that the country will still be dependent on roads in the short and medium term, increasing efficiency and promoting energy transition can have a comparatively larger impact on overall energy consumption of cargo movement in a much shorter timeframe. Therefore, electrified trucks and electrified locomotives could promote a real change and are crucial for a zero-emission scenario. Also, changes promoting the more efficient use of logistic operations (i.e., increased backhauling and truck occupation) and renewable fuels in general (including biofuels) are an important alternative for such a transition.

Transport infrastructure is vulnerable to the impacts of climate change and can lead to significant economic losses. The total value of transport assets exposed to climate risks totals over US$358 billion with flooding and landslides the main drivers of exposure. Climate adaptation investment in selected economic corridors will have a positive economic return, with US$2 of benefits for each dollar invested in adaptation. Total adaptation investment needs for the priority economic corridors equal US$470 million.

Additionally, effective emergency response mechanisms in the transport sector are critical to minimize economic losses due to traffic disruptions.

Transport is not the only infrastructure sector to affect air pollution. Although the Brazilian power matrix is one of the least carbon intensive in the world, its dependency on hydropower has been threatened by droughts and deforestation, periodically taking their toll on the availability of water to supply electricity. Additional hydropower potential is limited by scarcity and distance to urban centers. Throughout this millennium, Brazil has experienced an increased dependency on fossil fuel power generation, primarily natural gas. This is in part because of the large reserves found offshore in the country's southeast. Fossil fuel sources account for around 13 percent of the country's power generation. Biomass, wind power, and solar account for 9.1, 8.8, and 1.7 percent, respectively. Together with hydropower, they account for almost 85 percent of the country's power generation—well above the global profile. While wind power has witnessed growth in recent years, especially in the country's northeast, solar power generation has been timid despite experiencing a sharp fall in generation costs. A key decision to make is how Brazil will complement its dwindling hydropower potential. If it opts for fossil fuel sources, Brazil risks increasing its contribution to climate change and urban air pollution. This in turn threatens future productivity growth further via health impacts of increased urban air pollution.[51]

Box 3.2 Decarbonizing Brazil's Energy Sector =

Brazil's power system offers unique conditions to support decarbonization, and facilitate the decarbonization of other sectors through electrification. However, structural challenges may impede the sector's deep decarbonization. Brazil's offshore oil and associated gas reserves are among the largest in the world and Petrobras, the majority-public national petroleum company, accounts for 73 percent of the country's oil and gas production. Regarding the demand for coal, Brazil consumes the largest volume of coal in Latin America, dominated by the steel industry, but also including power production. Coal represents almost 40 percent of the sector's emissions. Importantly, the hydro-dominated power system is increasingly vulnerable to the effects of climate change, with the frequency and intensity of drought periods growing in recent decades, resulting in periodic energy crises that come with associated spikes in the cost of electricity. The current hydropower assets are aging, with an average age of 55 years for the large-scale hydropower assets, resulting in lower efficiency and capacity. Brazil's energy and climate change policies and laws have historically been strong in promoting renewable energy scale-up. However, recent policies and legislation have reduced ambition and set the country on track to increase energy sector emissions.

An exploratory decarbonization analysis was undertaken to identify policy priorities needed to accelerate decarbonization and resilience within the power sector, and support decarbonization of the economy more broadly. The analysis considered: (i) the cost impacts of reaching net zero emissions in the power sector by 2050 compared to the business-as-usual (BAU) power system expansion; (ii) the risks that climate change vulnerability pose to the power system and the cost of building resilience; and (iii) the costs to use the power system to support deep decarbonization of the energy sector, with a focus on transport and industry.

Using a low hydrology scenario, the model indicated that Brazil can obtain a resilient, net zero system at a slightly lower cost than a BAU system, which would be characterized by higher emissions with lower protection against hydrologic fluctuations. The power system can be efficiently utilized as a tool to decarbonize transport and industry, but will require massive investments for system expansion and deployment of innovative technologies, particularly if designed to be resilient to low hydrology. The overall economic costs of power system expansion

[51] See, for example: https://www.epe.gov.br/pt/abcdenergia/matriz-energetica-e-eletrica; https://www.eia.gov/international/analysis/country/BRA; and https://www.iea.org/countries/brazil.

to support increased electrification of the economy and fuel switch to green hydrogen are neutral, after taking into account the benefits provided to the transport and industrial sectors. Brazil's current thermal expansion plans bring significant financial and economic costs to the power system and economy overall. With the exclusion of the additional 8 gigawatts of new gas, Brazil could reach net zero at 20 percent lower cost compared to the net zero emissions in the power sector. Resilience can be designed with renewable energy resources and achieve a net zero scenario equally effectively as the BAU using the additional 8 gigawatts of new gas.

Decarbonizing the power sector can offer economic and fiscal benefits, improving economic competitiveness through lower tariffs and reduced fiscal outlays. Brazil can capitalize on its unique position and become a global leader in energy sector decarbonization and reap the benefits in terms of energy security, economic competitiveness, and leading on innovation. Also, Brazil can build resilience against climate change at a lower present cost under a net zero scenario than through the introduction of additional inflexible gas capacity. Private sector financing is expected to cover the majority of capital investments required to expand the power system, and existing fossil fuel subsidies could be redirected to support the energy transition in the isolated systems to minimize the fiscal burden on the public sector.

The key challenges of achieving deep decarbonization are the political economy and governance barriers to exiting thermal power, including the reversal of fossil fuel subsidies/tax benefits and the reversal of the gas capacity requirements set out in Law 14.182. Brazil's strategy for investments in its fossil fuel reserves will be taken in the context of high uncertainty regarding future demand. The government will need to assess the trade-offs between up-front investments and unknown long-term costs in designing its strategy to mitigate vulnerability of the power sector to climate change.

The alternative rests on the ability of the country to increase its reliance on renewables. In the short to medium run, substituting fossil fuel power generation for less polluting, renewable generation may not have a significant impact on productivity growth. Nonetheless, as the health impacts of urban pollution become more prevalent, this may be a factor to consider. Moreover, the overall energy transition from exhaustible to renewable power generation may occur with efficiency gains and a significant reduction in GHG emissions. In this transition and with generation costs plummeting, solar is likely to play a major role. This could further decentralize the system and thus diminish the reliance on single sources such as hydropower. Given the potential of residential generation via solar panels, it can even bring reliability to poorer dwellings where power provision is still informal and theft is rampant. The challenge, however, lies in the high fixed capital costs needed to ensure the transition (80 to 90 percent of total costs). Low interest rates that dominated global markets for the past 15 years have certainly helped with the global transition, but there are clear signs that this cycle is soon to be over. If Brazil is to embark in a significant manner on this transition to renewables like wind power and especially solar power, it cannot afford to wait much longer.

The lack of attention on climate change mitigation may lead to other casualties including stunting innovation. A number of technological advancements on climate-friendly activities are occurring, that is, the "green" economy. At face value, substituting an exhaustible energy source like petroleum for a new, renewable energy source like wind or solar may not have a direct impact on productivity; however, not engaging in decoupling economic growth from environmental degradation may delay the adoption of newer more efficient technology and hamper the promotion of innovation. An economy that does not innovate is unlikely to be able to boost its productivity and thus secure long-term sustained economic growth.

4. KEY RECOMMENDATIONS FOR SUSTAINABLE, LONG-TERM ECONOMIC GROWTH

Key Message 1

Reorient fiscal policy and increase public investments in infrastructure to stimulate the economy.

The level of public investment in infrastructure needs to increase substantially. Increasing investment is arguably the single biggest way for infrastructure to impact long-term economic growth, given the country's infrastructure gap. To meet and maintain the SDGs, total spending in infrastructure must increase by at least US$786 billion (or 3.7 percent of GDP per year) over the next decade. Private financing will be necessary to achieve this goal; however, Brazil must increase the level of public financing allocated to infrastructure.

Increasing public infrastructure investment will stimulate the economy. New research conducted for this report suggests the multiplier effect on Brazil's economy from public investment by the federal government is at least twice as high as that for public consumption and, although the evidence is currently less robust, the effect would appear to carry through at subnational levels. From a policy perspective, the implication is clear: reorienting spending to enable increased public investment in infrastructure by the federal government would stimulate the economy and lead to long term growth. Reverting to the essential question of how to undertake fiscal consolidation without hurting economic activity, it's clear the answer is to make better use of public spending.

Key Message 2

Establish a set of strategic investment and policy priorities to yield cost savings, and increase the country's productivity and global competitiveness.

