

World Bank Research *Digest*

VOLUME 13 ★ NUMBER 3 ★ SPRING 2019

Special Focus on
Urbanization and
Infrastructure Development

Building Sustainable Cities and Efficient Infrastructure

Our future is in cities. By 2050 nearly 70 percent of humanity will be living in cities and towns, up from around 50 percent today. Much of that urban growth will take place in the developing world, especially Sub-Saharan Africa and Asia. The rapid expansion of cities is expected to transform the way we live, work, and commute, with serious consequences for economic development and climate change.

Much of the world's urban expansion may occur in slum-like conditions, exacerbating economic disparities and exposure to health risks. And the speed and scale of city growth will mean accelerated demand for basic services, affordable housing, and jobs.

Infrastructure development usually lags behind urban population growth. Congested roads, inadequate public transport, and inefficient ports can undermine the competitiveness of cities. Overburdened schools, hospitals, and public safety net delivery systems can hamper poverty reduction efforts.

Rapid urban growth is also linked to environmental concerns. Cities consume close to 70 percent of the world's energy and account for more than 70 percent of global greenhouse gas emissions. As cities expand, their exposure to climate and disaster risk increases. Almost half a billion urban residents live in coastal areas or on riverbanks, vulnerable to floods, storm surges, and sea-level rise.

Yet urbanization also offers the potential to transform economies. With more than 80 percent of global GDP generated in cities, urbanization can contribute to sustainable growth if

managed well. Moreover, with younger and more-skilled populations, cities can capture demographic dividends.

And cities can play a vital part in tackling climate change. Some cities today are building efficient housing and improving road transport infrastructure, critical in reducing energy consumption as well as greenhouse gas emissions.

This issue features World Bank research aimed at supporting national and city-level policy makers in thinking strategically about the opportunities and challenges of urbanization. The first three studies look at who benefits from large public investments in transport infrastructure. They also reveal that realizing the benefits can depend on local and national conditions. The fourth study looks at the part that politics can play.

The next two studies highlight the importance of city planning, land policies, and efficient transit systems in fostering growth and improving job opportunities for poor urban residents. The following two, focusing on public intervention in the provision of infrastructure services, remind us of the pitfalls in distortionary policies. The last two underscore the importance of ensuring that infrastructure is resilient to extreme climate events.

Building cities that are safe, inclusive, resilient, and sustainable will require sound investment choices and intensive policy coordination. Researchers are exploring creative solutions to the challenges of urbanization—to help ensure that the decisions we make today shape healthy cities for tomorrow.

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Who Benefits from Investments in Bus Rapid Transit Systems? Evidence from Colombia

Knowing how new urban transport affects household welfare is key to designing policies to ensure that its benefits reach the poorest

Rapid urbanization is among the defining characteristics of developing economies. In Latin America 80 percent of people live in urban areas today, up from 49 percent in the 1960s; in Colombia 77 percent do, up from 45 percent. The rapid population growth in urban areas requires adequate infrastructure to support efficient provision of essential services. Urban transport services are particularly important; where they are lacking, the result can be congested roads, limited urban mobility, and misallocation of productive resources.

One response to these challenges has been the introduction of bus rapid transit (BRT) systems, which have multiplied in recent decades. BRT systems consist of a network of buses using dedicated lanes that allow rapid mobility. These systems operate in 205 cities around the world, transporting 34 million passengers a day.

In Latin America BRT systems were pioneered by Curitiba in Brazil and Quito in Ecuador. They soon spread to large capital cities, including Mexico City and Bogotá. After introducing the BRT system in Bogotá in 2001, Colombia later expanded it to other cities. One of these is Barranquilla, where a system known as Transmetro has been serving the metropolitan area, Colombia's fourth largest population center, since April 2010. The Transmetro system now has 18 stations on its main lines and more than 600 stops along its feeder lines. Passenger trips on the system rose from nearly 3.7 million in 2010 to more than 36.4 million in 2016.

The benefits of BRT systems for transport efficiency and the environment have been widely documented. But there is scant literature on how urban transport infrastructure affects household welfare—and few urban transport studies focusing on

midsize cities or developing countries. A recent study by Pfitze, Rodríguez-Castelán, and Valderrama-González seeks to help fill this gap in knowledge by investigating the distributional effects of Barranquilla's Transmetro system, which was originally intended to benefit the poorest households in the metropolitan area through better connectivity and lower fares.

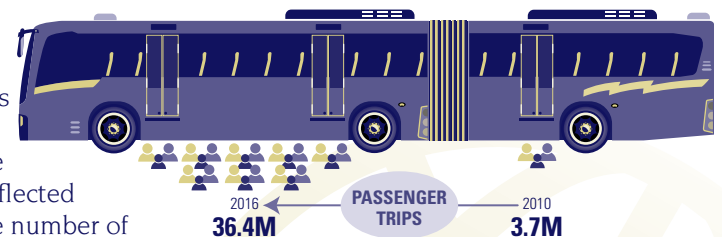
The analysis focuses on compositional changes that may have occurred in neighborhoods as a result of proximity to the opening of Transmetro stations. It combines geocoded information on the expansion of the Transmetro system with household survey data from the 2008–15 rounds of the main labor survey in Colombia (Gran Encuesta Integrada de Hogares). The survey is representative at the metropolitan-area level for 13 cities including Barranquilla and provides information on an ample set of welfare, housing, and labor characteristics. To assess the exposure of households to the Transmetro system, including both main lines and feeder line stations, the analysis aggregates households into blocks and then calculates the proximity of each block to bus stations as the distance from its center. The study analyzes 2,088 blocks over the 2008–15 period.

The findings show that after implementation of the Transmetro system, housing characteristics improved and housing prices rose. Proximity to stations had a strong effect on the quality of the housing stock, as reflected in an increase in the number of apartments, rooms, and exclusive toilets. In addition, home values and rents increased, though not as a direct effect of the proximity to stations but as a consequence of the improvement in the quality of housing.

Compositional changes in households living in proximity to Transmetro stations followed in response to the better and more expensive housing stock, with better-off individuals and

families replacing poorer ones. First, proximity to feeder stations increased the number of smaller households (with one or two members) in the area and reduced the number of large households (with more than five members). This change was related to a reduction in the number both of young adults ages 16–22 and of children. Second, the characteristics of adults living in proximity to Transmetro stations also changed, with more-educated adults replacing less-educated ones. These joint effects translated into a reduction in the number of households in the poorest two quintiles of the income distribution and, at the same time, an increase in the number of those in the richest quintile.

