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The Case of Mexico

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Abstract*

This technical note examines the interactions between infrastructure and productivity growth in Mexico. To address this relation, we follow an approach that seek to tie down infrastructure productivity improvements in terms of the impact of particular types of infrastructure on particular sectors, thus providing the basis for informed decisions on investment priorities for economic growth. We have been able to identify significant relations between labor and capital productivity improvements, or capital deepening (i.e., investment) in infrastructure-related sectors and labor productivity improvements in other sectors. Sectoral infrastructure priorities can be found in the transport and energy sectors, broadly defined, with effects that have regional differences. The nature of our results points to complementary policies and the need to improve the regulatory compact for infrastructure in Mexico. Our results recommend special attention to the regulatory/competition policy approach in transport, and the electricity wholesale market.

JEL classifications: R11, R49, O41, O54
Keywords: Productivity, Infrastructure, Growth, Productive sectors

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Executive Summary

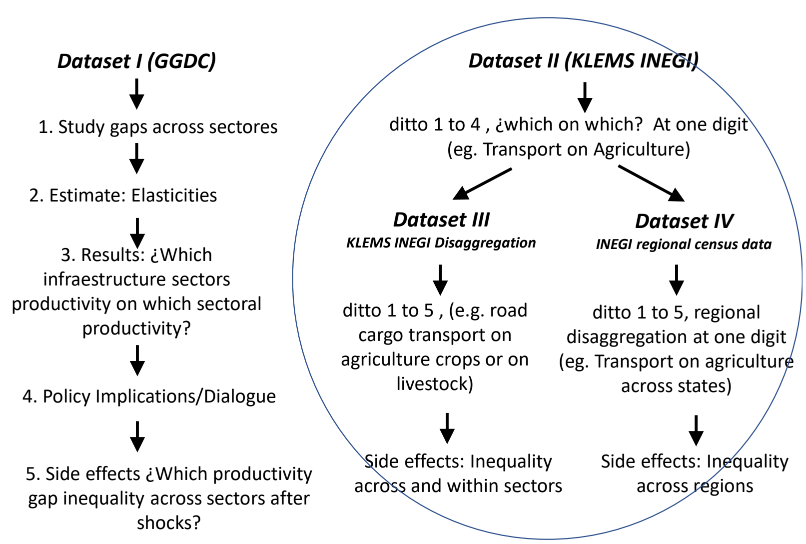
1. This report is part of a broad effort to address the role of infrastructure in fostering growth in the Latin American and Caribbean region. Against a background of existing methodologies to potentially address the link between growth and infrastructure, we follow an approach that seeks to tie down infrastructure productivity improvements and their effects on growth. Given the somehow overly aggregate level of analysis that macro approaches usually provide on the link between infrastructure and growth, the approach taken in this project attempts to provide an analysis that is more informative in terms of "*which infrastructure*" and for "*which sectors*" could be part of a growth strategy. This acknowledges that the role of infrastructure in fostering growth is country and sector-specific, and needs to be complemented with fiscal, institutional and other supporting policies. Thus, beyond a needed methodological analysis, country case studies based on this background should, in the end, provide useful elements for a country strategy in practice. The general background and objectives of this study, as well as the related literature, are presented in **Section 1**.

2. Starting with a conventional gaps analysis of infrastructure investment in Mexico, we find in **Section 2** that sectoral infrastructure priorities are in the transport and energy sectors, broadly defined, and that those priorities are located in the SE/E and NW/W regions of the country for transport and NE/SC for electricity. This initial evidence seems useful to address infrastructure for growth policy but is not in itself sufficient. It does not identify more precisely which types of infrastructure have impacts on which sectors and where in the country, how this relates to advanced/laggard sectors and regions in terms of productivity and, finally, what is the aggregate effect on the economy's productivity.

3. We contribute to this "priorities approach" by using a new dataset that allows a thorough analysis of which infrastructure sector matters for which other sectors. We also contribute by relating this with the regional allocation of infrastructure investment efforts. Our starting point and methodology draw from a previous paper that exploits a global panel (Ahumada and Navajas, 2019) and a case study on Argentina (Navajas et al., 2019) and that is based on a global data set based on GGDC and Penn World Tables. However, for the case of Mexico we take advantage of the KLEMS-INEGI growth accounting dataset, which represents a significant potential improvement on the previous dataset.

4. In **Section 3** we illustrate our dataset development efforts along with a preview of our research strategy. Given this dataset road map for Mexico, which is richer than those available for other Latin American and Caribbean countries, our data compilation started from our GGDC-based dataset covering labor productivity for 10 sectors and moved towards the KLEMS-INEGI dataset with the clear intention to improve in three dimensions. The first involves including capital series measures for all sectors, including those related to infrastructure (the latter being covered in our previous GGDC database with data from Penn World Tables). A second dimension involves broadening the potential scope of sectors in the analysis, particularly in the case of infrastructure-related sectors. Given the previous suggested path for data collection, two alternative databases were set up and used for this project. The first is the most natural extension to the type of data used in our global panel and Argentine pilot studies, and the second exploits the opportunity to disaggregate the data. As we use both GGDC and KLEMS at one digit level for comparison purposes, linking both datasets in order to cover the period 1971-2018, we call these datasets Dataset I and Dataset II, respectively. When we move to a higher sectoral disaggregation using KLEMS INEGI we create Dataset III. In a third and final dimension of improvement, when studying regional effects we use another dataset that comes from INEGI census data and measures sectoral labor productivity across Mexican states. Table 3.2 shows the use of the different Datasets for the research strategy of this case study. The circle indicates the final datasets used in the study.

Table 3.2
Sectoral productivity growth and infrastructure related sectors
Dataset and research strategy for Mexican case study



5. In order to assess the effects that productivity improvements in infrastructure related sectors have on other sectors of the economy, we extend an econometric methodology that is presented in detail in **Section 4**. Starting from an endogenous like production function framework, we specify three potential channels of influence of infrastructure that act through labor or capital productivity or through capital deepening (i.e., capital-labor ratio increases) with the relative importance of these effects to be determined empirically. The econometric approach models these effects for each sector of the economy using an automatic selection approach to estimation including other control variables and dealing with exogeneity and cross-dependence issues. The final "output" of this estimation process is an elasticity of productivity improvements in infrastructure related sectors or subsectors on other sectors or subsectors. Aggregate effects of assumed shocks on productivity can be estimated by a simple weighted adding-up across sectors.

6. Results from the estimation of elasticities start at one-digit aggregation of sectors as in Ahumada and Navajas (2019) and Navajas et al. (2019). Given these results, we move to estimate elasticities at the most disaggregated level that KLEMS-INEGI data allow. This is done in S**ection 5** (see Table 5.3 below). We find that *Cargo Road Transport* has an impact on *Agricultural Crops* and on *Manufacturing Transport Equipment. Electricity* productivity improvements have an impact on *Manufacturing Transport Equipment* and on *Wholesale and Retail Trade* and on *Hospitality Service* subsectors. *Storage* has an impact on *Agriculture Cattle*, *Production and Manufacturing*, *Food and Beverages* and *Textiles*. Finally, the "most" infrastructure-related subsectors within the Construction sector have an impact on Domestic Trade. *Civil Engineering* has an impact on *Wholesale and Retail Trade* and on *Hospitality* Services, while *non-residential construction* has an impact on *Hospitality Services*. In sum, infrastructure-related productivity shocks have sizeable macro effects; while some are direct, most occur through impact on other sectors' productivity. Additionally, the previous sectoral distribution of relevant elasticities falls in different sectors distributed across the ranking of productivity gaps. Therefore, infrastructure improvement has a positive (or at most neutral) effect on the productivity gaps across sectors.

Table 5.3

***Which on which* subsectoral effects: Long-Run Elasticity estimates of effects of infrastructure-related sectors**

Mexico 1971-2018	**Infrastructure-related Sub-Sector Effects**				
	UTL	TSC		CON	
On Labor Productivity of	*Electricity*	*Truck Transportation*	*Warehousing & Storage*	*Civil Engineering*	*Non-Residential Construction*
Agricultural Sector		**0.36**			
Crop Production		**0.68**			
Animal Production & Aquaculture			**0.27**		
Manufacturing Sector	**0.4**	**0.1***			
Transport Equipment Manufacturing	**0.52**	**0.15****			
Food, Beverage & Tobacco Manufacturing			**0.04****		
Textile, Clothing & Leather Industry			**0.11****		
Trade, Restaurants & Hotels Sector	**0.41****			**0.46**	
Wholesale & Retail Trade	**0.47****			**0.29**	**0.14***
Accommodation Services	**0.78**			**0.44***	

UTL: Utilities ; TSC: Transport, Storage & Communication ; CON: Construction
*** Indicates Capital Stock per worker effects*
** Indicates Capital Productivity*
Long-run effects from Human Capital detected for Agriculture Sector and Food, Beverage & Tobacco Manufacturing

7. With these results, we move in **Section 6** to explore evidence on the regional distribution of infrastructure projects in Mexico and find a negative relationship between investment efforts in infrastructure and the regional (economy-wide for each state) productivity gap. We thus complement the descriptive data presented in Section 2 by showing that the allocation of infrastructure investment efforts in Mexico somehow provides a rationale consistent with a strategy to close regional productivity gaps. Nevertheless, as noted above, this ordering or correlation is not informative on the regional impact of those efforts. We therefore inspect the evidence on the regional impact of sectoral productivity effects from infrastructure-related sectors using INEGI economic census data on sectoral productivity across Mexican States and estimate a cross-section of average sectoral labor productivity for four surveys from 1999 to 2018. We estimate five significant elasticities from the cross-section of 32 states: from Utilities to all three main sectors (Agriculture, Manufacturing and Trade and Hospitality Services), from Transport and Storage to Agriculture and from Construction to Trade and Hospitality Services. These effects are not, qualitatively speaking, inconsistent with one-digit results from KLEMS-INEGI reported in Section 4, even though they come from a completely different dataset. We find significant regional differences in these elasticities but no strong evidence that the observed impacts are related to either low or high productivity states. Construction is perhaps an exception, as it has significant

differential effects on the productivity of Trade and Hospitality Services in regions with low productivity in the South-West and West. Transport and Storage productivity has a positive differential effect on Manufacturing of a similar magnitude across several regions, although the overall effect is not captured for the whole sample. Utilities' productivity impact on Agriculture productivity has a differential positive effect on NE and NW. The same is true for the effects of Utility productivity on W and NW states' manufacturing productivity. Negative coefficients for these estimated effects are perhaps more interesting from a policy inquiry perspective on how certain efforts in infrastructure investment do not translate into productivity improvements. Diminished effects from improvements in Transport sector productivity on Agriculture show up in North Center, although not enough to eliminate the overall positive effect that transport has on agriculture in that region. On the other hand, productivity improvements in Utilities are associated with strong negative differential effects on Trade and Hospitality Services in East and South-West states of a magnitude sufficient to eliminate vanish the overall positive effects.

8. To sum up, the main results of this projects are, to our knowledge, a significant step towards understanding the interactions between infrastructure and productivity growth in Mexico. We have been able to identify significant relations between labor and capital productivity improvements, or capital deepening (i.e., investment) in infrastructure-related sectors and labor productivity improvements in other sectors. The lower level of aggregation of these estimated relationships, which we have been able to achieve thanks to the KLEMS-INEGI dataset, provides a detailed map of *which* infrastructure subsector matters—according to the evidence for Mexico—for *which* subsector of the economy, which at the same time is consistent with macroeconomic or aggregate activity data. This is a significant improvement, we believe, with respect to the received literature in regard to empirical results that may guide policy actions. Beyond a traditional gaps evaluation that indicated, in Section 2, and in too general terms, that transport and energy are important to boost infrastructure policy in Mexico and that the regional allocations of projects follows a rationale based on closing development gaps, we have both qualitatively and quantitatively determined which subsectors within the transport and energy sectors are important for which subsectors within the agriculture, manufacturing and domestic trade and hospitality services sectors. These sectors contain more than half the employment of the Mexican economy, are composed of subsectors that belong to both high and low-productivity segments and have a significant presence across regions. Our results give us some confidence to recommend that case

studies and project evaluations be oriented towards sectors where infrastructure has, according to our results, a significant macroeconomic or aggregate impact as well as a regional effect. The "priorities" approach that motivates our search for sectoral links between infrastructure and other sectors point to labor productivity improvements in cargo transport as a significant driver of agriculture productivity; electricity labor productivity as a driver of transport manufacturing and hotels services productivity; storage and warehouse labor productivity as a driver of rural activities productivity and civil engineering labor productivity as a driver of wholesale and retail productivity. Other significant effects come through capital productivity improvements of non-residential construction on wholesale and retail trade and of civil engineering on hotels services. Effects that come through capital deepening or intensity (i.e., capital labor increases) also come into this picture. They are present as effects of electricity on wholesale and domestic trade, cargo transport on transport equipment manufacturing and warehouse and storage on both food and beverages and textiles manufacturing.

9. The evidence that "disembodied" productivity improvements in infrastructure related sectors are significant and richer than "embodied" productivity improvements or even capital deepening is consistent with the view expressed in the IDB (2020) DIA report *From Structures to Services* and the empirical results stemming from Computable General Equilibrium Modeling exercises presented there, in the sense that "software" improvements in infrastructure are as important as "hardware" or investment efforts. This turns our attention to the importance of complementary dimensions that unlock or foster the effects of infrastructure investment as they become a focal point of policy recommendations. The IDB (2020) DIA report is also important as it gives substance to the type of economic effects that are behind productivity improvements in infrastructure. They come in the form of product or process innovations that significantly increase the flow of services from an existing capital stock. For example, improvements in digitalization may significantly increase the frequency of trains or road cargo trucks or the flow (and control of losses) of electricity transport and distribution. Demand effects in both cases, allowing demand to better meet supply or to control consumption flows, may also contribute to more services. Beyond these effects there are also important effects that come from organizational reallocations within infrastructure services that may come from better business and labor practices. These effects are notably related to improvements in regulation and competition as well as in less inefficient labor

regulations or better business procurement practices. They deserve a closer look in the case of Mexico as an extension of this study.

10. We thus conclude in **Section 7** with an argument that the nature of our results points to complementary policies and recommendations that can be drawn from this study. Coupled with previous diagnosis on the need to improve the regulatory compact for infrastructure in Mexico, our results recommend special attention on the regulatory/competition policy approach to transport and the design and working of the electricity wholesale market. These policy ingredients are necessary to promote productivity improvements and investments in infrastructure and to achieve desired impacts on other sectors. Differentials across regions also suggest that efforts to improve regulations may be well merited in some regions/states where there is a sub or underperformance of the impacts of infrastructure productivity and investment efforts on sectoral productivity performance. Our preliminary results suggest this is relevant for transport in the NC region and for electricity in the E and SW regions.

1. Introduction and Background

This study is part of an agenda to address the role of infrastructure in fostering growth in the LAC region. Against a background of existing methodologies to potentially address the link between growth and infrastructure, we follow an approach that seeks to determine infrastructure development strategies for sustainable growth. Following meetings with external advisors and IDB staff and given IDB studies on priorities for reaching higher per capita incomes, it was decided that infrastructure should play a significant role in this new strategy, at least for higher middle-income countries. At the same time, and given the somehow overly aggregate level of analysis that macro approaches usually provide on the link between infrastructure and growth, there was a demand for an analysis that could be more informative in terms of "*which infrastructure*" and for "*which sectors*" could be part of a growth strategy. This acknowledges that the role of infrastructure in fostering growth is country and sector-specific, and that infrastructure needs to be complemented with fiscal, institutional and other supporting policies. Thus, beyond a needed methodological analysis, country case studies based on this background should, in the end, provide useful elements for a country strategy in practice.

