Growth Lab

Growth through Diversification in Hermosillo

A Growth Diagnostic

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Growth Lab Working Paper Series
No. 239

December 2024

GROWTH LAB
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This paper may be referenced as follows: Fortunato, A., Arcay, G., Barrios, D., Bustos, S., Daboin, J., Lamby, L., O'Brien, T., Shah, T., Hausmann, R. (2024). "Growth through Diversification in Hermosillo." Growth Lab Working Paper, John F. Kennedy School of Government, Harvard University.

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Acknowledgments

This report is part of a nine-month research project the Harvard Growth Lab held in 2024 in collaboration with the Non-Profit Organization “Hermosillo, ¿Cómo Vamos?”. The project focuses on understanding the economic growth challenges in Hermosillo, analyzing the city’s growth opportunities, and helping design strategies for stronger economic growth. This project was a follow-up to another research engagement conducted by the Growth Lab in 2018 in collaboration with the Inter-American Development Bank (Barrios et al., 2018). We thank Bob Pell and Ernesto Stein, part of our research team as external experts, who provided vital insights into the research process and joined us in our field trips to Hermosillo. We also appreciate collaborating with our local counterparts, who provided feedback, facilitated data access, helped organize field trips, and provided insightful conversations. Notably, we want to express our gratitude to the project’s local coordination team in Hermosillo: Arturo Díaz Monge, Fernando García de León, Manuel Molina, and Ernesto Urbina as well as the team at “Hermosillo, ¿Cómo Vamos?” (Rocío del Carmen Rodríguez González, Jennifer Espinoza Ramos, and Nicolás Pineda). We also want to thank local policymakers that created time in their busy schedules to talk with us. At the state level, we thank Francisco Acuña and team (Chief of Cabinet), Margarita Vélez de la Rocha and Cynthia López (Secretaría de Economía). At the city level, we want to acknowledge input from Gertie Agraz (Agencia Municipal de Desarrollo Económico), IMPLAN, Agua de Hermosillo, and CIDUE. We also had the opportunity to conduct interviews with key private sector stakeholders from different companies like BD Medical, Cluster de Energía, Ford, Gamas Group, IAMSA, Leoni, Stanley Black & Decker, and TE Connectity.

1 Introduction

In this report, we study Hermosillo's economic performance and assess critical issues affecting the city's ability to achieve stronger economic growth. Although Hermosillo is far from experiencing economic stagnation, it fell behind other cities that managed to become successful economic hubs between 2010 and 2020. The main reason behind this trailing growth is Hermosillo's relatively low diversification and investment dynamics, especially in the manufacturing sector. We apply growth diagnostic testing on various potential constraints to economic growth: logistics, electricity, water, human capital, housing, and transportation. Although none of them have directly constrained economic growth in the past, some are explicit threats to increasing growth in the future, thus catching up with high-performing peers. Electricity, human capital, and logistics are comparative advantages, while water, housing, and transportation are threats.

In 2025, Mexico is expected to start a new period in its economic history marked by the promise of nearshoring and a new presidential administration. In the past, Mexico has gone through milestones that heavily impacted its economic development path, like the establishment of NAFTA and the China Shock (Hanson, 2010). The rise of Northern Mexico and other regions like El Bajío as global manufacturing hubs has resulted from greater integration with the North American market. This has brought foreign direct investments (FDI) targeted at establishing manufacturing sites primarily to cater to US demand and exports to the rest of the world. Mexico holds high expectations that nearshoring will bring opportunities of the same or greater magnitude. In that context, Hermosillo stands out as a city with the potential to exploit those opportunities and enhance its economic transformation. It is crucial to analyze its binding constraints for economic growth, comparative advantages, and potential concerns to understand how well-positioned Hermosillo is to take advantage of this momentum.

This report builds on previous diagnostic findings and recommendations. In 2017, the Harvard Growth Lab led a diagnostic effort to understand Hermosillo's economic

challenges (Barrios et al., 2018). The study focused on Hermosillo's economic performance three decades after the arrival of Ford in the city. The report documented weakening growth and a struggle for Hermosillo to remain at the frontier of the Mexican economy and compete with other cities globally that had caught up in their economic capabilities. The authors identified a problem of limited continued diversification of exporting industries and strong evidence of key issues in water, electricity, and urban mobility and logistics. This led to recommendations for a set of institutional responses by the city government.

The earlier diagnostic was completed before the COVID-19 pandemic and other events that have shifted the global economy since. For Mexico, in particular, United States incentives and policies around "nearshoring" have been a substantial change, alongside the updated tripartite trade agreement between the United States, Mexico, and Canada known as USMCA. The 2018 report also preceded the administration of President López Obrador and the national priorities and investments that have taken place under his leadership. Of course, change is nothing new for Hermosillo or any economy. As global, regional, and national circumstances have changed, Hermosillo has continued evolving as an economy and city. This report serves as an update to the 2018 diagnostic and an entry point into strategic issues in today's national, regional, and global economy.

Following this introduction and a methodological overview, the report is divided into four main sections. Section 3 provides a growth perspective on Hermosillo; Section 4 presents an analysis of growth constraints; Section 5 explains the local diversification challenge in detail; and Section 6 describes strategic policy areas to accelerate growth that result from this growth diagnostic analysis.

Section 3 describes Hermosillo's and Sonora's economic trajectory in the past two decades to explain the main economic growth problem. We present Hermosillo's growth problem as a "trailing growth" process where the city falls behind other higher-performing places in Mexico between 2010 and 2020. The main reasons behind this

underperformance are the lack of diversification into new manufacturing industries, low foreign direct investment, and low overall investment. We further explore this trajectory and growth problem through the lens of a spatial equilibrium model.

Section 4 conducts a constraints analysis that covers relevant areas previously identified by Barrios et al. (2018) and interviews with local stakeholders. These areas are logistics infrastructure, electricity, water, housing, and transportation. Additionally, we included an analysis of whether human capital is a constraint for economic growth in Hermosillo, which shows that the city has a comparative advantage. A review of the state of the local innovation ecosystem follows this analysis.

Section 5 unpacks Hermosillo's diversification challenge previously presented in Section 3. Through economic complexity theory, we analyze the city's industry and occupation composition compared to the rest of Mexico. We find that Hermosillo falls short in manufacturing diversity, resulting in a less complex economy than peer cities. Additionally, the city has missed many diversification opportunities in the past.

The conclusion synthesizes the report's key findings and policy recommendations. In addition, it includes two tables designed to provide a concise summary of the priority areas for policy action and potential strategic steps that can be taken to overcome the most significant constraints on economic growth and strengthen Hermosillo's competitiveness. Together, these tables serve as a starting point for policymakers, investors, and other stakeholders committed to accelerating Hermosillo's economic development.

2 Methodology

This report re-deploys the methodology of growth diagnostics on the economy of Hermosillo. A growth diagnostic starts with establishing a growth problem based on an economy's past performance — including its trajectory, drivers, volatility, and inclusiveness — and possible challenges for the future. Growth may be too weak to lift people out of poverty or to produce sufficient jobs, it may be too narrow and leave many people excluded from the process and benefits of growth, or it may be unsustainable in important ways. A growth diagnostic then utilizes hypothesis testing to evaluate what constraints are most to blame for the stated problem — in other words, what constraints are most binding. Constraints are often interrelated and suggest a syndrome that helps explain an economy's key needs and challenges moving forward. One benefit of a rigorous and systematic growth diagnostic is that the findings can then inform and prioritize policy, government action, and business and civil society efforts around key issues where relaxing constraints will likely significantly impact the population's growth, jobs, and well-being.

2.1 Growth Diagnostics

A growth diagnostic uses various tools, theories, and empirical methods of economics to evaluate potential constraints in a specific economy rigorously. This analysis centers on Hermosillo as a city and a larger agglomeration of economic activity that expands beyond the city's administrative limits and jurisdictional powers. As necessary to understand issues facing Hermosillo, this report also explores the broader economy of the State of Sonora. When testing any potential constraint — for example, water or electricity systems, urban mobility, or insecurity — four key tests help investigate whether the constraint is binding.

- *Test 1: Is the price (or shadow price) for the factor of production high?* A first clue that something is a constraint is often that the quantity of it is low (for example, low levels of education). However, for a constraint to be binding, it should also

have a high price in the relevant market (for example, returns to schooling, which reflects the price that businesses are paying for more educated labor). The price test is often challenging because many prices are administered, but other market signals can be gathered to identify shadow prices and their dynamics.

- *Test 2: Does movement of the constraint coincide with movement in the outcome of interest?* If a constraint is binding, then recent changes that relax or tighten the constraint should coincide with improvement or worsening, respectively, in the growth process and outcomes of interest (for example, employment, investment, or wage levels). If recent improvements on a constraint (for example, improved access to skilled workers) did not meaningfully improve the growth outcome, this is a strong signal that the issue is not binding.
- *Test 3: Do businesses and economic activities intensive in the constraint struggle more than others?* This test is sometimes known as “camels and hippos” to capture the intuition. In the desert, where water is scarce and binding for life, you tend to find many more camels than hippos because hippos are water-intensive while camels can survive on little water. In an economy, one can check for the same patterns. If a constraint is binding, then there will be few industries and businesses that are very intensive in that constraint, or those that are intensive will struggle much more than those that are not.
- *Test 4: Are economic agents working to bypass the constraint?* If a constraint is binding, businesses and other agents will likely try many approaches to overcome it. For example, if electricity outages are binding in an economy, back-up generators are widely used. If crime and insecurity are binding, there is widespread use of private security. This test is sometimes called “hippos in the Sahara” to expand on the earlier analogy. If one finds a business that is very intensive in what seems to be a binding constraint (like a hippo in the Sahara), there might be a reason why they can overcome it, but others cannot (for example, the business may get priority access to electricity while access to others is cut).

A growth diagnostic at the city level has a few important differences from a diagnostic at the national level, the most important being the relevance of spatial equilibrium. A city-level diagnostic — or any subnational diagnostic — must account for spatial equilibrium. Spatial equilibrium merely reflects that people are much more mobile within a country than across countries due to migration rules and other barriers to relocation. Within a country, people are generally free to move from local economies where opportunities are limited to places that offer more opportunities and a higher standard of living. One implication is that within-country differences in income per capita or unemployment rates will tend to be smaller than between-country differences as people move and markets equilibrate, to some extent, across space. Due to this, migration patterns and wage dynamics compared to the rest of the county can be more important indications of a city's growth performance. Housing supply and connectivity will impact how easily people can move into a growing city, whereas safety, education, and numerous other factors, in addition to jobs and wages, are "push factors" that influence how much of the population leaves.

2.2 Peer Selection

Growth diagnostics involves the use of comparative analysis. Instead of studying how places grow by themselves in general or on average, growth diagnostics is concerned with understanding the idiosyncrasies that make a given place different from a benchmark. Some of these differences may be particularly relevant in explaining how a place grows, or its growth might be constrained. To identify what makes a place different, we compare it to a control group composed of the most similar places. In the case of Hermosillo, we chose a peer group of cities that was estimated to be the most similar in terms of size and economic structure.

Our definition of a city follows the methodology of Atkin (2016). The most granular geographical level of disaggregation for many of the variables used in our paper is the municipality. However, Mexico has thousands of municipalities whose borders were drawn under heterogeneous criteria. For example, States in the South and center of

Mexico contain many more municipalities in a smaller territory than States in the North. The municipality of Hermosillo is one of the largest by physical territory, and it is even larger than some States such as Tlaxcala, Morelos, Aguascalientes, and Mexico City. If we compare Hermosillo to the entire universe of municipalities in Mexico, it will be at the top of the distribution for most variables. Hence, we first grouped municipalities into cities and selected a specific group of peer cities. We define cities following Atkin (2016). Essentially, municipalities are merged into metropolitan zones based on INEGI's definition. Then, additional municipalities are added if at least 10% of their working-age population reported commuting to a specific metropolitan zone in the 2000 population census.

Using relevant economic variables, we calculated a similarity metric to Hermosillo for all Mexican cities. This similarity metric was calculated using four size variables and seven sectoral composition variables. We measured a city's economic size by its total value added, its total wage bill, its total employment, and the number of economic units (firms) it has. There are eight broad sectors in the Economic Census: agriculture, mining and construction, manufacturing, commerce, business services, education and healthcare, hospitality and entertainment, and "other". We used the share of each sector in each city's value added as a proxy for their economic structure. Given Hermosillo's large agriculture sector, we dropped the variable for the share of value added in agriculture to select relatively more industrial cities in the peer group. With these eleven variables, we calculated the relative distance of each city from Hermosillo's values and reduced the dimensionality into a single metric.

An additional restriction was imposed to exclude outlier cities. For example, tourism-intensive cities such as Mérida and agricultural-intensive cities like Morelia and Tampico were dropped. The final set of peers includes the following 13 cities, ranked by their Euclidean proximity to Hermosillo: San Luis Potosi, Mexicali, Chihuahua, La Laguna, Querétaro, Aguascalientes, Reynosa-Rio Bravo, Puebla-Tlaxcala, Tijuana, Guadalajara, Monterrey, Juarez, and Saltillo. This final list of cities is highlighted in Figure 1.

Figure 1: Hermosillo's Peers in Mexico

Metropolitan Area	Entidad	Population	Average Income (Monthly)	Formal Sector Value Added Per Capita (Yearly)	Formal Employment	Formal Establishments	Manufacturing Share in Formal Employment	Manufacturing Share in Formal Value Added
Hermosillo	Sonora	927,042	25,970	127,845	220,725	31,599	21%	53%
Aguascalientes	Aguascalientes	1,075,365	13,128	117,884	266,917	44,744	34%	63%
Chihuahua	Chihuahua	982,589	38,672	97,079	254,687	32,638	36%	41%
Guadalajara	Jalisco	5,152,934	17,420	93,273	1,169,085	195,181	26%	39%
Juarez	Chihuahua	1,505,714	21,346	91,551	476,417	35,110	64%	67%
La Laguna	Coahuila-Durango	1,369,966	14,015	109,279	288,977	42,396	27%	61%
Mexicali	Baja California	1,042,395	18,917	86,239	224,721	29,280	37%	52%
Monterrey	Nuevo Leon	4,764,944	30,040	162,546	1,278,784	131,596	27%	37%
Puebla-Tlaxcala	Puebla-Tlaxcala	2,652,048	15,878	71,572	553,547	128,393	24%	46%
Queretaro	Queretaro	1,489,230	22,242	133,757	416,103	53,507	29%	52%
Reynosa-Rio Bravo	Tamaulipas	835,073	12,600	116,142	229,308	24,003	61%	35%
Saltillo	Coahuila	1,028,156	26,206	192,258	260,208	28,656	35%	73%
San Luis Potosi	San Luis Potosi	1,239,810	33,528	112,800	306,815	50,499	32%	57%
Tijuana	Baja California	2,036,832	20,119	82,151	525,835	54,379	50%	52%

Source: Own calculations based on Censo Económico and Censo de Población y Vivienda.

2.3 Spatial Equilibrium Framework

A spatial equilibrium model is a powerful framework to understand subnational dynamics and outcomes. As Glaeser & Gottlieb (2009) explain that in spatial equilibrium, incomes, housing prices, and population levels are endogenously determined by the interaction of productivity, amenities, and housing supply in different locations. Changes in these fundamentals will lead to population, income, and price adjustments until a new equilibrium is reached. For example, an increase in a city's productivity can initially raise incomes but also lead to inflows of workers until higher housing prices or lower amenities offset the income gains. Using this framework allows us to interpret patterns of prices, incomes, and population growth across cities to infer the underlying economic forces at work, like productivity or amenity changes. In this model, amenities are non-wage characteristics of a location that affect the desirability of living and working there. These factors include climate, safety, and other quality-of-life aspects (amenities), influencing migration patterns and the compensation required to attract and retain workers in different regions.

These spatial equilibrium dynamics play a crucial role in shaping the economic growth trajectory of a city over the long term. Cities with a favorable combination of productivity, amenities, and housing supply will typically experience sustained

population and economic growth as they continuously attract new residents and firms. This process is self-reinforcing. The arrival of new businesses and skilled workers further enhances the city's attractiveness, which attracts more businesses and new residents. However, the same forces that drive long-term growth can also create short-term challenges, such as rising housing prices, if the housing supply is not sufficiently elastic. External shocks to productivity or amenities can also alter a city's growth trajectory. In the case of Hermosillo, for example, a decline in external demand for goods manufactured in the city or the relocation of global supply chains due to nearshoring would be external shocks to productivity. Additionally, a change in the city's mean temperature due to climate change— a natural amenity — could be an external shock affecting economic growth.

The agglomeration of economic activities in cities fosters diversity and economic complexity through a dynamic spatial equilibrium process. As firms and workers co-locate in urban areas, they benefit from increased productivity, knowledge spillovers, and access to a broader pool of specialized inputs and services (Combes & Gobillon, 2015; Duranton & Puga, 2004). This concentration of diverse economic agents facilitates the exchange of ideas, skills, and technologies, leading to new and complex industries. Under a spatial equilibrium model, as the benefits of agglomeration increase, more firms and workers are attracted to cities, which further enhances the diversity and complexity of the urban economy as they introduce new skills, supply chains, and networks. However, this process is balanced by the costs and access to housing supply and the amenities that the city can provide in response to the increase in population. The interaction between these agglomeration benefits and costs ultimately shapes the spatial distribution of economic activities and the degree of diversity and complexity that cities can sustain.