The study's main results suggest that the development of the Transmetro system in Barranquilla had positive effects relating to transport efficiency and urban mobility—but that despite the original objective of benefiting poorer households through better connectivity, it also had a regressive distributional impact. This regressive effect was driven by significant displacement of poorer households and their replacement by middle- and upper-income households. The study thus contributes to the literature in two ways, both by investigating the overlooked distributional



effects of urban transport infrastructure and by questioning the often-unstated assumption that households do not relocate in response to public transport policies.

Tobias Pfitze, Carlos Rodríguez-Castelán, and Daniel Valderrama-González. 2018. "Urban Transport Infrastructure and Household Welfare: Evidence from Colombia." Policy Research Working Paper 8341, World Bank, Washington, DC.

Beyond Faster Travel: Assessing the Wider Economic Benefits of Transport Corridors

Better highways bring economic benefits beyond those from faster travel. But the gains can depend on local conditions

India's Golden Quadrilateral, a network of four- to six-lane express highways totaling 5,846 kilometers in length, connects the country's four top metropolitan cities—New Delhi, Mumbai, Chennai, and Kolkata (map 1). Its construction was launched in 2001, two-thirds complete by 2005, and mostly finished in 2007. By January 2012 its entire length was operational.

Large highway projects like this one are expected to benefit businesses through greater connectivity. But what about the potential wider economic benefits that may also matter in evaluating such projects? Building on earlier research, a paper by Melecky, Sharma, and Subhash examines the effect of the Golden Quadrilateral on such measures

as welfare (district-level GDP and household consumption); inequality (district-level poverty); social inclusion (total employment and female employment in regular wage jobs); and environmental quality (density of aerosol particles). The authors also look at structural transformation in employment (the shift from farm to nonfarm work), an intermediate outcome of interest.

Applying the “differences in differences” method to district-level data from 1994 to 2011, the authors estimate that the Golden Quadrilateral increased the share of nonfarm employment among women in India by 2.4 percentage points, with a corresponding proportional decline in their farm employment. It had a similar, though smaller, effect on male employment.

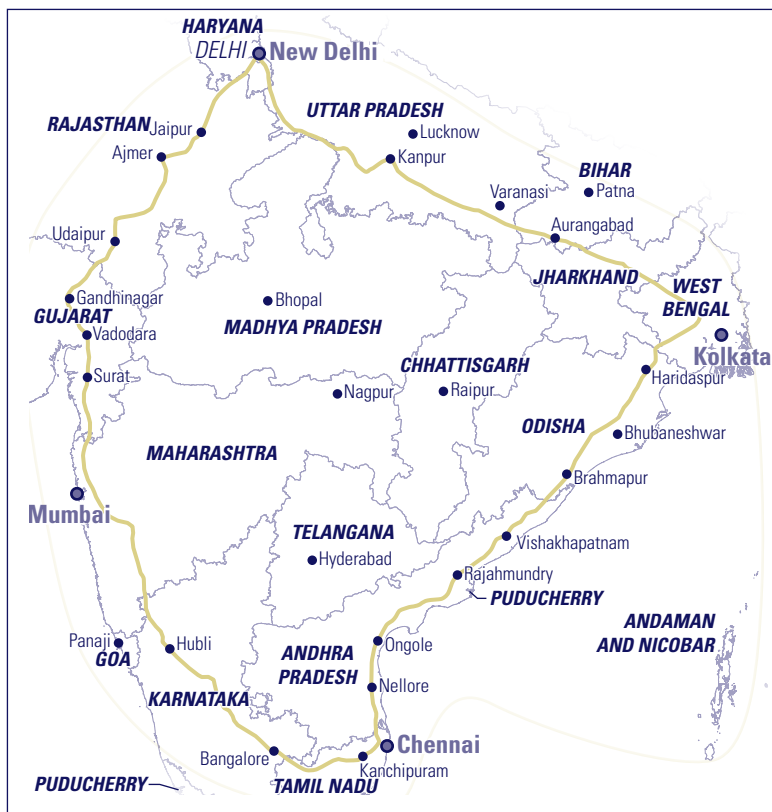
Overall, the authors find that the Golden Quadrilateral contributed significantly to the structural transformation of employment. The network also had a significant positive effect on district-level per capita GDP, though

this effect was not widely shared. It did not have significant positive effects on household consumption, poverty, or employment, including of women. Moreover, the evidence suggests significant trade-offs in effects, with GDP increasing while air quality decreased significantly.

The authors also examine how the effects of the Golden Quadrilateral could have depended on local conditions in a district—that is, on how well the land, labor, capital, and product markets function and on the quality of local institutions such as public governance. To estimate this possible dependence, they use interaction effects between the connectivity to the highway network and different measures of initial conditions in local markets. They find, for example, that the Golden Quadrilateral had a bigger positive effect on nonfarm employment in districts with a greater share of secondary education. Moreover, the highway network appears to have boosted total employment more—particularly for women—in districts with local governance of above average quality.

The results suggest that initial conditions in local markets are important in determining the outcomes of highway upgrades and the ways and extent to which wider economic benefits are shared across geographic units. The central mechanism through which highways are expected to affect development is increased trade across connected locations. This requires a reallocation of resources to more productive firms and to sectors of comparative advantage. Conditions in land, labor, capital, and product markets could matter because they affect this process of reallocation.

Map 1. India's Golden Quadrilateral Highway Network



Martin Melecky, Siddharth Sharma, and Hari Subhash. 2018. “Wider Economic Benefits of Investments in Transport Corridors and the Role of Complementary Policies.” Policy Research Working Paper 8350, World Bank, Washington, DC.

A Big Push or a Backwash? Economic Effects of Connecting a Hinterland

The Jamuna bridge in Bangladesh connected a poor hinterland to growth centers. How did the new links affect the local economy?

Can a greater connectivity act as a catalyst for economic growth and structural transformation in poorer regions? One test case might be the construction of a major bridge in Bangladesh. Spanning the Jamuna River, one of the largest rivers in the world, the 4.8-kilometer bridge connected about 30 million people living in chronically poor areas in the northwest to growth centers in the east, including the capital city of Dhaka and the port city of Chittagong. Since opening in 1999 the bridge has reduced freight costs by 50 percent, and travel time by three to four hours, from areas in the northwest to Dhaka.