The approach follows a proposal (Izquierdo, Navajas and Steiner, 2018) that considered available platforms for growth analysis considering their relevance and usefulness for a growth strategy based on infrastructure, namely "growth diagnostics" (Hausmann et al., 2005); "going for growth" (OECD, 2013); "development gaps" (Borensztein et al., 2014); "priorities for reaching higher per-capita incomes or PPI" (Izquierdo et al., 2016) and *"growth accounting"* (Mas, 2009), which includes "KLEMS accounting" (Hoffman et al., 2017a, 2017b; see also Guillén, 2013, for Mexico) as a promising avenue but one that involves significant data challenges given that infrastructure capital is not (unlike Mas, 2009) measured. The contribution of the report was also a preliminary exploration for disaggregating the effect of infrastructure on growth across different sectors. The resulting evaluation suggested a line of analysis that makes use of the GGDC Database (Trimmer et al., 2015) to address two areas. The first involves studying study sectoral productivity evolution across time for a given economy with the intention of determining whether productivity shocks in infrastructure-related sectors (Energy, Gas and Water; Transport, Storage and Communications or the Construction sector) could be shown to have an impact on other sectors of the economy. Second, the proposal further briefly elaborated on the roles for public and private sectors and the complementary institutions and policies that increase the likelihood of success of infrastructure investment in jumpstarting growth, stressing the role of regulatory institutions, competition policy, budget institutions and cost and demand management issues.

From this starting point there were two main efforts directed at implementing this approach. The first (Ahumada and Navajas, 2019) developed an empirical methodology for the study of infrastructure-related sectors' productivity shocks on sectoral productivity. The proposed methodology takes a departure from the vast literature on infrastructure and growth by enlarging the dimensionality (sectors) of the problem and positing a different channel to study the effects from infrastructure. Much of the literature on the effects of infrastructure since the seminal paper of Aschauer (1989) sees infrastructure as public or private capital additions with effects on aggregate output or growth. More recently, Ramey (2020) provides an updated and solid elaboration on the interplay between infrastructure and aggregate output performance, separating short and long-run effects and considering estimation issues. On the empirical research agenda, applied econometrics papers have studied the effects of infrastructure capital on growth (e.g., Calderón and Servén, 2014, 2016; Egert et al., 2009; and Estache and Garsous, 2012) or on aggregate output (Calderón et al., 2015), all pointing to the relevance of infrastructure for long-term growth. Instead, in the case of Latin Americ and the Caribbean, Teles and Mussolini (2011) do not find a long run relationship between an estimate of total factor TFP at an economy-wide level and measures of physical infrastructure in Argentina, Brazil, Chile and Mexico, between 1950 and 2000. Papers for Mexico within this literature are Soto et al. (2017)—which also exploits regional differences in Mexico—and Noriega and Fontela (2007). Across this vast literature there is no consensus on which infrastructure sector matters most for aggregate growth, with results that depend on the methodology employed, while to our knowledge there are no available results on sectoral growth effects of infrastructure (i.e., "on which" sectors). The literature usually assumes a production theory framework where *capital infrastructure* enters into a given aggregate economy-wide production function. Instead, we propose a production process where a *productivity* parameter A_s enters the sectoral production function of sector i, where s indicates an infrastructure sector and i indicates one of the other sectors.

From this we could estimate elasticities that can be informative on i) which infrastructure sector (energy, transport, construction) productivity improvement had most impact on ii) which sectors' productivity and iii) what would be the results for aggregate and sectoral (i.e., disparities) performance. For estimation this paper implemented a Time Series-Cross Section model using a global panel data set of 25 OECD, Latin American and Caribbean and Asian countries for 10 sectors from 1971 to 2015. Initial estimates on the effects of infrastructure productivity shocks on growth for Latin America and the

Caribbean were reported in the IDB Macro Report in March 2019 (Cavallo and Powell, 2019).[1] The second effort came in the form a country pilot study applied to Argentina by FIEL (Navajas et al., 2019).

This project can be understood, within the context of the previous studies, as having three broad main objectives. The first is to measure the impact of infrastructure on productivity growth at a sectoral and aggregate level, and the second is to address related econometric methodology and estimation issues. The third involves an attempt to measure the effects of infrastructure plans and efforts in Mexico at a regional level.

Measurement Issues

We have compiled a large and novel dataset to extend the methodology for the case of Mexico, attempting to improve upon—in terms of both the measurements undertaken in the global panel study and in the case study of Argentina, both in time extension and in sectoral coverage. Our existing data source (i.e., the GGDC data on labor productivity) covers from 1971 to 2014. Thus one immediate task of the project was to extend the data set on value added and employment by sector to 2018 using national accounts official statistics. However, our main efforts were directed at extending the sectoral dataset towards the KLEMS/INEGI framework, which is on the one hand shorter in its time span (1990-2018) but much richer in terms of sector. In **Section 3** of this report we provide a detailed description of the datasets used in this study. The transition to the KLEMS/INEGI data format in Mexico was crucial for making progress in this pilot case study in relation to previous cases because it allows us to enlarge considerably the number of subsectors within a given sector, in particular disaggregating within some infrastructure-related sectors. Using the KLEMS/INEGI format further us allows to measure own-sector capital, which was a missing variable in our previous dataset.

Econometric Methodology and Estimation Issues

We proceed as in the Argentine pilot case study (Navajas et al., 2019) with the previously noted advantage of having a better data framework. Our main objective will be to arrive at estimated elasticities from infrastructure-related productivity to sectoral productivity. This will allow us to add-up to aggregate effects for the economy with information on which infrastructure-related sector shows a larger impact and on which sectors these impacts occur. **Section 4** of this report presents our econometric framework, while

[1] Versions of the paper were presented in September through December 2019 in the Oxford Dynamic Econometrics Conference https://www.nuffield.ox.ac.uk/media/3699/dynamic-econometrics-conference-programme.pdf in the Valencia IVIE/KLEMS group seminar and in the UNT Tucumán Growth Seminar https://face.unt.edu.ar/web/theory-and-evidence/

Section 5 shows estimation results for both aggregated and disaggregated data. These elasticities are useful parameters in many respects. First, the estimates are important for providing econometric evidence that can be compared with implicit elasticities revealed in simulations done with other methodologies, such as those performed with Computable General Equilibrium Models (CGEM), such as those reported in Cavallo et al. (2019). Second, estimates are important to perform simulations of given or assumed increases in productivity growth in infrastructure-related sectors, for instance assuming a convergence to regional or world benchmarks. Thirdly, elasticities also inform on (or respond to) questions about the differential impact across sectors and to whether infrastructure productivity growth affects sectoral productivity gaps (Diao et al., 2017, Golin et al., 2013; Lagakos and Waugh, 2013; Sinha, 2016). Finally, they can be used to examine whether the strategy to invest in infrastructure as revealed in existing plans correspond to sectors where productivity impacts are higher.

Infrastructure Projects in Mexico: Are They Consistent with a Growth Strategy? Do They Level the Playing Field for Less Developed Regions?

A reasonable starting point is to see whether plans and investment efforts correspond to the observed gaps as detected by the gaps indicators. We perform this in **Section 2** below, where we find that transport and energy, the two sectors with the most visible gaps in the benchmarking against the region, represent a large part of efforts in recent years. We know this is not enough to grade infrastructure policy vis-à-vis growth. In fact, from a critical or inquisitive point of view of infrastructure plans, we point out that—as observed in some papers (e.g., Izquierdo et al., 2016)—the gaps approach orientation may not coincide with a productivity-impulse approach such as the one performed in our methodology or in CGEM exercises. Namely, growth impacts depend on elasticities that may point to priorities located in subsectors not necessarily at the bottom of the observed-gaps ordering. Thus, a reasonable extension of our methodological approach is to look in detail at gaps, investment efforts and plans against our previous empirical results. To do this may be quite different from country to country depending on the case, thus the importance of country case studies (led by a previous analytical/measurement framework). For instance, the pilot study for Argentina reported that, regarding the sectoral distribution of the investment requirements for closing gaps, it was mainly concentrated in investments in the energy sector (expansion of the power generation capacity) and in the transport sector (densification of the road network, railway and expansion of port capacity). This was found to be consistent a previous diagnosis of deterioration in the quality of provision and underinvestment in economic infrastructure and also with the efforts revealed in recent infrastructure policy and public-private partnership (PPP) programs. In the case of Mexico, we measure gaps and investment efforts and then review all these documents to provide a stylized summary of different proposals or existing plans. Our review also relates to some technical literature and reports from global institutions that have addressed infrastructure and growth issues in Mexico (Cantú, 2017; OECD, 2019; McKinsey, 2018; Global Infrastructure Outlook, 2019) that we will review to complement our analysis. The plan launched by Mexico at the end of 2019 (*Acuerdo Nacional de Inversion en Infraestructura*) and received wide coverage[2] has been under revision since them but the data gathered for its preparation points to a stock of existing and potential projects. The plan pointed to 147 projects in Transport, Communication, Water and Sanitation, Tourism and Health, with a substantial investment effort (more than USD 40 billion at the time of announcement). More important, existing and past projects can be obtained from Mexico Projects Hub (2020). We use this source in **Section 2** to assess the regional allocation of projects and in **Section 6** to evaluate if efforts are located in regions with disadvantages in terms of productivity gaps. The next section is, we believe, a good way to start this study as it puts in perspective the performance of infrastructure sectors in Mexico.

2. Reading Mexico Infrastructure Gaps, Investment Requirements and Territorial Allocation of Projects

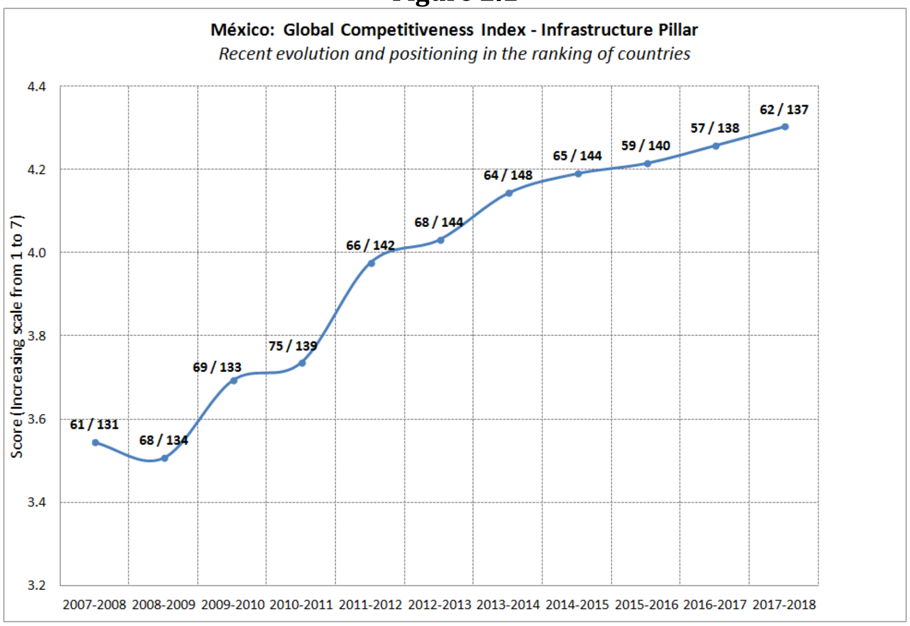
This section summarizes a longer and more detailed report (available upon request) performed for this project where we proceeded to estimate the investment required for Mexico for the closing of horizontal gaps at a sectoral level with the goal of achieving density and coverage of provision standards respective to regions and country groups (e.g., income groups). Additionally, a first approximation of the territorial distribution of economic infrastructure projects in execution and projected is presented. The section starts with a review of the recent evolution of Mexico's position in the infrastructure pillar world ranking included in the Global Competitiveness Index (GCI) elaborated by the World Economic Forum (WEF). Our main conclusions from an evaluation of the Mexican case are presented below.

Mexico has sustained a continuous improvement in its GCI score, while the increase in the number of countries surveyed has not eroded its relative advance in the ranking until the 2016-2017 edition. According to the 2019 edition, even though it has a better position in the ranking according to the infrastructure pillar, some lack of improvement in transport infrastructure is observed. Regarding the

[2] https://www.milenio.com/negocios/pni-2019-2024-prioriza-147-proyectos-infraestructura
http://www.revistainfraestructura.com.mx/plan-nacional-de-infraestructura/
https://www.forbes.com.mx/los-147-proyectos-que-desarrollara-la-ip-con-el-acuerdo-para-la-infraestructura/

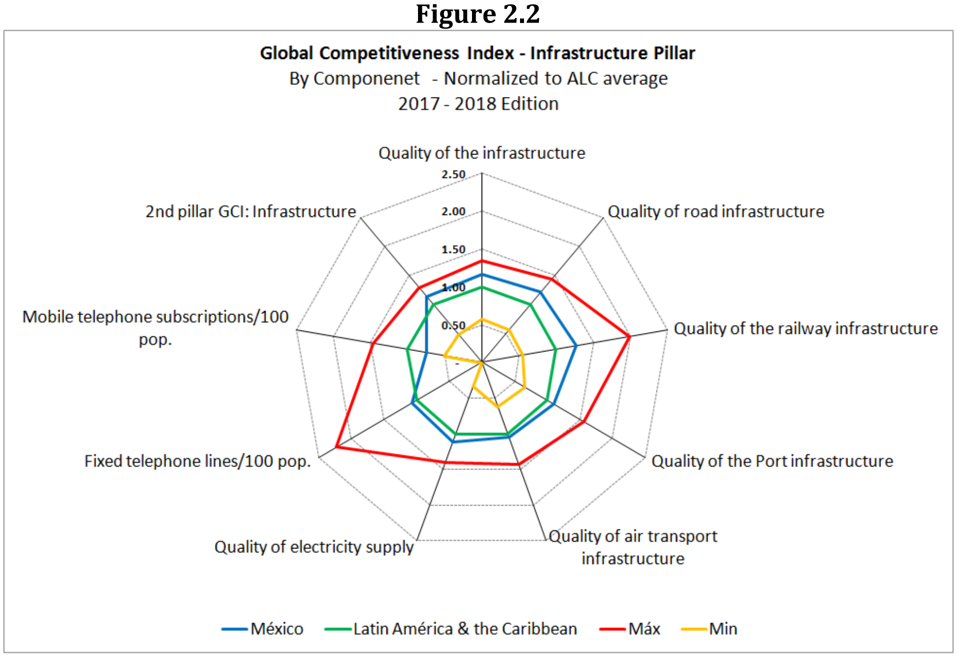
perception of quality in the provision of transport infrastructure services (roads, railways, ports, etc.) and the electricity supply, **in all cases Mexico shows a better score than the LAC average**.