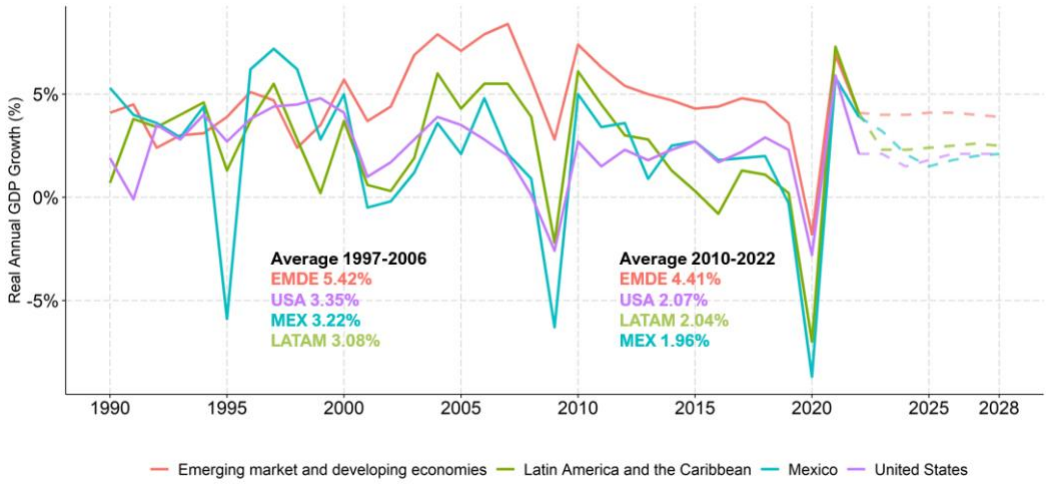
3 A Growth Perspective on Hermosillo

This section covers relevant aspects of Hermosillo's economic trends, both in the long and short term. We first examine Mexico's recent growth performance, followed by Sonora's and Hermosillo's trajectories. An overview of the national economic growth trajectory provides a relevant context for understanding regional challenges. Hermosillo has experienced economic growth in the past decades, which has led to relatively high living standards. However, Hermosillo shows slower economic dynamism than peer cities. We have defined this pattern as "trailing growth." The economy has the potential to grow faster, provide better jobs, and absorb more people, but barriers are preventing the city from growing as dynamically as aspirational peer cities.

3.1 Mexico's Economic Growth Trajectory

Since the 1990s, Mexico's economic growth has been slightly lower than that of the Latin American and Caribbean (LAC) region and the United States, and much lower than that of Emerging Markets and Developing Economies (EMDE). Figure 2 shows growth rates since the 1990s for Mexico and these three important benchmarks. After recovering from the Tequila crisis and until 2008, Mexico grew faster than LAC and slower than the USA, likely benefiting from the increased commercial integration with the USA. After a few years of somewhat faster recovery from the 2008 crisis, Mexico's growth closely aligned with the US and the LAC average for most of the decade that followed. Mexico was unique in 2019 as it experienced no growth. Mexico faced a deeper contraction than the US in 2020 amidst the COVID-19 pandemic, followed by a weaker initial recovery in 2021. Over the whole period, GDP growth for Mexico and the LAC region has run consistently and substantially below the average for middle-income countries (6.3% over 2000-2010 and 4.7% from 2010-2020 per World Bank data). Mexico is part of the emerging markets group but has consistently underperformed vis-à-vis that group. Looking ahead, according to IMF's projections, Mexico's pattern of underperformance is not expected to change in the coming years.

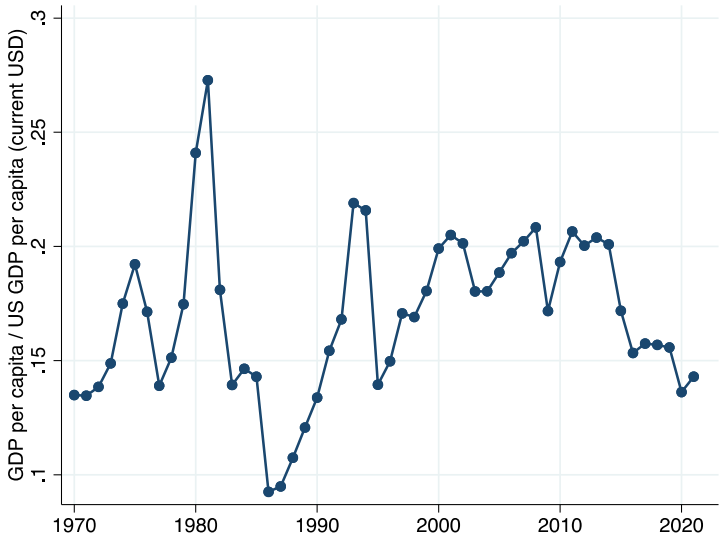
Figure 2: GDP Growth for Mexico, the United States, EMDEs, and the LAC Region



Source: IMF World Economic Outlook

Mexico has been unable to converge with the United States over the long term. Since Mexico's economic growth has primarily tracked and often been lower than US economic growth, Mexico has not achieved a path of convergence with the income per capita levels of its northern neighbor (Figure 3). In fact, since 2014, Mexico has widened the income gap with the US, dropping from 20% to below 15% of US income per capita levels. The economies of Mexico and the US are highly intertwined, as the US plays an outsized role as an importer of Mexican products (Harvard Growth Lab, 2024), but Mexican exports to the US have not increased enough to help bridge the income gap. Mexico has failed to converge to US living standards at the national level, and at the subnational level, as no region or city in Mexico has achieved meaningful convergence with US income levels on average over an extended period.

Figure 3: Mexican GDP Per Capita Convergence with the United States



Source: Own calculations based on World Bank World Development Indicators

Mexico has enjoyed strong economic growth in the last few years since COVID-19, but there is an expectation of a moderation in growth. Growth was estimated at 3.9% in 2022 and 3.2% in 2023 (International Monetary Fund, 2023). This has come along with elevated inflation (7.9% in 2022 and 5.5% in 2023) and very low unemployment (3.3% in 2022 and 2.9% in 2023). Thus, Mexico can be viewed as "overheating" in macroeconomic terms, and a slowdown would be natural. Inflation has come down substantially from its peak in late 2022, while unemployment continues to be very low. These trends have, once again, paralleled those in the United States. Many countries would envy Mexico's recent economic performance in globally turbulent times. Mexico now enjoys an appreciating currency, a well-capitalized banking system, a roughly balanced budget, and stable debt as a share of GDP. Yet, growth is still not on a trajectory to begin to see meaningful income convergence and is only marginally higher than the global middle-income average (3.6% in 2022). The IMF currently estimates that Mexico's growth is running above potential and anticipates a slowdown to 2.1% growth in 2024 and 1.5% growth in 2025. Growth may continue to outperform expectations, as has been the case in the US economy, but overperforming expectations would still

amount to relatively weak growth by global standards and no path to income convergence with the United States.

3.2 Economic Growth in Hermosillo and Sonora

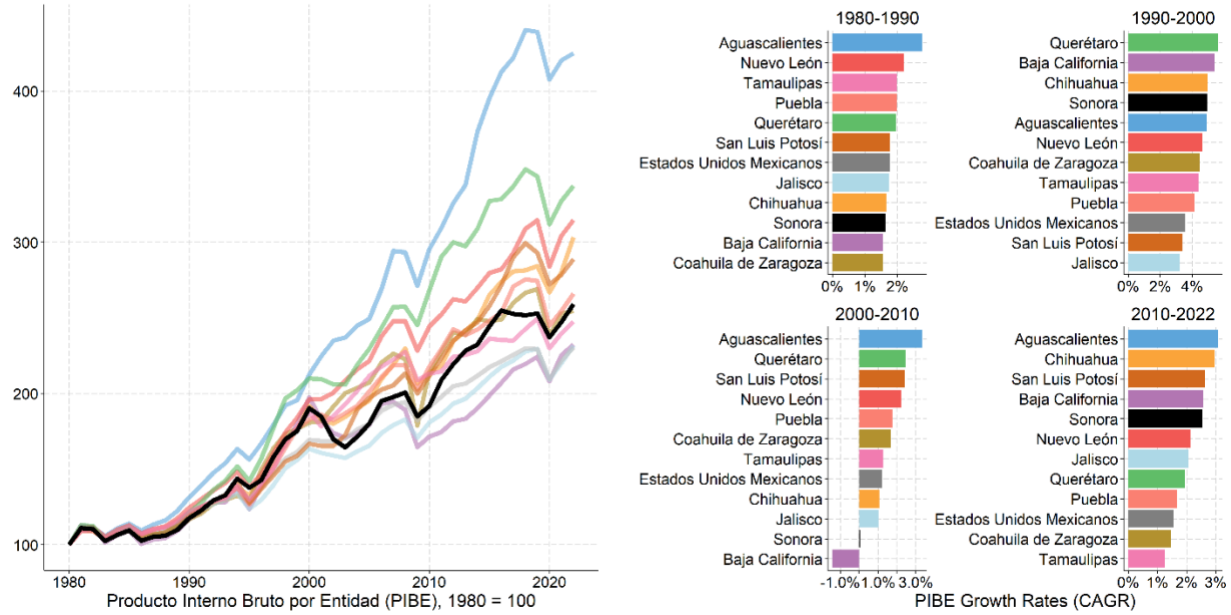
The economic history of Hermosillo is closely intertwined with that of Sonora. As the state's capital, Hermosillo has played a pivotal role in driving economic activity in the rest of the state through various channels, such as hosting company headquarters, exporting human capital, and producing inputs demanded by industries in other parts of Sonora. Equally, the rest of Sonora also contributes to Hermosillo's growth, with several cities serving as demand sources for output from Hermosillo. This underscores the economic significance of Hermosillo and the need to understand its economic trajectory by examining trends in Sonora.

3.2.1 Sonora

Sonora became a relatively prosperous state by growing faster than the Mexican average, but it has also lagged several states that experienced significant economic transformations. During the 1980s, Sonora's GDP per capita was 10th out of 32 Mexican states. Since then, Sonora has grown faster than several Mexican states. By 2019, Sonora ranked 5th in GDP per capita, 40% higher than the national average, yet 25% lower than Nuevo León (third in the ranking). As Figure 4 shows, Sonora has also experienced higher economic growth rates than Mexico as a nation during the 1990s and the 2010s, likely explained by the role of the North American Free Trade Agreement (NAFTA) in spurring economic growth for northern states in Mexico. Although Sonora experienced robust growth during the 1990s, it stagnated in the 2000-2010 period. Recently, Sonora faced a short slowdown from 2016 to 2019 that did not happen in peer states. Despite growing above the national average for the most part, Sonora's long-term economic growth dynamics during the whole period between 1980 and 2022 have fallen behind most of its peers. Although Sonora's GDP in 2020 was over 150% higher than in

1980, like Coahuila or Tamaulipas, other states like Nuevo León, Querétaro, Chihuahua, and Aguascalientes have more than tripled their GDP.

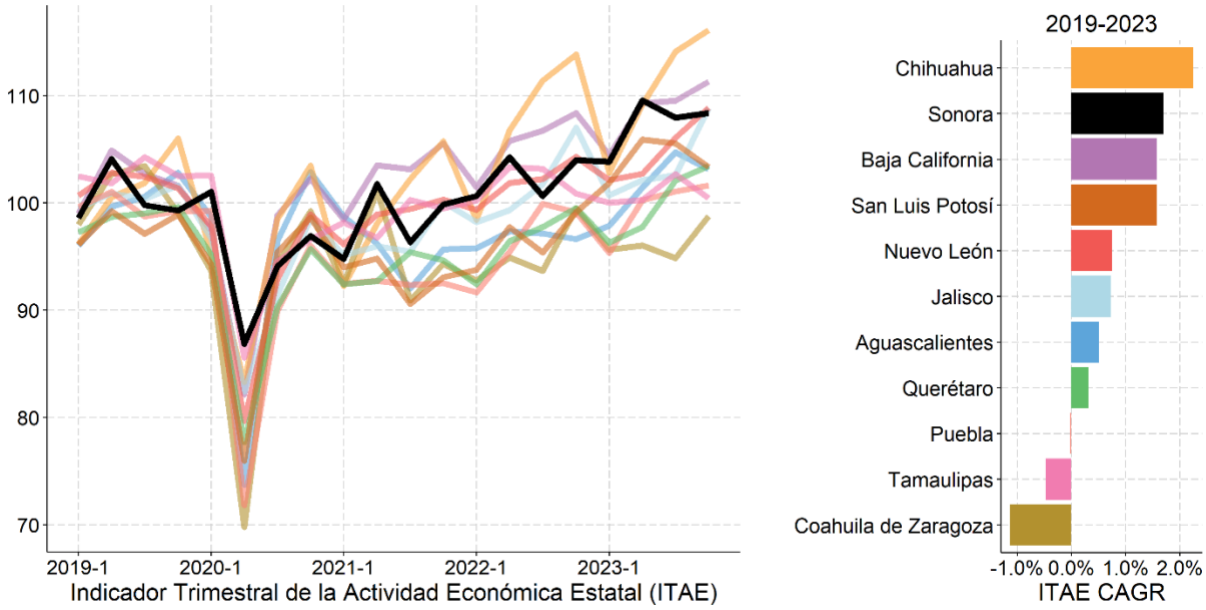
Figure 4: Sonora's Gross Domestic Product vs. Peers (1980-2022)



Source: Authors' calculations based on PIBE (2024).

Sonora's recent economic performance highlights a notable resilience and recovery in the face of COVID-19 economic impacts relative to its peer states. According to the Quarterly Index of Economic Activity (ITAE) of the Instituto Nacional de Estadística, Geografía e Informática (INEGI), from 2019 to 2023, Sonora experienced one of the highest compound annual growth rates (CAGR) among Mexican states, trailing only behind Chihuahua (Figure 5). This robust growth was led by secondary activities comprising manufacturing, construction, utilities, and mining. Specifically, the manufacturing and construction sectors have shown significant activity increases. Despite a dip in 2020 amidst the pandemic, these sectors rebounded strongly after 2021, contributing to the state's overall economic growth. These combined factors have enabled Sonora to outpace many of its peers in economic recovery and growth during the post-pandemic period. However, this does not necessarily reflect a sustainable economic trend or a structural change in Sonora's trajectory.

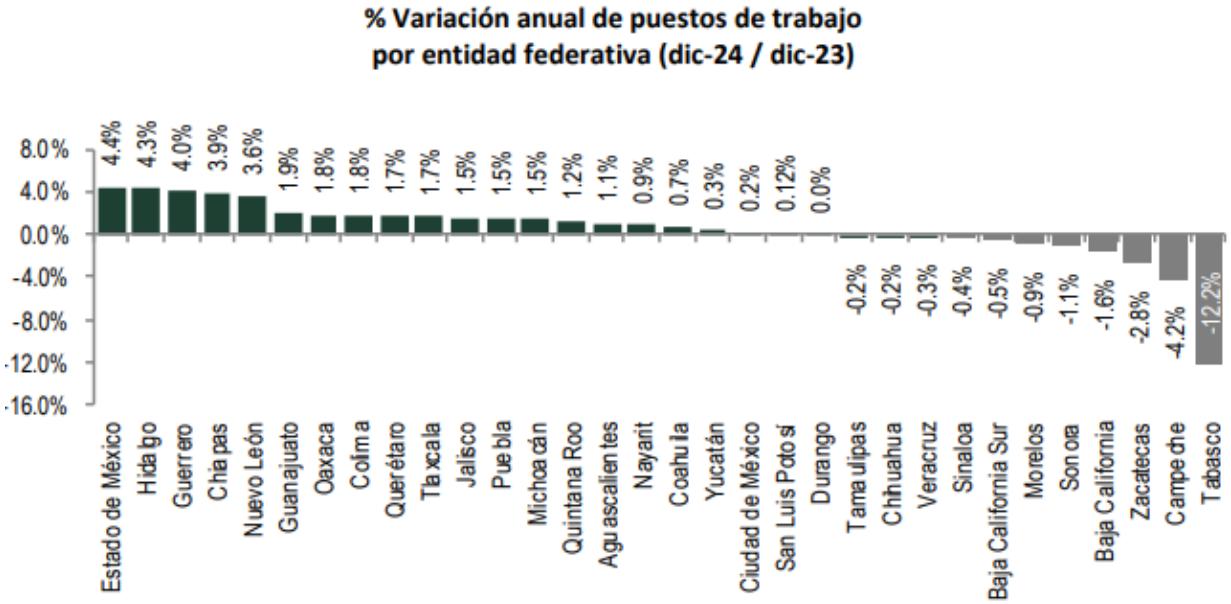
Figure 5: Index of Economic Activity of Sonora Vs. Peers (2019-2023)



Source: Authors' calculations based on ITAE (2024); INEGI.

More recently, Sonora's employment trajectory has underperformed when compared to the rest of Mexico. The employment data from the Instituto Mexicano de Seguridad Social (IMSS), which represent the formal sector, show that between December 2023 and December 2024, Sonora has lost jobs (Gobierno de México, Boletín de Prensa N009/2025). Other states like Aguascalientes, Querétaro, Nuevo León or Coahuila have continued to expand is formally employed population.