Using quasi-experimental study of the Jamuna bridge, a paper by Blankespoor, Emran, Shilpi, and Xu looks at how a large reduction in trade costs affects the pattern of structural change and agricultural productivity. In classic trade models lower transport costs lead to specialization according

to comparative advantage. But a large literature shows that they may instead cause a “backwash effect” in which resources leave the hinterland and high-productivity manufacturing concentrates in cities.

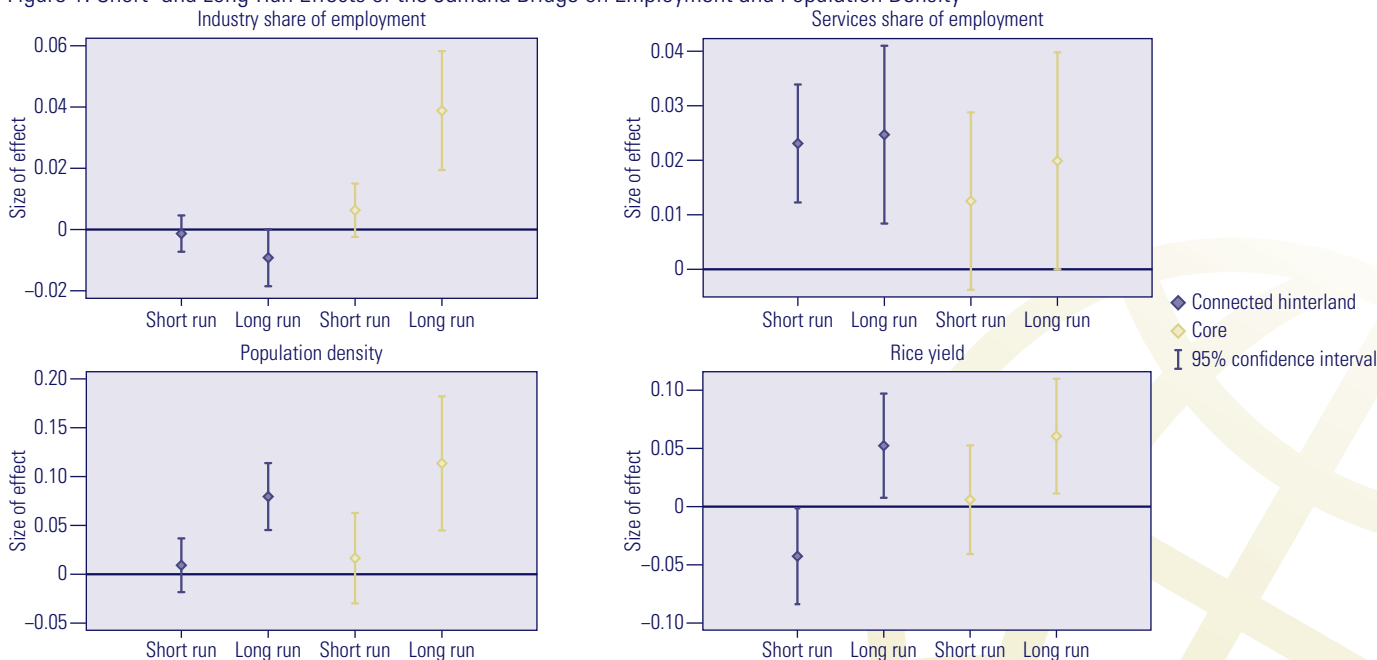
The paper develops a spatial general equilibrium model with a core and, at opposite sides of it, two hinterlands separated from the core by rivers and allows for productivity gains through agglomeration in agriculture and manufacturing. The model yields insights that differ from those of the standard core-periphery and trade models: The newly connected hinterland may experience higher population density and agricultural productivity despite significant deindustrialization. Even with greater specialization in agriculture, the share of agricultural employment may decline when interregional trade requires local services (such as processing and trading). And the strongest effects on the structure of employment may be felt not in the areas next to the bridge but in those that move out of market isolation as a result of the bridge.

For the empirical estimation of the model the authors use doubly robust

estimators in a “differences in differences” design in which the comparison hinterland is in a region that was supposed to be connected to the core (the capital city) by the proposed but not yet constructed Padma bridge. Results show that in the short run the Jamuna bridge leads to significant reallocation of labor from agriculture to services in the connected (treatment) hinterland but has no perceptible effects on the employment share of manufacturing, on population density, or on night-lights, a measure of overall economic activity (figure 1). In the long run the labor share of manufacturing declines in the connected hinterland and increases in the core, raising the possibility of backwash. But significant positive effects on population density and agricultural yields in the connected hinterland contradict backwash effects of the bridge. The effects of the bridge on the allocation of labor among sectors vary across areas, with relatively weak effects in those close to the bridge.

Brian Blankespoor, M. Shahe Emran, Forhad Shilpi, and Lu Xu. 2018. “Bridge to Bigpush or Backwash? Market Integration, Reallocation, and Productivity Effects of Jamuna Bridge in Bangladesh.” Policy Research Working Paper 8508, World Bank, Washington, DC.

Figure 1. Short- and Long-Run Effects of the Jamuna Bridge on Employment and Population Density



Note: Results from regression analysis comparing average differences in outcomes between areas connected by the Jamuna bridge (hinterland as well as core) and hinterland areas similarly remote but still unconnected. The short run is 2 years, and the long run 12 years, after the opening of the bridge.

Highway Politics in Mexico

Where federal highway spending is directed in Mexico can depend on electoral outcomes—and more so under divided government

Road investments can have big impacts on economic growth and development. This is because they facilitate trade through lower transaction costs and better access to markets, or because they may stimulate the spatial agglomeration of firms and local specialization, increasing local employment and productivity.

The placement of roads, however, may not be optimal when it arises from political rather than economic incentives—as with costly white elephant projects. While this problem seems to emerge mainly in autocratic settings, electoral competition can also generate resource misallocation, especially when politicians seek to improve their reelection prospects.

Still, empirical efforts to understand the role of political preferences in the subnational distribution of road investments face two major challenges: Disaggregated road expenditures are difficult to track, especially in developing countries. And subnational administrative jurisdictions may vary in ways that potentially correlate with both political preferences and public investment choices.

In a recent study Selod and Soumahoro address these challenges by applying a quasi-experimental design to a data set comprising election outcomes and georeferenced road data from Mexico. To guard against missing or poor road expenditure data, the authors extract from sheet maps spatially explicit measures of actual roads that were built (map 1). Combining these road statistics with data from nearly 10,000 legislative elections in more than 2,000 Mexican municipalities between 1993 and 2012, they compare changes in newly built roads across locations with different voting outcomes.