Figure 2.1



Source: Own based on The Global Competitiveness Report 2017–2018 Database.
https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018

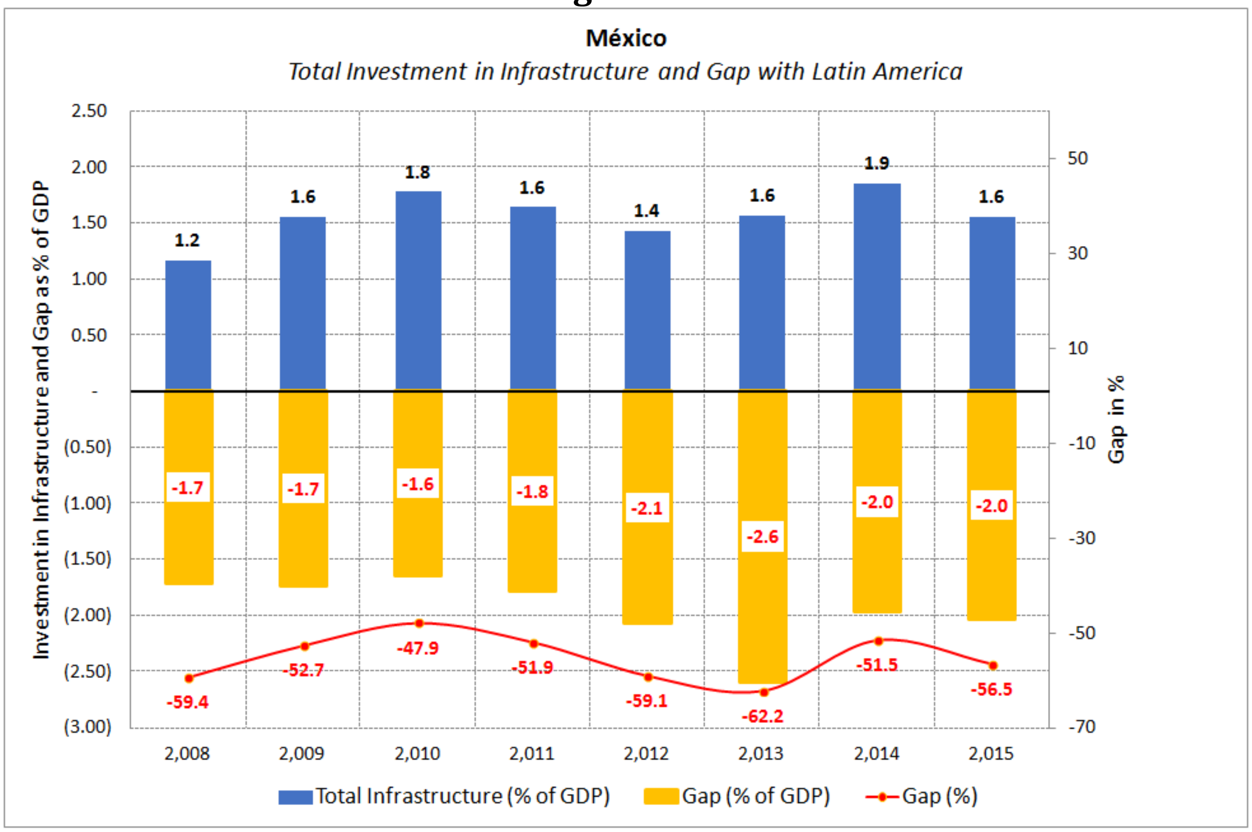
Figure 2.2



Source: Own based on The Global Competitiveness Report 2017–2018 Database.
https://www.weforum.org/reports/the-global-competitiveness-report-2017-2018

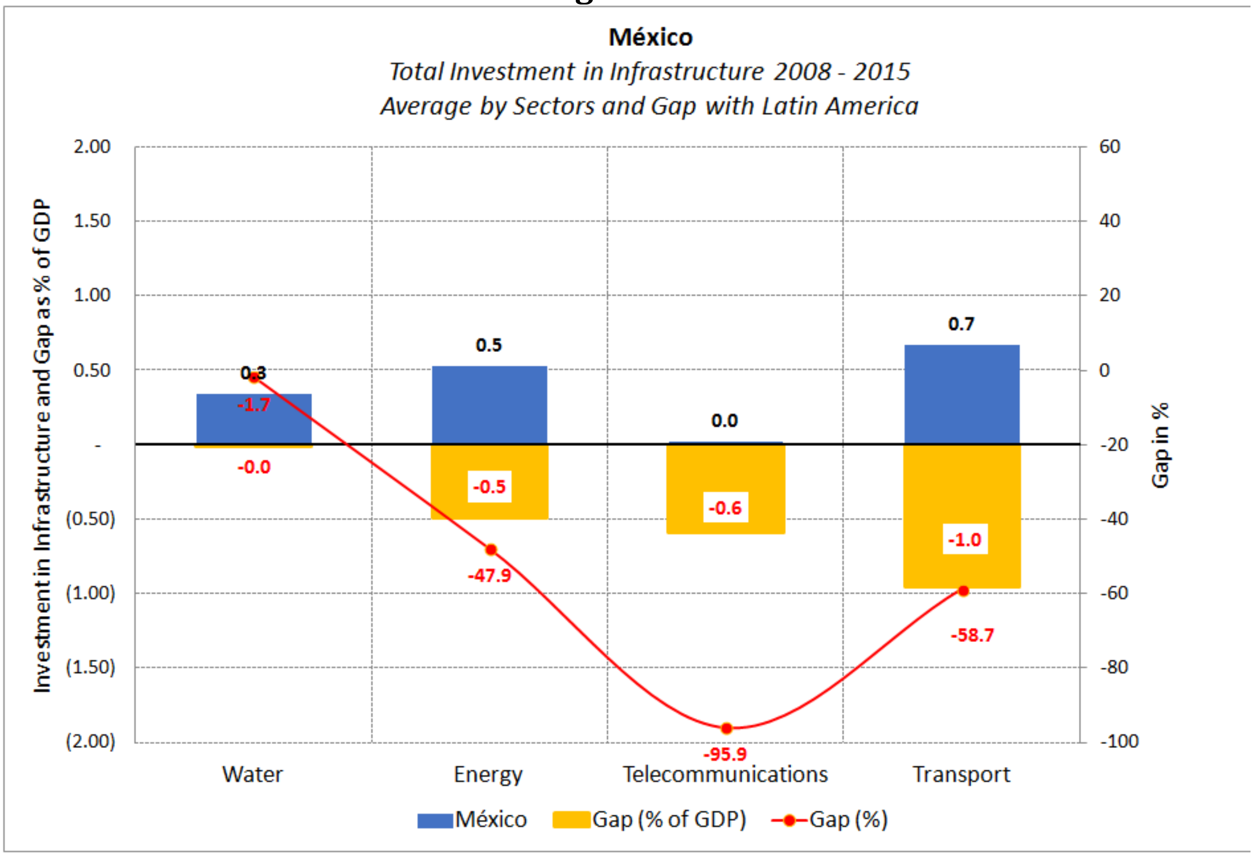
Expenditures on investment of economic infrastructure in the 2008-2015 period averaged 1.6 percent of GDP in Mexico. **In comparison with the LAC countries, the investment deficit is around 1.9 percent of GDP on average, representing a gap of 55 percent with the countries of the region**. The largest gap with respect to LAC is found in investments made by the private sector. The public sector explains 80 percent of the total investment in infrastructure in Mexico. **The largest sectoral gap in comparison with the countries of the region according to the amount of investment corresponds to the transport and energy sector**.

Figure 2.3



Source: Own based on InfraLatam Database. http://www.infralatam.info/

Figure 2.4



Source: Own based on InfraLatam Database. http://www.infralatam.info/

Mexico's infrastructure investment requirements vary widely according to the reference group for which the closure of the infrastructure service coverage gap is proposed. Thus, for example, in relation to upper-middle income countries, the group to which the country belongs, investment in infrastructure would reach 12.7 percent of GDP. The efforts are greater when the comparison is made with high-income countries, European countries or North America. In contrast, in the regional comparison with Latin American and Caribbean countries, the effort is somewhat more modest and is equivalent to 21.4 percent of GDP in 2019. Regarding the distribution of investment requirements by sectors in terms of GDP for each of the selected benchmarks, the comparison with any group of countries—by region or income level—shows that **the highest investment requirements are concentrated in energy and transport**.

Table 2.1

Infrastructure Stock
Mexico and selected countries
By Infraestructure Sector

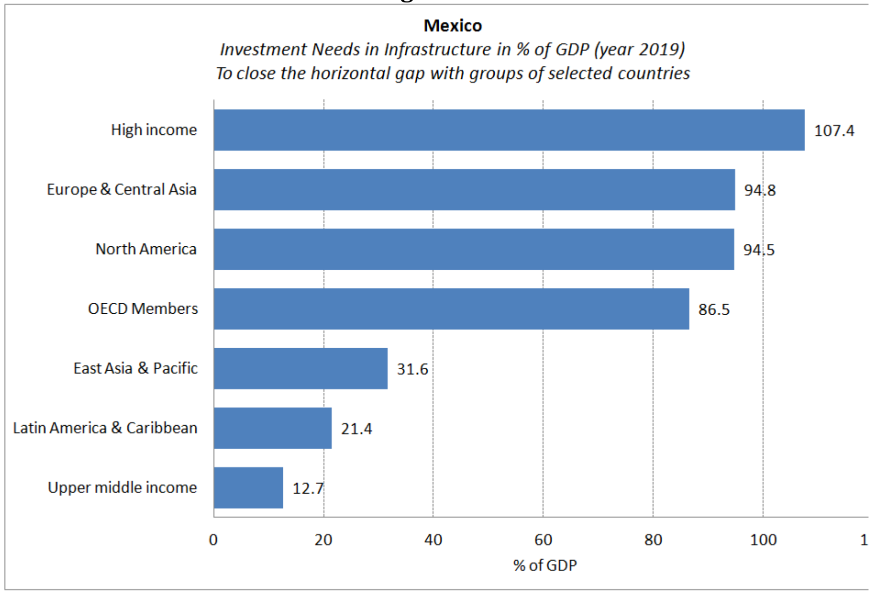
	Electric Generating Capacity (kW/ per capita)	Total Roads (km/Km^2)	Rail Lines (km/km^2)	Container Port Throughput (TEUs / GDP)	Fixed Telephone Subscriptions/ hab	Mobile cellular subscriptions/ hab	Fixed Broadband Subscriptions/ hab	Safe Water Access (% of population)	Safe Sanitation Access (% of population)
East Asia & Pacific	1.04	1.45	0.020	0.000034	0.18	1.06	0.114	78.6	72.1
Europe & Central Asia	1.83	4.91	0.040	0.000009	0.29	1.18	0.289	91.6	82.2
Latin America & Caribbean	0.95	1.07	0.010	0.000028	0.20	1.11	0.143	88.7	74.2
Argentina	0.87	0.10	0.006	0.000004	0.22	1.30	0.189	99.6	94.8
Brazil	0.77	0.23	0.004	0.000004	0.18	0.98	0.148	97.5	49.3
Chile	1.39	0.10	0.003	0.000016	0.16	1.33	0.172	98.6	77.5
Colombia	0.35	0.18	-	0.000010	0.14	1.28	0.133	73.2	17.0
Mexico	***0.61***	***0.20***	***0.007***	***0.000005***	***0.17***	***0.94***	***0.144***	***42.9***	***50.4***
Peru	0.45	0.11	-	0.000013	0.09	1.20	0.071	50.4	42.8
Uruguay	1.42	0.44	0.009	0.000016	0.33	1.49	0.282	99.2	95.7
Middle East & North Africa	1.36	0.94	0.016	0.000073	0.16	1.10	0.107	88.6	69.3
North America	3.31	0.29	0.010	0.000003	0.35	1.06	0.359	99.3	90.7
South Asia	0.43	0.86	0.018	0.000026	0.03	1.05	0.037	61.9	
Sub-Saharan Africa	0.13	0.20	0.004	0.000026	0.02	0.83	0.013	58.2	33.5

Mexico and selected countries by income level
By Infraestructure Sector

	Electric Generating Capacity (kW/ per capita)	Total Roads (km/Km^2)	Rail Lines (km/km^2)	Container Port Throughput (TEUs / GDP)	Fixed Telephone Subscriptions/ hab	Mobile cellular subscriptions/ hab	Fixed Broadband Subscriptions/ hab	Safe Water Access (% of population)	Safe Sanitation Access (% of population)
High income (H)	2.19	4.55	0.045	0.000024	0.33	1.26	0.285	97.6	90.6
Argentina	0.87	0.10	0.006	0.000004	0.22	1.30	0.189	99.6	94.8
Chile	1.39	0.10	0.003	0.000016	0.16	1.33	0.172	98.6	77.5
Uruguay	1.42	0.44	0.009	0.000016	0.33	1.49	0.282	99.2	95.7
Upper middle income (UM)	0.76	0.64	0.014	0.000022	0.14	1.07	0.112	83.3	64.1
Brazil	0.77	0.23	0.004	0.000004	0.18	0.98	0.148	97.5	49.3
Colombia	0.35	0.18	-	0.000010	0.14	1.28	0.133	73.2	17.0
Mexico	***0.61***	***0.20***	***0.007***	***0.000005***	***0.17***	***0.94***	***0.144***	***42.9***	***50.4***
Peru	0.45	0.11	-	0.000013	0.09	1.20	0.071	50.4	42.8
Lower middle income (LM)	0.28	0.34	0.010	0.000048	0.05	0.96	0.035	63.9	49.3
Low income (L)	0.08	0.13	0.007	0.000040	0.01	0.62	0.005	53.3	31.6
OECD Members	2.36	1.26	0.045	0.000009	0.32	1.20	0.328	96.4	89.2

Source: Own based on EIA-DoE US; World Bank WDI and UNCTAD.

Figure 2.5



Source: Own results.

Table 2.2

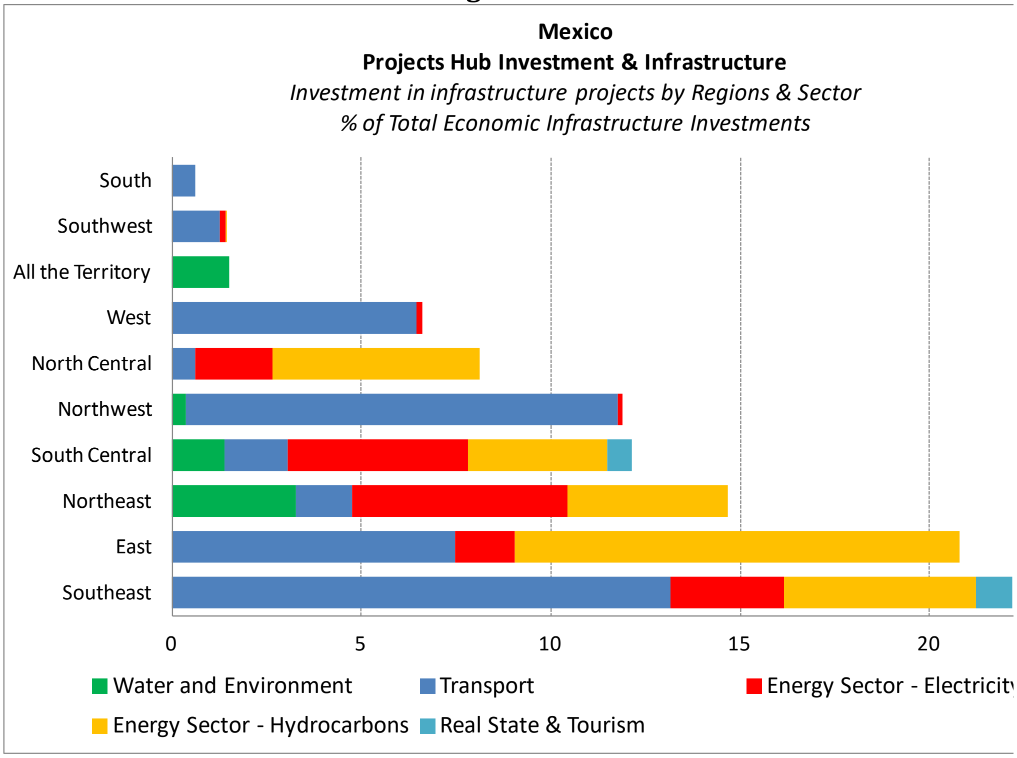
Infrastructure investment needs to close the horizontal gap
By Infraestructure Sector
As % of GDP

	Energy	Transport	Comunications	Safe Water Access & Sanitation	Total needs
East Asia & Pacific	14.21	16.14	0.65	0.62	31.61
Europe & Central Asia	40.14	51.04	2.70	0.87	94.75
Latin America & Caribbean	10.98	8.65	1.06	0.73	21.41
North America	88.85	1.86	2.77	1.06	94.54
High income	51.89	51.21	3.30	1.05	107.45
Upper middle income	4.70	6.79	0.65	0.53	12.68
OECD Members	57.74	24.57	3.15	1.02	86.48

Source: Own Results

Finally, the analysis of the list of projects included in Mexico Project Hub, coincides with the diagnosis in terms of sectoral needs. **Infrastructure projects related to transportation have a greater territorial presence in the South, while those related to electricity are in the North and those associated with hydrocarbons are located to the East**.