Figure 6: Annual Variation of Jobs by State (Dec 24-Dec 23)



Source: Gobierno de México, Boletín de Prensa N009/2025. https://www.imss.gob.mx/sites/all/statics/i2f_news/Bol009.pdf

3.2.2 Hermosillo

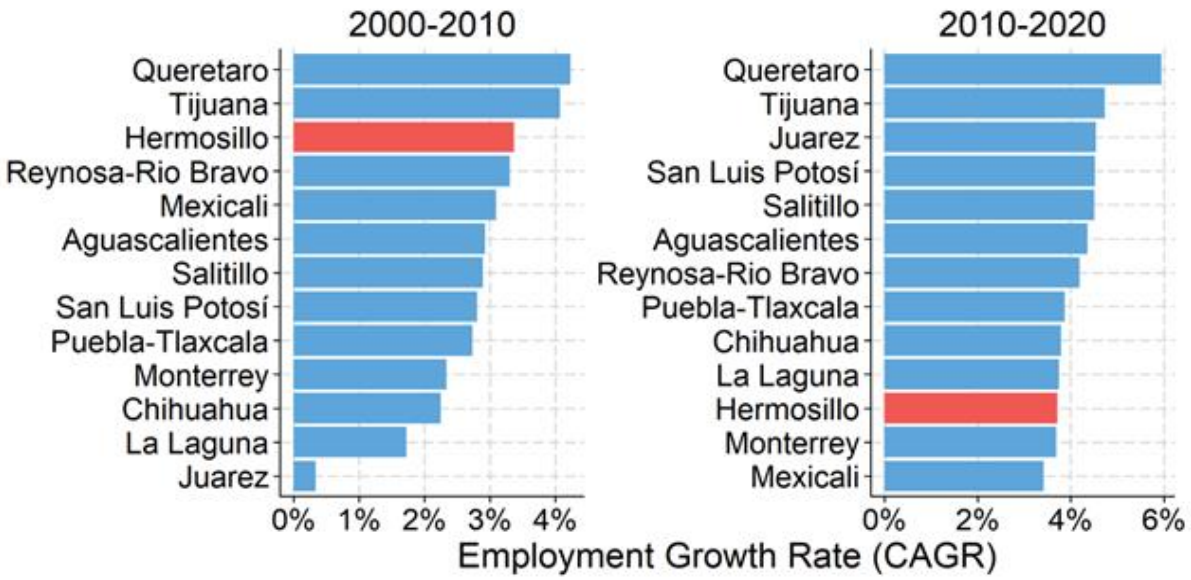
Hermosillo is also a wealthy city compared to the entire universe of municipalities in Mexico, but it is not as wealthy as some peer cities. In 2021, the city ranked 22nd in relative wealth across municipalities in Mexico, putting it in the top 1% of wealthiest municipalities.[1] However, Mexico is a big country with over 2400 municipalities, many of which are not comparable to cities like Hermosillo in population, industrial composition, or overall economic development. If we compare Hermosillo to the whole universe of Mexican cities or municipalities using any relevant variable for economic development, it will always be in the upper tail of the distribution. Hermosillo's development challenges fundamentally differ from those of many places in Southern Mexico and are far more similar to those of Mexico's largest and wealthiest cities. This is the primary motivation

[1] Based on the Relative Wealth Index developed by Data for Good, Meta.

for carefully selecting a group of peers to benchmark Hermosillo's economic performance. Hermosillo's ranking changes when zooming in on that group. Hermosillo is significantly less wealthy than similarly sized cities like Querétaro or Chihuahua as well as bigger cities like Mexicali, Juárez, Tijuana, and Monterrey.

Hermosillo's employment growth after 2010 lags behind other Mexican cities. Figure 7 shows that the annual rate (CAGR) of job creation in Hermosillo went from almost 3.4% over 2000-2010 to 3.7% over 2010-20. This 10% increase is a significant step forward in growth. However, that increase is the lowest amongst the peer group and is far behind the change in most other cities' growth rates. A salient example is Querétaro, a city that experienced a 40% increase in the rate of job creation between the two periods. Peer cities in Chihuahua experienced the largest change in job creation rates (above 70%), and ten of the thirteen cities in the group experienced an increase at least 20% higher than the job creation rate of 2000-2010. This indicates that the period from 2010 to 2020 was a significant growth opportunity for multiple cities in Mexico. Although Hermosillo was far from experiencing economic stagnation as it achieved stronger economic growth than before, it severely underperformed relative to most cities with similar characteristics. In this context, Hermosillo's slight uptick in growth is a tale of missed opportunities.

Figure 7: Employment Growth in Hermosillo Vs. Peers (2000, 2010, 2020)



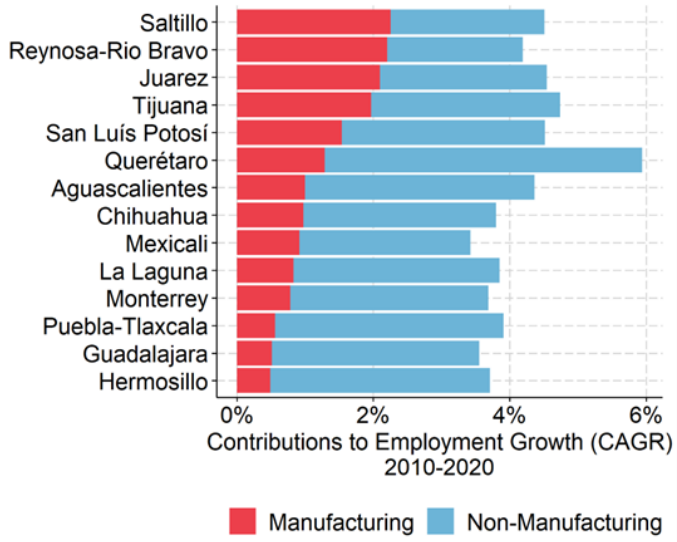
Source: Own calculations based on Censo de Población y Vivienda.

3.3 What is Hermosillo's Growth Problem?

Hermosillo's relative underperformance in 2010-2020 can be explained by a lower contribution of the manufacturing sector to employment growth. Figure 8 shows the total employment growth rate (blue) and the contribution of manufacturing job creation (red) by peer cities. The figure provides a few insights into the role of the manufacturing sector. First, manufacturing has been a small share of direct job creation in many cities, like Monterrey, La Laguna, or Mexicali. However, as we explain in Box 1, the indirect contribution of manufacturing to employment growth is critical. The direct contribution might seem small, but its effects on economic growth overall are significant. Second, the cities that experienced higher growth in 2010-2020 have also seen a major increase in manufacturing job creation. On average, high-performing cities have experienced much higher manufacturing growth than cities with relatively lower economic growth. Third, some cities within the high-performing group have had a relatively lower increase in manufacturing employment, like Querétaro or Aguascalientes. This might be due to a

relatively higher presence of high-skilled manufacturing jobs, which tend to have larger employment multipliers (see Box 1).

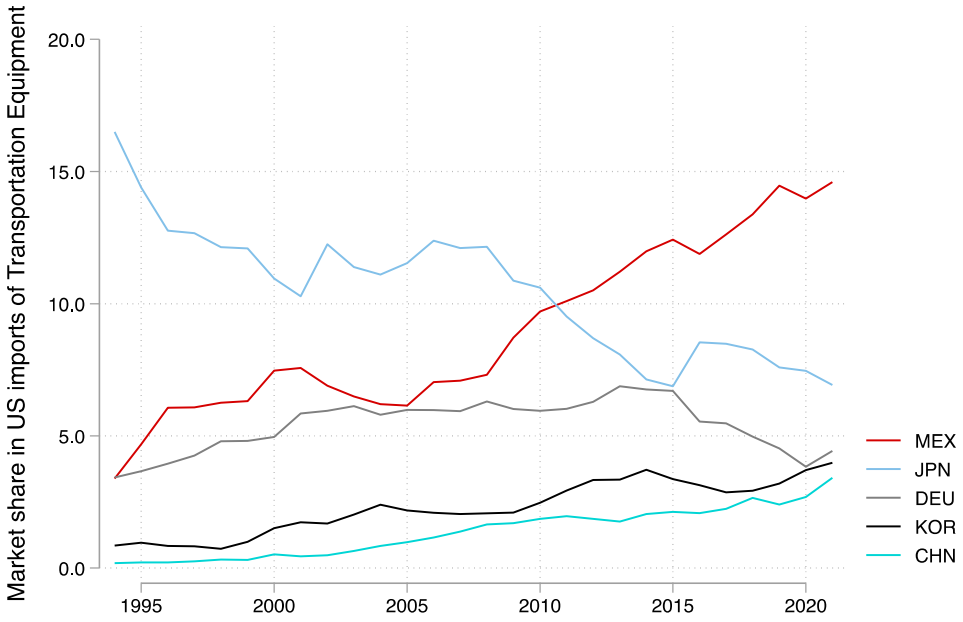
Figure 8: Manufacturing's Contribution to Employment Growth in Hermosillo Vs. Peers (2010-2020)



Source: Own calculations based on Censo de Población y Vivienda

Mexico became a leading exporter of transport equipment to the US between 2010 and 2020, which explains the growth opportunity many cities took advantage of to increase manufacturing output. Transport equipment represents a large share of global trade, with the US being one of the largest importers of these products. Over the past three decades, trade in transportation equipment has doubled, now representing nearly 8% of international trade. During this period, the US has consistently been the largest importer, accounting for 17% of global imports. Figure 10 shows the market share of US imports of transport equipment over time of the top five exporters in 2022. Since 2008, Mexico has significantly increased its market share of US imports of transport equipment, surpassing Japan and Germany, which have been the leading exporters to the US for decades. Mexico's market share doubled between 2008 and 2022, going from 7% to 14%.

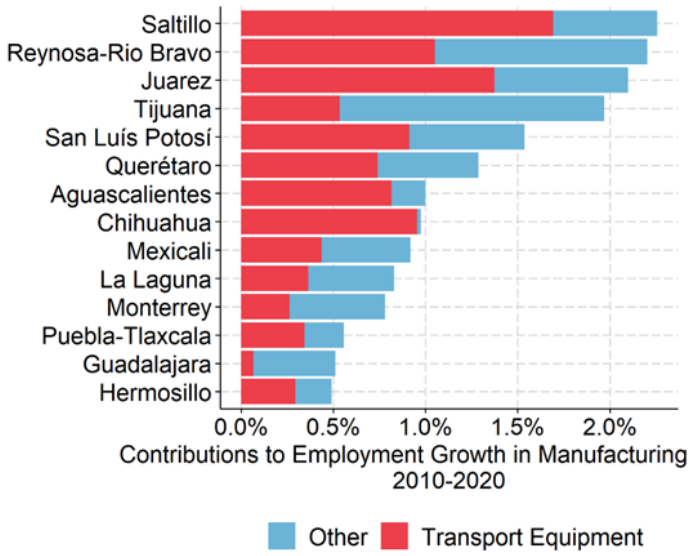
Figure 9: Market share in US imports of transport equipment



Source: Own calculations based on Atlas of Economic Complexity

The history of the transport equipment industry in Mexico is an example of FDI-led diversification. The industry is dominated by global Original Equipment Manufacturers (OEMs) that have established parts of their global supply chains in countries like Mexico. The OEMs invested in locating manufacturing plans in Mexico to cater to the increasing US demand for transport equipment, creating numerous opportunities in various cities nationwide. Figure 10 presents manufacturing employment growth by sector in Hermosillo and other comparable cities. The figure reveals that the transport equipment sector accounts for most employment expansion. While Hermosillo has benefited from a significant transport equipment sector, exemplified by the presence of Ford, it has not managed to expand this sector further as successfully as other comparable cities. This relative lack of dynamism in the transport equipment industry is meaningful as it represents a significant share of Hermosillo's economy overall and more than half of its manufacturing industry. In 2019, the industry represented over 60% of manufacturing value added, over 30% of total value added, 20% of total gross investment, and 10% of the city's total wage bill.

Figure 10: Transport Equipment Contribution to Manufacturing Job Creation in Hermosillo Vs. Peers (2010-2020)

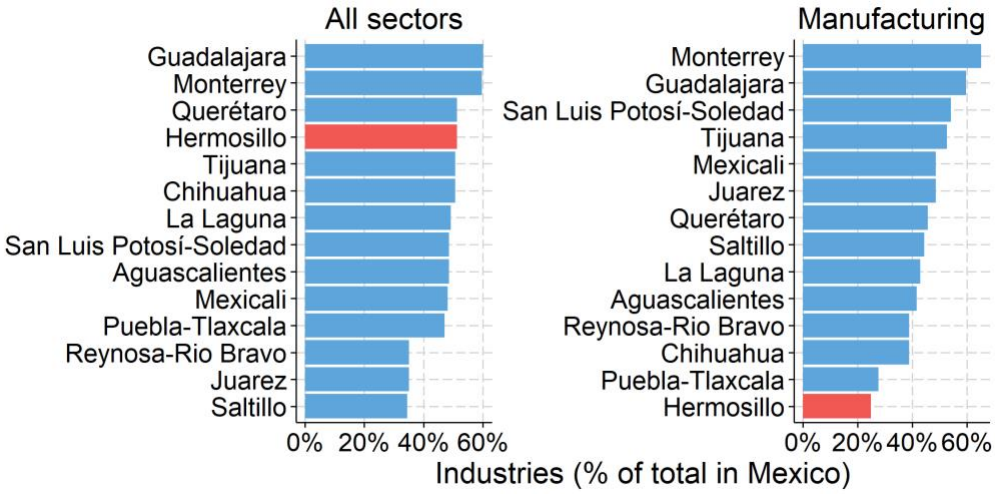


Source: Own calculations based on Censo de Población y Vivienda.

More prosperous cities in Mexico grew in the past decade by developing a dynamic and diverse manufacturing sector, which was not the case in Hermosillo. The performance of the transport equipment industry is not the only factor to blame for Hermosillo's performance during the 2010s. Ultimately, the relevance of the transport equipment industry within manufacturing is amplified by the lack of dynamism in other manufacturing industries. In the past two decades, other cities in Mexico managed to diversify into new manufacturing industries, expanding their productive capabilities and developing new and more complex economic activities. On the other hand, Hermosillo has maintained a consistently low diversity of manufacturing output. While the city boasts a wide variety of local services — like retail and other professional services — its manufacturing base remains relatively concentrated in a few activities. Although Hermosillo successfully attracted sophisticated industries decades ago, with the Ford plant being a prime example, it has not continued to develop more competitive sectors. This is reflected in the city's low diversity of manufacturing industries (Figure 11) and lack of diversification into new industries (Figure 12). Although services increasingly play a crucial role in creating economic opportunities worldwide due to premature

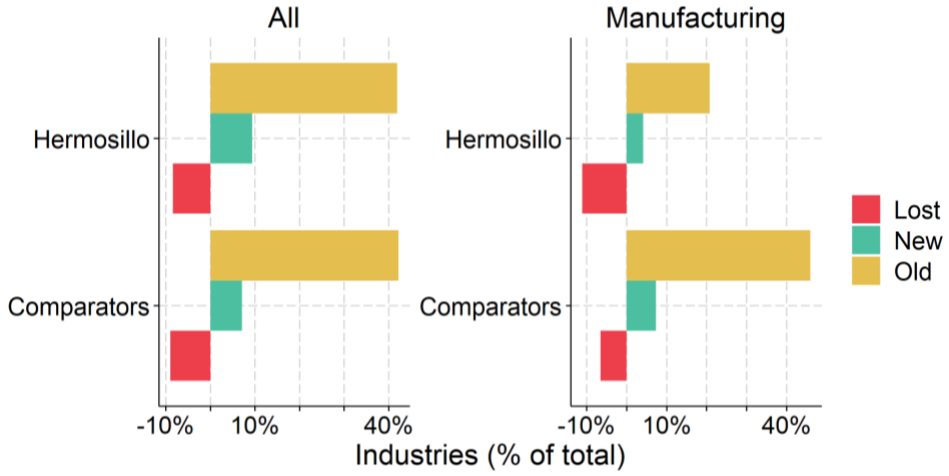
deindustrialization (Rodrik, 2015), the manufacturing sector has been the main growth driver in Mexico, especially in northern Mexico. A key consideration explaining the role of manufacturing in economic growth in Mexican cities is that manufacturing is the tradable sector par excellence. As a tradable sector, the development of new manufacturing industries contributes to direct job creation and significantly affects indirect employment growth, as we explain in Box 1.

Figure 11: Hermosillo's Diversity vs. Peers (2020)



Source: Censo de Población y Vivienda & DENUE. Diversity is measured as the proportion of the number of industries in the classification (N = 190 for all sectors, and N=72 for Manufacturing).

Figure 12: Diversification Dynamics in Hermosillo vs. Peers (2010-2020)



Source: Censo de Población y Vivienda & DENUE. This figure shows a decomposition of diversity in 2020 compared to 2010. Old Industries are industries that were competitive in 2010 and remained competitive in 2020; Lost Industries are those that were competitive in 2010 but are no longer competitive in 2020; New Industries are those that became competitive in 2020.

Box 1: Local Employment Multipliers in Mexico

Despite a relatively small share of employment growth in Hermosillo and comparable cities coming from tradable industries, it remains crucial to focus on attracting and promoting these sectors. Tradable industries drive economic expansion by bringing external income into the local economy, fostering innovation, and increasing productivity. They create a ripple effect, stimulating demand for local goods and services and generating additional employment opportunities. Thus, prioritizing the growth of tradable industries can lead to more robust and sustainable economic development for the entire city.

Whenever a local economy generates new direct jobs by attracting new industries, additional indirect jobs may be created, primarily through increased demand for local goods and services. However, this positive impact on employment is partially offset by general equilibrium effects resulting from changes in local wages and service prices. The net effect of job creation depends on the relative strength of supply and demand elasticities, making it an empirical question.

How many jobs are created by tradable industries across cities in Mexico? To answer this question, we utilize a simple yet influential methodology introduced by Moretti in 2010 and Moretti and Thulin in 2013. Our findings indicate that each additional new manufacturing job in a city creates 1.6 jobs in the non-tradable sector within the same city. As the workforce expands and wages rise, local goods and services demand increases. This effect is notably more pronounced for skilled jobs due to higher earnings. Specifically, adding one skilled job in the tradable sector generates 2.5 jobs in local goods and services. In contrast, the impact of adding an unskilled job is slightly less than one additional job in the local sector. Moreover, our analysis shows that the expansion of jobs in the manufacturing industry draws up to 43% of its workforce from other manufacturing sectors.