Increasing the level of investment will have a direct impact on inclusion, productivity, and climate change if spent efficiently. Recent economic trends underscore Brazil's dependency on natural resources. Investing proceeds from finite resources, such as minerals and fossil fuels, into renewable resources, human capital, and technology, such as sustainable agriculture and forestry, education and innovation, can support Brazil's eventual transition to a more productive and sustainable economy. In addition, identifying and prioritizing key areas in need of urgent attention, such as the maintenance of existing road infrastructure, will lead to future cost savings and when combined with the sustainable expansion of rail and waterways will strengthen Brazil's position as one of the world's top agricultural producers and exporters. Meanwhile, investing in universal access to basic services and building resilient infrastructure as part of a broader disaster prevention and management program will help address Brazil's inequalities while safeguarding the country's future labor force.

a) Low levels of infrastructure investment have led to an imbalance in the supply of and demand for logistics services, which is partially responsible for the overreliance on roads, exacerbating existing quality challenges. Inadequate infrastructure, especially poor road conditions as well as limited rail and waterway services, are a severe bottleneck to the timely delivery of Brazil's fast-growing agricultural and mineral commodities (as well as general cargo) to the country's main export gateways. Poor road conditions lead to significant delays and increased costs for shippers, thereby

decreasing the competitiveness of multimodal transport operations and negatively impacting productivity and economic growth. However, repairs are often only undertaken once conditions have deteriorated to the point of impassibility, significantly increasing the costs of repair. Furthermore, Brazil's road infrastructure is ill-prepared for extreme weather events, exacerbating the extent of disrepair. Investing in road operation and maintenance will diminish existing production and transportation losses, increase transport times and logistics efficiency, potentially lower fuel consumption and thus vehicle emissions, and more importantly, increase overall productivity while boosting Brazil's global competitiveness.

b) Brazil currently ranks 56 out of 161 countries on the Logistics Performance Index (LPI), lagging Mexico, India, China, Canada, and the United States. Dropping 15 places since 2010, Brazil is the only BRIC country whose performance decreased. Brazil's vast dimensions, high heterogeneity of transport infrastructure, widespread distances between producing and consuming regions, and a transport matrix that is highly dependent on roads make for a complex logistics and freight system. This implies a number of economic, social, and environmental distortions, such as low fuel-efficiency, and high transport costs and emissions. Sustainably expanding Brazil's rail and waterways will strengthen its position as one of the world's top agricultural producers and exporters.

c) Brazil has achieved near universal access to several key infrastructure services. Notably, almost all Brazilians now have access to electricity and improved drinking water (figure 6). However, progress has been uneven and access to improved sanitation and adequate sewage treatment is significantly lagging. Access to high-quality infrastructure services is a function of income and geography and poor Brazilians (especially those living on the urban fringe) and indigenous peoples are disproportionately affected, jeopardizing the health and wellbeing of millions of Brazilians, and impacting the country's aspirations for an inclusive society. Allocating adequate resources to ensure universal access to affordable and reliable infrastructure services by 2030 will help Brazil address its longstanding battle to eradicate poverty.

   Brazil frequently experiences extreme rains, flooding, severe droughts, and other weather-related disasters that affect the country's economic growth, infrastructure, ecosystems and social development. Land use planning in Brazil has not kept pace with the rapid urbanization that has led to millions of Brazilians living in precarious environments and from 1991 to 2010, flash floods and induced mudslides accounted for 74 percent of all weather-related deaths in Brazil. Meanwhile, Brazilian firms lose approximately US$22 billion (1.27 percent of GDP) every year because of infrastructure-related disruptions. The majority (55 percent) are caused by failures to transport infrastructure followed by power (44 percent) and water (two percent). There is a clear need for resilient infrastructure as part of a broader disaster prevention and management program in Brazil that will require a concerted effort across all levels of government.

   Investing in universal access to basic services and building resilient infrastructure as part of a broader disaster prevention and management program will help address Brazil's inequalities while safeguarding the country's future labor force.

Key Message 3

Develop and implement a comprehensive infrastructure governance strategy that focuses on increasing technical capacity at subnational levels to increase private participation.

Brazil would benefit from overhauling its infrastructure governance framework beginning with an emphasis on capacity building. Brazil has one of the highest degrees of fiscal decentralization and strongest public-private investment (PPI) frameworks among Latin American countries. Some states have implemented significant private-public partnerships (PPP), indicating that subnational governments are critical to both public and private infrastructure investment. However, planning capacity in Brazil, especially at the subnational level, is comparatively weak and concentrated in a select few states and municipalities. Consequently, many states remain caught in a perpetual cycle of impoverishment given the lack of (i) good-quality, reliable infrastructure; and (ii) capacity to secure and regulate resources needed to expand access to, and maintain, new infrastructure. This is a key component of Brazil's legacy of inequality and a major hurdle to increased productivity and competitiveness that warrants the government's full attention.

Reforming the current PPP framework would encourage wider participation across all levels of government. Addressing the country's PPP pipeline will require project structuring alternatives to support the high number of projects from low-capacity municipalities and states, and new financial instruments, such as infrastructure funds and guarantees, to unleash private participation, sine qua non for wider use and implementation of the law by local governments. Brazil would also benefit from an enhanced privatization strategy that includes asset recycling programs and revising legal constraints that currently prevent guarantees for concessions and PPPs. This is especially pertinent to eliminating barriers to guarantees by subnational governments with less capacity.

Improvements within Brazil's business environment are needed to attract private investment. The benefits from increased private investment in infrastructure on productivity and long-term growth are well understood, but the direct and indirect benefits of attracting greater private investment to Brazil's transport sector, and especially the expansion of existing rail and waterway operations, could be exponential. For example, investing in short-distance transport lines would directly increase the density of Brazil's rail and waterway networks and improve access to multimodal transport services. In turn, this would increase competition among logistics providers; reduce reliance on Brazil's overburdened road networks, potentially reducing the frequency of maintenance, costs to shippers, and environmental impacts; increase employment opportunities; and increase Brazil's global competitiveness. Adjusting policies to incentivize private investment in rail and waterways could also help address demands from other industries as well as attract new markets.

Reorienting regulatory frameworks to incentivize better performance would increase Brazil's competitiveness. Brazil is one of the most closed economies among the G-20 countries. Domestic regulations that prevent competition and protect rent seeking are common, ranging from labor laws to inappropriate, subsidized credit from government institutions, such as development banks and government bailouts. These prevent improvements in the quality of infrastructure stocks and stifle innovation. This explains, at least in part, the long-run productivity lag prevalent in Brazil's economy. The lack of investment in quality is further aggravated by climate change. Existing investments and

infrastructure stocks fail to build adequate resilience to current and future climate change impacts, worsening the productivity lag and leading to a vicious cycle.

Shoring up existing gaps in regulatory governance would help mitigate political influence. Regulatory uncertainties can significantly increase perceptions of risk and undermine the economic viability of many projects. This results in political interference in regulatory agencies and discretionary policy shifts, which negatively affect perception of risk by the private sector increasing the cost of projects. An example of this is in the electricity subsector, where operators were persuaded to lower tariffs in exchange for the advanced renewal of concessions and additional public sector lending to the industry. The effects of such decisions undermine not just the sector in which they are implemented, but all other sectors as well, as confidence in already limited preestablished frameworks is undermined.

Regulatory frameworks must guarantee and safeguard transparency. Alleviating the different principal-agent problems associated with the provision of infrastructure requires the utmost transparency to observe and control the actions of agents. Transparency also allows civil society to hold the government accountable. An important focus of any sound reform agenda must therefore include increasing and ensuring transparency.

Specific Subsector Recommendations

A review of subsectors found most suffer from similar challenges: chronic underinvestment and an overemphasis on capital infrastructure to the detriment of maintenance programs; limited and/or skewed accessibility impacting opportunities and access to services; weak institutional strength, especially subsectors with programs that are regulated and/or implemented at the subnational level; and limited, or in the case of guarantees, thwarted, opportunities for private sector investment. Finally, all subsectors experience challenges related to the limited vertical integration of planning and programming and would benefit immensely from capacity building efforts and increased inter-agency coordination if not collaboration, especially between federal and subnational governments. Below is a snapshot of some of the most pressing challenges and recommendations faced by Brazil's infrastructure subsectors.

Transport and Logistics

Insufficient attention is given to routine road maintenance and Brazil's road network is suffering from accelerated degradation. Specific policy recommendations include adopting and implementing the Proactive and Resilient Investment and Maintenance Program to address fundamental challenges, increase resilience to climate change, and prepare road infrastructure for the implementation of intelligent transport systems. As maintenance begins to improve, consider preparing the road network for future fleet electrification and hydrogenation.

Improving the integration of Brazil's roads into a comprehensive, multimodal transport system will support efforts to improve logistics and increase future productivity while strengthening global competitiveness. Specific recommendations to encourage a more balanced logistics network include: (i) sustainably expanding the country's rail and waterways by increasing network densities and the number of multimodal terminals; (ii) revising policies to reduce market concentration and discourage oligopolies;

(iii) integrating the road freight tax system to discourage the use of less efficient routes; and (iv) ensuring new investments target greater synergies with return cargo operations.