Specifically, the authors examine whether municipalities that voted for candidates from the ruling presidential party afterward received a disproportionate share of federally funded highways. To identify political bias in road building, they compare changes in highway length between municipalities where the presidential party barely won and those where it barely lost the legislative race. The rationale for this approach is that elections decided with razor-thin margins involve a random component that makes it reasonable to assume similarities between locations with highly contested races.

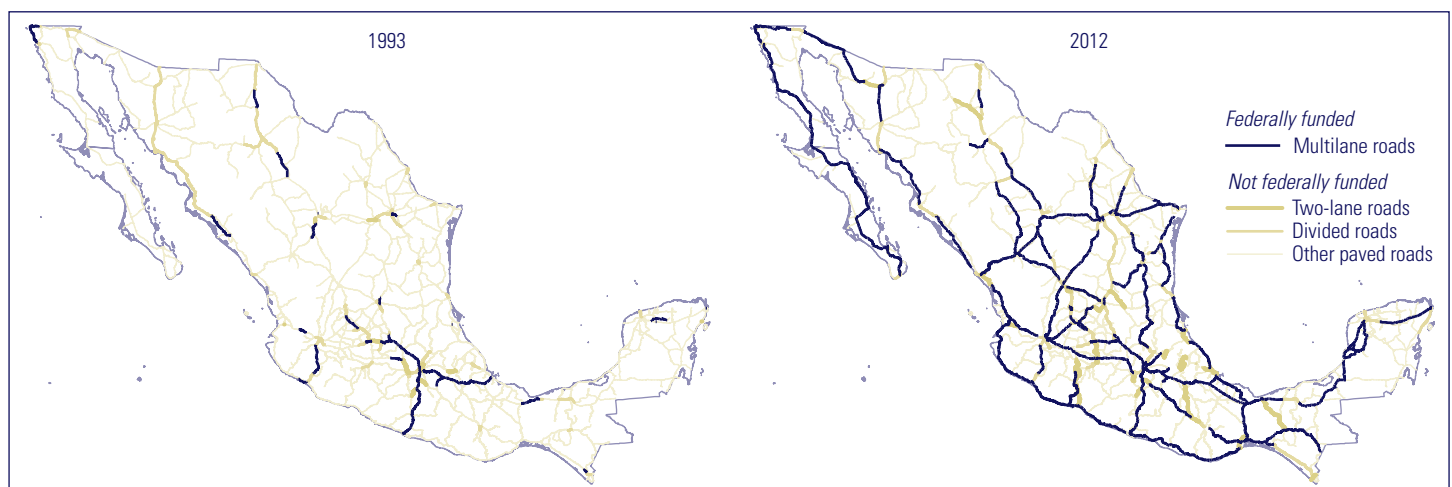
Results suggest that in the four to five years after an election, federal highways built in municipalities backing the presidential party in legislative

elections more than doubled compared with those in locations lost to the opposition. Alignment with the presidential party's legislative candidates increased federal highway provision but had no significant effect on state and rural roads that are not federally funded. Interestingly, there is no evidence of allocation bias in federal highways when the winner of the legislative race was from the majority in the chamber of deputies or when the authors exclusively examine presidential election outcomes rather than the legislative election outcomes. So it is the interaction between the executive and legislative branches that generated political bias in highway building. Overall, the study underscores how the relationships among different branches of government could distort resource allocation.

To shed light on why this distortion occurs, the study discusses two potential explanations. First, politicians may target resources toward constituencies with common ideological interests and policy priorities. For example, evidence from the United States suggests that Democrats are more inclined to spend heavily on education while Republicans tend to prioritize defense spending. The study could not substantiate this prediction, as none of the dominant parties in Mexico exhibited a differentiated preference for road investments. Second, legislative instability in the form of divided

(continued on page 12)

Map 1. Road Network in Mexico, 1993 and 2012



How Does the Shape of Latin American Cities Affect Their Productivity?

A city's spatial structure matters for its productivity—suggesting that city planning and land policies can serve as tools to help foster growth

Different cities can use land and space in very different ways. Local governments, through land use regulations and other urban policy instruments, can influence where economic activities, urban infrastructure, and households are located. And the spatial structure of cities, or urban form, is thought to have important influence on the emergence of agglomeration economies and congestion costs—and thus on a city's level of productivity—but also on the sustainability of cities and their quality of life. The same channels—matching, learning, and sharing—that are used to explain the emergence of agglomeration economies are also thought to be at the core of the links between urban form and city productivity.

Differences in the occupation of urban space have consequences for the transport modes used (for example, by favoring the use of private vehicles over public transport), for commuting times in cities, and for the type and intensity of human interaction. Denser cities are thought to improve labor productivity through better matching of firms and workers and enhanced interactions that facilitate the spread of tacit knowledge, both of which are thought to occur more easily the

closer people and firms are located together. But while the links are well established through a theoretical framework, few empirical studies have examined the relationship between urban form and economic performance; moreover, there is still little evidence linking the presence of agglomeration economies with the form that cities take.

In Latin America, where more than 80 percent of the people live in cities, understanding the links between city form and productivity is critical for policy makers. The challenges of topography may have prevented dense development in some cases, as many Latin American cities are located in rugged topographies with natural barriers. Moreover, rapid urbanization combined with limited infrastructure investments may have led to urban forms that pose a barrier to the rise of agglomeration economies, limit the interactions among firms, and make it hard for workers to reach their jobs. A better understanding of the links between urban form and productivity can shed light on whether urban policy has a part to play in supporting city productivity and, through that, economic growth.

In a recent paper Duque, Lozano-Gracia, Patino, and Restrepo examine the links between urban form and city productivity using different urban form metrics for a comprehensive sample of Latin American cities with more than 50,000 inhabitants in 2010. One of the

main contributions of this work is the creation of a comparable series of city shape indicators for 919 cities in Latin America, used to characterize urban structure and create a proxy measure of a city's economic performance. These were derived from city extents created from a consistent time series of nighttime lights imagery from the Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS).





The authors characterize city shape with three key interrelated dimensions of urban form: the border's shape and perimeter; the internal structure of urban area; and the land use patterns observed within city boundaries and reflecting the use of space and the distribution of people within the city.