Model Estimates

Using data from the 2000, 2010, and 2020 Census of Population, we estimate variants of the following models:

$$\Delta e_{c,t}^{NT} = \alpha + \beta_1 \Delta e_{c,t}^{T} + \lambda_t + \varepsilon_{c,t}$$

$$\Delta e_{c,t}^{T`} = \alpha + \beta_2 \Delta e_{c,t}^{T2} + \lambda_t + \varepsilon_{c,t}$$

Where $\Delta e_{c,t}^{T}$ and $\Delta e_{c,t}^{NT}$ are the changes over time in the log number of jobs in city *c* in the tradable and non-tradable sectors, respectively $\Delta e_{c,t}^{T1}$ is the change in the log number of jobs in a randomly selected part of the tradable sector, and $\Delta e_{c,t}^{T2}$ is the change in the log number of jobs in the rest of the tradable sector, and λ_t is an indicator for the second period. The sample includes two observations per city, corresponding to the periods 2000–2010, and 2010–2020. Standard errors are clustered at the city level. In practice, $\Delta e_{c,t}^{T}$ is measured using changes in manufacturing employment, while $\Delta e_{c,t}^{NT}$ includes all other industries, excluding agriculture, mining, government, and the military. In equation 1, β_1 measures the elasticity of non-tradable jobs to an increase in tradable jobs, which we expect to be positive. Finally, in Equation 2 the coefficient β_2 measures the elasticity of tradable jobs to an increase in other tradable jobs. This last coefficient could be positive if there are complementarities across tradable industries, but most likely, it will result in a negative estimate capturing the substitution effect since expansions of tradable industries often take workers from incumbents.

Table 1 presents the estimates of equations 1 and 2. Column 1 shows an estimate of the non-tradable employment elasticity (β_1) of 0.3. This indicates that a ten percent increase in manufacturing jobs in a city is associated with a three percent increase in employment in local goods and services. Given that there are almost five non-tradable jobs for each tradable job in Mexico, this implies that 1.6 jobs are created in the non-tradable sector within the same city for each additional job in manufacturing.

We can derive more detailed insights by splitting tradable jobs into skilled and unskilled categories and re-estimating equation 1. Column 2 of Table 1 shows that the elasticity of non-tradable employment to an increase in high-skill employment is 0.095, while the estimate for low-skill employment is 0.213. Considering the relative prevalence of each job type, these estimates imply that an additional high-skill job generates 2.5 additional non-tradable jobs, whereas an additional low-skill job creates only one additional non-tradable job.[2]

Table 1: Local multipliers for tradables and non-tradables

	Change in non-tradable employment		Change in tradable employment
VARIABLES	(1)	(2)	(3)
Change in tradable employment	0.304***		
	(0.108)		
Change in skill tradable employment		0.095**	
		(0.042)	
Change in unskilled tradable employment		0.213**	
		(0.085)	
Change in tradable employment			-0.433***
			[-0.80, -0.15]
Observations	380	380	380
R-squared	0.188	0.189	0.14
Additional jobs	1.60		-0.43
from skilled		2.56	
from unskilled		0.81	

Robust standard errors clustered by city in parentheses
*** p<0.01, ** p<0.05, * p<0.1

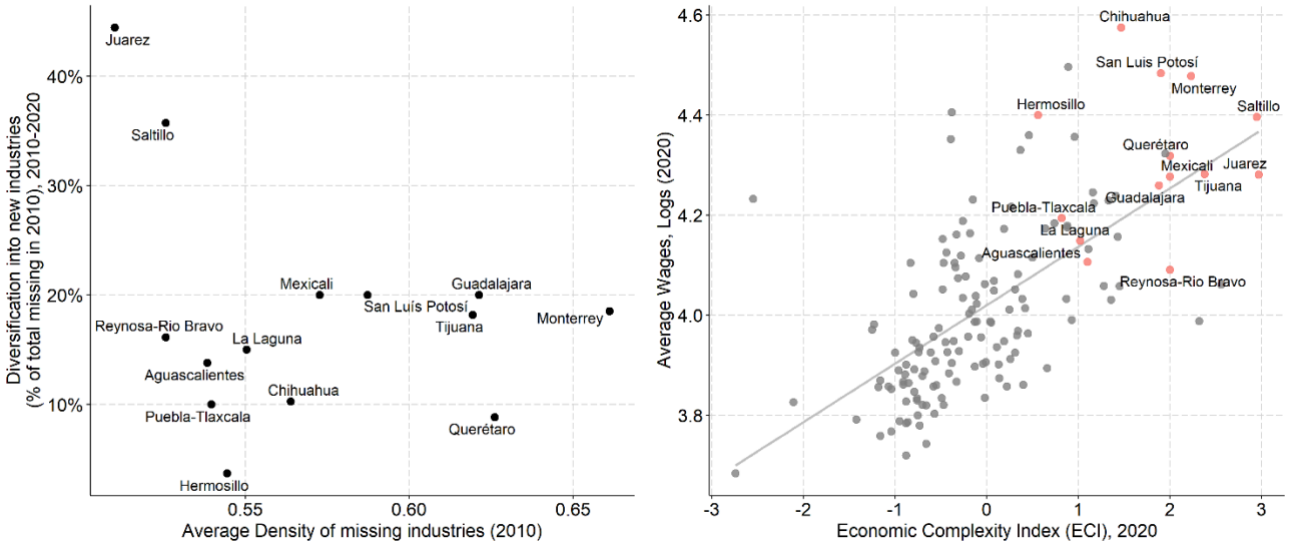
Column 3 of Table 1 present the estimate of equation 2, where β_2 captures the complementarity or substitution of tradable jobs. We randomly split the set of tradable industries into two equally sized groups, estimate the coefficient, and repeat the process a thousand times. The reported coefficient is the mean estimate, with the 95% confidence interval shown in square brackets. The estimated coefficient is negative, implying that an expansion in jobs of a tradable industry takes, on average, 43% of its growth from other industries. Therefore, the full multiplier benefit for non-tradable jobs is only achieved when a net creation of tradable jobs exceeds this substantial substitution effect.

[2] These estimates of additional job creation in the non-tradable sector are consistent with those found by Moretti (2010) for the United States during the period 1980-2000.

Hermosillo missed several opportunities to expand its productive capabilities. The lack of diversification into manufacturing industries compared to other cities in Mexico reflects the fact that Hermosillo fell behind when it comes to taking advantage of the city's productive capabilities, which are many. The left graph in Figure 13 shows how feasible it was to develop new industries on average in 2010 (average density of missing industries in the X axis) against the share of new industries (as % of missing industries in 2010) that Hermosillo managed to develop in the next ten years (Y axis). In 2010, Hermosillo had many opportunities in the sense that developing new industries was equally or more feasible than for cities like Aguascalientes, Saltillo, or Juárez. Nevertheless, the share of those industries that Hermosillo developed between 2010 and 2020 was the lowest in the peer group. Other cities managed to develop many more of those nearby opportunities.

Hermosillo's missed opportunities are reflected in the fact that the complexity of its economy is too low for its wage levels. The right graph in Figure 13 shows the Economic Complexity Index (ECI) of Mexican cities against their average wages in 2020. ECI measures the relative sophistication of the productive capabilities in each geographical area. What explains Hermosillo's relatively low ECI compared to peers (highlighted in red) is its scarcity of high-complexity manufacturing industries. As the figure shows, ECI strongly correlates with average wages in Mexico (this is also true for income per capita and internationally). ECI is also predictive of economic growth as places with high levels of complexity relative to their income are expected to increase the rate at which they generate income. However, places with low complexity relative to their income or wages, like Hermosillo, need to diversify into new and more complex industries to increase their economic growth rates. If Hermosillo is to catch up with economic growth, the city should enhance its economic complexity with the proper diversification strategy.

Figure 13: Missed Opportunities in 2010-2020 (left) & Hermosillo's Economic Complexity Index vs. Average Wages, logs (right)

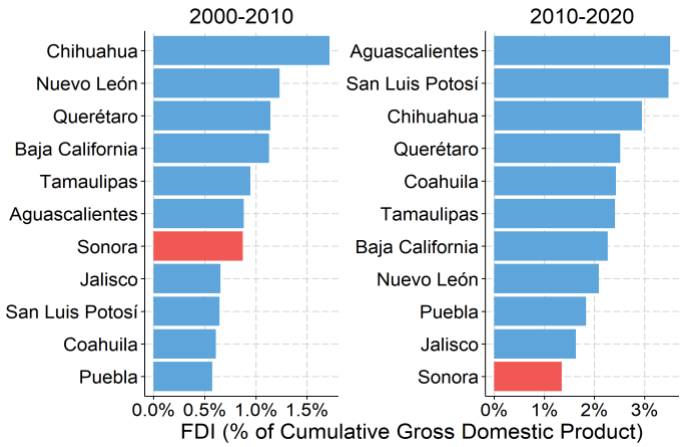


Source: Own calculations based on Censo de Población y Vivienda

Finally, low investment levels, particularly foreign investments, also explain Hermosillo's trailing growth. Figure 14 shows that the city's investment rate as a share of output and per worker has been consistently low between 2004 and 2019. Although investment per capita is also relatively low in other cities like Mexicali, Tijuana, or Juárez, their manufacturing sector comprises much more labor-intensive industries, as they specialize in maquiladoras. In 2019, income from maquilas was less than 10% of total income in Hermosillo, while it was above 70% in Juárez, 40% in Tijuana, and close to 30% in Mexicali (Censo Económico). Figure 15 shows that the volumes of FDI in Sonora were average when considering FDI as a share of GDP between 2000 and 2010. After 2010, Sonora has seen a generalized decline in FDI in absolute terms and as a share of GDP. More recently, although Sonora saw the highest FDI inflows in 2023, over 70% of that was in mining, that is, investments that go where the natural resource is and are not necessarily driven by other economic or policy factors. In 2015-2023, Sonora's total FDI was almost 40% lower than in 2006-2014, and new investments saw an even sharper decline as they went from 32% to 14% of total FDI. Manufacturing FDI in Sonora during 2006-2023 was lower than in any other peer and declined by 16% during the second half of that period. More recently, in the first quarter of 2024, total FDI in Mexico was 9% higher than in the first quarter of 2023 (Secretaría

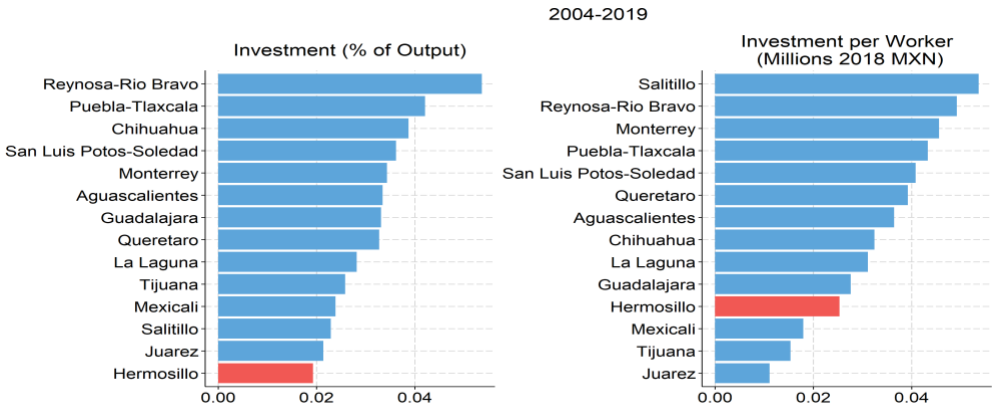
de Economía, 2024). Although most investments were concentrated in Mexico City, peers like Nuevo León, Baja California, Chihuahua, Jalisco, Querétaro, and San Luis Potosí experienced a significant increase in FDI while Sonora did not.

Figure 14: FDI in Sonora vs. Peers (% of GDP)



Source: Authors' calculations based on Censo Económico.

Figure 15: Total Investment in Hermosillo vs. Peers as a share of Output (left) and per Worker (right) in 2004-2019



Source: Authors' calculations based on Censo Económico.

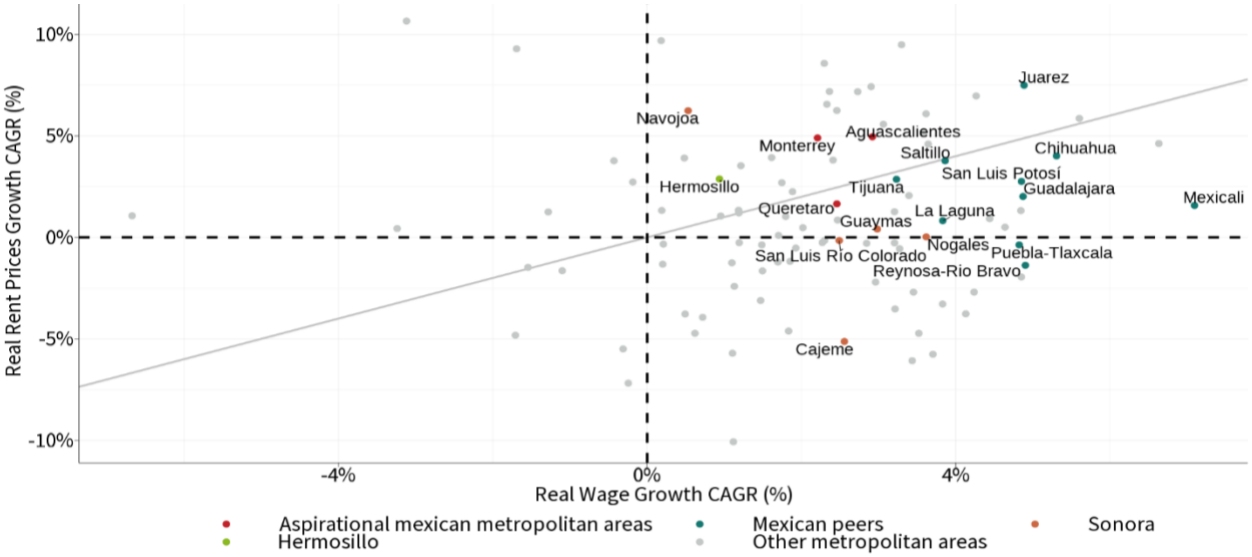
3.4 Hermosillo's Trailing Growth through the Lens of Spatial Equilibrium

We can understand Hermosillo's economic growth prospects through a spatial equilibrium model. In spatial equilibrium, wages, cost of living, and amenities interact and jointly determine the size of a city's population, thus affecting its population and

employment growth. If wages go up in Hermosillo, the population growth rate will increase as long as the housing supply is sufficient to accommodate the new population. Suppose the housing supply is constrained by factors like a regulatory environment that discourages the development of more housing units. In this case, the new housing demand created by higher wages will result in higher housing costs and a lower population growth rate. Housing prices would increase until living in Hermosillo does not have a wage advantage, given its living costs. Similarly, amenities are another factor determining population growth, boosting or holding it back. A place can lack green areas, be too hot, unsafe, or not have enough cultural, recreational, or culinary services for people to want to live there if they do not get enough economic compensation. On the other side, cities with good educational opportunities or good public safety could offer lower wages in equilibrium, as these amenities act as compensation for workers. Our analysis in Appendix 8.2 sheds light on all three factors (wages, cost of living, and amenities) and decomposes them further to identify relative strengths and threats to growth.

The slower-than-ideal rate of job creation in Hermosillo results in wages that are not high enough to attract more workers, given the city's cost of living and amenities. Wages reflect the interplay between labor demand (firms) and labor supply (workers), partially determined by the city's productivity, living costs, and amenities. While high wages could indicate a rapidly rising labor demand, they are also shaped by factors such as local living costs (e.g., housing, transportation) and amenities (e.g., safety, education, weather). In Hermosillo, wages have remained at the top of the wage distribution in Mexico, partly due to a higher cost of living and fewer amenities, which require additional compensation. However, slower productivity growth has translated into slower population and employment growth than in peers, as the city has been unable to generate the same economic opportunities as faster-growing cities like Querétaro. Hermosillo's slower job creation has resulted in a more stagnant economic environment, reflected in slow wage growth and a decline in real wages net of housing costs (Figure 16).

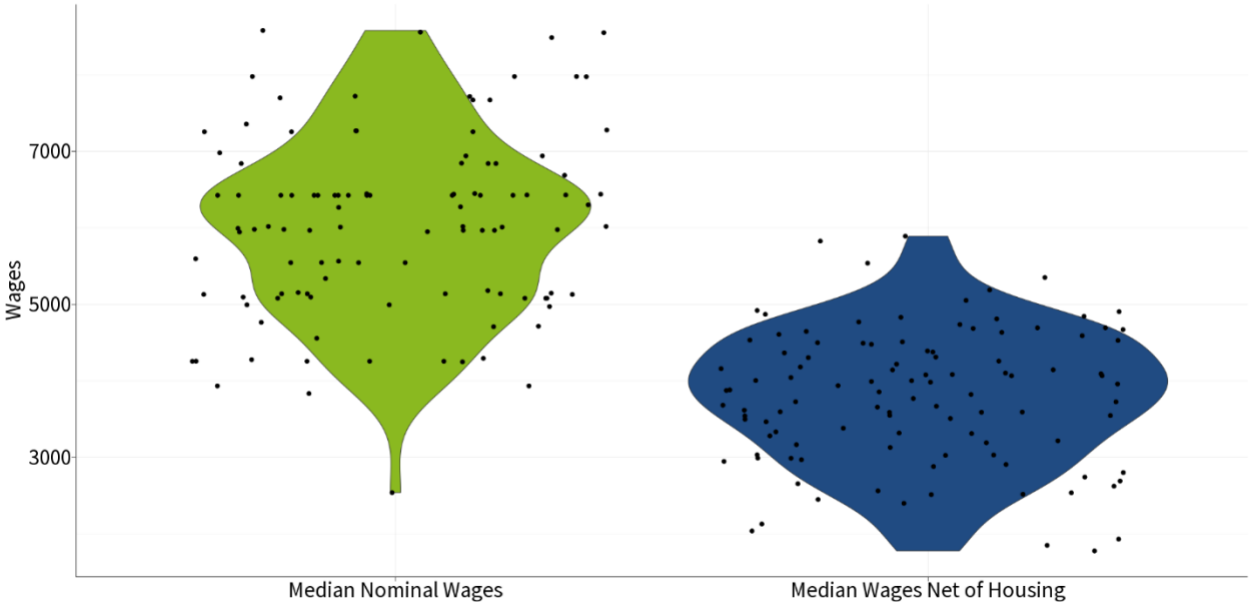
Figure 16: Growth of Real Wages and Real Renting Prices (2015-2020)



Source: Own calculations based on Censo de Población y Vivienda 2020, Encuesta Intercensal 2015, and Encuesta Nacional de Ingresos y Gastos de los Hogares.