The private sector has played a key role in financing, delivering and efficiently operating rail infrastructure since the network's privatization in the 1990's. Nevertheless, unaddressed gaps in the accounting framework prevent the use of guarantees, encouraging costly alternatives and holding back significant infrastructure development. The lack of standardization strongly contributes to lower operational efficiency of Brazil's rail system. Brazil should advance technical standards for railways to better integrate its logistics system. A simplified granting modality was recently sanctioned and there is a need to establish clear definitions regarding the authorization regime, to safeguard trunk corridors and limit space for policy-driven decision-making. With respect to commuter rail and metro systems, less than half of Brazil's states have rail-based transit systems. Brazil's commuter rail and metros are mostly operated by public companies, yet private sector participation has steadily grown. A lack of regulation has held back new private investments in passenger railway systems, particularly in smaller states.

Brazil is a highly urbanized country with 85 percent of its population living in cities mainly located along its vast coastline. Mass transit systems have seen a steady decrease in ridership over the last decade, a trend that was reinforced with the recent mobility restrictions arising from COVID-19. Brazil's cities have limited financial and technical resources for transport infrastructure/ Electromobility is still in its early stages and expected to evolve gradually and heterogeneously in the coming decades. Some areas for policy attention include: (i) reforming the regulatory framework to support municipalities to receive alternative revenues to support transit systems, (ii) promoting the use of electric vehicles for public transportation through financial and non-financial incentives to support energy transition to sustainable mobility, and (iii) supporting metropolitan authorities to integrate and monitor intermodal and metropolitan transport, including increased monitoring capacity with technology and innovation, fare integration and mobile payment, etc.

Energy

Brazil's power system can fully decarbonize without increasing costs when compared with the current business-as-usual (BAU) scenario providing an opportunity for the transport and industry sectors to decarbonize at minimal cost, thanks to electrification and green hydrogen. Going beyond the decarbonization of electricity generation, Brazil's power system can be used to efficiently decarbonize harder-to-abate sectors of transport and industry. Brazil's current thermal expansion plan is associated with significant financial and economic costs for the power system and economy overall. A net-zero scenario could be more resilient by replacing the 8GW of new gas with increased renewable energy capacity and storage to ensure security of the supply at a low additional net cost. Given Brazil's competitive advantages in renewable energy, the country could become a leading producer of green hydrogen. Brazil has exceptional prospects to produce, consume and/or export green hydrogen, which can help accelerate energy transition while diversifying exports and attracting investment.

Specific policy recommendations include: (i) leveraging offshore wind policies, deploying green and blue hydrogen infrastructure for domestic use and exports (incl. steel, etc.), and diversifying the ethanol market to maximize the long-term benefits and increased competitiveness of innovative, renewable electricity and frontier energies, (ii) developing Brazil's carbon market to reduce the costs of climate

inaction, and mitigate the risk of re-carbonizing the electricity sector, and stranded assets, (iii) repowering hydro, and increasing hydropower resilience as well as the electricity system's flexibility (e.g. transmission, storage, forecast, hydro hybridization) to manage electricity supply risks, and (iv) increasing the financial efficiency and stability of electricity distribution through, for example, net billing, time-of-use tariffs, improved cost management, non-traditional business models, and enhanced consumer protection.

Water and Sanitation

Brazil's institutional framework governing the water supply and sanitation sector is complex and fragmented. A new legal framework, approved in 2020, provides greater legal clarity especially for private operators, but its successful implementation, which is ongoing, could still be challenging. The new legal framework creates a more robust role for the national regulator, who is tasked with establishing national guidelines for the provision of WSS services. This is expected to resolve the country's long-standing problem whereby countless regulatory agencies with insufficient financial resources and structural capacity to enact and enforce local and state regulations, results in weak or even non-existent regulatory oversight that is subject to local political interference. The new framework also promotes competition between public and private companies, ensuring services are provided by the operator most capable of delivering on the terms of the contract. The federal government can help ensure the success of the new legal framework by coordinating its implementation and providing incentives for service providers and municipalities to align themselves with national guidelines. Alternative financing instruments for operators will be crucial to speed up the sector's expansion and ensure universal access, especially to adequate sanitation. Specific recommendations include: (i) developing and implementing a strategic plan, including models, to rapidly expand access in under-served areas, ensuring its integration with policies and investments for land use planning and social housing, and (ii) supporting a water secure future, adopt and implement an integrated water resources management strategy for planning and use that include resilient infrastructure.

Digital Development

The number of Brazilians using the internet rose from less than 3 percent of the total population in 2000 to over 70 percent in 2018 and Brazil has excellent first and middle-mile connectivity. Still, the number of households with a fixed broadband subscription remains relatively low (less than 50 percent), limiting opportunities. These indicators are well below the OECD average and partially reflect the relatively high cost of subscription charges. The quality of services is subpar and although Brazil has a good fiber optic network, fixed broadband speeds are below all benchmarks, including LAC. While 3G and 4G coverage are comparable to OECD and high-income benchmarks, 5G is just emerging. Consequently, its deployment is below all benchmarks, except within LAC. Brazil's infrastructure, colocation market, and cloud services are exceptional, though mostly concentrated in the southern regions.

Some potential policy recommendations include i) Enhancing co-ordination among federal, state and municipal levels to promote deployment, and the quality and reliability of services; ii) Initiating the implementation of projects funded by the universal service fund (FUST) to improve connectivity, including connecting schools and support for the newly created Group for Monitoring the Costing of School

Connectivity Projects; and iii) Implementing the National Cybersecurity Strategy by establishing a wide community of digital security leaders from the public and private sectors.

Concluding Remarks

The evidence is clear: Brazil must increase public spending on infrastructure and spend more wisely and efficiently. This is all the more urgent in the context of Brazil's extreme climate variability and reliance on exhaustible resources. The reform agenda proposed in this report comprises three overarching recommendations centered on: increasing investments in infrastructure, defining priority investment areas, governance and capacity building, and increasing private sector participation. The need to increase public investment is obviously critical, yet the proposed reform agenda is unlikely to succeed without addressing the most important factor that has historically limited the infrastructure sector's progress: capacity. No amount of funding will resolve Brazil's infrastructure challenges without a substantial investment in capacity-building resources. Brazil must develop and implement an extensive capacity-building program. This will require buy-in, coordination, and rigor across all levels of government with a particular emphasis on bottom-up approaches. Increased capacity will be especially crucial to tackling resilience, sustainable energy, and increased private sector participation, in addition to achieving universal access to quality infrastructure services.

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Appendix A. Detailed Policy Recommendations by Subsector

A review of key subsectors found that most suffer from similar challenges: chronic underinvestment and an overemphasis on capital infrastructure to the detriment of maintenance programs; limited and/or skewed accessibility impacting opportunities and access to services; weak institutional strength, especially subsectors with programs that are regulated and/or implemented at the subnational level; and limited, or in the case of guarantees, thwarted, opportunities for private sector investment. Finally, all subsectors experience challenges related to the limited vertical integration of planning and programming and would benefit immensely from capacity-building efforts and increased interagency coordination if not collaboration, especially between federal and subnational governments.

Key policy recommendations have been summarized in a table for each subsector. When available, more detailed descriptions have been provided.

Digital Development

Remarkably, the number of Brazilians using the internet rose from less than 3 percent of the total population in 2000 to over 70 percent in 2018. Brazil has excellent first- and middle-mile connectivity, with connections to 15 submarine cable systems and a dense and growing optical fiber backbone. Still, the number of households with a fixed broadband subscription remains relatively low (less than 50 percent), limiting opportunities. These indicators are well below the Organisation for Economic Co-operation and Development (OECD) average, and partially reflect the relatively high cost of broadband subscription charges. For example, a fixed-line monthly broadband subscription is estimated to cost 2.4 percent of the average per capita monthly income and a mobile monthly broadband subscription exceeds 4 percent, above the industry's affordability target of 2 percent and inaccessible to the bottom 40.

While 3G and 4G coverage are comparable to OECD and high-income country benchmarks, 5G is just emerging and therefore, its deployment is below all benchmarks, except within Latin America and the Caribbean (LAC). In terms of data infrastructure, Brazil's infrastructure, colocation market, and cloud services are remarkable, although infrastructure is mostly concentrated in the southern regions. Brazil has 47 internet exchange points (IXPs), 73 colocation data centers, and 12 cloud on-ramps (to lower costs of data sharing, scalable and flexible deployment options, lower capital spending, and access to innovative applications) also in the south.

Quality of both fixed broadband and mobile services are below benchmarks. Although there is a good fiber optic network, fixed broadband speed is below all benchmarks, even LAC. Average download speeds of mobile services are below both OECD and high-income country benchmarks.