Figure 2.6



Source: Own based on Mexico Proyects Hub.

3. Measurement: Datasets and Research Strategy

Table 3.1 summarizes our search of available sectoral productivity datasets for Mexico. They are the GGDC sectoral dataset (available from 1971 to 2011), used in the global panel and Argentina pilot study, which covers output and labor for 10 sectors; the LA KLEMS project dataset, which covers output labor and capital for the same 10 sectors and is available from 1990 to 2015; and the KLEMS-INEGI dataset, which also covers output, capital and labor from 1990 to 2018 (overlaps with the LA KLEMS with the same aggregate sector series) but allows disaggregation up to 99 sectors in total and has a richer definition of capital, as shown to the right of Table 3.1. Finally, the OECD statistics dataset also has output and labor disaggregated for 98 sectors from 1993 to 2018.

Table 3.1

México	GGDC	LAKLEMS	KLEMS INEGI Mexico	OECD Stat
Variables	Q - L	Q - L - K - TFP	Q - L - K - TFP	Q - L
Sectors	10	10	99	98
1971	*(starts 1950)*			
1972				
1973				
1974				
1975				
1976				
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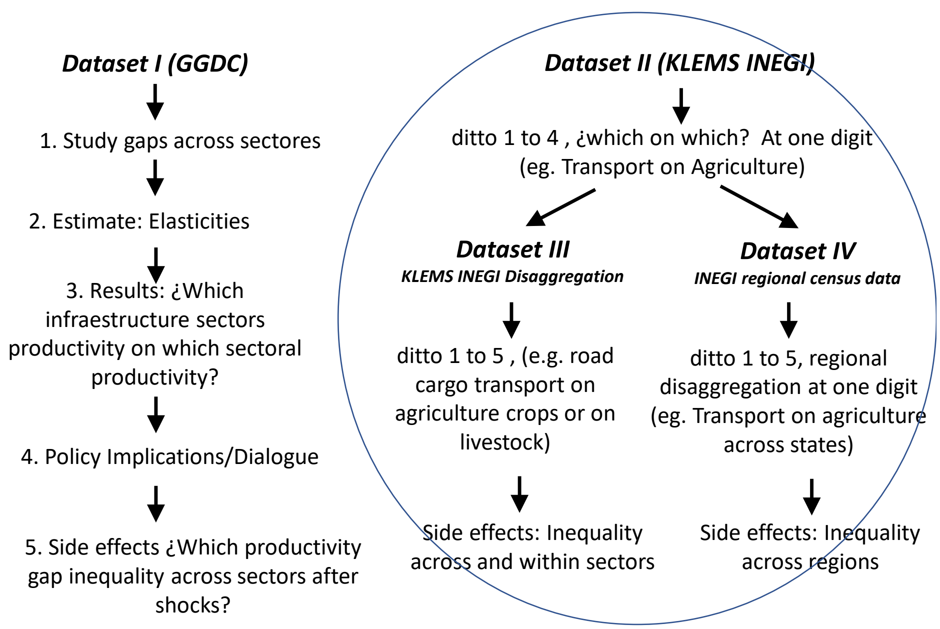
2016				
2017				
2018				

Given this dataset road map for Mexico, which is richer than those available for other Latin American and Caribbean countries, our data compilation started from our GGDC-based dataset covering labor productivity for 10 sectors and moved towards the KLEMS-INEGI dataset with the clear intention to improve in two dimensions. The first is to include capital series measures for all sectors, including those related to infrastructure (the latter being covered in our GGDC database with data from Penn World Tables). The second dimension is to broaden the potential scope of sectors in the analysis, particularly in the case of infrastructure-related sectors. Given the previous suggested path for data collection, two alternative databases were set up and used for this work. The first one is the most natural extension to the type of data used in our global panel and Argentine pilot studies. The second exploits the opportunity to disaggregate the data.

As we use both GGDC and KLEMS at one-digit level for comparison purposes, linking both datasets in order to cover the period 1971-2018, we call these datasets Dataset I and Dataset II, respectively. When we move to a higher sectoral disaggregation using KLEMS INEGI we create Dataset III. Finally, when studying regional effects in Section 6 we use another dataset that comes from INEGI and is based on sectoral labor productivity across Mexican states. Table 3.2 shows the use of the different datasets for the research strategy of this case study. The circle indicates the final datasets used in the study. In the following subsections we describe their main contents.

Table 3.2
Sectoral productivity growth and infrastructure related sectors
Dataset and research strategy for Mexican case study



Dataset II: 1971-2018 KLEMS-INEGI Dataset (extrapolated with GGDC for 1971-1989)

Our initial database flips around the template-extension order and stems from the INEGI-KLEMS project data for output (GVA), employment and capital stock for the period 1990-2018. These series are used as a template and extended back to 1971 using GGDC data (regarding GVA and labor). The capital stock series extension method is thus equivalent to that of the other database; what changes in essence are the sectoral labor productivity series. Other control variables are added to this database for further exploration: measures of Natural Disaster events taken from EM-DAT,[3] the Polity Democracy-Autocracy Index from the Systemic Peace Polity 5 Project, and a civil violence measure from the Systemic Peace MEPV Project.[4]

Table 3.3. Dataset II. 1971-2018 KLEMS-INEGI dataset with GGDC dataset link

code	*Variable description*	*Observations*	*Unit*	*Source*
y_i	**Labor productivity**		Log - Thousand 2013 mexican pesos per worker engaged	GGDC, INEGI/KLEMS
k_i	**Capital stock per worker**		Log - Thousand 2013 mexican pesos per worker engaged	GGDC, INEGI/KLEMS
hc	**Human Capital Index**		Index	PWT 9.1
trade	**Trade as % of GDP**	*(exports + imports)*	% of GDP	World Bank
sav	**Gross Domestic Savings**	*GDP less final consumption expenditure*	% of GDP	World Bank
pl_gdpo	**Price level of CGDPo (PPP/XR), price level of USA GDPo in 2011=1**	*Inverse of real exchange rate*	Index	PWT 9.1
age	**Age Dependency Ratio**	*Ratio of dependents to working age populatio*	% of working-age population	World Bank - United Nations
earth	**Earthquake event**	Affecting >0.1% population or GDP	Binary Dummy	Emergency Events Database (EM-DAT)
storm	**Storm event**	Affecting >0.1% population or GDP	Binary Dummy	Emergency Events Database (EM-DAT)
flood	**Flood event**	Affecting >0.1% population or GDP	Binary Dummy	Emergency Events Database (EM-DAT)
droug	**Drought event**	Affecting >0.1% population or GDP	Binary Dummy	Emergency Events Database (EM-DAT)
polity	**Democracy/Autocracy Index**	(-10) means pure autocracy, (10) pure democ	Index (-10,10)	Systemic Peace Polity 5 Project
violence	**Civil violence events score**	From 0 (none) to 10 (highest score)	Score	Systemic Peace MEPV Project

Dataset III: 1971-2018 KLEMS-INEGI Dataset (extrapolated with GGDC for 1971-1989) with Sub-sectorial Disaggregation

The data available in the INEGI project based on KLEMS methodology[5] spans from 1990 to 2018 and provides further sectoral detail, enabling us to zoom in into each of the nine sectors defined in Database I & II. Among other variables, the INEGI-KLEMS data supplies Gross Value Added, Labor, Capital Stock and Education-level measures for a total number of 77 sectors (net of broad sectors and categories). This detailed disaggregation allows greater specificity on identifying which infrastructure "subsector" impacts on which non-infrastructure "subsector." Our first step involved abridging some sectors, focusing in

[3] https://www.emdat.be/database
[4] https://www.systemicpeace.org/
[5] https://www.inegi.org.mx/programas/ptf/2013/

greater detail on a total of 33 sectors of interest. Thus, Database III consists of 33 sectors (net of broader sectors) and is flexible to later zooming in on condensed sectors if research efforts demand so.

As in the case of Dataset II this database flips around the template-extension order and stems from the INEGI-KLEMS project data for output (GVA), employment and capital stock for period 1990-2018. The difference is that we extend this sectoral coverage to 33 sectors, as shown in Table 3.4. These series are used as a template and extend back to 1971 using GGDC data (regarding GVA and labor) for the aggregate one-digit classification. In other words, Database III extrapolates sub-sectoral data with one-digit sectoral data. Other control variables are added to this database for further exploration: measures of Natural Disaster events taken from EM-DAT,[6] the Polity Democracy-Autocracy Index from the Systemic Peace Polity 5 Project, and a civil violence measure from Systemic Peace MEPV Project.[7]

Database IV: Regional Disaggregation of Sectoral Productivity from INEGI Census Data

Our next research avenue depicted in Table 3.2 involves regional disaggregation in studying infrastructure shocks on labor productivity, in particular: are there interactions involving sectors *between* regions as well as *within* regions? If so, *which sector*, of *which region*, impacts on *which sector* of *which region*? This scope also allows identification of specific localizations for shocks on infrastructure-related sectors, as well as possible regional spillovers across sectors. Two available datasets provide means for answering these questions.

Digitalized census data with sectoral compatibility are uploaded for the years 2018,[8] 2014, 2009 and 2004,[9] including the following variables for a detailed account of subsectors corresponding to SCIAN 2013 classification and 32 States: Value Added, Employment (as labor force engaged) and Capital Stock (open in capital subtypes). Census data do not account for public sector activity (in any sector of involvement), which must be taken into account upon comparing between datasets and drawing conclusions.

[6] https://www.emdat.be/database
[7] https://www.systemicpeace.org/
[8] https://www.inegi.org.mx/app/saic/default.html
[9] https://www.inegi.org.mx/app/saich/v2/

Table 3.4 Sectoral classification of Database III, shares in value added, employment and productivty gaps

Code	*Sector*	*Share VA 2018*	*Share L 2018*	*LP Gap 2018*
Eco	**Total**			
agr	**Agriculture, forestry, fishing and hunting**	**3.3%**	**7.7%**	**0.44**
agr0	Crop production	*63.2%*	*77.4%*	*0.82*
agr1	Animal production and aquaculture	*30.2%*	*16.8%*	*1.80*
agr2	Forestry and logging	*3.6%*	*1.5%*	*2.35*
agr3	Fishing, hunting and trapping	*2.6%*	*2.8%*	*0.94*
agr4	Support activities for agriculture and forestry	*0.4%*	*1.5%*	*0.29*
min	**Mining, quarrying, and oil and gas extraction**	**5.0%**	**1.0%**	**5.20**
min0	Oil and gas extraction, Support activities for mining, and oil and gas extraction	*80.4%*	*43.8%*	*1.84*
min1	Mining and quarrying (except oil and gas)	*20.2%*	*57.3%*	*0.35*
utl	**Utilities**	**1.6%**	**0.6%**	**2.87**
utl0	Electric power generation, transmission and distribution	*78.9%*	*42.2%*	*1.87*
utl1	Natural gas distribution, Water, sewage and other systems	*21.1%*	*57.8%*	*0.36*
con	**Construction**	**7.3%**	**11.9%**	**0.61**
con0	Residential building construction	*50.6%*	*43.1%*	*1.18*
con1	Non-residential building construction	*18.4%*	*25.3%*	*0.73*
con2	Heavy and civil engineering construction	*16.8%*	*17.4%*	*0.96*
con3	Specialty trade contractors	*14.2%*	*14.2%*	*1.00*
man	**Manufacturing**	**16.6%**	**18.5%**	**0.90**
man0	Food manufacturing Beverage and tobacco product manufacturing	*28.6%*	*18.4%*	*1.55*
man1	Textile mills Textile product mills Clothing manufacturing Leather and allied product manufacturing	*4.2%*	*10.8%*	*0.39*
man2	Wood product manufacturing Paper manufacturing Printing and related support activities	*3.3%*	*4.5%*	*0.73*
man3	Petroleum and coal product manufacturing	*1.4%*	*0.5%*	*3.05*
man4	Chemical manufacturing Plastics and rubber products manufacturing	*10.8%*	*8.4%*	*1.29*
man5	Non-metallic mineral product manufacturing	*2.5%*	*3.5%*	*0.70*
man6	Primary metal manufacturing Fabricated metal product manufacturing	*9.7%*	*8.3%*	*1.17*
man7	Machinery manufacturing	*4.4%*	*5.1%*	*0.87*
man8	Computer and electronic product manufacturing	*8.5%*	*11.1%*	*0.76*
man9	Electrical equipment, appliance and component manufacturing	*3.1%*	*4.9%*	*0.63*
man10	Transportation equipment manufacturing	*20.2%*	*16.4%*	*1.23*
man11	Furniture and related product manufacturing	*1.1%*	*2.7%*	*0.41*
man12	Miscellaneous manufacturing	*2.3%*	*5.4%*	*0.42*
trh	**trade + rh**	**20.7%**	**19.6%**	**1.05**
trade	**Wholesale & Retail trade**	**18.3%**	**15.0%**	**1.22**
rh	**Accommodation and food services**	**2.4%**	**4.6%**	**0.51**
rh0	Accommodation services	*51.0%*	*20.9%*	*2.44*
rh1	Food services and drinking places	*49.0%*	*79.1%*	*0.62*
tsc	**ts + com**	**9.8%**	**7.4%**	**1.32**
ts	**Transportation and warehousing**	**6.8%**	**6.7%**	**1.01**
ts0	Air transportation	*3.3%*	*1.7%*	*1.97*
ts1	Rail transportation	*1.8%*	*0.6%*	*2.91*
ts2	Water transportation	*1.0%*	*0.3%*	*3.23*
ts3	Truck transportation	*51.4%*	*41.6%*	*1.24*
ts4	Transit and ground passenger, Pipeline, Scenic and sightseeing transportation	*31.6%*	*39.9%*	*0.79*
ts5	Support activities for transportation	*6.9%*	*6.4%*	*1.08*
ts6	Postal service, Couriers and messengers	*2.2%*	*3.0%*	*0.75*
ts7	Warehousing and storage	*1.2%*	*6.4%*	*0.18*
com	**Information and cultural industries**	**3.0%**	**0.7%**	**4.32**
com0	Publishing industries Motion picture and sound recording industries Broadcasting (except Internet)	*14.0%*	*53.2%*	*0.26*
com1	Telecommunications, Data processing, hosting, and related services	*86.0%*	*46.8%*	*1.83*
fire	**fin + re + pro + sup**	**22.9%**	**7.1%**	**3.24**
fin	**Finance and insurance**	**5.0%**	**1.4%**	**3.49**
fin0	Monetary authorities - central bank Securities, commodity contracts, and other financial investment and related activities Insurance carriers and related activities	*19.0%*	*32.9%*	*0.58*
fin1	Credit intermediation and related activities	*81.0%*	*67.1%*	*1.21*
re	**Real estate and rental and leasing**	**12.1%**	**1.5%**	**7.95**
re0	Real estate	*91.7%*	*82.3%*	*1.11*
re1	Rental and leasing services Lessors of non-financial intangible assets (except copyrighted works)	*8.3%*	*17.7%*	*0.47*
pro	**Professional, scientific and technical services**	**2.0%**	**1.9%**	**1.08**
sup	**Administrative and support, waste management and remediation services**	**3.8%**	**2.2%**	**1.70**
serv	**edu + heal + cult + other + gov**	**12.7%**	**26.2%**	**0.48**
edu	**Educational services**	**3.9%**	**6.4%**	**0.61**
heal	**Health care and social assistance**	**2.2%**	**3.1%**	**0.70**
cult	**Arts, entertainment and recreation**	**0.5%**	**0.6%**	**0.79**
other	**Other services (except public administration)**	**2.1%**	**9.0%**	**0.23**
gov	**Public administration**	**4.1%**	**7.1%**	**0.57**