Hermosillo's median wages have remained at the higher end of the Mexican distribution partially because of higher housing costs and disamenities. As seen in Section 4.7, housing costs in Hermosillo are relatively high for its income level, which corresponds partially with a city of higher wages. Similarly, as explained in Appendix 8.2, weather is a significant disamenity, as higher maximum temperatures tend to discourage settling in Hermosillo, which requires economic compensation for the city's workers. In the opposite direction, public safety is an asset for Hermosillo as the city exists in the context of a relatively high-violence region in the north of Mexico. These factors combined result in a wage level (net of housing costs) that is driven by the cost of living. This is shown in Figure 17, as wages adjusted by the cost of housing tend to have smaller differences and have a more compact distribution than unadjusted nominal wages. This is consistent with what is seen in the United States wage distribution (Moretti, 2013).

Figure 17: Distribution of Median Nominal Wages and Median Wages Net of Housing Costs



Source: Own calculations based on Censo de Población y Vivienda 2020 and Encuesta Nacional de Ingresos y Gastos de los Hogares Note: The graph denotes the distribution of wages. It is noticeable that the distribution of median wages goes from 2,000 to 9,000 Mexican pesos, and the distribution of wages net of housing goes from 2,000 to 6,000, which is more compact.

Within the amenities that Hermosillo has to offer, it is important to highlight the role of public safety in their role as a magnet for workers that come into the city. Security is one of the top national concerns in Mexico, as it is shown in the World Enterprise Survey by the World Bank, especially in the north of Mexico where violence tends to be higher. Despite this, in Appendix 8.2 we can observe that violence rates in Hermosillo tend to be relatively lower than in the rest of the north of Mexico (Figure 109), which acts as an asset in the attraction of workers from other places in the country. Migrants that come into Hermosillo, tend to be from places that are relatively more violent, especially from within Sonora.

The slower real wage growth and the rising living costs resulted in slower employment growth. As seen in previous sections, the slower economic dynamism resulted in slower job creation in the same period. Despite this and the rising living costs, Hermosillo experienced net positive migration between 2015 and 2020. As shown in Appendix 8.2, this results from its wage differentials with the rest of Mexico, especially

with Sonora, and the relative safety of Hermosillo compared with other cities in the state and the country. All of these factors highlight the need for a city that increases its economic dynamism, keeps a responsive housing supply, and maintains public safety as a key asset to capitalize on the growth opportunities that will arise in the short and medium term.

4 Constraints Analysis

Our Growth Diagnostic report analyzes inputs of Hermosillo's production function to determine if they were binding constraints to catch up with successful cities through higher economic growth. We treat Hermosillo's economy as a production function that converts particular inputs into economic output. The factors of production prioritized for analysis were informed by the Growth Lab's previous growth diagnostic on Hermosillo (Barrios et al., 2018) and are central to economic growth and diversification. The factors are logistics infrastructure, electricity, water, human capital, housing, and transportation. Each subsection focuses on a particular input to production, first explaining the context and then applying diagnostic testing to determine whether it is a relative asset or liability for growth. Policy responses are then suggested where applicable.

The logistics infrastructure of Hermosillo has not been a constraint to growth overall. Hermosillo's proximity to the US and its road and rail connections have been a source of comparative advantage that motivated numerous companies to locate in the city. However, decreasing international flight connections and the distance to a big port may constitute a competitive disadvantage compared to peers.

Electricity has not been a binding constraint for growth but represents a significant growth opportunity. Wholesale electricity prices, as well as industrial tariffs, are among the lowest in the country. The private sector does not exhibit signs of avoiding electricity consumption. Instead, many competitive electricity-intensive industries locate themselves in Hermosillo. These all signal an economy that is not constrained by electricity provision. Sonora is endowed with globally competitive solar potential and has recently become the leader in installed solar capacity for all of Mexico. This presents a significant growth opportunity for the state as the world seeks to decarbonize.

While water has not been a binding constraint to growth, unsustainable aquifer extraction threatens future growth. While the city has struggled with water provision

in the past, the relatively high presence of industries that are intensive in their water use sends a strong signal that it has not held back growth. These water-intensive industries have not exhibited different growth patterns from the rest of the economy, and surveys of economic units show increasing satisfaction with the overall provision of water. However, data from CONAGUA and a substantial body of literature on water use in Sonora identify sustainability concerns related to water extracted from underground aquifers. The report argues sustainability can be achieved and compatible with growth if price mechanisms are improved to allow water to be reallocated to its most socially desirable uses.

Human capital is one of Hermosillo's main assets, but the city is falling behind in terms of innovation. Hermosillo's population is highly educated compared to its peers, and the city is the epicenter of Sonora's university system. The labor market does not pay a high price for workers with education degrees at all levels (primary, secondary, tertiary, and PhD), signaling no shortage of skills. We also do not observe companies paying a premium to attract human capital from elsewhere, indicating they can find the skills they need within the city. In turn, the city is host to a thriving academic ecosystem, ranking among the top 10 for Mexican cities in academic publications, research authors, and citations. Data also indicates that firms in Hermosillo rank highly in when it comes to improving their existing technology to increase productivity. However, Hermosillo underinvests in research and development and, as a result, has very low numbers of patents registered locally.

There are warning signs that problems with the housing supply are increasing the cost of living, thus becoming a binding constraint for Hermosillo to achieve its economic growth potential. The city experienced a steeper increase in housing prices between 2023 and early 2024 compared to most of its peers, signaling a growing mismatch between housing demand and supply (Índice SHF Precios de Vivienda 2024). Building regulations and infrastructure investment costs, partially stemming from lower water availability from residential construction, have limited the growth of low-income housing supply. Changes in INFONAVIT financing policies have further restricted areas

where new housing can be developed, limiting horizontal expansion and increasing land costs within current urban areas. As a result, informal settlements, known as *invasiones*, have emerged around the city, lacking essential services and infrastructure. Additionally, nearby towns like Miguel Alemán have seen significant population growth despite the increased commuting distances and costs. These trends suggest that housing could become a binding constraint for economic growth in the near future if not addressed promptly.

Another component of living costs is urban transportation, which has increased the shadow price of labor and might have impacted the city's competitiveness. Despite being relatively compact compared to other Mexican cities, Hermosillo's urban structure creates inefficiencies due to the spatial mismatch between residential areas and job centers. This mismatch increases transportation costs and commute times, affecting workers and firms. The city's zoning policies have prevented the emergence of mixed-use areas, resulting in workplaces far from working-class housing areas. The spatial mismatch between jobs and housing makes its transportation system much more relevant in overcoming these differences. However, in its current state, the transportation system does not solve this problem, as evidenced by a dysfunctional bus network where workers might have to transfer up to 3 times to move between their house in the north and their job in the industrial zones in the south. To overcome this, firms offer private transportation to their workers at a potentially high cost, while some workers increase their cost of transportation through car ownership.

The analysis of these factors ultimately identifies opportunities and threats to Hermosillo’s economic development. Hermosillo’s position concerning logistics, electricity, and human capital presents comparative advantages, while water, housing, and transportation pose potential threats to rapid growth. Policymakers, civil society, and the business community can address opportunities and threats, helping to move Hermosillo onto an accelerated growth path.

4.1 How do national issues reflect at the local level?

Recent business surveys overwhelmingly indicate that corruption and insecurity are the top business concerns across Mexico. The World Bank conducts a standardized, large-scale Enterprise Survey across all countries every few years, and the latest iteration in Mexico was conducted in 2023. In one part of this survey, business leaders are asked to choose their top constraint from fifteen different options (see Figure 18). In 2023, businesses in Mexico selected the two options at extremely high levels: “corruption” (31% of firms) and “crime, theft, and disorder” (29% of firms). In fact, Mexican firms selected corruption at the second highest rate of any country of all time going back to 2006, when these surveys began (behind only Panama in 2010 at 32.5% of firms). On crime, theft, and disorder, Mexico in 2023 was the fourth highest of any country at any time, lower than only South Africa in 2007 (40%), Venezuela in 2010 (32%), and El Salvador in 2006 (31%). Businesses in Mexico chose these as their top constraints at high levels in the previous survey iterations in Mexico in 2006 and 2010 as well, but the share of firms choosing these two constraints skyrocketed in 2023. In other countries, business surveys point to a variety of different issues, such as electricity access, finance, or education, so the very clear message from businesses in Mexico on corruption and crime must be meaningful.

Figure 18: Share of Firms Indicating Top Constraint by Various Firm Type

	finance	land	licensing	corruption	courts	crime	customs	electricity	education	labor regs	instability	informality	tax admin	tax rates	transportation
All	10.8	0.9	2.8	31.2	0.1	29	1	5.9	1.2	3.5	0.1	4.5	1.1	3.9	3.9
Direct exporters	3.8	0	7	61.5	0.6	4.2	16.5	0.1	1.1	0	0	1.5	0	1.9	1.7
Non-exporter	10.9	0.9	2.8	30.9	0.1	29.3	0.8	6	1.2	3.5	0.1	4.5	1.2	4	3.9
Top manager is female	17.8	0	1.7	34	0	30.3	0.3	2.4	0.1	0.1	0	2.6	0.4	6.7	3.5
Top manager is male	9.5	1	3	30.7	0.1	28.7	1.1	6.6	1.4	4.1	0.2	4.8	1.3	3.4	4
Central	5.9	0.1	3.9	33.4	0	7.6	1	7.9	1.6	7.7	0.3	10.6	1.8	10.5	7.6
Central North	18.1	1.8	3.2	20.5	0	29.3	2.6	8.4	2.7	9.3	0	1.6	1.7	0.3	0.6
Mexico City	11	1.3	0.7	41.8	0.1	27.3	0.2	7.2	0	0.3	0.4	0.2	1.6	3.7	4.3
North	5.9	0.3	1.2	33.3	0.3	48	0.8	0.1	1.5	0	0	0.8	0	1	6.8
South	12.5	0.8	6	27.1	0	28.1	0.1	6.5	0	0	0	12.3	0.7	6	0
10+% foreign ownership	16.3	0.6	4.3	15.6	0	6.2	4.7	5.3	1.2	2.5	3.4	13.2	1.2	14.4	11.1
Domestic	10.6	0.9	2.7	31.8	0.1	29.8	0.8	5.9	1.2	3.5	0	4.1	1.1	3.5	3.6
All Manufacturing	12.6	0.1	0.7	30	0.1	23	3.7	6.3	0.9	7	0.4	3.5	1.5	5.9	4.2
Food	4.9	0	0.1	42.5	0	23.3	0.2	16.2	1.7	0	1.1	6.8	0.6	1.8	0.7
Garments	6.3	0.8	2.4	41.3	0	18.2	10.9	7.6	0.2	0	0	3.8	2.1	5	1.3
Other Manufacturing	16	0.1	0.7	24.6	0.2	24.1	4.1	3.2	0.7	10.2	0.3	2.6	1.6	5.9	5.8
Textiles	4.8	0.4	0.1	39.8	0	8.5	0.4	7.1	1.1	0.3	0	2	2.9	32.2	0.5
All Services	10.2	1.1	3.5	31.7	0.1	31	0	5.8	1.3	2.3	0.1	4.8	1	3.3	3.8
Construction	12.2	9.8	14.9	26.2	0	6.9	0.1	3.6	0	17.7	0.5	0.5	0.6	1.8	5.2
Hotels	9.3	0	0.7	46.3	1.7	10.7	0	12.7	0.1	0	0.3	12.7	2.7	2.8	0
Other Services	10.1	1.1	1.6	37.2	0.1	29.4	0	5.5	1.8	1.1	0	3	0.8	3.9	4.2
Retail	10	0	4.1	25.3	0	38.1	0.1	5.8	1.2	1.4	0	6.7	1.2	2.8	3.4
Large (100+)	12.1	1.1	10.5	28.3	0	7.6	5	3.9	1.6	1.5	1.7	1.6	0.8	10.2	14.1
Medium (20-99)	4.5	1.7	2.4	32.5	0.4	20.1	2.5	4.2	0.9	11.3	0.1	3	1.4	4.6	10.1
Small (5-19)	12.7	0.6	2.2	31.1	0	33.9	0.1	6.7	1.3	1.1	0	5.2	1.1	3.1	0.9

Source: The World Bank Enterprise Survey

Crime is a major issue for most parts of the economy, but corruption is a major issue for nearly all businesses. Corruption was generally the top constraint across almost all the subgroups of firms in the survey in terms of industry, size, and location. Only foreign-owned businesses reported corruption as their top constraint at a substantially lower share of 16% — which is still a very high share among foreign firms for a country at Mexico's level of income. The issue of crime, on the other hand, had large variation across business types. Very large firms (100+ employees), foreign firms, and the industries of textiles, construction, and hotels all reported crime as their top constraint at lower rates (6-11% of firms in those groups). Only 4% of exporters named it as their top constraint — this group had an extraordinary 62% of firms say corruption. This suggested that some types of businesses can manage to reduce their vulnerability to crime as a constraint, likely by paying the cost of security, but few can avoid

significant issues of corruption. Notably, questions on bribery in the Enterprise Surveys suggest that Mexico is high but not extreme in prevalence of bribery — aside from when it comes to the prevalence of gifts or informal payments to get electrical and water connections, which are very high — which suggests that bribery alone cannot explain Mexico's outlier status on corruption as a constraint highlighted by businesses.

Business crime and corruption within policing and the justice system are prevalent nationwide, which results in low reporting of crimes and other measures taken by businesses and individuals to lower risk. Given the prevalence of crime and insecurity, Mexican authorities and independent organizations collect and publish a very large amount of data on reported crimes and perceptions of insecurity. These resources help to explain what type of crime businesses face most and how patterns of crime and insecurity vary across states and cities. For example, indicators of crime incidence and perceptions of insecurity are compiled annually by INEGI through the *Encuesta Nacional de Victimización de Empresas (ENVE),* which surveys businesses, and the *Encuesta Nacional de Seguridad Pública Urbana (ENSU),* which surveys individuals in urban areas. Based on ENVE, the most common crimes for businesses include extorsion and robbery of money, goods, and supplies. However, the costliest types of crimes include kidnapping, vehicle theft, and merchandise robbery during transit. Surveys also show that businesses and individuals see high corruption and low effectiveness across local police and the justice system. Reporting of crimes is extremely low based on survey evidence, especially regarding extorsion and kidnapping, where well over 90% of incidences go unreported. Businesses spend significantly on their security while individuals change their behaviors to reduce their exposure to potential crimes.

Crime and corruption are national issues, but the City of Hermosillo tends to perform better with respect to these issues, especially in terms of perceptions of security and trust in institutions. Though many crimes go unreported, data on reported crimes by city is also extensive and available from resources such as the *Secretariado Ejecutivo del Sistema Nacional de Seguridad Publica* and the *Observatorio Nacional Ciudadano*. Overall, survey data and official crime data show that Hermosillo

has a lower occurrence of violent crimes, including homicides, and the costliest types of business crime. This includes freight robbery, which is especially important given the importance of trade across the border with the United States. Hermosillo also consistently has higher trust in local police and other authorities than the country as a whole and versus other cities in the state. The State of Sonora, meanwhile, has seen a deterioration in public security. The state overall includes municipalities with among the highest homicide rates in the country and in the world for that matter, and worse indicators of many types of crime. Based on ENVE data, the State of Sonora has among the highest rates of business crime incidence, and the perception of public security has been worsening consistently from 2011 to 2023 at one of the most rapid rates of any state.

Overall, we can conclude that Hermosillo is far from immune to the issues of crime and corruption that affect the nation but has a comparative advantage in safety versus other places in the country and the state. Despite being relatively better than much of the country, residents of Hermosillo report that violence and insecurity are among their very top concerns per surveying by *Hermosillo ¿Como Vamos?.* In a 2023 survey, 16.3% of respondents said this is the most important problem, behind only streets and paving (18%). Corruption was also the 6th response (5.7%) among the 16 response options. Public spending on security has increased over the last four years and local surveys have also shown a noteworthy increase in confidence in the municipal and state police. Residents of Hermosillo express relatively high satisfaction, as evidenced by the re-election of the city's mayor in June 2024, even in an election year where a majority in the city voted for a President and national candidates from the opposing party. This puts Hermosillo in an interesting position where it carries some business risks of the state and the country, but where it offers relatively more security. When multinational businesses evaluate locations, Hermosillo cannot overcome the risks that companies face in Mexico on its own. But among businesses seeking to locate in Mexico, including for reasons of U.S. nearshoring incentives or any number of reasons, Hermosillo's relative performance versus other parts of Mexico should be an asset. At

present, it is unclear if investment promotion efforts are sufficiently making this case for Hermosillo.