Table A.1 Key Findings and Potential Policy Recommendations: Digital Development

Key Findings	Potential Policy Recommendations
• The rural-urban divide is considerable, with 85% of the urban population (aged 16–74) using the internet, compared to only 52% in rural areas (IBGE 2021). • More than half of fixed broadband subscriptions (58%) exhibited speeds above 12 megabits per second in June 2019. • In 2020, Brazil approved legislation (Law 14109/2020) governing the USF to expand broadband services. One of the first projects proposed is to improve connectivity in schools. • Brazil suffers from more cyberattacks than any other country in LAC with an average of 1,390 attacks per minute. • Claro and Telefónica's 5G networks now serve 15 and 8 cities, respectively.	• Enhance coordination among federal, state, and municipal levels to promote deployment, and the quality and reliability of services. • Initiate the implementation of projects funded by the Universal Service Fund (USF) to improve connectivity, including connecting schools and support for the newly created Group for Monitoring the Costing of School Connectivity Projects. • Implement the National Cybersecurity Strategy by establishing a wide community of digital security leaders from the public and private sectors. • Support the Monitoring Group for the Implementation of Solutions to Interference Problems in bands 3,625 to 3,700 megahertz (GAISPI) to accelerate 5G deployment.

Electricity

Brazil's electricity sector has been going through a series of crises, creating pressures on tariffs. Since early 2020, three crises have impacted the sector: (i) COVID-19; (ii) extreme drought; and (iii) the global fuel crisis, with inevitable consequences on tariffs.

The first crisis led to a reduction in consumption, and consequently an increase in tariffs to cover costs that were unaffected by the decrease in demand (e.g., transmission and distribution charges and power generation). Then, in 2021, Brazil experienced the worst drought in almost 100 years of hydrological records. This led to an explosive increase in distribution expenses to cover associated costs, especially those related to the significant increase in thermoelectric generation, and consequently unsustainable cash deficits that reached more than R$12 billion by the end of the year. Exceptional measures were needed to cope with the severe hydrological conditions, the most important being the implementation of the "Water Shortage Tariff Flag" of R$142/megawatt-hour, applied from August 2021 to April 2022 for all captive consumers. The third, and most recent, crisis is a result of the Russia-Ukraine war, which triggered an international fuel crisis that has impacted supply costs for Brazil's isolated systems. In addition, the rise in fuel prices impacts inflation indices (both IGPM and IPCA), against which almost all Brazilian electricity sector (SEB) contracts are indexed. As a result of these crises, the electricity sector has become significantly indebted.

However, the need for recent tariff adjustments is symptomatic of a deeply outdated model. Over the years, a series of charges and taxes have been added to the sector's bill. Taxes currently account for 32 percent of the average composition of an electricity bill. On the other hand, system "charges," which include subsidies that have been charged to the system, represent 11 percent, more than double that of transmission. Such structural problems within the sector have increased the intensity of the effects of the recent crises and it has become essential to revisit the sector's model. For example, among the system

charges is the Energy Development Account (CDE), which costs more than double that of the entire transmission system. A significant portion of the CDE is related to discounts for transmission and distributions (tariff for the use of the distribution system [TUSD]/ tariff for the use of the transmission system [TUST]). Specifically, 61 percent is related to subsidies for renewable sources, while the remaining difference is related to other discounts (e.g., irrigation, rural, water and sanitation, etc.).

At the same time as the sector was weathering these crises, the privatization law for Eletrobrás (Law no. 14.182 of 2021) came into effect mandating quotas for natural gas from thermal plants.[52] The energy from these plants will be considerably more expensive than energy from other sources capable of fulfilling the same functions for several reasons: (i) the high price of natural gas, especially since the beginning of the war in the Ukraine; (ii) the location of several plants far from natural gas reserves and far from the main load centers, resulting in the need for new pipelines (as well as new transmission lines to bring the power to the load centers); and (iii) high dispatch inflexibility.

Additional costs associated with the new law include: additional subsidies for small hydroelectric plants (PCHs) and extending the PROINFA program (Incentive Program for Alternative Sources of Electric Energy), with the future costing of plants at prices far above the costs of new renewable energy projects. The economic impact of the so-called "jabutís" could be enormous. A recent analysis found the impact of implementing the law would result in US$25 billion (50 percent) in higher costs (to 2050), while greenhouse gas emissions in 2050 would be 30 percent higher. This work commissioned by the World Bank shows that that the present cost (to 2050) of the net zero scenario would be equivalent to the cost of implementing the new law.

Congress is currently discussing Bill No. 414/202129 (PL 414) on the sector's modernization. The new regulatory framework proposal is based on six major topics: (i) rationalization of subsidies; (ii) new model for contracting the adequacy and reliability of supply; (iii) market opening; (iv) long-term sustainability of the distribution sector; (v) treatment of some generation, transmission, and distribution concessions; and (vi) improvement in price formation. Of these, the first three have special relevance to tariff reforms and would affect the majority of the population.

The three main challenges associated with subsidies are: (i) the tight time frame for new renewable projects to start operations in order to retain the discount on the transmission tariff; (ii) prohibiting the application of the discount on the transmission tariff for low-voltage consumers who migrate to the free market and buy energy from incentivized sources; and (iii) limiting subsidies to remote self-production operations. The end result of these limits on subsides will be a long-term reduction of the CDE and, therefore, the average tariff for final consumers.

The new law also introduces a new model for supply reliability contracting, also called separation of capacity (or lastro in Portuguese) and energy, which aims to separate the contracting of supply reliability (currently embedded in the physical guarantee of energy and power capacity) from the contracting of

[52] This law included among its provisions the obligation to contract 8 gigawatts from natural gas thermal plants by 2030. These thermal plants will be contracted as reserve energy in 15-year contracts at prices corrected from the 2019 A-6 auction and must generate annually at least 70 percent of their power. In addition, the law establishes several parameters for their location, mostly in regions that do not have a natural gas supply point. The first auction, for 2,000 megawatts, is scheduled for September 2022.

energy commodities. This aims to ensure the proper allocation and distribution of costs associated with reliability to all consumers.

Finally, the new law includes measures to ensure the open market will be economically and financially sustainable, notably: (i) a new charge for overcontracting; and (ii) the so-called "regulatory backpack." The costs of overcontracting resulting from migrating to the free market will be shared between captive and free consumers. This charge, from the regulated consumer's point of view, will radically change their current reality, where costs with overcontracting due to migrations to the ACL (the free electricity market) are recognized as involuntary and, therefore, passed on to captive consumers only. Finally, the regulatory backpack means all charges paid by a captive consumer will be "carried" (in case of migration to the ACL) to avoid migrations only with the bias of cost "leakage."

In short, the revisions currently under discussion are a formidable window of opportunity for Brazil, considering its competitive advantage for renewables, to approach a net-zero-carbon economy.

Table A.2 Key Findings and Potential Policy Recommendations: Electricity Sector

Key Findings	Potential Policy Recommendations
	• Maximizing long-term innovation and competitiveness benefits from renewable electricity and frontier energies: offshore wind policy, green and blue hydrogen infrastructure deployment for domestic uses and exports (including steel, etc.), and ethanol market diversification. • Reducing cost of climate inaction and risk of electricity sector "recarbonization" and stranded assets: carbon market development. • Managing electricity supply risk: repowering hydro, increasing hydropower resilience and the electricity system's flexibility (transmission, storage, forecast, hydro-hybridization). • Strengthening the financial strength of the electricity distribution sector: net billing, time-of-use tariff, management of system's costs, development of nontraditional business models, consumer protection.

Transport

Roads

Little attention is given to maintenance and roads are suffering from accelerated degradation, partially due to climate impacts. Only a small fraction of the road network is maintained per year meaning the majority of roads are not repaired until conditions are deplorable, thereby significantly increasing maintenance costs. The Proactive and Resilient Investment and Maintenance Program (PRIMP) seeks to correct this institutionalized problem by changing the way road assets are managed. Instead of waiting until roads are at the end of their life cycle, roads in moderate condition are prioritized, spreading the cost of maintenance over time. The rehabilitation of road segments in extremely poor condition is prioritized using established criteria on use, density, and strategic importance. Another important

measure is the change to design-build-maintain type contracts set using global prices with interventions defined based on budget availability and programs for most of the road network. Finally, the PRIMP seeks to implement intelligent transport systems (ITSs) to improve the operation of highways, and the use of Optical Character Recognition (OCR) (e.g.,, to identify license plates) and drones for better monitoring, thus facilitating user access to services offered.

Brazilian road infrastructure is not prepared for extreme weather events. Brazil's transport sector and road infrastructure in particular are insufficiently prepared for present and future climate change impacts. The government must invest more heavily to create a resilient road network. Drainage systems must be improved including conducting detailed hydrographic studies and improving the drainage and storage of rainwater. Vulnerable areas should be mapped and routinely monitored. Together with the changes proposed in the PRIMP, climate change impacts will be more readily managed.

Integrate the road network with other modes of transport, especially railways, improving the logistical infrastructure for the flow of, among other things, agro-industrial production. A more detailed socioeconomic study on integrating the various modes of transport, with a focus on railways, is needed. Such a study should include the schedule of works and interventions aimed at improving the efficiency of transport logistics, economic development for the rural population, and reducing costs. This is key to reducing the average number of vehicle kilometers per trip. Multimodal transport can impact the likelihood of road accidents by reducing the extreme lengths travelled and driver fatigue.