Sector disaggregation presents, on one hand, vast opportunities for specificity, but challenges on the other. Particularly, a shortcoming is the definition of the Agriculture sector. Economic Census data only accounts for fishing, aquaculture, and auxiliary services related to agricultural and forestry activities, thus excluding proper Agriculture and Forestry activities from its scope. This impairs the sectoral translation from previous databases into Database IV regarding this particular sector. Data from agricultural, forestry and livestock activities are reported in different censuses[10] and surveys.[11,12] They typically refer to physical production and related variables for years other than those in the Economic Census, however, and are therefore difficult to integrate into our dataset in a straightforward harmonized manner.

Additionally, missing data for particular subsectors and States complicates the assembly of a comprehensive and consistent panel with granular data. For example, upon searching for subsectoral detail on infrastructure-related sectors, subsectoral data may be available for just a few states. We propose a top-down approach of broad sector inspection, with the opportunity to zoom in on specific subsectors in as data availability allows.

A second possible dataset involves annual data for all 32 states. Value Added data[13] include a 32-sector disaggregation (net of broader categories) and cover the period 2003-2018. Employment data[14] are available for 12 sectors (although on first inspection Mining is jointly presented with Utilities and a "Non-Specified" sector is also present) and covers the period 2005-2020. Thus, annual data for labor productivity can be constructed for a sectoral-regional panel with annual frequency, keeping in mind that capital stock is not available in the same fashion. Although sectoral granularity may be inferior to that of Census data, the time frequency allows for closer inspection of shock propagation dynamics.

4. Econometric Modeling Approach

As mentioned above, most of the literature on infrastructure and growth has an underlying framework where capital infrastructure enters into the production function process of the economy at an aggregate level, but distinctions are made among several forms of capital infrastructure. Thus, beyond capital infrastructure effects, there is less effort to capture productivity spillovers stemming from infrastructure

[10] http://en.www.inegi.org.mx/programas/cagf/2007/
[11] https://www.inegi.org.mx/programas/ena/2019/
[12] https://www.inegi.org.mx/temas/agricultura/#Tabulados
[13] https://www.inegi.org.mx/programas/pibent/2013/
[14] https://datos.gob.mx/busca/dataset/indicadores-estrategicos-poblacion-ocupada-por-actividad-economica

productivity towards the economy, not to mention other disaggregated sectors. On the other hand, historical evidence documents well the fact that infrastructure acts as a catalyst to spur and diffuse sectoral innovations (Murphy, 2020). To capture the interactions from a richer set of channels we submit a production process where a productivity parameter A_s enters the sectoral production function of sector i

$y_i = A_i K_i^{\propto_i} L_i^{1-\propto_i} A_s^{\beta_s}$ (1) i= other sectors

$y_s = A_s K_s^{\propto_i} L_s^{1-\propto_s}$ (2) s= infrastructure sectors

Rearranging terms we write

$$\frac{y_i}{L_i} = A_i \left(\frac{K_i}{L_i}\right)^{\propto_i} \left(\frac{y_s}{L_s}\right)^{\beta_s} \left(\frac{K_s}{L_s}\right)^{-\beta_s \propto_s} \quad (1')$$

$$log \frac{y_i}{L_i} = logA_i + \propto_i log\left(\frac{K_i}{L_i}\right) + \beta_s log\left(\frac{y_s}{L_s}\right) - \beta_s \alpha_s log\left(\frac{K_s}{L_s}\right) \quad (3)$$

This framework better accommodates the channels from infrastructure related sectors productivity shocks into other sectors and is also consistent with the usual channel operating through infrastructure capital. In fact, infrastructure can have an impact on other sectors through its capital stock, the productivity of capital or the productivity of labor. In the case where $\propto_s \approx 0$ then labor productivity shocks in the infrastructure sector capture shocks in the productivity parameter A_s, while in the case where $\propto_s \approx 1$ infrastructure capital productivity is the main driver of effects on sectoral labor productivity. Given this formulation we need an econometric approach that, controlling for other factors and dealing with exogeneity and interdependencies, selects among those alternative channels, extracts elasticities from different (which) infrastructure-related productivity improvements towards different (on which) sectoral productivity improvements.

To move towards the empirical modeling stage, we use the pilot-country-case estimation framework suggested in Ahumada and Navajas (2019) global panel data model, in order to model the effects of productivity improvements in infrastructure-related sectors on other sectors of the economy. The modeling strategy is based on time-series equation for each "s" sector so as to obtain country specific elasticities of the effect of productivity growth in sector "j" on sectors "s". Given that country and time or even development stage specificities of infrastructure have an impact on growth (Estache and Garsous, 2012) these elasticities need not be in the same j-s relation neither be of a magnitude similar to that of the global panel model. From an econometric modeling perspective, the approach described in equations (1) to (3) below is similar to the global panel model's but uses time series equations for the "s" sectors. (*Note*:

notation is changed from the previous section denoting "s" for sectors and "j" for infrastructure related sectors).

Initially we started with unrestricted models of labor productivity (output per worker in logs, y) for a given sector "s" (agricultural, manufacturing, etc.) using, in each case, as explanatory variables labor productivity of the three "j" infrastructure sectors ($y_{utl}, y_{con}, y_{tsc}$) along with our proxies for the capital per worker of the same infrastructure sectors ($k_{utl}, k_{con}, k_{tsc}$) so as to distinguish productivity from stock of capital effects. This formulation is basically the one applied to Dataset I (GGDC) and in our previous case study for Argentina (Navajas et al., 2019). In the case of Mexico we have Dataset II (KLEMS INEGUI) which allows for the measurement of capital labor ratios for each sector k_s,for all s and $k_{utl}, k_{con}, k_{tsc}$ for all j=utl,con,tsc being infrastructure-related or not. This is the fundamental difference between Datasets I and II, apart from their different results insofar as measurement is concerned, as described in a previous report for this project. Also included, for both datasets and in the unrestricted model, is a set of control variables, (x) two different measures of trade openness (exports plus imports of each country as a share of GDP and also as a share of the sample's total exports plus imports), along with a human capital index, a political index and the total and machinery capital stock per worker. For the same unrestricted models, we included impulse dummies for outliers (for a specific year observation).

To handle such large information set, an automatic algorithm (*Autometrics*, see Doornik, 2009 and Hendry and Doornik, 2014) helped us to select the relevant variables. It uses a tree search to discard paths rejected as reductions of the initial unrestricted model based on ordered squared t-statistics, given a p-value provided by the researcher.[15] Given the time behavior of the data we take into account the possibility of unit roots and evaluate cointegration according to the following approach. The unrestricted models of labor productivity are formulated for their log differences and the explanatory variables expressed in log levels and log differences (see Banerjee et al., 1993).

Therefore, the starting unrestricted models have the following form for a given economy "s" sector,

$$\begin{aligned}\Delta y_{s,t} = {} & \alpha_s + \delta_s\, y_{s,t-1} + \mu_s\, k_{s,t-1} + \beta_{s,utl}\, y_{utl,t-1} + \beta_{s,con}\, y_{con,t-1} + \beta_{s,tsc}\, y_{tsc,t-1} + \varphi_{s,utl}\, \Delta y_{utl,t} \\ & + \varphi_{s,con}\, \Delta y_{con,t} + \varphi_{s,tsc}\, \Delta y_{tsc,t} + \theta_{s,utl}\, k_{utl,t-1} + \theta_{s,con}\, k_{con,t-1} \\ & + \theta_{s,tsc}\, k_{tsc,t-1} + \lambda_{s,utl}\, \Delta k_{utl,t} + \lambda_{s,con}\, \Delta k_{con,t} \\ & + \lambda_{s,tsc}\, \Delta k_{tsc,t}{}' + x_{t-1}{}'\, \phi_s + \Delta x_t{}'\, \tau_s + \varepsilon_{s,t} \qquad t \\ & = 1, \ldots, T \qquad (4)\end{aligned}$$

[15] We used 1% target (probability) values. *Autometric*s evaluates diagnostic tests for time series-model. The reported models passes all of them except heteroskedasticity in some cases, for which consistent standard errors were included.

where "t" indicates each year for sector "s". In the first row we have the long-run effects of labor productivities given (as δ_s is expected to be significantly negative under cointegration) by the negative value of $\beta_{s,utl}/\delta_s$, $\beta_{s,con}/\delta_s$, $\beta_{s,tsc}/\delta_s$, that is the long-run infrastructure sector elasticity, respectively.[16] The next row indicates the impact effects of changes in infrastructure productivities. Similarly, the third and four rows include parameters for the long-run and short-run effects of capital per worker of the infrastructure and the last row for the control variables in the vector x' respectively. All variables are in logs (except the political index).

From the log functional form in Equation (4) we can also obtain the effects of infrastructure sector capital productivities, as well. In this case the estimates should not reject the hypothesis that $\beta_{s,j=} - \theta_{s,j}$ for *j = utl, tsc, con* because when they hold the corresponding effects becomes $\beta_{s,j}\ y_{j,t-1} - \theta_{s,j}\ k_{j,t-1} =$ $\beta_{s,j}$ (ln (Y/L) - ln (K/L) = $\beta_{s,j}$ (ln (Y/K). Therefore the estimate of $\beta_{s,j}$ is the elasticity with respect to capital productivity of the *j* infrastructure sector.

It is important to note that equation (4), nesting levels and differences, allows us to have variables which enter the model either into the long run or short run, or both. The advantage of estimating this type of model is that it can be easily reparametrized as an error correction (EC) model which includes growth rates and deviations from the long-run relationship. For example, when there is only a long-run effect of a *j* infrastructure sector, say construction, on a given *s* sector productivity, the restricted equation (4) would have the next EC representation,[17]

$$\Delta y_{s,t} = \alpha_{si} - \delta_s\,[y_{s,t-1} - \beta^*_{s,con}\, y_{con,t-1}] + \varphi_{s,con}\ \Delta y_{con,it} + \varepsilon_{st} \qquad (5)$$

where $\beta^*_{s,con} = \beta_{s,con}/\delta_s$

If the variables were first order integrated, we could test whether or not this long-run relationship is a cointegration vector evaluating the significance of the t-statistic of the lagged explained variable (of the estimated coefficient of δ_s). Although the distribution of this statistic is non-standard when there is no cointegration, the critical values derived from the response function in the Monte Carlo study of Ericsson and MacKinnon (2002) can be used to test cointegration.[18]

[16] The long run elasticities are derived from $\Delta y_{jt} = \Delta x'_t = 0$.
[17] For simplicity we show this for one sector, construction, but it can be generalized for a multivariate case.
[18] A useful approximation of the critical values of the *t-statistics* from the response function, which could be seen as a multivariate unit roots, is given by the rule "3-2-3", that is the critical value is *-3 -0.2 K-0.3 (d-1)* where *K* is the number of variables in the long-run relationship and *d* is the number of deterministic components such as constant, step dummies and trends.

Since our main interest is to evaluate the long-run effects of infrastructure productivity during the automatic selection we kept fixed (an option of *Autometrics*) the log levels of productivity, apart from the constant term and only dropping the non-significant ones after estimation. We also initially assumed: i) there are no effects among the different economic sectors and ii) the explanatory variables are all exogenous. To evaluate these assumptions for the selected models we performed the following post-estimation checks.

With respect to i), we test long run sectors interdependence from augmenting the selected model from equation (4) for a given sector by the other sectors lagged levels and testing their significance.[19] The augmented equation could be considered as one of a VEC (Vector Error Correction) for the different sectors' productivities while the productivities and capital for the related infrastructure sectors could be considered as external variables of this system. Regarding ii), we re-estimate the models by instrumental variables in cases when infrastructure (log differences) variables enter contemporaneously into the selected models. Our main identification assumption is that capital per worker in the infrastructure sectors is exogenous and therefore can be used as a valid instrument, as detailed in the different cases. For long-run effects of different sector productivities on infrastructure related sectors productivity we check if they are significant in the inverted (one of the VEC) reduced-form equations, when modeling the different sectors. If it were significant, we would not have structural effects but those of the reduced form.[20]

We can note (see Hendry, 2007) that in the case of variables with unit roots representation we can have different sources of no exogeneity. To see it in the simple case of the conditional model of equation (5) which assumes cointegration of the labor productivity of the sector with that of the infrastructure, the marginal model for construction could be,

$$\Delta y_{con,t} = \rho[\, y_{s,t-1} - \beta^{*}_{s,con}\, y_{con,t-1}] + \omega_{con}\ \Delta y_{s,t-1} + \varepsilon_{con,t} \qquad (6)$$

While ω_{con} is associated with Granger Causality from the "s" sector on construction, it is neither necessary nor sufficient to be zero for a valid conditional model to obtain consistent estimates of the parameters in (2).[21] For weak exogeneity, $\rho = 0$ is needed; that is, the EC term does not enter the marginal model. Given that we started with a conditional model then, $\rho = 0$ requires that the effect of $y_{s,t-1}$ should be not significant in (3). Therefore, no level of sector "s" enters into each equation of infrastructure

[19] For the models with variables entering into the long run we did not find significant effects at 1% except for manufacturing. Some short-run effects were found in some cases; however, they imply only small changes in the long-run elasticities.
[20] No long-run effects (of different sectors productivity) on infrastructure related sectors productivity were found.
[21] When the model has one lag in levels, there is no effect from $\Delta y_{s,it-1}$.

sector which has effects on sector "s". This evaluation is often called LR exogeneity. However, the contemporaneous effect of $\Delta y_{con,t}$ can be associated, apart from the long-run effect, with $E[\varepsilon_{con,t}.\, \varepsilon_{s,t}] \neq 0$. Thus, we use IVE to have consistent estimates from a single equation like (5).