Using a series of empirical strategies, the authors estimate the relationship between measures of urban productivity and urban shape. The results show that the shape of the urban extent, the inner-city connectedness, the level of urbanization, and the population level have a statistically significant influence over the productivity level of the city. The authors also find evidence of the presence of a congestion effect on productivity as cities become denser. According to these results, a compact, dense, and well-connected city meets important conditions for being highly productive.

An important conclusion from this work is that a city can grow in different shapes and still achieve high productivity by guaranteeing a high rate of inner-city connectedness (equally, a compact but poorly connected city can show low productivity). The results also underscore the fact that urban form tends to persist over time, requiring policy makers to think far ahead and ensure good accessibility within cities. This has important implications for policy makers because mayors often ask what they can do to improve the productivity of their cities. City planning and land management policies are not often regarded as instruments to foster productivity and growth in cities. The results in this work suggest otherwise: these are important tools that local governments have at hand to increase productivity in Latin American cities.

Characterizing City Shape

The authors use seven indicators of urban form to characterize city shape. The examples here illustrate high and low values for two of these: *Roundness* measures the share of the urban area that is inside the equal-area circle about its center of gravity. *Smoothness of perimeter* is the ratio of the perimeter of the equal-area circle to the perimeter of the shape.

	High	Low
Roundness		
Smoothness of perimeter		

Juan C. Duque, Nancy Lozano-Gracia, Jorge E. Patino, and Paula Restrepo. 2019. "Urban Form and Productivity: What Is the Shape of Latin American Cities?" Policy Research Working Paper 8697, World Bank, Washington, DC.

Getting to Jobs in Nairobi

Traveling to a job can be costly and time-consuming in Nairobi. This is especially so for poorer residents, limiting their job opportunities

In cities where people can easily reach job opportunities, whether by foot or by public transport, the labor market can be more productive. That benefits both the urban economy and workers.

Cities create agglomeration economies, the productivity gains that result when enterprises are clustered together. Poor job accessibility can inhibit these productivity gains by making it difficult to match jobs and job seekers. By contrast, good job accessibility—with city residents able to reach a large share of job opportunities within a reasonable amount of time—can boost the productivity gains.

For workers, job accessibility plays a part in employment outcomes in two ways: by affecting the probability of finding a job and by affecting the quality of the matching (more or less well paying, more or less formal). Just as important, limited job accessibility may disproportionately affect economic outcomes for disadvantaged workers. In many African cities reliable and affordable transport is lacking. Low-income workers may live far from clusters of jobs and thus face higher job search and commuting costs, or they may be too poor to use transport and thus have no option other than to walk to work. These circumstances, by

limiting their employment opportunities, could trap them in poverty.

A recent paper by Nakamura and Avner looks at these issues through an empirical analysis of the spatial distribution of job accessibility, housing rents, and poverty in Nairobi, Kenya. To disentangle them, the authors combine multiple data sources on job locations, road and minibus networks, and household consumption and housing costs. The overall level of job accessibility in a city depends on the locations of jobs and workers' residences as well as transport networks. And which households have good access to job opportunities hinges on the trade-offs they face between job accessibility, living conditions, and housing costs when choosing an area to live.

The analysis finds that workers and jobs are poorly connected in Nairobi. On average, residents can access fewer than 10 percent of existing jobs by foot within an hour. Even when using a minibus they can reach only about a quarter of the jobs within that time.

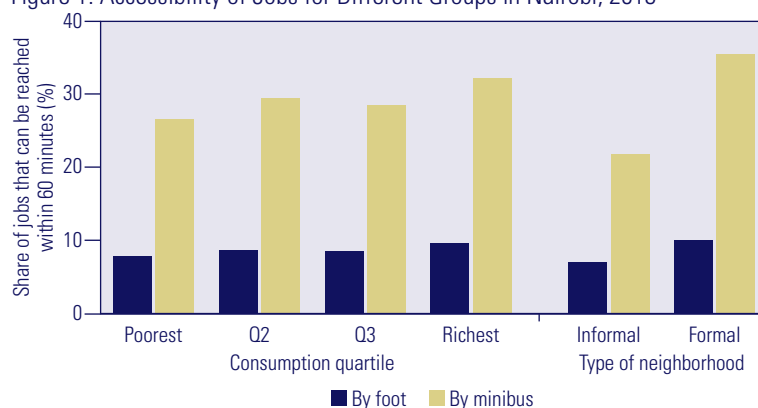
Poorer households and those living in informal settlements face even more limited job accessibility. Compared with richer households (those in the fourth quartile of per capita consumption), poor households (those in the first quartile) can reach on average 20 percent fewer jobs by foot within 60 minutes (figure 1). Similarly, residents of informal settlements can reach 30 percent fewer jobs by foot within 60 minutes than can

residents of formal residential areas.

As the authors demonstrate through econometric analysis, part of the reason that poorer households in Nairobi have more limited job accessibility is that living in housing with better job accessibility is costly, imposing constraints on their choice of residential location. Living in areas closer to job opportunities is costly not only because housing quality and living conditions tend to be better in such areas, but also because job accessibility itself is valued as an amenity in the housing market.

How to improve job accessibility among low-income households? There are several possible ways. On the supply side, promoting the development of affordable transport networks is essential over the long term. For example, facilitating the extension of minibus services to underserved areas that are home to many low-income households would help reduce their job search and commuting costs. In large, high-density informal settlements that may lack adequate space for transit, a transport right-of-way could be introduced as part of slum upgrading projects, to support the economic integration of these settlements with the rest of the city. On the demand side, such policies as cash transfers could be effective in the short term.

Figure 1. Accessibility of Jobs for Different Groups in Nairobi, 2013



Shohei Nakamura and Paolo Avner. 2018. "Spatial Distributions of Job Accessibility, Housing Rents, and Poverty in Nairobi, Kenya." Policy Research Working Paper 8654, World Bank, Washington, DC.

Public Infrastructure and Structural Transformation

A recent study shows that public infrastructure is an important driver of the structural transformation of developing economies

Economists recognize certain processes as key features of successful economic development. One of these is structural transformation—the reallocation of inputs to more productive activities, such as from agriculture to manufacturing or, later, from agriculture and manufacturing to services. Another is public infrastructure (or public capital) formation.

Moreover, cross-country data suggest that these two processes are significantly correlated. A recent study by Perez Sebastian and Steinbuks, using World Bank data for 263 economies, shows that the quality of electricity infrastructure (as proxied by average monthly power outages) is worse in economies depending more heavily on agriculture—and that it improves as manufacturing accounts for a growing share of GDP (figure 1).