Prepare road infrastructure for alternative energy sources (e-mobility and hydrogen). Also, prepare the road network in the country for addressing the future electrification and hydrogenation of the fleet in the country.

Improve road safety and road traffic enforcement in Brazil to reduce the number of traffic-related deaths. By investing in better road maintenance and safe road design, enforcing traffic violations (e.g., drug and alcohol abuse, speed enforcement, risky drivers, etc.), and promoting behavior change, Brazil can reduce the average number of traffic-related deaths and injuries suffered by Brazilians. Specifically, ITSs/OCR/drones can be leveraged to conduct a survey of critical points of accidents on highways and support the implementation of countermeasures to reduce accidents.

Table A.3 Key Findings and Potential Policy Recommendations: Roads Sector

Key Findings	Potential Policy Recommendations
• Little attention is given to maintenance and roads suffer from accelerated degradation. • Brazilian road infrastructure is not prepared for extreme weather events. • Brazil's transport system is not integrated and relies heavily on the road network. • Almost half (45%) of all energy-related CO_2 emissions stem from vehicles. • Traffic-related accidents are one of the leading causes of death in the country, especially among young people.	• Support adoption and implementation of the PRIMP, including preparation of road infrastructure for the implementation of intelligent transport systems (ITSs). • Support initiatives designed to increase resilience to climate change. • Integrate the road network with other modes of transport, especially railways, improving logistics for the flow of, among other sectors, agro-industrial production. • Support the transition to electric vehicles. • Support measures designed to improve road safety.

Ports

Brazil has an extensive coastline of 8,500 navigable kilometers responsible for more than 90 percent of all exports. There are 36 ports in the country, administered by dock companies, or delegated to municipalities, states, or public joint ventures. Over the last 25 years, the export volume at ports has tripled, propelled by road expansion and rail resurgence. Consequently, port access infrastructure has become the sector's major bottleneck, including rail, road, and oil pipelines—each one controlled and regulated by a distinct entity.

An integrated logistics approach for transport infrastructure planning, involving different modes of transport at the national and regional level, is key for the country to level up logistical efficiency. The adoption of cross-sector commitments, such as the obligation to provide connectivity land and maritime concessions, can help the development of integrated corridors. Moreover, different transport regulatory agencies should be guided primarily by the National Logistics Plan, in order to facilitate dialogue, while avoiding infrastructure gaps and miscoordination.

Table A.4 Key Findings and Potential Policy Recommendations: Ports Sector

Key Findings	Potential Policy Recommendations
• The rapid expansion of exported volume has led to bottlenecks in the infrastructure for accessing ports. • Difficulty coordinating different regulatory entities involved in port operations (e.g., roads, railways, waterways, and pipelines.	• Adoption of cross-sector commitments, including obligations of complementary investments in other modes of transport. • Better coordination of regulatory agencies, guided primarily by the National Logistics Plan.

Railways: Freight

The private sector has played a key role in financing, delivering, and efficiently operating rail infrastructure since the network's privatization in the 1990s. The first wave of investments, however, was targeted at rehabilitating existing infrastructure rather than expanding coverage. Moreover, most of the network granted so far features the fortunate combination of well-known demand and low intramodal competition. The way forward is more complex: the network's expansion will require substantial investments, which are intrinsically linked to financing challenges resulting from an absence of revenues in the early years, precisely at the stage of intense disbursements.

Nevertheless, unaddressed gaps in the accounting framework prevent the use of guarantees, encouraging costly alternatives and holding back significant infrastructure development. So far, Brazil has not been able to launch a public-private partnership (PPP) at the federal level, and attempts to create a guarantee fund, such as ABGF[53] and FGIE,[54] have also failed. The country must urgently carry out the

[53] The Brazilian Agency for Management of Guarantee Funds and Guarantees (ABGF) is a public company, created by law and linked to the Ministry of Economy. Among its purposes is the role of providing guarantees for concessions and PPPs.

[54] The Infrastructure Guarantee Fund (FGIE) is a private fund administrated by ABGF, created in 2014, with the purpose of guaranteeing, directly or indirectly, coverage for any risks, including nonmanageable ones, related to concessions. In May 2021, the congress approved a Provisional Measure allowing the government to restructure the FGIE and to capitalize it up to US$2.2

necessary accounting reforms to enable such instruments. Such a measure would accelerate investments, enabling assets to be built without up-front public sector spending and avoiding inefficient and costly alternatives, such as escrow accounts and revenue earmarking. In addition, the aforementioned reform will be crucial for building market confidence and demonstrating the government's commitment to its infrastructure program and fiscal stability.

The lack of standardization strongly contributes to lower operational efficiency of the Brazilian rail system. Infrastructure sharing is particularly inefficient due to mismatches in signaling, track specifications, and gauging. Moreover, the absence of stringent signaling specifications and regulations means the industry must develop bespoke solutions and operators end up with little choice but to depend on private suppliers for maintenance and upgrades.

Brazil has to advance technical standards for railways to better integrate its logistics system. Following the example of the European Union Agency for Railways and other international experiences, the country should establish comprehensive norms for interoperability, covering a wide range of topics such as: infrastructure specification (gauges, track capacity, geometry, etc.), signaling and telecommunication rail systems, traction and alternative fuels, as well as rolling stocks. This would help not only support logistics but also has the potential to promote the consolidation of the national rail sector and Brazil's penetration of the global railroad parts and equipment market.

A simplified granting modality was recently sanctioned, yet the criteria to determine when to apply each modality are still unclear. In December 2021, Brazil introduced a new law (the so-called authorization regime) to attract private investments for the expansion of Brazil's railways. Under this new regime, private entities can develop and operate railroads without a bidding process. Technically, the choice between concession and authorization would depend on the most suitable mechanism, according to each project's business model. Authorization should be restricted for segments where there is no demand explicitly identified to the point of justifying a concession, and financial viability that allows for the payment of grants. In these cases, companies interested in connecting destinations by rail and/or lowering the costs of logistics at their own risk could have segments granted through the simplified modality. Concessions must remain the preferred model for trunk corridors since they constitute the strategic backbone for the national logistics system. So, it is in the government's interest to secure its ownership. Additionally, concessions are subject to more stringent regulations to prevent market discrimination and monopolies, in addition to enabling the collection of fees.

Authorization can be a valuable tool to attract investments. In specific cases, authorization can help Brazil achieve its logistics and climate goals, but if indiscriminately used, can potentially deregulate the sector and affect the National Logistics Plan. Such concerns should be clearly addressed to limit space for politically driven decisions. Moreover, although lowering restrictions is necessary to encourage the private sector's participation in nontrunk projects, the government must still maintain some level of

billion (R$11 billion) for: (i) structuring infrastructure projects; (ii) backstopping concession risks, through guarantee instruments; and (iii) participating in regulated investment funds. The provisional measure also mentions that projects located in the north, northeast, and mid-west will have preference (https://www.in.gov.br/en/web/dou/-/medida-provisoria-n-1.052-de-19-de-maio-de-2021-320936333).

control over competition, clearly setting forth criteria for approval and rejection of proposals as well as environmental and social safeguards, through public disclosure and universal access to information.

Table A.5 Key Findings and Potential Policy Recommendations: Railways/Freight Sector

Key Findings	Potential Policy Recommendations
• Innovation in contracting mechanisms to attract private investment and decentralize the sector. • Technical challenges in operating the rail network have affected its efficiency and logistics integration across the country. • Consolidation of the emerging regulatory framework and authorization regime.	• Reforms in the accounting framework to accommodate payment and credit guarantee mechanisms. • Establishment of comprehensive norms for interoperability, to promote standardization of railways. • Clear definitions regarding the authorization regime, to safeguard trunk corridors and limit space for policy-driven decision-making.

Railways: Commuter Rail and Metro Systems

Less than half of Brazil's states have rail-based transit systems. Among Brazil's 26 states plus the federal district, only 12 offer commuter-rail-based transport. While regional and long-distance railways exist, for example, Vale currently operates two regional trains (Vitória a Minas Railroad [EFVM] and Carajás Railroad [EFC]), capacity restrictions and low speeds mean they operate more like a tourist attraction than a competitive transport alternative. Metro systems, on the other hand, play an important role in large metropolitan regions, providing mass transit services in dense areas such as São Paulo and Rio de Janeiro, where the majority of the commuter rail system is also located. In 2018, 3.7 billion passengers were transported by metro and commuter rails across the country, averaging 10.9 million passengers per day.

Brazil's commuter rail and metros are mostly operated by public companies, yet private sector participation has steadily grown. During the 1990s, part of the passenger rail system was transferred from the federal government to the states. Remaining commuter networks, however, are still linked to the federal government, administered by a state-owned enterprise, the Brazilian Urban Transport Company (CBTU), which is planned to be privatized. Today, the two largest metro systems, São Paulo and Rio de Janeiro, are partially operated by private entities and in 2021 São Paulo granted the first two commuter rail lines to the private sector, through a transaction structured by the International Finance Corporation.