5. Elasticities Estimates of Infrastructure-Related Sectors' Impacts on Sectoral Productivity

Figure 3.2 shows that a central objective of the methodology is to estimate the "which on which" decomposition of the impacts that changes in the productivity of infrastructure-related sectors have on sectoral productivity. In this section we report results of elasticities estimated first for (one digit, database II) aggregate sectors and simulate the economy-wide impact of an assumed improvement in productivity in infrastructure-related sectors. Given these results, the search for disaggregated sectoral research exploits the link between transport and utilities and agriculture, manufacturing and domestic trade. Thus, the second results reported below show elasticities at subsectoral levels and is, to our knowledge, an original contribution on the effects of infrastructure on other sectors.

Aggregate One-Digit Sector Effects (Dataset II)

Table 5.1 shows the summary of estimated elasticities for one-digit sectoral data. Econometric results are reported in section A.5.1 of Appendix A.5, shown in Table A.5.1 for the estimation of equation (4) above and in Table A.5.1.1 for long-run solutions (equation (5) above), which fed into the elasticities of Table 5.1.

Concerning labor productivity elasticities effects (shown in red in Table 5.1), we found that Transport has impacts on Agriculture, Manufacturing and Public and Social Services; Utilities has an impact on Domestic Trade and Construction on Financial and Real Estate Services.[22] In regard to the effects operating from capital productivity improvements in infrastructure-related sectors towards sectoral labor productivity, we found that Construction have an impact on Mining and Domestic Trade (indicated with "*" and in blue). Finally, concerning elasticities from capital (labor) intensity to sectoral labor productivity we found that Utilities have an impact on Agriculture and Manufacturing (shown with "**" and in green). This latter effect is the usual way to evaluate the impact of infrastructure on productivity and growth, while the previous effects (that operate through the productivity of labor and capital in

[22] This set of effects is richer or broader that the exploratory ones found (but not reported) with Dataset I. In particular, they coincide with the effects of Transport on Agriculture, and of Construction on Financial and Real Estate.

infrastructure-related sectors towards sectoral labor productivity) show that the channels whereby infrastructure affects productivity and growth are much broader than the provision of capital.

Table 5.1

Which on which : Long-Run Elasticity estimates of effects of infrastructure-related sectors			
Mexico 1971-2018	**Infrastructure-related sector Productivities**		
On Labor Productivity of	UTL	TSC	CON
Agricultural Sector	**0.98****	**0.38**	
Mining Sector			**0.70***
Manufacturing Sector	**0.59****	**0.76**	
Trade, Restaurants & Hotels Sector	**1.33**		**0.56***
Finance, Insurance & Real Estate Sector			**0.38**
Public & Social Services		**0.28**	**0.28****

UTL: Utilities ; TSC: Transport, Storage & Communication ; CON: Construction
**Indicates Capital Productivity   **Indicates Capital Labor*
Long-run effects from Human Capital detected for Mining & Financial Sectors

This initial exercise motivates our search for a more detailed sectoral analysis undertaken below with more disaggregated data. However, it already shows a contribution to the measurement of the impacts of infrastructure on productivity growth. In Table 5.1 we are able to identify significant relations between labor and capital productivity improvements, or capital deepening (i.e., investment) in infrastructure related sectors and labor productivity improvements in other sectors that we believe are richer than concentrating on capital stock effects, which is the dominant way of measuring these effects in the literature. The estimated relationships provide an initial map (which becomes more detailed in Table 5.3 below) of *which* infrastructure subsector matters—according to the evidence for Mexico—for *which* subsector of the economy, that at the same time is consistent with macroeconomic or aggregate activity data. This is a significant improvement, we believe, with respect to the received literature insofar as empirical results that may guide policy actions because it widens the span or vision of actions related to the improvement of sectoral productivity from infrastructure policy, as it calls attention not only to investment efforts but also to regulatory actions that will complement and determine the productivity of infrastructure services stemming from existing or new capital. Table 5.1 tilts the balance towards productivity effects as opposed to capital stock effects.

Following a conventional descriptive gaps evaluation we found, in Section 2 and in general terms, that transport and energy seemed important to boost infrastructure policy in Mexico and that the regional allocations of projects followed a rationale based on closing development gaps. Table 5.1 contributes to giving more substance to that initial measurement, pointing to which sectors benefits from improvements in infrastructure labor and capital productivity, as well as investment or capital intensity. The former productivity-related effects dominate over capital intensity effects. The evidence in Table 5.1 that "disembodied" productivity improvements in infrastructure related sectors are significant and richer than "embodied" productivity improvements or even capital deepening is consistent with the view expressed in the IDB (2020) DIA report *From Structures to Services* and the empirical results stemming from Computable General Equilibrium Modeling exercises presented there, in the sense that "software" improvements in infrastructure are as important as "hardware" or investment efforts. We go deeper into the sectoral allocation of these effects in Table 5.3.

The IDB (2020) DIA report gives substance to the type of economic effects that are behind productivity improvements in infrastructure. They come in the form of product or process innovations that significantly increase the flow of services from an existing capital stock. For example, improvements in digitalization may significantly increase the frequency of trains or road cargo trucks or the flow (and control of losses) of electricity transport and distribution. Demand effects in both cases, allowing demand to better meet supply or to control consumption flows, may also contribute to more services. Beyond these effects there are also important effects that come from organizational reallocations within infrastructure services that may come from better business and labor practices. These effects are notably related to improvements in regulation and competition as well as in less inefficient labor regulations or better business procurement practices.

Example-Simulation of Relative Magnitude of Effects Assuming a Catch-up to Best Performer in LAC

Elasticities as reported above are the main outcome or result of this methodology, as they indicate which infrastructure sector impacts on which sector through which channel. However, they do not indicate the actual magnitude of effects, as they depend on the size of the shocks assumed. In other words, elasticities need being complemented by shocks to assess the magnitude of their final impact and its decomposition.

When productivity improvements in infrastructure-related sectors occur, they give rise to direct and indirect effects on the economy-wide productivity. Direct effects are computed by weighting the increase in labor productivity by the employment share in the corresponding infrastructure related sector. Indirect effects come through the impact on other sectors and are again weighted by that sector's employment share.[23] As the evidence shows that the impacts operate across several sectors, we presume that the direct effects on aggregate productivity of productivity improvements in infrastructure-related sectors will be smaller relative to the indirect effects. This will be so for given or assumed improvement in labor and capital productivity (or capital intensity) in infrastructure-related sectors. Measuring these effects will depend on an assumed exercise which has illustrative purposes, as performed in the case study of Argentina (Navajas et al., 2019).

Table 5.2 below illustrate the results of an exercises that assumes that the shocks in labor or capital productivity (or capital intensity) in infrastructure-related related sectors in Mexico is equivalent to the annual rate that closes the gap with the performance of the best (country) performer in the Latin American and Caribbean region. Of course, this is arbitrary in regard to the relative position of Mexico and does not tell how this assumed convergence will be brought about. It only represents orders of magnitude of effects in a fashion that uses a given benchmark for illustrative purposes.

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[23] See Ahumada and Navajas (2019). Productivity improvements in infrastructure related sectors "j" affects aggregate productivity performance through direct (own) and indirect effects. Expression below decomposes all the effects needed to compute or simulate effects.

$$\Delta\log\left(\frac{y}{l}\right) = \sum_j \alpha_j \Delta\log\left(\frac{y}{l}\right)_j + \sum_i \alpha_i \left(\eta_{\frac{y}{l}_i,\frac{y}{l}_j} \Delta\log\left(\frac{y}{l}\right)_j + \eta_{\frac{y}{l}_i,\frac{y}{k}_j} \Delta\log\left(\frac{y}{k}\right)_j + \eta_{\frac{y}{l}_i,\frac{k}{l}_j} \Delta\log\left(\frac{k}{l}\right)_j\right)$$

where i=*1,…7* are other sectors, j=*utl, tsc, con* are infrastructure related sectors and α are labor share ratios. The expression decomposes the final effect on aggregate productivity growth in a "direct or own" effect (the first term on the RHS) and an "indirect" effect that depends on the infrastructure-related sector (j) elasticity (defined for labor productivity y/l, capital productivity y/k and capital-labor k/l) of the sectoral (i) labor productivity, and the rate of growth (or, for simulation purposes, the convergence to a benchmark of the rates of growth) of y/l, y/k and k/l in the infrastructure related sector j. Employment shares α_i and α_j also drive the magnitude of effects. This expression is easy to compute given the set of relevant elasticities taken from Table 5.1 and the labor shares and assuming an increase in annual rates of growth of productivities in the infrastructure-related sectors.

In Table 5.2 it can be seen that, under these assumed shocks, indirect effects are much more significant than own or direct effects. It also indicates a ranking of infrastructure-related sectors (which) in their share of total and indirect effects, as well as a ranking of sectors through which indirect effects operate (on which). These latter rankings depend, of course, on the relative magnitude of assumed shocks and must be taken cautiously and seen as only one illustration. For instance, capital (labor) intensity effects end up being very significant, although smaller than productivity effects, because of the magnitude of the assumed shock embedded in the convergence exercise. This in turn affects the relative performance on infrastructure-related sectors and the ranking of effects across sectors.

Table 5.2 - Magnitude Simulation of Effects for Mexico (in annual growth rates)

		Own Effect	Indirect Effect			Total Impact	
			Labor Productivity	Capital Stock per worker	Capital Productivity		
LAC Best Performer Catch-up		0.28%	1.37%	1.24%	0.29%	3.18%	***Share***
							On Total
Which	*Utilities*	0.01%	0.85%	0.56%	-	1.41%	44%
	Construction	0.18%	0.07%	0.68%	0.29%	1.22%	38%
	Transport S&C	0.09%	0.46%	-	-	0.55%	17%
							On Indirect
On Which	*Agriculture*	-	0.10%	0.33%		0.43%	15%
	Mining	-			0.01%	0.01%	0%
	Manufacturing	-	0.23%	0.23%		0.46%	16%
	Trade R&H	-	0.85%		0.28%	1.13%	39%
	Finance I&RE	-	0.07%			0.07%	2%
	Public & Social Services	-	0.13%	0.68%		0.81%	28%

Note: catch-up is defined as the necessary increase in labor productivity's annual growth rate to reach that of a benchmark case
For capital productivity estimates, the catch-up necessary jumps considered correspond to those used for labor productivity catch-ups
For capital stock per worker estimates, the catch-up necessary jumps considered correspond to capital stock per worker measures
LAC's Best Performers for 1971-2015 period regarding LP growth are Brazil (Utilities), Costa Rica (Construction) and Chile (Transport S&C).
Regarding capital stock per worker growth, Chile stands out in all three sectors.

Disaggregate Sub-Sectoral Effects (Dataset III)

Consistent with one-digit sectors effects, we move to perform the estimation of long-run effects of productivity improvements in infrastructure-related subsectors (for example electricity or cargo transport) on sub-sectoral productivities (for example agricultural crops, textiles or retail trade). We concentrate, based on the evidence found for one digit estimation, on the long-run effects of productivity improvements in all infrastructure-related subsectors on the labor productivity of (subsectors of) Agriculture, Manufacturing and Domestic Trade Services. Our estimation procedure allows us to work with many variables in the right-hand side of subsectoral productivity equations, where all the relevant subsectors (see Table 3.4) are considered for estimating equations.

Table 5.3 summarizes the findings of the elasticities estimated at subsectoral levels with our Dataset III. Econometric results are reported in Section A.5.2 of Appendix A.5, shown in Table A.5.2 for the estimation of equation (4) above and in Table A.5.2.1 for long run solutions (equation (5) above), which fed into the elasticities of Table 5.2. As in Table 5.1 for one-digit estimation, labor productivity elasticities are denoted in red, capital productivity effects denoted in blue and "*" and capital-labor effects denoted in green and with "**".

Table 5.3

Which on which **subsectoral effects: Long-Run Elasticity estimates of effects of infrastructure-related sectors**

Mexico 1971-2018	**Infrastructure-related Sub-Sector Effects**				
	UTL	TSC		CON	
On Labor Productivity of	*Electricity*	*Truck Transportation*	*Warehousing & Storage*	*Civil Engineering*	*Non-Residential Construction*
Agricultural Sector		0.36			
Crop Production		0.68			
Animal Production & Aquaculture			0.27		
Manufacturing Sector	0.4	0.1*			
Transport Equipment Manufacturing	0.52	0.15**			
Food, Beverage & Tobacco Manufacturing			0.04**		
Textile, Clothing & Leather Industry			0.11**		
Trade, Restaurants & Hotels Sector	0.41**			0.46	
Wholesale & Retail Trade	0.47**			0.29	0.14*
Accommodation Services	0.78			0.44*	

UTL: Utilities ; TSC: Transport, Storage & Communication ; CON: Construction
*** Indicates Capital Stock per worker effects*
** Indicates Capital Productivity*
Long-run effects from Human Capital detected for Agriculture Sector and Food, Beverage & Tobacco Manufacturing

Results show a very rich and informative landscape of long run effects of improvements in the productivity of infrastructure-related subsectors on subsectoral labor productivity. We find that Cargo Road Transport have an impact on Agricultural Crops and on Manufacturing Transport Equipment. Electricity productivity improvements have an impact on Manufacturing Transport Equipment and on Wholesale and Retail Trade and on Hospitality Service subsectors. Storage has an impact on Agriculture Cattle Production and Manufacturing Food and Beverages and Textiles. Finally, the more infrastructure-related subsectors within Construction have an impact on Domestic Trade. Civil Engineering works have an impact on Wholesale and Retail Trade and on Hospitality Services, while non-residential construction has an impact on Hospitality Services. In sum, infrastructure-related productivity shocks have sizeable macro effects. While they can be direct, they occur mainly through other sectors productivity. In addition, the previous sectoral distribution of relevant elasticities falls in different sectors distributed across the ranking of productivity gaps. Therefore, infrastructure has a positive (or at worst neutral) effect on productivity gaps across sectors.

6. Regional Impacts of Infrastructure Productivity Improvements: An Exploration

This section report results exploiting Dataset IV (see Section 3 and Table 3.2) on the regional impact of infrastructure related productivity sectors on sectoral productivity. As a preliminary study, reported in **Appendix A.6.** we use spatial data on infrastructure projects and census data on labor productivity and capital-labor intensity across states and find a correspondence of the allocation of projects with the (aggregate or economy wide) productivity gap across Mexican states. We find that that the allocation of projects has an equalizing effect by being negatively related to regional productivity levels and/or capital endowments. Thus we complement the descriptive data presented in Section 2 by showing that the allocation of infrastructure investment efforts in Mexico somehow conforms a rationale consistent with a strategy to close regional productivity gaps. Nevertheless, as noted above, this ordering or correlation does not inform on the regional impact of those efforts.