4.2 Logistics infrastructure

Hermosillo's logistical connections to the rest of Mexico and the outside world have not been a constraint to growth overall. The proximity to the US motivated numerous companies to set up in Hermosillo as road and rail connections are good and frequently used. Hermosillo is also not a remote place compared to other commuting zones in Mexico and its peers. Nonetheless, certain weaknesses remain as the port and airport have limited capacity to handle container shipments and international flight connections have decreased over time. While logistics-intensive companies have developed in Hermosillo, the larger distance to a big port with significant container capacity may be a competitive disadvantage compared to several peers. The following sections will analyze Hermosillo's logistical connectivity on land (road & rail), sea, and air in more detail. The connectivity within the city of Hermosillo will be discussed in section 4.7.

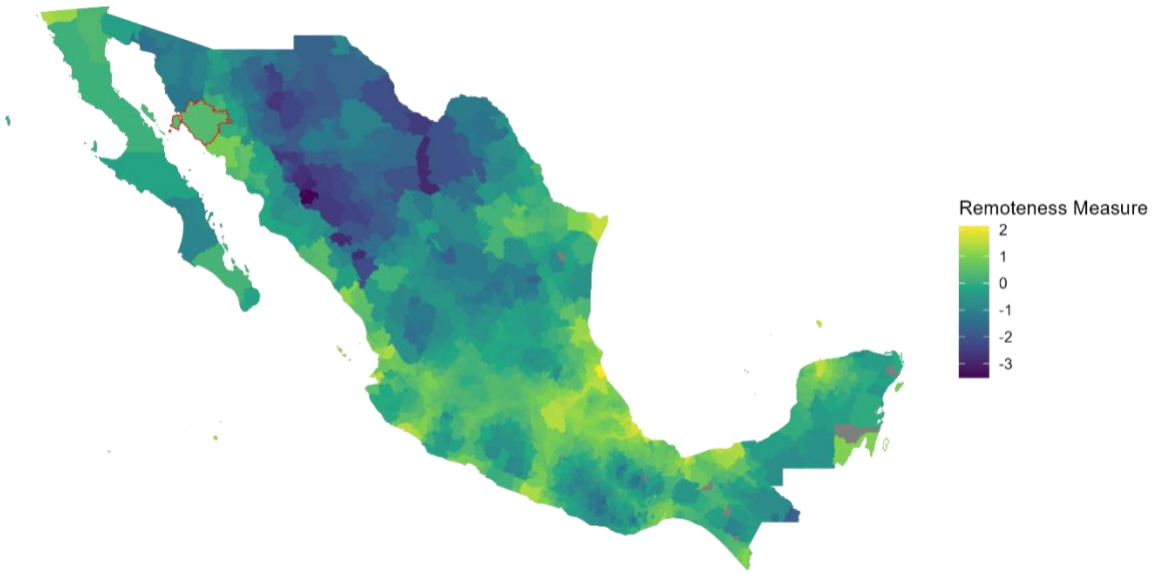
The findings are in line with the previous report (Barrios et al., 2018) as Hermosillo has a range of options to connect to the outside world but several weaknesses remain. Notwithstanding the existing weaknesses, Hermosillo has been able to develop a comparative advantage in logistics-intensive industries. This shows that while there is room for improvement, the weaknesses are unlikely to have held back growth at a larger scale. The state government's attention on expanding the capacity of the Port of Guaymas and thus addressing one of these weaknesses is promising.

4.2.1 Remoteness

Relative to the rest of Mexico, Hermosillo is not a very remote city as it is proximate to population agglomerations and has good access to a port. The remoteness or centrality of a place has a significant impact on its productive capabilities. Places with access to larger population agglomerations and ports can easily access a

diverse set of capabilities to produce complex goods and services. Conversely, a more remote place will struggle to develop complex economic activities as the set of capabilities it can access is more restricted by its location. We quantify how remote Mexican commuting zones are by combining with equal weight (1) the driving time to other population agglomerations;[3] and (2) the driving time to the nearest port. The calculations consider proximity to US commuting zones across the border and follow a methodology from previous analyses (Bùi et al., 2023). The remoteness index is computed such that places with lower scores are more remote, and places with higher scores are more central (i.e., more connected to other places). Figure 19 shows how remote different commuting zones are. Hermosillo (highlighted in red) is among the more central commuting zones in Mexico (in the 65th percentile).

Figure 19: Remoteness of Mexican Commuting Zones



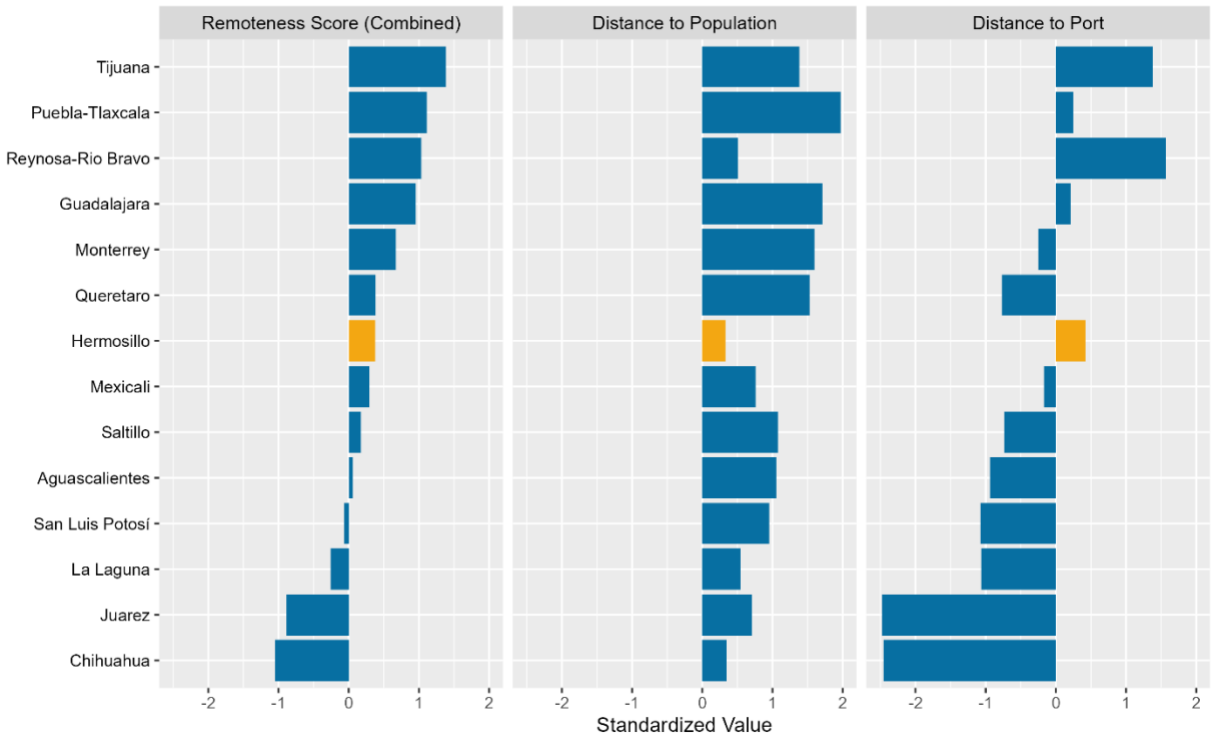
Source: Authors' own calculations, Note: A higher value in the remoteness measure means that a location is less remote, i.e. more central.

Compared to its peers Hermosillo is neither very remote nor is it in a very central location. While Hermosillo is relatively more distant to other population

[3] This is a combination of the driving time to the nearest Commuting Zone of at least 500,000 people and the driving time to all other commuting zones, weighed by how long it takes to get to each destination and how many people live in each destination.

agglomerations it has the advantage of close access to a port. Figure 20 shows the combined remoteness score and the individual components after they have been standardized. Hermosillo appears to be relatively further away from other population centers than many of its peers. Several places, such as Tijuana or Mexicali, are closer to large agglomerations in the US, and other areas, such as Puebla, Saltillo, and Monterrey, are close to agglomerations within Mexico. However, the proximity to the port of Guaymas is an advantage that Hermosillo has over many peers that are significantly further away from the next port. Chihuahua and Juarez stand out in the peer group as the next port is at a large distance for them. In sum, Hermosillo is not remote when it comes to access to goods and markets because of its port and proximity to the US. It is more remote than peers in proximity to other agglomerations, which may be a disadvantage for diversification and innovation.

Figure 20: Remoteness Measures - Peer Comparison

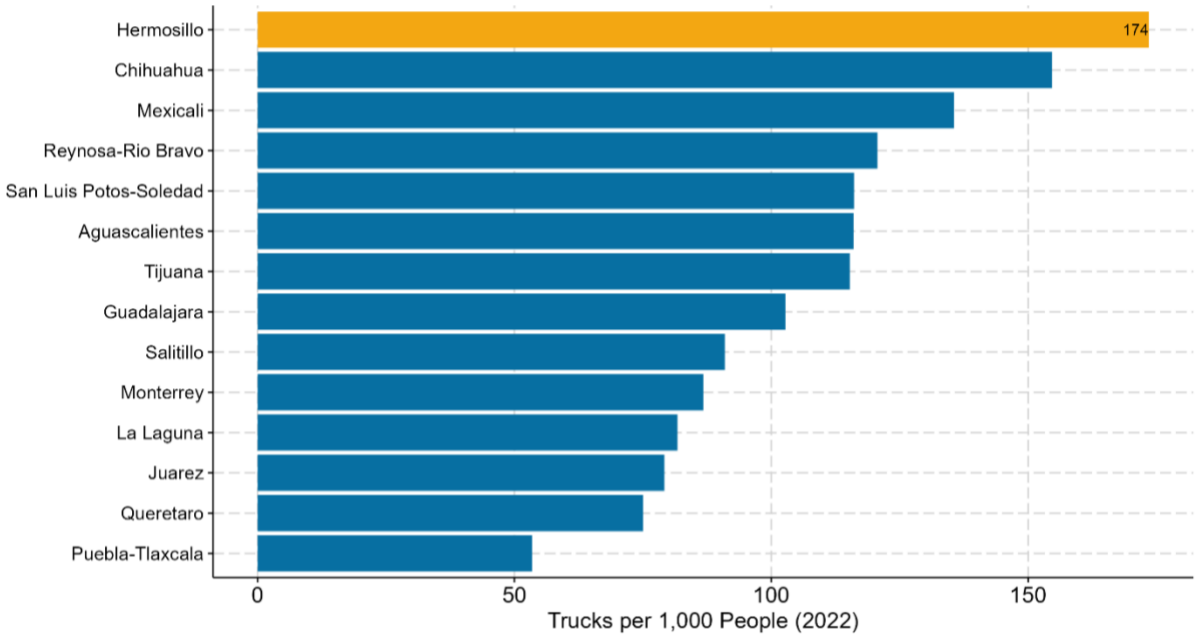


Source: Authors' own calculations Note: As the values are standardized they can be interpreted as standard deviations above or below the mean for all commuting zones in Mexico.

4.2.2 Road & Rail Transport

Hermosillo's most important infrastructure connection is through land transport on roads and railways. The Federal Highway 15 connects Hermosillo and Nogales, the main border crossing used for goods shipments between Hermosillo and locations in the USA. While shipments go across the US, the proximity of Hermosillo to the growing cities of Tucson (4.5h driving time) and Phoenix (6h driving time) have been important factors in attracting economic activity. The importance of road transport for Hermosillo is also highlighted by the fact that it has the highest ratio of trucks to inhabitants across its peer group (Figure 21). This may be driven both by the intensity with which Hermosillo's companies use logistical services as well as a higher reliance on road transport due to weaknesses in direct port infrastructure. It is noteworthy that Hermosillo has a higher truck per capita ratio than border towns such as Tijuana or Reynosa-Rio Bravo which are heavily concentrated in road transport and maquiladora manufacturing.

Figure 21: Trucks per Capita - Hermosillo and Peers (2022)



Source: Own calculations based on Secretaría de Comunicaciónes y Transportes

Additionally, Hermosillo is well connected via the railway line that allows for direct connections with the border crossings in Nogales and Mexicali and the port in

Guaymas. The rail infrastructure is a key connection point for Hermosillo's Ford plant with rail sidings directly at its facility. Shipping cargo through rail requires significant planning ahead and is less flexible than regular road transport. Therefore, it is likely to be a good option for large plants with regular shipment schedules but less feasible for smaller companies.

4.2.3 Maritime Transport

Hermosillo has good port connectivity, as the port of Guaymas is only 134km away, but the port's size and limited capacity to handle container shipments make its proximity less of an advantage. While the port is an important asset to the Hermosillo, it is mostly focused on minerals and oil and has limited ability to handle agriculture or container shipments. The port of Guaymas is the 13th largest port in Mexico, capturing 2.49% of all cargo in terms of tonnage. However, it is very limited in handling container shipments – its market share of container cargo of all Mexican ports was only 0.18% in 2023.

The port of Guaymas is largely focused on mineral shipments while the capacity to handle agricultural and container cargo is low and has reached the limit with existing demand. In 2023, mineral shipments made up 58% of all cargo (Figure 22) followed by oil products with 27%. Agricultural shipments (11%) and container cargo (2%) are only a small part of the port's cargo. This is related to the infrastructure of the port as it is smaller in size than other ports on the Pacific coast. Thus, it can only handle smaller container volumes from smaller ships as larger ships cannot enter the port and the container handling infrastructure is more limited. The demand for a higher capacity for container shipments exists as the current capacity is being utilized to 89% in 2022 and demand is projected to surpass the capacity in 2024.

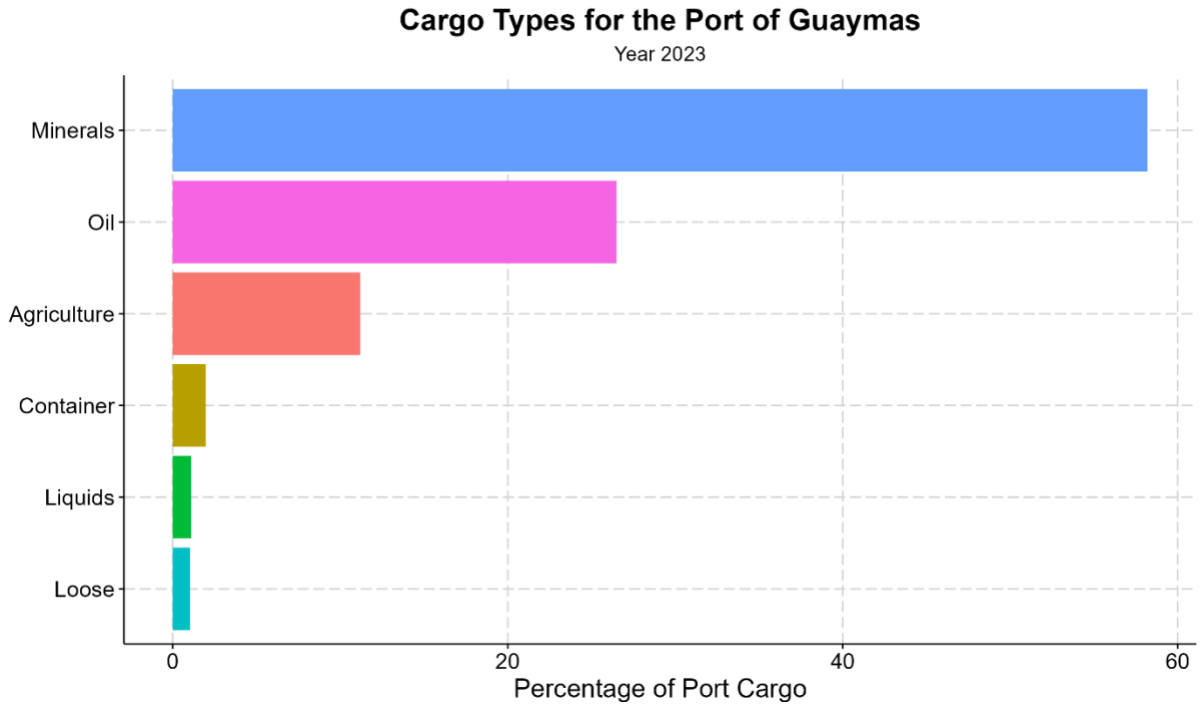
The limited ability of the port of Guaymas to handle container shipments leads many companies from Sonora to choose other ports to handle their container shipments. Table 2 shows that Manzanillo (Mexico's 3rd largest port) handles most of Sonora's port shipments, including its containers. Even Baja California's port of

Ensenada handles more of Sonora's container cargo than Guaymas. This indicates that the proximity to the port of Guaymas may not be a competitive advantage for Hermosillo. The inability to handle larger volumes of container and agricultural shipments certainly leads to cost increases in logistics as companies largely opt to use the port of Manzanillo. This may have limited companies that are more intensive in the use of port services from choosing Hermosillo as their location.

Local stakeholders are aware of the limitations of the Port of Guaymas and expansion plans are being implemented. The Plan Sonora includes aims to improve the infrastructure of the port. Key components of this are to increase the depth of the port which would allow it to service larger vessels as well as to improve the infrastructure for handling goods and connecting the port to the rest of the country[4]. The expansion of the capacity of the port of Guaymas had the effect that Ford could use the port for shipments to of its cars for the first time (Madry, 2024). Expansions of the port will have a positive impact on Hermosillo. Nevertheless, the port of Guaymas will never be able to compete with that of Manzanillo given the differences in size and location. A long-term strategy should have a clear vision of what role the port could play.