A lack of regulation has held back new private investments in passenger railway systems, particularly in smaller states. Even the most developed states regulate current concessions by contract, without having an established framework. Rail mobility projects require substantial investments and, in most cases, farebox revenues are insufficient to fund operational costs and recover the investment, resulting in public subsidies. Therefore, having a well-established regulatory framework is crucial for attracting the private sector to support the expansion and privatization of systems. Governments must also seek other sources of funding to support urban rail development, such as transit-oriented development, land value capture, infrastructure development charges, and so on.

Table A.6 Key Findings and Potential Policy Recommendations: Railways/Commuter Rail and Metro

Key Findings	Potential Policy Recommendations
• Incomplete decentralization of passenger rail from the federal to regional governments. • Lack of a regulatory framework for passenger railways.	• Rapid conclusion of transfer of passenger rail network to regional governments. • Create specific regulation for rail passenger systems at national level, acting as guidance for regional regulations and to attract private investment.

Urban Mobility

Mass transit systems have seen a steady decrease in ridership in the last decade, a trend that was reinforced with the recent mobility restrictions arising from COVID-19. There was a huge drop in bus ridership in Brazil in 2020, but public transport has been losing passengers for a decade now—mostly to private vehicles (cars and motorcycles). The motorization rate increased from 19.6 cars per 100 inhabitants in 2008, to 31.5 cars per 100 inhabitants in 2018, that is, in 10 years there was an increase of more than 50 percent in the Brazilian motorization rate (Observatory of the Metropoles 2019). The reduced demand of mass transit systems, in turn, contributed to a decreasing ability of the concessionaires to maintain adequate service levels and meet contractual service obligations, making it more difficult to retain passengers.

The federal government, through the Ministry of Regional Development, defines overarching laws and policies that support and guide the subnational governments to regulate and finance urban transport, but state and municipal governments are responsible for urban transport planning and financing. The National Urban Mobility Policy was approved in 2012[55] and guides how cities should plan and regulate their urban transport systems. Among other things, it prioritizes sustainable modes of transport—public and active transport—and drives cities to plan urban transport to reduce social inequalities and improve urban mobility accessibility conditions. It also mandates that all cities with over 200,000 people must develop an Urban Mobility Plan.

However, Brazilian cities have limited resources dedicated to transport infrastructure, in most cases insufficient to face the rapid process of urban growth, and need further regulation to tax private vehicles and promote investment capacity. In Brazil, most trips are nonmotorized (43 percent), followed by those made in private vehicles (29 percent) and public transport (28 percent). Although in larger urban areas like São Paulo the share of nonmotorized transport is lower and of public transport higher—closer to 35 percent—major investment in low-carbon and climate-resilient mass transit systems, such as bus rapid transit systems, can provide high-quality services at an affordable cost.

In most Brazilian cities, the operation of public transport—especially bus systems—is financed only by the passenger's tariff, which is showing not to be financially sustainable. São Paulo, Curitiba, and Brasília are three of the few cities that offer subsidies to municipal bus transport systems. Subsidies are more common for metro and urban rail, as seen in Fortaleza, Belo Horizonte, and Porto Alegre. Cities have been discussing subsidies and alternative sources to finance public transport and tax private vehicles, which could be supported by the further regulation of the National Urban Mobility Plan, including a regulatory

[55] Law No. 12.587/2012.

framework to support municipalities to receive auxiliary revenue (from publicity, retail, real estate), additional gasoline/diesel taxes, emission taxes, parking management revenue, congestion and emissions taxes, and land value capture mechanisms. In addition, contractual reforms are necessary to revamp bus systems, changing business models and remuneration formulas by unbundling operations from fleet provision and fare collection to increase system efficiency and improve services. Many cities around the world have been managing their bus services through a two-tier model, where the public sector is usually responsible for infrastructure development, service planning, and regulating and managing operations, while the private sector procures bus fleets, operates bus services, and manages fare collection according to specifications and standards set in contracts. Some cities at the forefront of urban mobility have been successfully testing different operational models that unbundle bus operation services from fare collection and fleet provision to leverage the specialization of each providing agent.

In Brazil, electromobility is still in the early stages and is expected to have gradual and heterogeneous evolution in the coming decades. A scalable roll out of e-buses will happen slowly, with more intense gradual adoption in regions that are denser and with higher income, such as São Paulo, as it will require some level of public investing or subsidies because of higher initial capital investments. Unbundling fleet provision and operation has proved to be an attractive model for international investors and also enables the introduction of electric buses in the fleet. Although e-buses offer much lower operational costs, they have considerably higher up-front capital costs than diesel buses.[56] Most bus operators do not have access to credit to purchase high-cost e-buses; therefore, the current operational model ends up delaying the deployment of greener public transport. Therefore, the reform of contracts is expected to improve the efficiency of the system, as well as advance the electrification of the fleet, and ultimately attract more users to public transport.

[56] In Brazil, e-buses are four times more expensive than diesel buses.

Table A.7 Key Findings and Potential Policy Recommendations: Urban Mobility

Key Findings	Potential Policy Recommendations
• Mass transit systems have seen a steady decrease in ridership in the last decade, a trend that was reinforced with the recent mobility restrictions arising from COVID-19. • Transport systems have been struggling to survive with tariff revenues only. • Demand for cars and motorcycles have been increasing, leading to increased greenhouse gas emissions and road incidents. • There are few incentives for municipal operators to buy e-buses. Brazil manufactures and exports diesel buses and does not have import tax exemptions or incentives for manufacturing e-buses. • There are few incentives to improve road safety and adequate infrastructure to promote sustainable active mobility.	• Regulatory framework to support municipalities to receive alternative revenues to support transit systems (e.g., additional gasoline/diesel taxes, emission taxes, tariff stabilization funds, parking management revenue, congestion/emissions taxes, ancillary revenue, land value capture, etc.). • At the subnational level, reform bus contract models by (i) unbundling operations from fleet provision and fare collection management to leverage private sector participation and increase system efficiency; and (ii) changing the remuneration formula to improve service quality, by remunerating costs and performance as well as implementing technical and user tariffs to reduce demand risks. • Promote use of electric vehicles for public transportation through financial and nonfinancial incentives, to support energy transition to sustainable mobility (e.g., regulations that limit emissions, specific credit lines/funds, fiscal incentives to stimulate local supply, federal government co-financing with subnational governments to increase scale and lower the price of e-buses, etc.). • Transport regulations that prioritize sustainable modes (increased street space for active transport, curbside management, traffic calming, mobility-as-a-service, etc.). • Support metropolitan authorities to integrate and monitor intermodal and metropolitan transport, including increased monitoring capacity with technology and innovation, fare integration, mobile payment, etc.

Airports

The private sector has played a key role in financing, delivering, and efficiently operating Brazil's airports through a program of PPP concessions. The operation and investment of the country's largest airports in terms of passenger traffic have been transferred to the private sector. During the last decade, consortiums led by global airport operating companies with proven experience in the field have competed through public tenders to achieve 20- and 30-year contracts to upgrade and operate airfields and terminals. Since 2011, this program has managed to attract the largest international airport operators such as Munich Airport, Zurich Airport, Egis, Changi Airport, Fraport and Vinci Airports. A total of 44 airports have upgraded their infrastructure to comply with international standards of safety, security, and level of service for an aggregated amount of US$15 billion. Another 17 airports are projected to be tendered in 2022 (among them are Rio de Janeiro Santos Dumont and São Paulo Congonhas, both of them being the largest domestic hubs of the country along with São Paulo Guarulhos).

While in the first rounds of concessions the National State had maintained a 49 percent share in the operating companies (among them, those of São Paulo Guarulhos, Rio de Janeiro Galeao, and Brasilia), starting in the fourth round that took place in 2017 the government decided not to hold shares in any future concessions. In addition, the federal government has stated that its intention is to sell its 49 percent shares of the first groups of concessions to fully disengage from the operation, maintenance, and investment in these airports. This sale is expected to take place within the next 18 months.

Brazil's air transport market is dominated by three airlines, which held a combined 85 percent market share in 2019: LATAM (31 percent), Gol (31 percent), and Azul (23 percent). In general terms, the Brazilian market has experienced slower growth rates between 2011 and 2019 than those registered at other countries in the region. In the domestic segment, the number of offered seats in Brazil has decreased at a 1.2 percent compound annual growth rate (CAGR) (with countries such as Colombia, Chile, Bolivia, Argentina, and Peru all surpassing CAGRs of 7 percent in this same period), while the international segment registered a CAGR of 3.1 percent, below the growth rates of Colombia, Chile, Peru, and Bolivia.