But the understanding of how these two important processes interact is limited. For example, how much does public infrastructure formation matter in structural transformation, and vice versa? And how do different constraints to public capital accumulation affect economic growth and structural transformation?

To answer these questions, the study develops a multisectoral general equilibrium model of unbalanced economic growth and analyzes it quantitatively. Public infrastructure enters the model as a complementary factor that increases the productivity of private inputs such as labor or capital. The quality of public infrastructure affects firms' operating costs. Lack of public capital adds to those costs—such as when poor electricity networks require firms to rely on generators—and thus acts as a barrier to firms' entry into markets. Conversely, good public infrastructure is conducive to the creation of large business clusters that generate increasing returns and lower barriers to firms' entry.

The analysis uses data for Brazil, focusing on the post-hyperinflation period between 1995 and 2013. Brazil is widely considered to be in deep need of infrastructure investment. And the country offers high-quality data for validating the model predictions.

The results show that the accumulation of infrastructure accelerates structural transformation. According to the model simulations, public capital formation explains 5 percent of the total variation in the share of manufacturing (as measured by gross value added) observed in Brazil's economy over the period of the study—and 15 percent of that for services. For agriculture, public capital formation

generates a change in share larger than that obtained from the data and accounts for 59 percent of the combined contribution of public infrastructure and relative productivity growth.

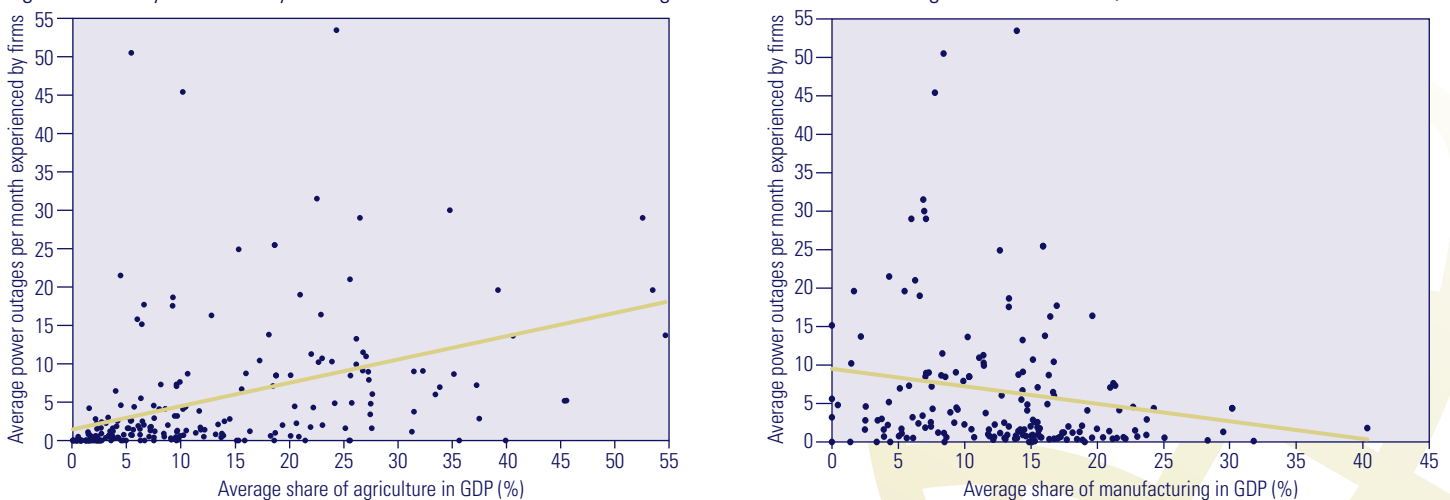
The study also conducts experiments relating the model simulations to public infrastructure policies. Two of these consider what might have happened if Brazil, rather than allowing public capital formation to fall from an average 5.7 percent of GDP in the 1970s to an average 3.4 percent in 1985–2009, had instead maintained it at the level of the 1970s.

In the first experiment the increase in the ratio of public capital formation to GDP comes as a consequence of stronger partisan incentives in favor of public spending. The result is an increase in the share of manufacturing and declines in the shares of agriculture and services. There is also a substantial positive effect on total GDP and production levels. GDP per capita rises by 10 percent. And the increase in output is especially strong in manufacturing, thanks to its important role in capital accumulation and to the greater efficiency of smaller firms that operate under diminishing returns to private inputs.

In the second, the increase in public capital formation occurs because of improvement in the management of public investment, so that a larger share of public investment spending ends up being converted into public

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Figure 1. Quality of Electricity Infrastructure and Income Shares of Agriculture and Manufacturing in 263 Economies, 2006–15



Buses, Houses, or Cash? Choices and Consequences in Reforming Public Transport Subsidies

Subsidizing public transport can have complex effects in a city. So can other policy approaches aimed at achieving the same goals

Policy makers use urban transit subsidies mainly to help improve equity—by making it easier for people, especially poor people, to access jobs and other opportunities. Yet some studies show that such subsidies fail to reach the poor and instead benefit middle-income groups the most. Even if they did reach those in need, would transit subsidies be the best way of improving welfare, or would other policy tools be more efficient? Moreover, by artificially reducing commuting costs, don't policy makers run the risk of encouraging urban sprawl with all its negative consequences?

A paper by Avner, Mehndiratta, Vigié, and Hallegatte tackles these questions by focusing on the urban area of Buenos Aires, Argentina. The authors use data from 2012, a time when public transport fares in the city were heavily subsidized. Transit subsidies that year amounted to more than \$5 billion (0.7 percent of Argentina's GDP) and covered two-thirds of the cost of public transport trips. While

the system has since been reformed, including as recently as January 2018, looking back a few years provides interesting insights and could shed light on possible effects of recent fare increases.

Using a simple urban economics model, the authors run four different scenarios:

- Removing the transit subsidy with no compensation
- Replacing the subsidy with a lump sum transfer
- Replacing the subsidy with a general construction subsidy
- Replacing the subsidy with a construction subsidy targeting areas with high accessibility to jobs

What does the model show about likely effects? First, replacing the transit subsidy with a cash transfer could generate welfare and efficiency gains (table 1). For Buenos Aires in 2012, this would have translated into an additional \$325 per household in equivalent income, or 1.75 percent of the average household budget in 2014.