[4] A special focus lies on building out a road between the port of Guaymas and the state of Chihuahua.

Figure 22: Cargo Types for the Port of Guaymas - 2023



Source: Own calculations based on Dirección General de Puertos data

Table 2: Hermosillo & Sonora Port Connectivity and Usage

Port	Road Distance from Hermosillo (km)	Total Usage from Sonora (th. tonnes)	Container Usage from Sonora (th. tonnes)
Guaymas	134	15,408	529
Topolobampo	505	36,580 (100% Oil)	0
Mazatlán	885	438	301
Ensenada	928	1,188	773
Manzanillo	1,189	394,699	78,061
Lázaro Cárdenas	~ 1,500	2,358	2,358

Source: 5-year plans of the respective Ports

4.2.4 Air Transport

Hermosillo has a direct air connectivity through its airport which has been growing in terms of passenger volume but is limited in its ability to handle cargo shipments

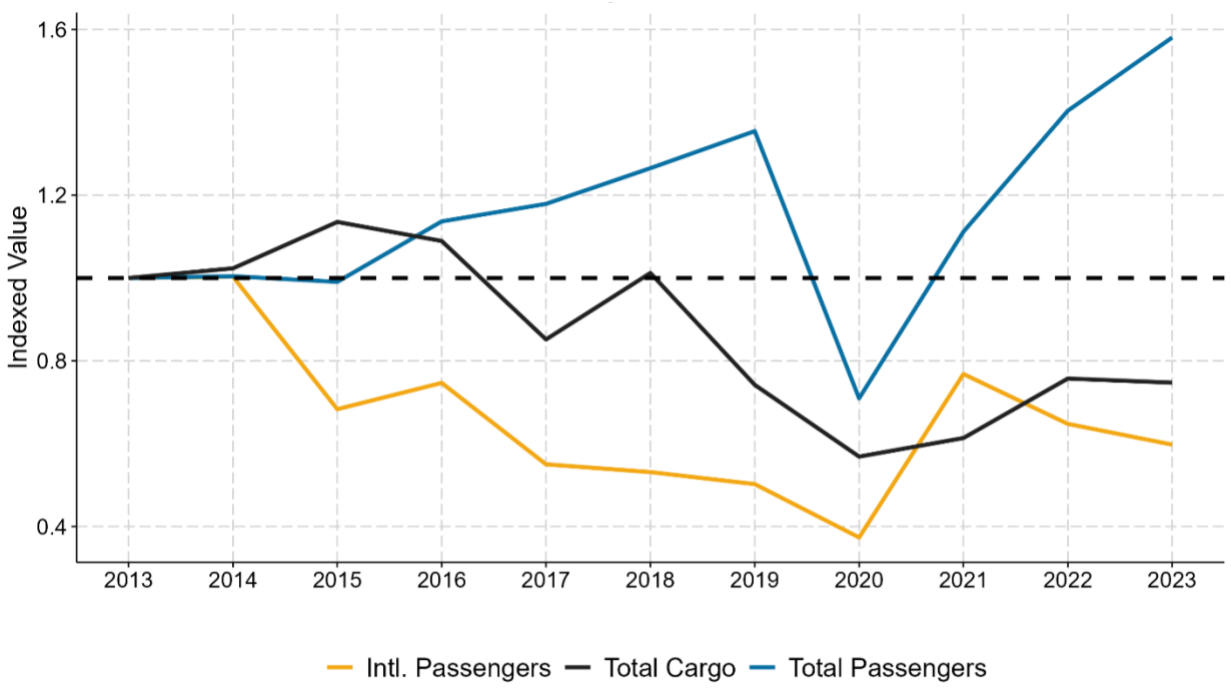
and only has one international connection. Hermosillo's airport (HMO) is the 12th largest airport in terms of passengers and serviced 2.13 million passengers in 2023. It captured 1.8% of Mexico's air passenger market in that year. However, its share of the overall air cargo volume in Mexico is only 0.74%.

The overall volume of passengers using the airport has consistently grown since 2015, but international connections have decreased significantly. The increased passenger volume in the airport of Hermosillo is fully due to increased domestic travel volume as the number of direct international connections and passengers has decreased over time (Figure 23). Up until 2017 Hermosillo had three direct international connections servicing Phoenix, Los Angeles, and Dallas. This was reduced to only 1 direct flight from 2018 onwards to Phoenix[5]. Other airports in cities of a similar size have more international connections. The airports of Querétaro and Aguascalientes have six and four direct international connections respectively[6]. This is important because research shows that business travel is conducive to the development of knowhow (Coscia et al., 2020). Through business travel companies and branches connect with each other which allows them to learn from one another. Therefore, the decrease of direct international connections is a bad sign for Hermosillo.

Hermosillo's airport is handling 30% less cargo today than it did 10 years ago (Figure 23)**.** The amount of cargo shipped via the airport experienced a pronounced decline between 2018 and 2020 and has not recovered since. As this decline pre-dates the pandemic it cannot be driven the effects of it. The decline came from lower cargo volumes that were received from San Luis Potosí and Tijuana airport.

[5] From December 2021 to July 2022 there was also a regular connection to the airport of Dallas.
[6] Querétaro has direct connections to San Antonio, Dallas, Houston, Atlanta, Chicago and Detroit. Aguascalientes has direct flights to Los Angeles, Dallas, Houston and Chicago.

Figure 23: Hermosillo's Airport - Development over Time



Source: Own calculations based on Agencia Federal de Aviación Civil

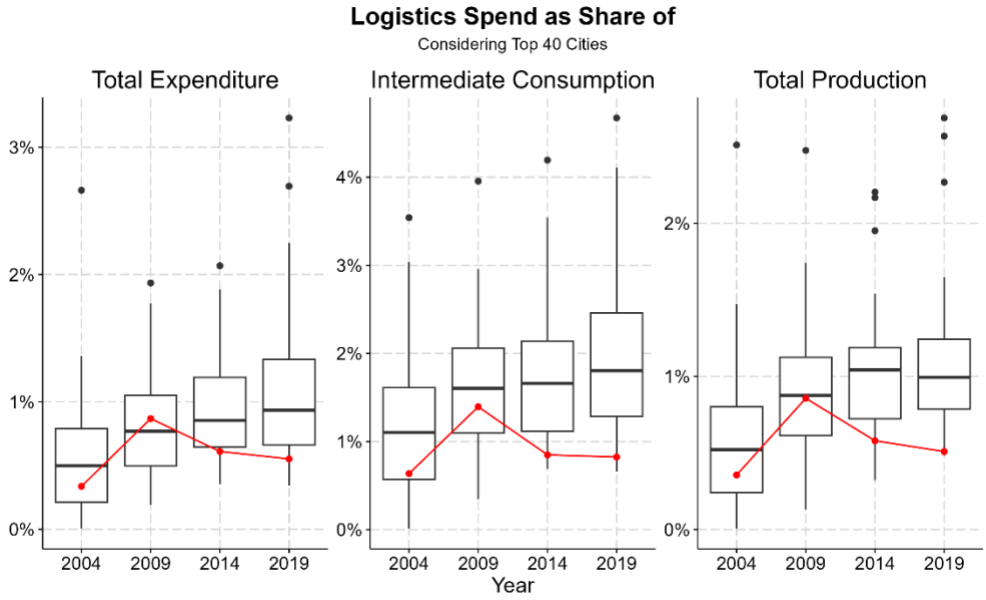
4.2.5 Diagnostic Testing

4.2.5.1 Prices and Quantities

The logistical connectivity of Hermosillo has an important impact on the shape of its economy – companies in Hermosillo have lower logistics expenditures relative to their overall costs and output that firms in other large Mexican cities. We can analyze the logistics expenditures of companies from Hermosillo and compare them with those from other cities using the Economic Census. At first glance, it is striking that logistics expenditures in Hermosillo relative to measures of total expenditures, intermediate consumption, and total production are among the lowest of the comparison group, which consists of Mexico's 40 largest cities (Figure 24). Except for the year 2009, Hermosillo's expenditures have been consistently below the median of the group; in 2019, they are among the lowest in the group. The variable we are analyzing is logistics expenditures which is a combination of price and quantity, meaning how much logistic services cost companies from Hermosillo and how often they use them. The finding from

Figure 24 may therefore be driven either by low quantities (i.e. companies from Hermosillo using logistics services comparatively less) or by low prices (i.e. logistics services being comparatively cheaper in Hermosillo)[7].

Figure 24: Logistics Expenditures - Relative to Output and Costs

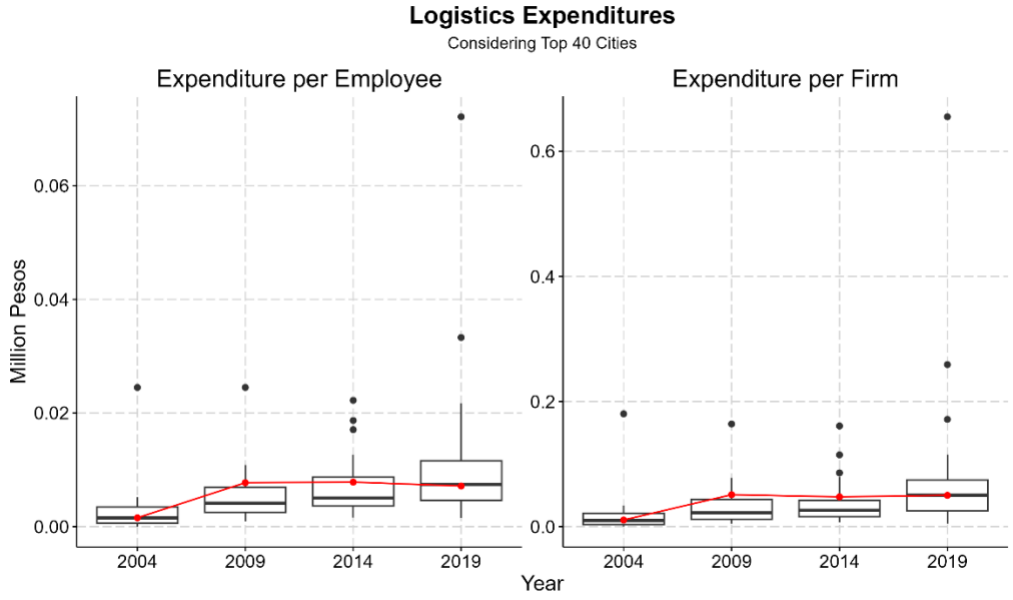


Source: Own calculations based on the Economic Census from INEGI

In terms of logistics expenditures per firm or per employee, Hermosillo fares similar to the comparison group – the level of logistics expenditures of firms is similar but less important relative to overall costs. When analyzing the logistics expenditures per employee or per firm Hermosillo's economy is at the median of the comparison group in 2019 and has seen among the highest expenditures in the comparison group for previous years (Figure 25). Companies in Hermosillo appear to be spending similar amounts on logistics than in peer cities in absolute terms but it is a lower share of their operating cost. This indicates that Hermosillo's economy is not concentrated in activities that are less logistics-intensive as the expenditures per employees and firms are on par. A closer analysis of logistics-intensive industries and their presence or absence in Hermosillo will clarify this further.

[7] It could also be a combination of both: low prices and low quantity, but that seems less likely.

Figure 25: Logistic Expenditures - Relative to Number of Employees and Firms



Source: Own calculations based on the Economic Census from INEGI

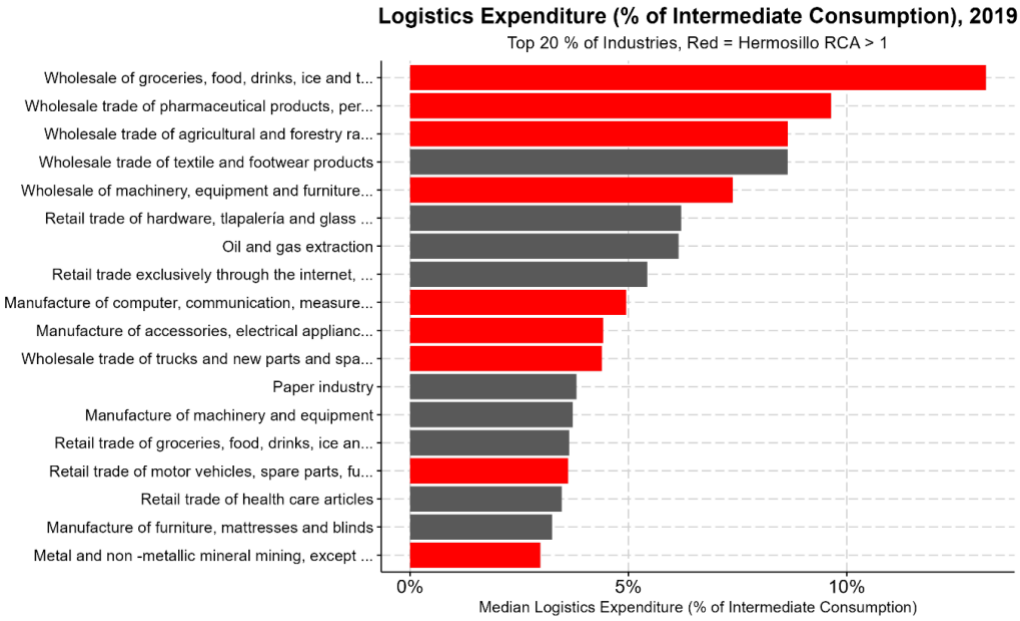
4.2.5.2 Camels and Hippos

As the logistics connectivity of Hermosillo is an important factor shaping the structure of its economy, the presence or absence of logistics-intensive industries can be informative. If the logistical connectivity were a constraint in Hermosillo we would expect logistics-intensive industries to be relatively absent in the economy of the city. To analyze this, we must first define what industries can be considered "logistics-intensive". In doing so we follow the methodology from previous sections and distinguish between price-sensitive and quantity-sensitive industries.

Hermosillo has a significant presence in industries that we consider to be sensitive to high logistics prices. The industries that are "price-sensitive" industries with respect to logistic prices are those for which logistics expenditures are a large share of their intermediate consumption. These are mostly wholesale and retail industries as companies in these industries often do not have a large value add but focus on retail and

distribution activities (Figure 26). Industries in which Hermosillo is highly competitive[8] are highlighted in red. As the figure shows, Hermosillo is competitive in nine out of the eighteen identified logistics-intensive industries in terms of price sensitivity.

Figure 26: Logistics-Intensive Industries: Price Sensitive



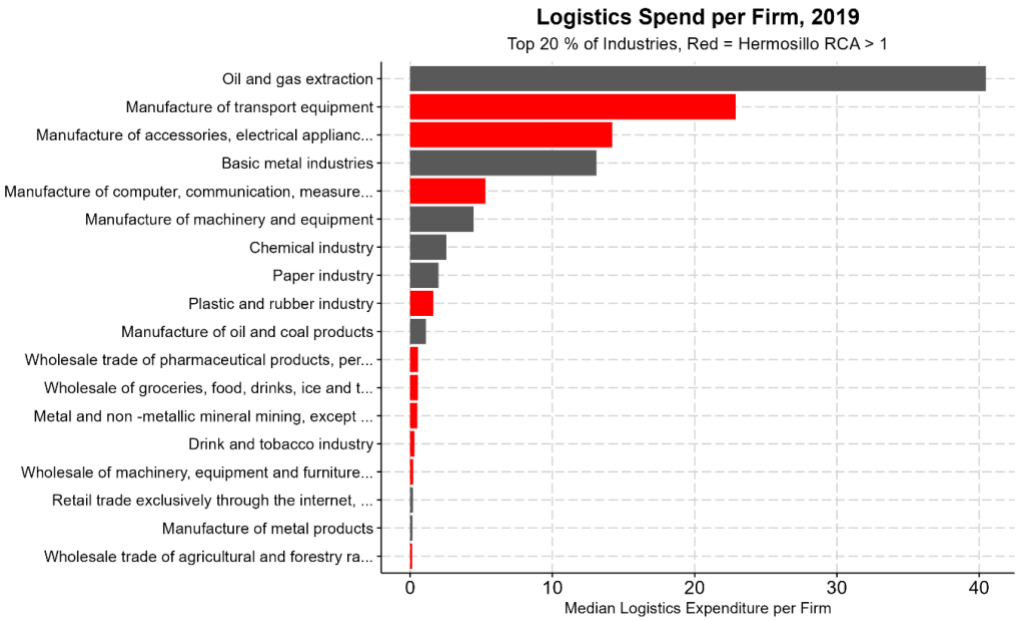
Source: Own calculations based on the Economic Census from INEGI

While the previous identified industries have the highest logistics expenditures in relative terms it is also crucial to analyze industries with the highest absolute logistics expenditures. We term these industries as being "quantity-sensitive" industries because they require a lot of logistics services. These tend to be industries that transport many raw materials and their derivatives (oil and gas extraction, basic metal industries, chemical industry etc.) as well as manufacturing industries with many different inputs (i.e. manufacturing of transport equipment, manufacturing of accessories, electrical appliances). Industries highlighted in red are those in which Hermosillo is highly competitive (Figure 27). The figure shows that Hermosillo is competitive in numerous quantity-sensitive industries. Companies in Hermosillo which

[8] These are industries in which Hermosillo has a revealed comparative advantage (RCA) that is equal to or larger than 1.

may be driving this may include the Ford and AT Engine (manufacturing of transport equipment) as well as Leoni and TE Connectivity (manufacture of electrical appliances). All of these are companies that use many imported inputs for their production processes and export their final products.