Following the research strategy of this project depicted in Table 3.2 above, we use Dataset IV to test regional differences in infrastructure related sector elasticities of sectoral productivities. This involves a return to one-digit sectoral analysis due to data limitations as we have to move out of the KLEMS-INEGI dataset used so far and instead have to rely on economic census data on sectoral labor productivity made available by states. We concentrate on the three sectors studied in detail with Dataset III: Agriculture, Manufacturing and Domestic Trade, but we come back to one-digit aggregation. We seek to detect differences across eight regions (the same as used for the study of investment allocations in Appendix A.6., ordered by the aggregate productivity gap of the region), and we estimate a cross-section OLS model of the average of the census values for four years (99,04,09,14) with automatic selection and multiplicative dummies to capture regional differences. The results of this estimation are reported in Table 6.1, with reported coefficients significant at 1%. Details of regression outputs are reported in Section A.5.3 of Appendix 5, shown in Table A.5.3. With Dataset IV we estimate five significant elasticities from the cross-section of 32 states: from Utilities to all three sectors (Agriculture, Manufacturing and Trade and

Hospitality Services), from Transport and Storage to Agriculture and from Construction to Trade and Hospitality Services. These effects are not, qualitatively speaking, inconsistent with the one-digit results from the KLEMS INEGI Dataset III reported in Table 5.2, even though they come from a completely different dataset. The estimation reported in Table 6.1 proceeds by testing the effects of regional dummies, which are ordered from the highest to the lowest level of aggregate or economy-wide labor productivity. The lower panel of Table 6.1 provides the definition of regions in terms of Mexican states. Figure 6.1 shows the Mexican territory map with the selected states for the regression analysis.

Table 6.1 Regional Elasticities of Productivity Impacts from Infrastructure Related Sectors

On Which Sector?		*Agriculture*			*Manufacturing*			*Trade, Hotels & Restaurants*		
Infrastructure-related Sector		Utilities	Construction	Transport & Storage	Utilities	Construction	Transport & Storage	Utilities	Construction	Transport & Storage
Whole Sample Elasticity		**0.062**		**1.006**	**0.120**			**0.187**	**0.270**	
Regional Dummies	SE									
	NE	0.047					0.081			
	SC						0.081			
	NC			-0.039			0.081			
	NW	0.068			0.032					
	E				0.032					
	SW						0.081	-0.183	0.181	
	W						0.081	-0.183	0.180	

**Regional dummies were ordered following a decreasing ranking of Labor Productivity from highest (SE) to lowest (W) where the median Region was NC.*

Regional Detail

Region	*Included States*
South-East	Campeche, Quintana Roo, Tabasco, Yucatán
North-East	Coahuila, Nuevo León, Tamaulipas
South-Center	Ciudad de México, Estado de México, Morelos
North-Center	Aguascalientes, Guanajuato, Querétaro, Potosí, Zacatecas
North-West	Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa, Sonora
East	Hidalgo, Puebla, Tlaxcala, Veracruz
South-West	Chiapas, Guerrero, Oaxaca
West	Colima, Jalisco, Michoacán, Nayarit

Table 6.1. should be read as follows. It reports the across-states effects of labor productivity improvements in infrastructure-related sector on the labor productivity of our three main sectors (as shown in Table 5.1). The "Whole Sample Elasticity" indicates the results across all Mexican states. Meanwhile, the "Regional Dummies" detect the heterogenous effects across regions, and they are significant only for some sectors and some regions. Positive dummies indicate that the elasticity is higher in that region, while negative effects show the opposite. For example, an improvement in labor productivity in Utilities (which is mainly driven by electricity) has a positive impact across all states in all three sectors, with elasticities ranging from 0.062 in Agriculture to 0.12 in Manufacturing and 0.187 in Trade, Hotels and Restaurants.

However, regional dummies indicate where these effects are stronger or weaker. Positive regional dummies in NE and NW states for agriculture and NW and E states for manufacturing show these additional effects, indicating regions where projects possibly have had more significant impacts. On the other hand, while impacts across states from improvement in Utilities productivity on other sectors is positive and larger than in Agriculture and Manufacturing, there are two regions such as SW and W where the effects disappear. These means that there is an underperformance of spillover effects in those regions, which calls for closer scrutiny of obstacles to such improvements.

Results in Table 6.1 show significant regional differences in the elasticities. However, we find no strong evidence that the observed impacts are related to either low or high productivity states. In other words, they are in general located predominantly in neither high nor low-productivity states. Construction is perhaps an exception, as it has significant differential effects on the productivity of Trade and Hospitality Services in regions with low productivity in the South-West and West. Transport and Storage productivity has a positive differential effect on Manufacturing of a similar magnitude across several regions, although the overall effect is not captured for the whole sample. Utilities' productivity impact on Agriculture productivity has a differential positive effect on NE and NW. The same happens on the effects of Utility productivity on W and NW states manufacturing productivity. As mentioned above, negative coefficients in Table 6.1 are perhaps more interesting from the perspective of a policy inquiry on how certain efforts in infrastructure investment do not translate into productivity improvements. Diminished effects from improvements in Transport sector productivity on Agriculture show up in North Center, although not enough to eliminate the overall positive effect that transport has on agriculture on that region. On the other hand, productivity improvements in Utilities are associated with strong negative differential effects on Trade and Hospitality Services in East and South-West states of a magnitude sufficient to eliminate the overall positive effects.

Figure 6.1

Mexico - Regional Partition

7. Final Remarks, Complementary Policies and Recommendations

The main results of this project are, to our knowledge, a significant step forward towards the understanding of the interactions between infrastructure and productivity growth in Mexico. We have been able to identify significant relations between labor and capital productivity improvements, or capital deepening (i.e., investment) in infrastructure-related sectors and labor productivity improvements in other sectors. The lower level of aggregation of these estimated relationships, which we have been able to achieve thanks to the KLEMS-INEGI dataset, provides a detailed map of *which* infrastructure subsector matters—according to the evidence for Mexico—for *which* subsector of the economy, that at the same time is consistent with macroeconomic or aggregate activity data. This is a significant improvement, we believe, with respect to the received literature in regard to empirical results that may guide policy actions. To put it in other terms, our "priors" to guide a policy dialogue in Mexico on the subject matter of this project, namely "the identification of infrastructure sectors to boost productivity in low performing sectors or enhancing productivity in sectors with high productivity growth potential," have been significantly enhanced after the results obtained with our methodology and data. Beyond a traditional gaps evaluation that indicated, in overly general terms, that transport and energy are important to boost infrastructure policy in Mexico and that the regional allocations of projects follows a rationale based on closing development gaps, we have advanced to give substance, both qualitative and quantitatively, to which subsectors within the transport and energy sectors are important for which subsectors within the agriculture, manufacturing and domestic trade and hospitality services sectors. These sectors contain more than half the employment of the Mexican economy, are composed by subsectors that belong to both high and low-productivity segments and have a significant presence across regions. Our results give us some confidence to recommend that case studies and project evaluations be oriented towards sectors where infrastructure has, according to our results, a significant macroeconomic or aggregate impact as well as a regional effect. The "priorities" approach that motivates our search for sectoral links between infrastructure and other sectors points to labor productivity improvements in cargo transport as a significant driver of agriculture productivity, electricity labor productivity as a driver of transport manufacturing and hotels services productivity, storage and warehouse labor productivity as a driver of rural activities productivity and civil engineering labor productivity as a driver to wholesale and retail productivity. Other significant effects come through capital productivity improvements of non-residential construction on wholesale and retail trade and of civil engineering on hotels services. Effects that come through capital deepening or intensity (i.e., capital labor increases) and that usually regarded as infrastructure investment also come into this picture in different forms. They are present as effects of electricity on wholesale and domestic trade, cargo transport on transport equipment manufacturing and warehouse and storage on both food and beverages and textiles manufacturing.

The evidence that "disembodied" productivity improvements in infrastructure-related sectors are significant and richer than "embodied" productivity improvements or even capital deepening is consistent with the view expressed in the IDB (2020) DIA report *From Structures to Services* and the empirical results stemming from Computable General Equilibrium Modeling exercises presented there in the sense that "software" improvements in infrastructure are as important as "hardware" or investment efforts. This turns our attention to the importance of complementary dimensions that unlock or foster the effects of infrastructure investment as they become a focal point of policy recommendations. In effect, one of the puzzles of infrastructure investment efforts is that they may not deliver the expected services if other distortions prevents that from happening. The recent IDB (2020) DIA report openly endorses such view. Several barriers such as financial and regulatory constraints, inadequate competition policy, fiscal-budgetary problems, low capabilities within the public sector, among others, can conspire against the possibility of physical infrastructure spurring growth across the economy (Helm and Mayer, 2016). Thus sectoral policy becomes critical, and to avoid second-best problems what is needed is a strong "regulatory compact" that maximizes the effect of infrastructure productivity improvements. Some reports and studies for Mexico go in this direction (; OECD, 2018, 2019b). This position comes from a reasonable policy approach, despite the fact that in our regression analysis we have not obtained strong effects from regulatory control variables, possibly due to the quality of data. Nevertheless, we have obtained significant effects of human capital on agriculture, and trade intensity in manufacturing. Far from being a nuisance, these results do not contradict the view that policy complementarities regarding the working of markets where infrastructure services may enhance or retard productivity improvements.

Thus, infrastructure policy is not just adequate capital provision and project selection; it goes beyond the public/private provision of capital to consider the organization of services and their markets. In the case of Mexico, our results therefore recommend special attention to the regulatory/competition policy approach to transport and the design and working of the electricity wholesale market. These policy ingredients are necessary to promote productivity improvements and investments in infrastructure and to achieve desired impacts on other sectors. Differentials across regions also suggest that efforts to improve regulations may be merited in some regions/states where there is a sub or under performance of the impacts of infrastructure productivity and investment efforts on sectoral productivity performance. Our preliminary results suggest this is relevant for transport in the NC region and for electricity in the E and SW regions.

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Appendix A.5. Estimates of Infrastructure-Related Sectors' Impacts on Sectoral Productivity: Econometric Results

A.5.1 Aggregate One-Digit Sector Effects (Dataset II)

Note: For variables definitions see Table 3.3 in the main text. Table A.5.1 corresponds to the estimation of equation (4), while Table A.5.1.1 corresponds to equation (5) in the main text.

Table A.5.1. Aggregate one-digit sector effects (Dataset II)

Explanatory Variable \ Dependent Variable	Δy_{agr}	Δy_{min}	Δy_{man}	Δy_{trh}	Δy_{fire}	Δy_{serv}
Constant	-0.404 **	0.26 **	-0.395 **	-0.045	0.336 **	0.25 **
IMPACT EFFECTS						
Δy_{con}				0.111 *		
Δy_{tsc}				0.304 **		0.23 **
$(\Delta y - \Delta k)_{con}$				0.186 **		
LEVEL EFFECTS						
Lagged Dependent	-0.359 **	-0.195 **	-0.454 **	-0.125 **	-0.306 **	-0.231 **
$y_{tsc_{t-1}}$	0.136 **		0.345 **			0.064 **
$y_{utl_{t-1}}$				0.131 **		
$y_{con_{t-1}}$					0.115 **	
$k_{utl_{t-1}}$	0.351 **		0.267 **			
$(y-k)_{utl_{t-1}}$				0.058 **		
$(y-k)_{con_{t-1}}$						0.064 **
$(y-k)_{con_{t-2}}$		0.136 **				
hc_{t-1}					0.075 **	
hc_{t-2}		0.104 **				
DUMMIES						
Impulse 80		0.015 **				
Impulse 81	0.016 **					
Impulse 82					-0.012 **	
Impulse 90	0.019 **					
Impulse 91	0.015 **					
Impulse 92						0.006 **
Impulse 03			-0.015 **			
Impulse 09				-0.011 **		
Impulse 13			-0.012 **			
Impulse 14		-0.027 **				
Step 82 - 90				0.009 **		
Step 89- 78			-0.005 **			
Step 01-82					-0.006 **	
Step 97		0.009 **				
Step 06		0.016 **				
Step 14			0.017 **			
Adjusted R^2	**0.55**	**0.66**	**0.81**	**0.87**	**0.65**	**0.6**
Observations	46	46	45	46	45	46

** Significant 5% ; ** Significant 1%*

Table A.5.1.1

Sector	**Solved long-run equations for aggregate one-digit sector effects (Dataset II)**
Agriculture	$y_{agr} = const + 0.98\ k_{utl} + 0.38\ y_{tsc}$ (SE) (0.10) (0.09)
Mining	$y_{min} = const + 0.70\ (y - k)_{utl} + 0.53\ hc$ (SE) (0.19) (0.10)
Manufacturing	$y_{man} = const + 0.76\ y_{tsc} + 0.59\ k_{utl}$ (SE) (0.05) (0.06)
Trade, Hotels & Restaurants	$y_{trh} = const + 0.56\ (y - k)_{con} + 1.33\ y_{utl}$
Finance, Insurance & Real Estate	$y_{fire} = const + 0.38\ y_{con} + 0.24\ hc$ (SE) (0.07) (0.03)
Public & Social Services	$y_{serv} = const + 0.28\ (y - k)_{con} + 0.28\ y_{tsc}$ (SE) (0.03) (0.07)

Notes: * Calculated from the estimates of Table A.5.1

A.5.2. Disaggregate Subsectoral effects (Dataset III)

Note: For variables definitions see Tables 3.3 and 3.4 in the main text. Table A.5.2 corresponds to the estimation of equation (4), while Table A.5.2.1 corresponds to equation (5) of the main text.