Azul Airlines has significantly expanded its operations between 2011 and 2019, registering a 9.1 percent CAGR in this period. The Brazilian low-cost carrier has increased its operations in Brazil during the past decade through: (i) the acquisition of Trip Linhas Aereas in 2014; and (ii) the development of an extensive point-to-point network strategy, typical for a low-cost carrier. Azul's connectivity is spread out across Brazil's regional capitals and main urban population centers, with one distinctive key strategy: offering services to/from second- and third-tier regional airports where LATAM and Gol do not offer any services.

In 2012 Chile's LAN Airlines completed the merger with TAM Linhas Aereas to form the region's largest airline holding: LATAM Airlines Group. In Brazil, LATAM concentrates its operations in its bases of São Paulo Guarluhos, Sao Paulo Congonhas, and Brasilia. The airline remains as Brazil's largest international operator, leading the offering of international seats in both São Paulo Guarulhos and Rio de Janeiro Galeao, and accounting for one out of four international seats to/from Brazil in 2019 (more than doubling the international offering of the second-largest carrier, Gol).

Brazil has particularly witnessed the process of airline consolidation that took place in the entire world. After the LAN and TAM merger, in May of 2022, Gol and Avianca (LAC's second-largest airline group with its main base in Bogota, Colombia) announced their consolidation into a new holding company called Abra Group Limited. Under this agreement, each airline will maintain its own brand and continue to operate separately. Abra will also own low-cost carriers Viva Colombia and Viva Peru, which recently announced plans to join Avianca. In addition, the holding will have a convertible debt representing a minority interest investment in Chile's low-cost carrier Sky Airline.

In terms of policy developments, since 2015, the Brazilian government has decided to implement a liberalization approach in the negotiation of ASAs with other nations, signing several open skies agreements in the process. In May of 2019, Brazil's National Senate passed a law which approved foreign ownership of Brazilian airlines up to 100 percent. The cap was completely lifted from its previous limit of 20 percent, allowing any foreign investor to operate a carrier, which is in essence granting a Seventh and Ninth Freedom to any airline that would be interested to own a subsidiary in Brazil.

In October of 2020, the Brazilian government implemented the "Voo Simples" ("Simple Flights") Program, containing a set of 50 policy initiatives aimed at the alignment of Brazilian regulations with international standards. The program seeks to simplify the sector's regulatory framework, attract foreign investments, reduce regulatory costs, increase legal certainty, and encourage the entry of new airlines. To achieve these objectives, the main initiatives of the program are: (i) simplification in the process of certification and renewal of pilots' licenses; (ii) expansion in the number of testing facilities; (iii) simulator training period extended from once every 12 months to once every 24 months; (iv) simplified aircraft registration process; (v) simplification of the approval process for new on-board equipment; (vi) to encourage fleet renewal, simplification of processes regarding certification of aircraft and their components; and (vii) private aerodrome certification will now only be necessary once construction works are completed.

As reported by the Brazilian Association of Airline Companies (ABEAR), the aviation sector in Brazil is facing a series of challenges and among them, the cost of airport infrastructure and high taxes and duties are mentioned: (i) Airport concessions: as a consequence of the airport PPP program, there has been an associated impact of a significant increase in fees and charges; (ii) Taxes: the sector is heavily taxed where duties are applied to most components of the value chain; (iii) Cost of fuel: Brazil suffers from a very high cost of the jet fuel (Jet A-1), accounting for as much as 30 percent of the airline's operating costs; (vi) Judicialization: there seems to be an abuse of the consumer protection rights with a lack of capacity by the government to differentiate manipulative claims from international best practices; (v) Safety/security, infrastructure, airspace and air cargo, and regulatory issues: the airline association identifies a series of issues that are to be resolved through the implementation of regulatory changes; and (vi) Regional aviation: Brazil lacks a formal program of public service obligations that should serve essential air routes.

Table A.8 Key Findings and Potential Policy Recommendations: Airports Sector

Key Findings	Potential Policy Recommendations
• Brazil suffers from a very high cost of the jet fuel (Jet A-1), accounting for as much as 30% of the airline's operating costs; taxes on fuel are also an important component of the cost. • There seems to be an abuse of consumer protection rights; lack of capacity by the government to differentiate manipulative from valid claims. • Safety/security, infrastructure, airspace, air cargo, and regulatory inefficiencies. • Concession of airports to private operators has derived high costs for the use of infrastructure. • The aviation sector is heavily taxed where duties are applied to most components of the value chain. • Lack of a formal program of public service obligations to serve essential air routes.	• Jointly work with IATA and ALTA aiming at a reduction in the tax composition of aircraft fuels or exploring the possibility of importing it directly. • Adopt international practices with respect to conflict resolution and the creation of alternative instances for mediation. • Implementation of regulations addressing issues with respect to carbon dioxide emissions, availability of biofuels, and prices for cargo storage. • Involvement of the airlines in the formulation of airport concession contracts, supervising operational and financial aspects. • Adoption of a new simpler fiscal system, competitive and consistent with the development of the industry. • Development of a Public Service Obligation program on essential services to new destinations.

Water and Sanitation

Brazil has a complex and fragmented institutional setup for water supply and sanitation (WSS) in which each of the country's more than 5,000 municipalities are legally mandated to provide WSS services within their municipal borders. In most cases, municipalities delegate their operation to their respective state. This is largely due to insufficient technical and financial capacity. At the same time, all of these enterprises are subject to policies of the federal government. Considering Brazil consists of 26 states, the federal district, and 5,570 municipalities, this decentralized configuration translates into enormous inequalities between the country's many WSS operators in planning, regulation, and quality of services.

In addition to creating a complex institutional arrangement, Brazil's 2007 legal framework governing the water sector was seen by all market players as outdated and ineffective. The new legal framework, approved in June 2020, has moved the sector in the direction needed to bring legal certainty to the activities of private operators, but implementation could still be difficult. Despite these challenges, there is general support for the new water and sanitation law.

An important innovation of the new legal framework is a more robust role for the National Water and Sanitation Agency (ANA), which will now establish national regulatory guidelines for WSS services. This is expected to solve a long-standing problem of the country having countless regulatory agencies, many of them lacking minimum financial resources and structural capacity to act, and to enforce local and state regulations. This makes their oversight of the network weak or even nonexistent and leaves them subject to local political interference.

The new legal framework also brings improvements in service provision that will promote competition between public and private companies, ensuring services are provided by the entity best able to meet the goals and terms of the contract. The new framework creates incentives for formation of regional blocs. These will allow economies of scale in the provision of services and cross-subsidies in which smaller, more needy municipalities will benefit by banding together with larger municipalities that have more resources. Finally, the new framework will encourage greater public engagement in the sector and greater awareness of the benefits realized through universal access.

For the new legal framework to be truly effective, assertive participation by the federal government will be essential. The government should act as an articulator between subnational units and should provide incentives for service owners and municipalities to align themselves with national guidelines. The federal government will also have to increase alternatives for financing so that operators can obtain the capital they need to speed up the sector's build-out.

Table A.9 Key Findings and Potential Policy Recommendations: Water and Sanitation Sector Key Findings	Potential Policy Recommendations
• Implementation of WSS reforms and the 2020 Law are targeting larger urban centers and primarily water supply, while limited emphasis has been given to underserved areas including rural, indigenous, and informal settlements, particularly to improve access to sanitation. • The country will need to do more with less resources and find ways to optimize its budgetary allocation and spending efficiency through strong governance systems within the sector. • The recent COVID-19 crisis and its impact on the water sector has reinforced the importance of building the sector's resilience against such climate- and non-climate-related shocks and crises. It is imperative that actions be taken to reduce impacts in cities, such as integrated urban water management, and on the circular economy, including flood and drought monitoring and preparedness, and nature-based solutions to improve resilience.	• Develop a strategic plan to expand access to underserved areas, for example, develop and implement institutional and integrated models for urban and rural WSS expansion, for underserved urban areas, WSS services should be integrated with policies and investments for land use and social housing. • Improve coordination between ANA and the National Health Foundation (FUNASA) to ensure compliance with the conditions and targets established in federal and local guidelines. • Improve efficiency and governance, for example, federal and state budgeting processes can be brought to bear to incentivize greater WSS investments and improvements in service providers' operational and commercial efficiency, and performance-based contracts can improve the quality of the implementation of the law, and make budget execution transparent and efficient. • Build resilience against climate and other crises by adopting climate adaptation and mitigation measures. For example, drought management in Brazil needs to advance from a crisis management approach to one based on risk management. • Supporting integrated urban water management could help advance the water security agenda, and improve the availability of water for various productive and nonproductive uses.

Water Resource Management (WRM)

There are several challenges in Brazil in the context of use and protection of water resources, including economic, social, and environmental elements. There is a direct link to water from every household and industry, be it demand for supplies, energy production, food, and many other consumer goods, in addition to protecting ecosystems. At the same time, there are highly dynamic processes between water and society that are constantly changing: climate, rainfall, and water availability, which increase uncertainty, variability, and scarcity. The production chains, their location, and economic relationships also change, which are reflected in the amount of water needed.