Second, removal of the transit subsidy would lead to only moderate reductions in urbanization over time. This suggests that the argument that low transit fares exacerbate urban sprawl is likely overplayed. But removal of the subsidy would affect

commuting patterns. The most obvious consequence is that higher fares would lead to a decline in public transport ridership and to more carbon-intensive trips. But rising transport costs would also encourage people to move closer to their jobs, substantially reducing commuting distances. As a result, the increase in commuting-related emissions of carbon dioxide (CO₂) would remain limited under most scenarios.

Third, replacing the transit subsidy with a lump sum transfer would have significant short-term redistributive effects for the heaviest users of public transport. For tenants in the hardest-hit areas, lower accessibility would trigger a decrease in housing rents over the medium term that would partially offset the rising fares. This adjustment in rents would benefit tenants and newcomers to the urban area but would penalize homeowners, who would face both higher commuting costs and lower resale values for their property.

These results paint a complex picture of public transport subsidies in the urban area of Buenos Aires. An ideal solution would be to channel lump sum transfers only to the poorest households. This would require detailed registries recording households' incomes and their evolution over time. Second best would be to have transit subsidies benefit only the poorest households. This solution would protect low-income transit users without dramatic negative effects on efficiency or the environment. It would also ease the pressure on public resources.

Table 1. Effects under Prospective Alternative Scenarios Compared with the Baseline Scenario of Public Transport Subsidies in Buenos Aires in 2050

Percentage change

	With no public transport subsidy	With a lump sum transfer	With a general construction subsidy	With a targeted construction subsidy
Urban sprawl				
Average distance to city center	-6.97	-3.65	-7.10	-8.73
Urbanized area	-0.40	1.71	-0.51	-0.76
Average density in urban area	0.40	-1.68	0.51	0.77
CO₂ emissions				
Public transport share	-19.15	-18.95	-19.14	-19.18
CO ₂ emissions from commuting	1.28	5.11	1.12	-0.69
Welfare				
Household utility	-3.73	1.30	-2.67	-2.69

Paolo Avner, Shomik Raj Mehndiratta, Vincent Vigié, and Stephane Hallegatte. 2017. "Buses, Houses or Cash? Socio-Economic, Spatial and Environmental Consequences of Reforming Public Transport Subsidies in Buenos Aires." Policy Research Working Paper 8166, World Bank, Washington, DC.

Improving the Resilience of Peru's Road Network to Climate Events

A new model helps identify where investments can have the greatest impact in keeping traffic flowing during flood disruptions

In Peru nearly all cargo travels by road. That can mean big challenges for businesses, because Peru's difficult topography and climate sometimes lead to closures of important roads. In 1982–83, for example, a severe El Niño event caused flash floods and landslides, and most bridges on the northern parts of the Pan Americana road, along the Peruvian coast, were destroyed. Not all have been rebuilt, and many temporary structures remain.

How can countries like Peru improve the resilience of their transport networks in a context of scarce resources and growing climate uncertainty? A study by Rozenberg, Briceno-Garmendia, Lu, Bonzanigo, and Moroz seeks to identify where investments can have the biggest impact on the functionality of Peru's transport network. The authors create a geospatial model to simulate the consequences

of removing one particular transport link, such as a bridge or a road. They run this model for each link in the network, one by one. After considering every possibility, they identify the most critical links as those whose removal from the network would force many users to travel for much longer or at a much higher cost or would prevent them from reaching certain destinations (figure 1).

With the critical links identified, the authors overlay a map of the transport network with maps of extreme events such as floods and landslides. After identifying the links exposed to such events, they estimate their vulnerability: What does it take to disrupt or shut down a road? How high can the water rise before a bridge becomes impassable for trucks?

The next step is to determine how likely those climate events are. That's where things get tricky. For many places there are not enough historical data to properly estimate the return period of a climate event. And even when there are, climate change is making projections much less reliable—the flood risks of yesterday are no longer a

possible future risks to guide investment decisions.

How does one choose whether to increase maintenance or to invest in bigger culverts and elevate roads? Or perhaps building new roads is a better option, to ensure that people have an alternative route if the main link is disrupted?

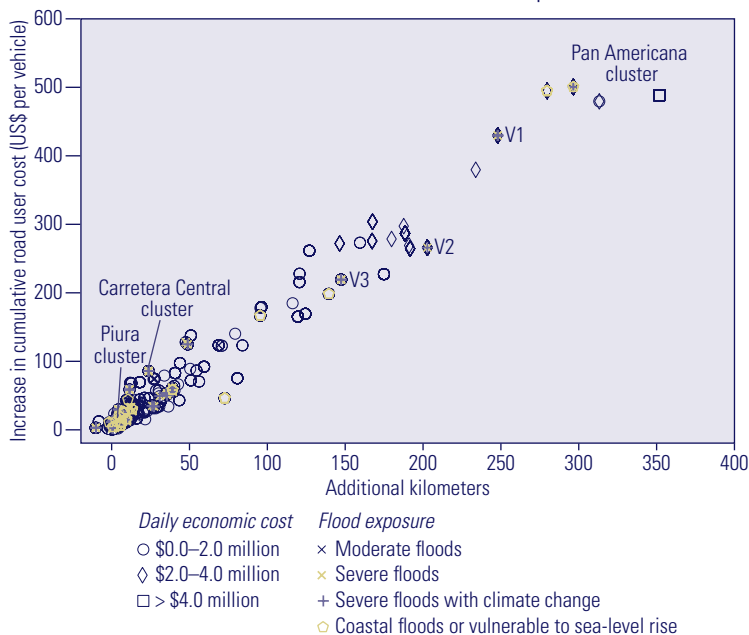
This is where the “decision making under deep uncertainty” method comes in. For each critical link the authors “stress-test” many different strategies by calculating their economic performance across a range of future conditions. They identify those that will yield acceptable economic returns whatever happens to the climate, the traffic, or the vulnerability of the link.

Unsurprisingly, the most robust strategy depends on the context. Increasing maintenance always yields positive returns and is often a robust option, but it does not prevent catastrophic impacts in places where the risk can be very high. In high-risk places, increasing redundancy is a better option despite the high cost of building new roads.

The stress tests also allow identification of the main conditions that will make an investment succeed or fail—and usually it's only a few factors that matter. For example, building a tunnel on the Carretera Central, one of the most critical roads, would have positive net benefits only under some conditions of discount rate and the frequency of annual disruptions on that road.

Importantly, the authors find that factoring climate risk into the economic analysis of projects could change the prioritization of a portfolio and allow projects initially neglected to get funds for completion or implementation.