Table A.5.2. Disaggregate sub-sectoral effects (Dataset III)

Explanatory Variable \ Dependent Variable	Δy_{agr}	Δy_{agr0}	Δy_{agr1}	Δy_{man} [a]	Δy_{man10} [b]	Δy_{man0}	Δy_{man1}	Δy_{trh}	Δy_{trade}	Δy_{rh0}
Constant	-1.04 **	-0.404 **	-0.255 *	-0.388 **	-0.979 **	-0.613 **	-0.647 **	-0.339 **	-0.521 **	-0.291 **
IMPACT EFFECTS										
Own $\boldsymbol{\Delta k}$				0.409 **		0.177 **	0.2 *			
Δy_{con2}								0.166 **		
Δy_{ts0}										0.312 **
Δy_{ts3}				0.381 *	0.623 **				0.401 **	
Δk_{utl0}					0.527 **					
$(\Delta y - \Delta k)_{con1}$									0.101 **	
$(\Delta y - \Delta k)_{con2}$									0.087 **	
LEVEL EFFECTS										
Lagged Dependent	-0.613 **	-0.289 **	-0.374 **	-0.207 **	-0.506 **	-0.612 **	-0.45 **	-0.327 **	-0.292 **	-0.233 **
Lagged Own $\boldsymbol{k}$	0.106 *		0.091 **			0.15 **	0.068 **			
$y_{ts3_{t-1}}$	0.223 **	0.197 **								
$y_{ts7_{t-1}}$			0.082 *							
$y_{con2_{t-1}}$								0.15 *	0.078 *	
$k_{utl0_{t-1}}$				0.083 **	0.263 **			0.134 **	0.158 **	0.184 **
$k_{ts7_{t-1}}$						0.025 **	0.048 **			
$(y-k)_{ts3_{t-1}}$				0.021 *	0.076 **					
$(y-k)_{con1_{t-1}}$									0.057 **	
$(y-k)_{con2_{t-1}}$										0.103 **
hc_{t-1}	0.261 *					0.484 **				
DUMMIES										
Impulse 81			0.086 **							
Impulse 83				-0.075 **			-0.057 *			
Impulse 86				-0.059 **						
Impulse 91									0.05 *	
Impulse 94										-0.149 **
Impulse 03				-0.069 **		-0.062 **	-0.113 **			
Step 89 * $k_{agr,\,t-1}$	0.088 *									
Step 81						0.092 **		0.107 **		0.085 **
Step 82									0.083 **	
Step 85						0.08 **	0.09 **			
Step 88							-0.045 **			
Step 89		-0.072 **	-0.025 *							
Adjusted R^2	**0.27**	**0.35**	**0.39**	**0.0157** [c]	**0.0523** [c]	**0.77**	**0.65**	**0.54**	**0.85**	**0.68**
Observations	47	47	46	46	46	46	46	46	46	46

** Significant 5% ; ** Significant 1%*

[a] *Modelled by IVE with additional instruments: Δk_{ts3} , $\Delta k_{ts3,\,t-1}$, $\Delta y_{ts3,\,t-1}$*

[b] *Modelled by IVE with additional instruments: Δk_{ts3} , and Impulse Dummies for 82, 92, 09*

[c] *Sigma for IVE Modelling*

Table A.5.2.1 *

Sector & Subsector	**Solved long-run equations disaggregate sub-sectoral effects (Dataset III)**
Agriculture	$y_{agr} = const + 0.36\ y_{ts3} + 0.17\ k_{agr} + 0.14\ S1{:}\,1989\ k_{agr} + 0.43\ hc$ (SE) (0.07) (0.06) (0.05) (0.14)
Crop Production	$y_{agr0} = const + S1{:}\,1989 + 0.68\ y_{ts3}$ (SE) (0.12)
Animal Production & Aquaculture	$y_{agr1} = const + S1{:}\,1989 + 0.22\ y_{ts7} + 0.24\ k_{agr1}$ (SE) (0.09) (0.07)
Manufacturing	$y_{man} = const + 0.40\ y_{utl0} + 0.10\ (y - k)_{ts3}$ (SE) (0.04) (0.04)
Transportation Equipment	$y_{man10} = const + 0.52\ y_{utl0} + 0.15\ (y - k)_{ts3}$ (SE) (0.05) (0.05)
Food. Beverage & Tobacco	$\Delta y_{man0} = const + 0.24\ k_{man0} + 0.04\ k_{ts7} + 0.79\ hc$ (SE) (0.04) (0.01) (0.11)
Textile, Clothing & Leather	$y_{man1} = const + 0.15\ k_{man1} + 0.11\ k_{ts7}$ (SE) (0.03) (0.03)
Trade, Hotels & Restaurants	$y_{trh} = const + 0.41\ k_{utl0} + 0.46\ k_{ts7}$ (SE) (0.08) (0.13)
Trade	$y_{trade} = const + 0.47\ k_{utl0} + 0.29\ y_{con2} + 0.14\ (y - k)_{con1}$ (SE) (0.06) (0.09) (0.05)
Accomodation Services	$y_{rh0} = const + 0.78\ y_{utl0} + 0.44\ (y - k)_{con2}$ (SE) (0.08) (0.11)

*Notes: * Calculated from the estimates of Table A.5.2*

A.5.3. Regional Impacts of Infrastructure Productivity Improvements (Dataset IV)

Regions (r) and states are denoted by numbers corresponding to the lower panel of Table 6.1. State and region dummies are identified by that number.

Table A.5.3. Regional impacts of infrastructure productivity improvements (Dataset IV)

Explanatory Variable \ Dependent Variable	y_{agr}	y_{man}	y_{trh}
Constant	-2.65	10.3 **	6.27
LEVEL EFFECTS			
y_{utl}	0.062 **	0.12 **	0.19 **
y_{tsc}	1.01 **		
y_{con}			0.27 **
REGIONAL LEVEL EFFECTS			
$r2 * y_{utl}$	0.047 **		
$r4 * y_{utl}$	0.068 **		
$(r6 + r7) * y_{utl}$			-0.183 **
$(r4 + r5) * y_{utl}$		0.032 **	
$r0 * y_{ts}$	-0.039 **		
$(r0 + r2 + r3 + r6 + r7) * y_{ts}$		0.081 **	
$r6 * y_{con}$			0.181 **
$r7 * y_{con}$			0.18 **
DUMMIES			
Impulse 1	1.14 **		
Impulse 6	1.07 **		
Impulse 10	-0.929 **		
Impulse 13		1.68 **	
Impulse 16			-0.319 **
Impulse 17	-0.75 **		-0.372 **
Impulse 18			-0.338 **
Impulse 26		0.593 *	
Impulse 27		1.87 **	
Impulse 29	-1.95 **		
Impulse 30		0.7 **	
Adjusted R^2	**0.9**	**0.84**	**0.84**
Observations	32	32	32

** Significant 5% ; ** Significant 1%*

Appendix A.6. The Regional Location of Infrastructure Investments Efforts and Productivity Gaps in Mexico

This Appendix summarizes our examination study of the regional allocation of infrastructure investment projects in Mexico. We gather spatial data[24] on infrastructure projects and census data on productivity and capital intensity across states in order to illustrate stylized facts and proceed towards a simple econometric exploration of the relationship between the territorial allocation of infrastructure investment projects and productivity and capital stock gaps across states. Information and results are presented for the economy as a whole and for infrastructure sectors in particular.

In order to jointly analyze the behavior of the productivity and capital stock gaps derived from the census information and the projected investments, the investment database was adjusted, omitting the projects to be developed in "the entire territory" of Mexico that had been identified by the Mexican *Hub de Proyectos* portal.[25] The list of projects to be developed "throughout the territory" correspond to investments associated with water and environment, which are comparatively negligible for our purposes and unassigned to a particular state / region.

Regarding census data, two measures were constructed: one corresponding to labor productivity (Value Added / Labor) and another associated with capital stock per worker (Capital Stock / Labor), for each of the Mexican States. The relationship between both variables results as expected and no atypical behaviors are observed. Continuing with the analysis of census economic information and that corresponding to projected investment projects, we evaluate the relationship between planned infrastructure investments per worker (or in terms of percentage share in total planned investments) and labor productivity (VA / L) or capital stock per worker (K / L). The first relationship seeks to answer whether greater investments are planned/located where productivity is higher, while in the second case it seeks to establish whether infrastructure spending is intended to "complete" the stock of capital that allows raising the productivity of labor.

The exploration of the previous relationships is highly biased by cases of some particular states. In all cases, the same five states of Mexico appear as outliers: Quintana Roo, Veracruz, Tabasco, Campeche, and Colima. Taking this into account, we proceeded to explore the investments projected for

[24] The 2010 National Population and Housing Census, updated in 2014, presents the Map of the National Geostatistical Framework of Mexico (https://www.inegi.org.mx/app/biblioteca/ficha.html?upc=702825292805). Within the framework of the Census, the classification of states and municipalities of the United Mexican States is presented (https://www.inegi.org.mx/contenido/productos/prod_serv/contenidos/espanol/bvinegi/productos/nueva_estruc/702825064303.pdf), including the 31 states plus the Federal District, as well as 2,456 municipalities and 16 delegations (for Mexico City).
[25] https://www.proyectosmexico.gob.mx/en/projects-hub/

the aforementioned states and by infrastructure sector. The objective at this stage is to identify the existing biases in terms of the concentration of investments between etates and infrastructure sectors, in order to control them in a later stage of econometric exploration. These figures are presented in the table below.

Table A.6.1. Distribution of Investment Projects by Sectors
Selected States, Millions of USD and % of Total

	Water and Environment	*Construction and Tourism*	*Energy Sector - Electricity*	*Energy Sector - Hydrocarbons*	*Transport*	*Total*
Total Investments	**1,016**	**250**	**2,710**	**4,681**	**6,833**	**15,490**
% of Total Investments by Sector	*6.6*	*1.6*	*17.5*	*30.2*	*44.1*	*100.0*
Subtotal Selected States	**-**	**149**	**9**	**1,438**	**3,642**	**5,238**
% of Total Selected States	-	*59.6*	*0.3*	*30.7*	*53.3*	*33.8*
% of Total Investments by Sector	-	*2.8*	*0.2*	*27.5*	*69.5*	*100.0*
Quintana Roo		149			1,988	2,137
Veracruz			7	656	987	1,650
Tabasco			2	782		784
Colima					617	617
Campeche					50	50

Source: Own based on Hub Mexico.

The table shows that 44.1 percent of the proposed infrastructure investments correspond to the Transport sector, followed by 30 percent in the Hydrocarbon sector. Additionally, 53 percent of the funds directed to Transportation are concentrated in the five states mentioned above, which in turn account for 70 percent of the funds among all sectors included.

At the state level, 55% of the transportation funds corresponding to the five states analyzed are directed to Quintana Roo, with Campeche on the other end, with a very low level of projected infrastructure investment. Quintana Roo is characterized by a very low capital stock and very low labor productivity (relatively speaking), while Campeche is described by the opposite. In Campeche, the oil industry is one of the main activities, having displaced fishing as a historical activity along with wood, while Quintana Roo, located in the Yucatan Peninsula, is mainly tourism-based.

The previous exploration allows us to preliminarily infer that greater investments are planned in states where capital stock per worker and labor productivity are lower (e.g., Quintana Roo) while lower infrastructure investment is assigned to high performing States (e.g., Campeche). Thus, it is suggested that infrastructure expenditures are directed to compensate the investment deficit (so as to close the gaps regarding capital stock and labor productivity), rather than towards where productivity is highest (so as to maximize the impact of infrastructure spending).

To further explore this proposal, a simple econometric approach is later developed keeping in mind that the former analysis suggests the need to control for the states mentioned above. In order to normalize labor productivity and capital stock per worker values per state, we construct the respective gaps relative to economy-wide levels. Preliminary analysis indicates that higher investments per worker are projected where the gap in the capital stock or labor productivity is lower (laggard states).

The next step in this exploration stage refers to the relationships between planned investments at the infrastructure sector level (Utilities, Construction and Transport S&C) with labor productivity and capital stock per worker measures at the state level. It is important to bear in mind that investments are highly concentrated in sectors as well as states. For example, planned investments for the energy sector (hydrocarbons) are concentrated in only 10 states. For the transportation sector in particular—which represents 44 percent of the projected investment included in Hub México—the relationship between investment and gaps yields the expected results: higher investments per worker are planned where productivity and capital stock per worker are lower, both in levels and gaps. The sStates with behavior at the extremes of the distribution, in the same way as in the cases of investments added by sectors, correspond to Campeche and Quintana Roo, and in some cases Mexico City.

Econometric Exploration of the Relationships between Gaps and Projected Investment Amounts

In order to explore whether projected infrastructure investment efforts are distributed according to state (productivity and capital stock) gaps (i.e., underperforming or overperforming) we fitted a simple OLS model of the form:

$$(1)\quad Invest_i = \alpha + \beta y_i + \mu oil_i + \delta state_i + \theta density_i$$

Or alternatively:

$$(2)\quad Invest_i = \alpha + \gamma k_i + \mu oil_i + \delta state_i + \theta density_i$$

where $\boldsymbol{i}$ represents state and $\boldsymbol{Invest_i}$ indicates infrastructure investment normalized by Gross Value Added. $\boldsymbol{y_i}$ stands for Labor Productivity (in logarithms or gaps relative to National labor productivity) and $\boldsymbol{k_i}$ for capital stock per worker (with same specifications as for labor productivity). $\boldsymbol{oil_i}$ is a binary dummy identifying states differentially involved in oil extraction (Veracruz, Tabasco, Tamaulipas, Chiapas, Campeche), $\boldsymbol{state_i}$ is a binary dummy controlling for the remaining states identified in the previous discussion not covered by $\boldsymbol{oil_i}$, and $\boldsymbol{density_i}$ stands for population density. Summary results reported from alternative models are depicted in Table A.6.2.

Results validate the hypothesis that projected infrastructure investment efforts seem to be differentially focused on laggard states (in terms of labor productivity or capital stock per worker). Significant $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ coefficients for different specifications of labor productivity and capital stock per worker imply a robust relationship across states. Significant, positive coefficients for $\boldsymbol{\mu}$ (not shown) control for focused investments in high-productivity states related to oil extraction. Changes in the outlier dummy specification (for example, separating laggard outliers from advanced, in terms of labor productivity) did not significantly improve model performance. Additionally, we conclude mapping Infrastructure Investment Efforts, Labor Productivity and Capital Stock per worker Gaps to illustrate these relationships on a georeferential manner (Figure A.6.1).

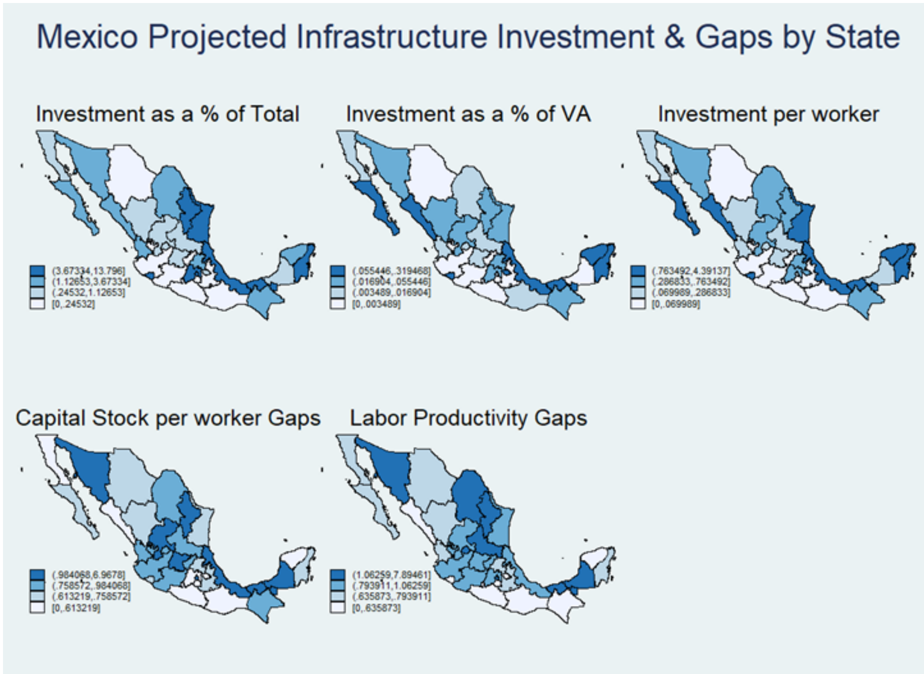
Altogether, contrasting regional projected infrastructure investment with corresponding metrics of labor productivity and capital stock per worker reveals a focused pattern of investment effort that attempts to partially balance out state-level productivity or capital stock, rather than enhancing these asymmetries.

Table A.6.2. OLS Regression Results

Endogenous Variable	Exogenous Variables	Coefficient	P-value	R-squared
Infrastructure Investment / Value Added	*Log-Labor Productivity*	-0.022	0.004	0.90
	Log-Capital Stock per worker	-0.023	0.007	0.90
	Labor Productivity Gap	-0.010	0.006	0.90
	Capital Stock per worker Gap	-0.011	0.009	0.90

Oil-State and State-Specific Dummies were statistically significant in every case at P<0.001, and with positive sign
States identified with Oil Dummy: Veracruz, Tabasco, Tamaulipas, Chiapas, Campeche
States identified as Outliers: Quintana Roo, Colima

Figure A.6.1



Source: Own based on Mexico Hub and INEGI 2018 Census.