The National Water Resources Policy defines the WRM structure, regulating uses, conceiving strategies, and implementing necessary actions to ensure water security for the people and for the production systems that provides them employment and income. The management structure is necessary to provide an understanding of the changes it entails, assess the impact of these changes, and design new strategies and actions to reduce impacts, providing capacity to adapt and thrive in face of these changes.

Recent water crises in the country have profoundly impacted several sectors showing increasing vulnerability and risk. The WRM governance structure needs improvements to become more effective.

The lack of preparation, response, and adaptation capacity to these challenges will financially impact the population, severely limiting opportunities for economic growth and to establish a fair, inclusive, and sustainable development model.

Table A.10 Key Findings and Potential Policy Recommendations: Water Resource Management

Key Findings	Potential Policy Recommendations
• The perception of water abundance in Brazil must be changed. WRM is needed to support development opportunities, securing water for multiple, competing demands and improving water quality, enabling more return on invested capital. • Water value is increasingly evident and WRM becomes necessary to evidence the value to society, find economic solutions to maintain and expand the existing infrastructure, and propose allocation arrangements that consider the economic value of other water uses, avoiding losses in existing investments and conflicts with other water basins. • WRM systems are linked to other sectors, especially hydropower. It is important to seek balanced water allocation solutions to avoid optimal solutions from one sector reflecting negatively on others. Solutions need to be flexible with the capacity to accommodate impacts from extreme events. • Climate change is reflecting on WRM now: the future water security relies on today's adaptive actions. It is important to share and coordinate governance actions, sector policies, planning and operation of mid- and long-term infrastructure, and contingency measures against extreme events.	• Integrate sector planning for water use (e.g., sanitation, energy, irrigation/livestock, industry, water infrastructure for multiple uses, and environment) with water resources planning. • Improve watershed-level water resources planning, especially in transboundary basins. • Strengthen role of the National Water and Sanitation Agency (ANA) (responsible for implementing the National Water Resources Policy), especially in supporting and strengthening decentralized and participatory WRM. • Structure state management agencies according to WRM complexity and improve their effectiveness to properly operate and perform their functions. • Seek strategies and mechanisms for sustainable WRM. • Develop an integrated and coherent financial plan for WRM. • Negotiate and plan the allocation of water resources considering the different objectives and regional, current, and future demands.

Private Sector Participation

Infrastructure Governance

Substantial benefits can be achieved through improved infrastructure governance. Creating a proper infrastructure governance framework is fundamental for governments to properly plan, budget, deliver, regulate, and evaluate infrastructure investments. According to the OECD, an infrastructure governance framework should include the following 10 principles:

1. Establish a national long-term strategic vision that addresses infrastructure service needs.
2. Manage the integrity and corruption threats at all stages of the process, from project conception to delivery.
3. Establish clear criteria to guide the choice of delivery mode (PPP vs direct public provision, etc.).
4. Ensure good regulatory design and maintain a predictable regulatory framework for investment.

5. Integrate a consultation process early enough so that decisions benefit from real stakeholder engagement.
6. Coordinate infrastructure policy across levels of government in such a way that investment decisions by central and subnational governments are coherent.
7. Guard affordability and value for money by using and applying cost-benefit and other methods rigorously and consistently.
8. Generate, analyze, and disclose useful data to increase transparency and ensure accountability.
9. Integrate mechanisms to evaluate the performance of assets throughout their life cycle.
10. Review existing infrastructure resilience in the face of evolving natural and manmade risks and develop guidelines to future proof new infrastructures.

Although the Government of Brazil already has some aspects of these principles in place, they are not arranged as part of a larger institutional arrangement. This makes it harder for Brazil to properly organize and optimize its infrastructure investments.

The development of an infrastructure governance framework in Brazil must also include an effective institutional arrangement between all levels of government that allows for: efficient infrastructure investment; the development of standardized methodologies and appraisal documents to develop PPPs; the creation of a linear PPP project cycle with a clear definition of institutional roles for all stakeholders involved, and the reduction of bottlenecks; and finally improve the capacity of government officials involved in the process.

It is expected that once these are in place, the Government of Brazil would be in a better place to generate a feasible PPP pipeline of projects and deliver more infrastructure with less time. This is because an infrastructure governance framework has the power to increase transparency and trust in the system, ensure predictability, assure affordability, making it a market with characteristics similar to developed economies—with the advantage of the market size of Brazil, which is already appealing to international investors.

Solving the Project Structuring Bottleneck

One of the main constraints faced by the Brazilian government is the lack of a systematic approach to support the preparation of projects for market in a timely manner and with the level of quality needed. The size of Brazil's pipeline does not make this an easy task and all the existing agencies (e.g., the Brazilian Development Bank [BNDES], Caixa Economic Federal [CEF], the Planning and Logistics Company [EPL], etc.) are already operating at full capacity.

The government could leverage its vast experience structuring transport, water, and energy PPPs to support subnational governments by developing standard guidelines for project structuring. For example, the government could create financial models, examples of bidding documents, public consultation processes, contracts, and so on, for adoption by the different state and municipal PPP units. In addition, there should be an effective transfer of knowledge to these units regarding the federal government's rich concession experience. This could be implemented through exchange programs between PPP unit employees and BNDES/CEF staff, hands-on training, consulting services provided by BNDES/CEF to specific projects, and so on.

In addition, the Government of Brazil should either consider refunding and making available the Infrastructure Fund enacted by the provisional measure (MP) or create a new fund to support project structuring. An Infrastructure Fund has the potential to scale up the federal government's current level of support for project structuring in Brazil.

Financial Instruments to Unleash PPIs

Asset Recycling/Divestment

The country's limited fiscal space has forced the government to optimize government incomes and expenditures. Consequently, the government is now planning to divest or liquidate part of its 153 state-owned enterprises. Asset recycling could help the government leverage public capital in a resource-constrained environment by reducing the size of the state through the sale of assets that are not related to the core functions of government and optimizing the use of existing assets through leasing, ensuring the maximum gains from their use/exploitation. The interesting caveat of "capital recycling" via-a-vis regular divestment is that in an asset recycling the government must redeploy the capital gains toward the improvement or creation of infrastructure assets (ideally based on the economic/infrastructure development plan).

This process recycles previous taxpayer's funds that have been locked up in older assets to pay for new or renewed assets to meet the demand of future generations. This avoids the need to continually raise taxes or increase borrowing and debt levels. The population retains access to the public services and benefits provided by the older assets, but now also gains from additional or improved services and benefits provided from reinvestment in new and/or improved infrastructure.

As in a well-structured PPP, asset recycling can benefit the public and private sector. It can be easily aligned with the government's infrastructure development plan, while helping the private sector avoid the construction phase of greenfield projects and instead focus on operating the assets as efficiently as possible.

The government should therefore further refine its privatization strategy toward asset recycling. The privatization of Correios and Eletrobras are great opportunities for the development of such frameworks and for this modality of private participation in infrastructure to be showcased in the country. Such a framework should include, but not be limited to, the identification of assets to be privatized, technical and financial studies, changes in law and regulations needed, and associated improvements to the communications strategy.

Guarantees

Given the current inability for the public sector to issue guarantees to the benefit of concessions and PPPs, an effort should be made to remove legal constraints to award guarantees to PPPs, as well as properly create mechanisms to account for such guarantees and contingent liabilities of PPP projects. Providing guarantees can be a way of optimizing the current budget available in Brazil toward the development of more and better infrastructure. There are a number of projects, especially in social sectors and in certain types of economic PPPs, such as water and sanitation, that can only be sustained if the federal government provides a guarantee to back up the transaction.

Appendix B. Links to Background Papers

Activity A. Understanding the Fiscal Costs and Risks in Infrastructure in an Era of High Debt Vulnerabilities

1. Belt Tightening in Infrastructure SOEs: The Effects of Negative Shocks on Performance

Activity B. Analyzing the Effects of Public Investment and Social Transfer Multipliers on Long-Term Growth

2. Estimating the Effects of Public Investment on Growth in Brazil: A Fiscal Multiplier Approach

Activity C. Understanding the Political Economy of Brazil's Infrastructure Sector

3. The Political Economy of Brazilian Infrastructure

Activity D. Public Expenditure Review and Infrastructure Gap Analysis

4. Estimating the Infrastructure Investment Gap
5. Assessing the Differences in Infrastructure Investment Needs between the Plano Integrado de Longo Prazo da Infraestrutura (PILPI) and World Bank Estimates

Activity E. Private Sector Participation

6. Fostering Private Sector Participation in Infrastructure in Brazil

Activity F. Benchmarking Sector Performance in Brazil

7. Regulatory Performance: A Case Study of Brazil's Water Sector

Activity G. Decarbonizing Infrastructure

8. Background papers for the CCDR for Brazil