Figure 1. Critical Links in Peru's Road Network: Estimated Effect of Their Removal on Road User Cost and Distance, and Their Exposure to Floods



Note: A moderate flood is more than 30 centimeters (cm) with a return period of 10 years or less, a severe flood is more than 50 cm with a return period of 10 years or less, and a coastal flood has a return period of 100 years or less. V1, V2, and V3 are segments on the Pan Americana.

good guide for those of tomorrow. Moreover, vulnerabilities are changing as maintenance practices evolve. And finally, current traffic patterns are hard to identify, and future ones even harder to predict. All these factors together make it hard to foresee the risk that the transport network will face in a few years. So the result is a range of

Julie Rozenberg, Cecilia Briceno-Garmendia, Xijie Lu, Laura Bonzanigo, and Harry Moroz. 2017. "Improving the Resilience of Peru's Road Network to Climate Events." Policy Research Working Paper 8013, World Bank, Washington, DC.

The Vulnerability of Manufacturing Firms to Unreliable Water Infrastructure

Firms in poorer economies suffer more from the effects of drought on water supplies, and the problems may worsen with climate change

Water affects the private sector through a myriad of channels, direct and indirect. This is evident from its prominent role in the global Sustainable Development Goals, nearly all of which are linked to water. And consider the manufacturing sector, an important source of growth especially in developing economies. It provides jobs. It drives modernization. And it can be hurt by inadequate water infrastructure. Where the public water supply is unreliable, it can drive firms to costly alternative sources.

Yet few studies have given water infrastructure an important role in the private sector. The World Bank Enterprise Surveys, which provide the most consistent coverage of firm-level data globally, do contain information on water outages. But when respondents are asked to rank the top obstacles they face, water is not among the options, though power, communication, and transportation are. Similarly, the World Bank's Ease of Doing Business Index includes electricity but does not cover water infrastructure or access to water. But all this could change as the growing focus on climate change continues to push looming water challenges to the front lines of policy.

In exploring the complex pathways through which water affects the private sector, a first step is to establish a set of narrower relationships. A recent paper by Islam and Hyland starts by asking two questions. First, what are the potential determinants of poor water infrastructure? One issue is the extent to which water infrastructure can cope with extreme variability in rainfall. Climate change will result in more frequent wet spells in more humid areas—and more frequent dry spells in more arid ones. This may have asymmetric effects across economies, as water infrastructure in the developing world may be ill equipped to cope with weather extremes.

Second, how does the quality of water infrastructure affect firm performance? It could be that the reliability of water supply has little effect on firm productivity and that the lack of attention given to water as a factor in the business environment has not been a mere oversight. But it also could be that firms in many economies have adapted production strategies to poor water infrastructure.

The study is the first to explore both questions using a data set that is truly global. The analysis draws on firm-level data from the World Bank Enterprise Surveys, covering more than 16,000 manufacturing firms in a cross-section of 103 economies between 2009 and 2015.

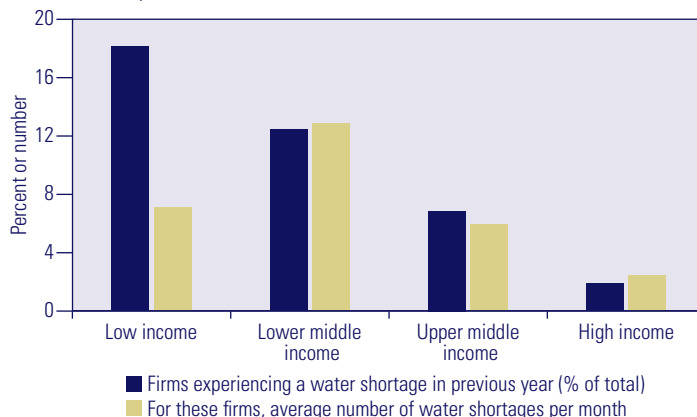
The study brings to light several new insights. Across the globe,

manufacturing firms are vulnerable to the effects of drought on water supplies, with the overall impact driven by the effect in low- and lower-middle-income economies. While wealthier economies appear to have water infrastructure in place that can buffer the effects of unanticipated droughts, this is not the case in these poorer economies (figure 1).

Beyond this, the study finds that unreliable water supplies have a negative effect on firm output that is both statistically and economically significant. Moreover, this effect is more acute in low- and lower-middle-income economies and in water-intensive sectors, further evidence that the consequences of a changing climate will not be equally borne. These economies and sectors may need to consider policies to improve the reliability of water infrastructure or to boost their resilience to interruptions in water supplies.

With a changing climate and increasing urbanization, the problems of poor water infrastructure in many economies may worsen in the foreseeable future. Unless steps are taken to improve the infrastructure, the effect on the private sector will only grow. And in the face of looming water challenges, there is a greater need than ever for high-quality data on water infrastructure quality and private sector water use to support future research.

Figure 1. Severity of Water Infrastructure Problems by Income Group, Various Years, 2009–15



Asif Islam and Marie Hyland. 2018. "The Drivers and Impacts of Water Infrastructure Reliability: A Global Analysis of Manufacturing Firms." Policy Research Working Paper 8637, World Bank, Washington, DC.

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Highway Politics in Mexico

(continued from page 5)

government may be conducive to greater distributive spending. In fact, the study finds evidence of greater distortion in highway provision when the president's party held fewer legislative seats than the opposition.

Thus distributive politics fueled by divided government, itself a manifestation of the democratic game, could

result in allocative inefficiency. This may in turn constrain returns to infrastructure and exacerbate regional disparities, an important question for future research.

Harris Selod and Souleymane Soumahoro. 2019. "Highway Politics in a Divided Government: Evidence from Mexico." Policy Research Working Paper 8710, World Bank, Washington, DC.

Public Infrastructure and Structural Transformation

(continued from page 8)

capital. Compared with the previous scenario, the sector shares do not change much, because the same amount of investment goods can now generate stronger capital accumulation. But the effects on GDP and sectoral production remain substantial.

Finally, the study looks at the practice in many developing economies of subsidizing electricity. By limiting the government's capacity to invest in electricity infrastructure, this practice can have a significant negative effect on GDP per capita and the share of manufacturing in the economy.

Fidel Perez Sebastian and Jevgenijs Steinbuks. 2017. "Public Infrastructure and Structural Transformation." Policy Research Working Paper 8285, World Bank, Washington, DC.

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