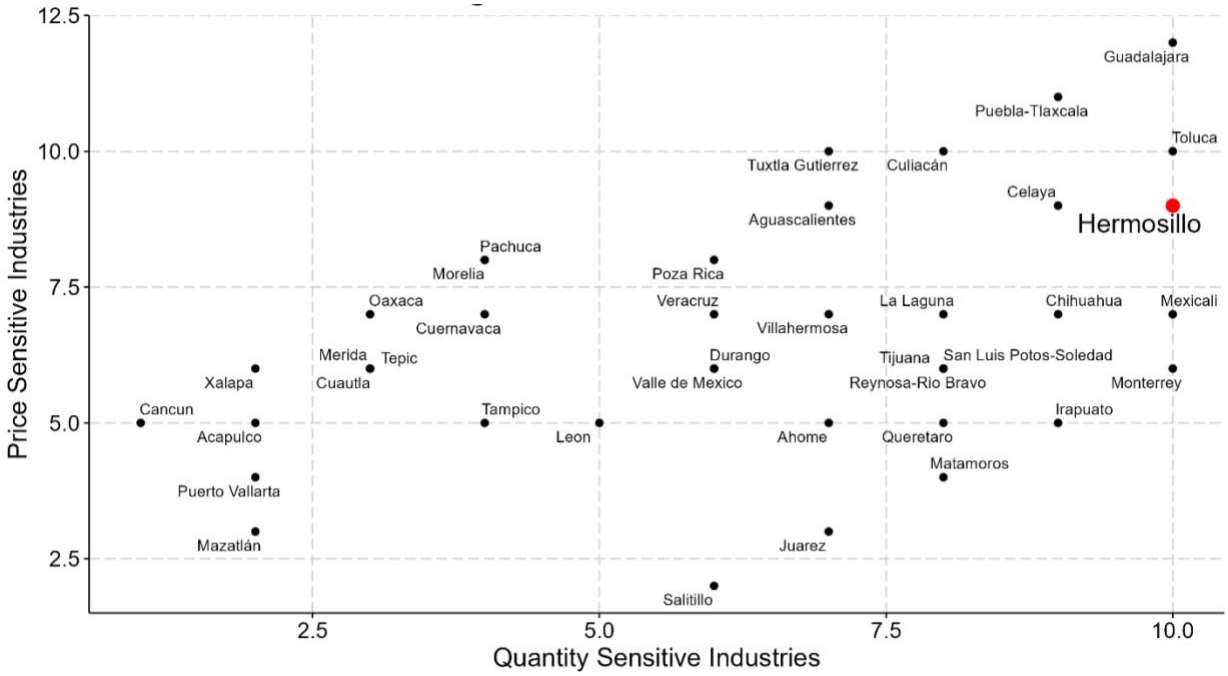
Figure 27: Logistics-Intensive Industries: Quantity Sensitive



Source: Own calculations based on the Economic Census from INEGI

As the analysis has shown, Hermosillo is highly competitive in a large number of logistics-intensive industries both in those that are price-sensitive as well as quantity-sensitive. To put this into perspective we compare the number of logistics-intensive industries in which Mexico's 40 largest cities are competitive in, in both dimension: price and quantity sensitivity. Figure 28 shows that Hermosillo is among the top performers in both dimensions. This is an indication that the logistics infrastructure of Hermosillo has not been a binding constraint. It may also indicate that the low spending on logistics as discussed in section Figure 28 is likely due to comparatively lower prices and not a lower quantity of logistics services. The presence of many logistics-intensive industries in Hermosillo show that the quantity of logistical services demanded by its companies is relatively high.

Figure 28: Number of Logistics-Intensive Industries with an RCA > 1



Source: Own calculations based on the Economic Census from INEGI

4.2.6 Key Takeaways

The analysis in this section has shown that Hermosillo has a range of good logistical connections, but several weaknesses remain. The limited container capacity of the port of Guaymas is an area of improvement that has been identified a long time ago. Many Sonoran firms had to operate through the port of Manzanillo instead, which may not have stopped them from operating in Hermosillo but increased their cost. Expanding the capacity of the port of Guaymas will certainly reduce logistics costs for firms in Hermosillo that can operate through Guaymas instead of Manzanillo. Recent expansion works have led to the first pilot project with Ford, which points towards progress in this area (Madry, 2024). An additional weakness is the fact that Hermosillo's airport only has one direct international connection (Phoenix). Other airports in cities of a similar size have more international connections. Research shows that business travel is conducive to the development of know-how (Coscia et al., 2020), and thus, having more international connections might allow Hermosillo to develop more

business connections. Similarly, the connection to other population centers matters to develop knowhow. Thus, Hermosillo's relatively higher distance to other population centers may have put it at a disadvantage to develop know-how and increase its complexity.

The presence of logistical-intensive industries indicates that the logistical weaknesses have not held back growth at a larger scale but addressing them may help Hermosillo to reach its full potential. Hermosillo has managed to develop a comparative advantage in industries that are intensive in the use of logistical services. Given its good connectivity to the US border many companies in logistically intensive industries have settled there. This indicates that the identified weaknesses may not have held back growth at a large scale thus far. However, Hermosillo is trying to catch up to peers that are taking advantage of nearshoring opportunities at a larger scale. Addressing the logistical weaknesses may help the city in realizing its potential and attracting more investments into Hermosillo.

4.3 Electricity

Electricity in Hermosillo is not a binding constraint on economic growth; in fact, its excess capacity and renewable power potential present a valuable opportunity for the future. However, limitations in distribution infrastructure pose a challenge that must be addressed to fully capitalize on this potential. Hermosillo has among the cheapest electricity prices in the country, while Sonora has an excess capacity for power generation. Due to the excess capacity, Hermosillo also experiences fewer blackouts than other parts of the country. This has been a recent development as the electricity market reforms from 2015 led to significant private investment in solar power generation in Sonora. The recent capacity additions have made Sonora the leading Mexican state in solar power capacity. As Sonora has among the best solar power potential in the country, this could be used to attract companies that are looking to reduce their carbon emissions.

While the previous report found the lack of a more efficient and economic supply of electricity may have constrained Hermosillo in attracting new businesses and diversifying its economy – the context has changed significantly since then but some challenges remain. Since conducting the previous analysis in Hermosillo in 2017-2018, Hermosillo's electricity system significantly changed. The federal market reforms from 2015 were followed by renewable energy auctions and private sector investments, which saw Sonora attracting new solar park developments totaling capacity additions of 1.8 GW between 2018 and 2023. However, the lack of sufficient distribution infrastructure is limiting the attraction of new businesses in Hermosillo. This challenge is not unique to Hermosillo but is a widespread issue across Northern Mexico.

4.3.1 Mexico's Electricity System – Context and Developments

Mexico's electricity system is growing and, to date, is still largely dependent on fossil fuel resources, but its renewable generation is increasing. In 2023, the total electricity consumption reached 351,695 GWh, of which 75.7% came from fossil fuels and 24.3% from clean energy sources (Secretaría de Energía 2024). The grid's capacity has grown by 34% since 2016 as the economy grows and more industrial processes are being electrified. The challenge to meet future demand is significant as the installed capacity is projected to increase by 88% between 2024 and 2038,[9]Nearly doubling the size of the grid is a challenge of itself and increasing demand due to nearshoring may require the government to reach even more ambitious targets.

As the demand for electricity in Mexico increases, the system is reaching its limits in certain areas of the country. Overall reliability metrics of the electricity system of Mexico have compared favorably in international rankings[10], indicating that thus far, the system has been able to meet the demand adequately. However, in May and June of

[9] The installed capacity in 2023 was at 93,788 GWh and the strategy laid out by the Ministry of Energy plans for an installed capacity of 176,516 GWh in 2038.

[10] The World Bank Doing Business Indicators rank Mexico at a 7 out 8 in terms of "Reliability of supply and transparency of tariff index" which is significantly higher than the Latin American & Caribbean average of 4.4 and just below the OECD high income average of 7.4.

2024 the reserve margin of the grid reached levels below 3%, which led to outages (Garcia & Barrera, 2024). The goal of the operator is to reach a reserve margin of at least 6%. The fact that recent data indicates consistent levels below that is a signal that the system cannot keep up with the demand.

There are localized bottlenecks in Mexico's electricity system that expand beyond the overall difficulty of keeping up with the demand at the national level. Several areas of the country, such as the Northwest and the South, are experiencing more and longer outages, which shows that the transmission and distribution system has localized weaknesses (CRE, 2023). Lacking transmission and distribution infrastructure in high-demand areas such as Monterrey makes it, at times, very costly to transmit electricity into these areas since the capacity is maxed out. This leads to high electricity prices and blackouts which in turn significantly affect business operations. Moreover, anecdotal evidence indicates that firms are having difficulty getting the electricity capacity they are demanding in certain high-demand areas. This may end up deterring investments in these places. In turn, Hermosillo and Sonora may offer advantages for companies that require highly reliable electricity supply given the generation capacity available in the state, as the following sections will show.

4.3.2 Market Structure

Historically, the market structure of Mexico's electricity system has been dominated by a state-owned vertically integrated monopoly. The *Comisión Federal de Electricidad* (CFE) controlled generation, transmission, and distribution activities within the grid and was also the grid's operator. While the government allowed independent power producers (IPPs) to generate electricity they had to sell to the CFE through long-term power purchasing agreements. Outside of IPPs the only private sector activity allowed was the self-generation of power on site done by companies. With this exception, the power sector was fully in the hands of the public sector through CFE.

In the years 2014-2015, the Peña Nieto administration reformed the structure of Mexico's power market through a constitutional reform, opening it up for private

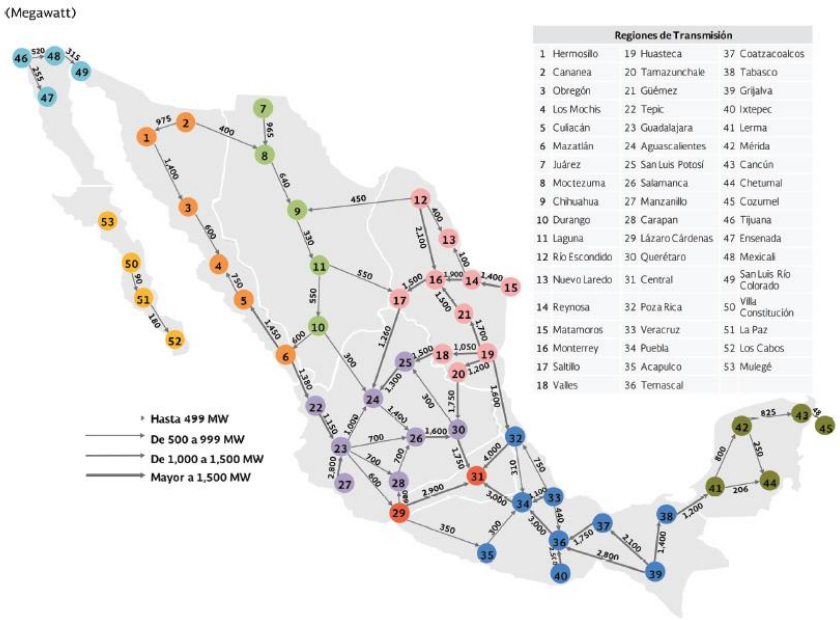
sector engagement. While transmission and distribution activities remained with the CFE, electricity generation and its commercialization were opened to the private sector. This meant that private parties could generate electricity and sell it to industrial customers (i.e., “qualified users”) on a wholesale market while using the transmission and distribution infrastructure owned by the CFE (Figure 29). Additionally, the CFE organized electricity auctions focused on increasing renewable generation assets that would contract with the CFE via an offtake agreement. These market reforms led to significant private sector investment, especially in renewable energy generation assets (Binz et al., 2019).

The status of a “qualified user” is important because it allows companies to contract with private suppliers and to benefit from potentially lower prices on the wholesale market. To qualify as a “qualified user” the minimum power need of the company needs to be 1 MW. Alternatively, multiple users can also bundle their demand to reach this minimum threshold of 1 MW – this is an attractive opportunity for industrial parks which can bundle the electricity consumption of companies within the park. Being a “qualified user” allows companies to contract with private electricity suppliers which are likely to have a larger price differentiation across the country than the CFE and can also meet demands for “green electricity” more easily.

Due to the reforms from 2014-2015 most of the renewable electricity generation comes from the private sector in Mexico, except for hydropower. Of all installed wind capacity (7 GW), 90% comes from the private sector, and in the case of solar power (7.4 GW), this is even true for 98.3% of all installed solar capacity (Secretaría de Energía, 2024). The noteworthy renewable generation assets owned by the CFE are 12.1 GW of hydroelectric generation and 0.95 of geothermal (ibid.). The private sector assets can be classified into three different categories of generation purposes: a) long-term contracts with the CFE b) self-generation c) selling power to private sector consumers.

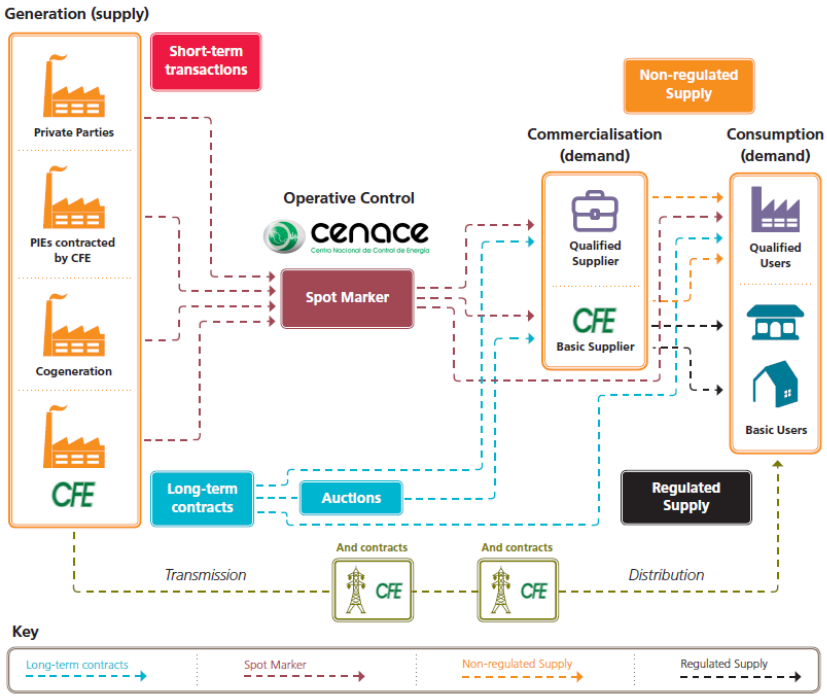
The administration of President Andrés Manuel Lopez Obrador (AMLO) has attempted to return to a state-dominated electricity market. A key proposed change was to grant priority to the dispatch of CFE-owned assets instead of a merit-order dispatch system. Any private generation assets would come online only after CFE generation was dispatched. This would strongly discourage private investment in this area. Additionally, any long-term auctions in the wholesale market were put on hold, and existing licenses for self-generation and IPPs were challenged (Solís, 2022). However, these legislative actions were rejected by the Supreme Court of Justice as a reform of the energy sector requires a constitutional change instead of regular legislative actions. However, the government did not achieve a two-thirds majority. Thus, the liberalized market structure initiated by the constitutional reforms from 2014/2015 is still in power. However, legal uncertainty has slowed down private investment in this area, and private developers state that delays in the permitting system have prevented new private assets from coming online (García, 2024).

Figure 29: Mexico Power Transmission Infrastructure



Source: Secretaría de Energía 2024

Figure 30: Power Market Structure in Mexico



Source: Wood 2018.

4.3.3 Sonora's and Hermosillo's electricity system

Sonora is a net exporter of electricity as its installed capacity exceeds what is needed for its consumption. The state is the fifth largest power producer of all Mexican states, but in terms of consumption, it ranks tenth. The installed capacity of Sonora is 9.47GW, while the maximum demand in 2023 was 5.6GW (CENACE 2023). Consequently, much of the power that gets produced in Sonora is transmitted to other states such as Colima, Jalisco, and Nayarit. The generated power in the state grew from 926.7 GWh in January 2018 to 1203.8 GWh in January 2023 – a growth rate of 30% over the five-year period. The growth in generation has come from significant expansion in gas-powered generation as well as solar power generation (Figure 32). Its generation

mix is dominated by fossil fuel generation**;** 75% stems from fossil fuel-based generation[11] and 25% from renewable sources – 22% from solar and 3% from hydropower.

Sonora has among the best solar potential in Mexico due to its consistent solar radiation (

Figure 31**.)** Mexico has very competitive solar resources in a global comparison. Most of its potential is concentrated in the northern part of the country. The leading states in this regard are Baja California, Baja California Sur, Sonora, and Chihuahua.[12] Sonora and Chihuahua have the additional benefit of having larger land masses available and being connected with the rest of the country via the transmission infrastructure. The solar resources in Sonora are also highly competitive internationally – the national auctions led to a price of 20.8 $/MWh for the solar projects in 2018, with most of the buildout happening in Sonora (Binz et al., 2019). This is well below the $29 MWh estimate of the LCOE for photovoltaic power in the US (Lazard, 2024).

Following the reforms of the electricity market, Sonora experienced a large buildout of solar power capacity and became the leading state in Mexico in this regard. In 2015 Sonora had an installed solar power capacity of 26.57MW – this increased to 1,845MW in 2023 due to private sector investments. The CFE auctions led to the development of eight solar parks with a total capacity of 930 MW. The other 915MW of solar capacity were developed by companies with the purpose of selling electricity directly to large industrial users. This spur in solar capacity made Sonora the leader in installed solar capacity in Mexico. In 2023, its installed photovoltaic capacity reached 1,423 MW (Figure 33). The development of solar power in Sonora and Mexico as a whole was led by private investment.

Within the context of AMLO's administration, the approach has changed: The CFE is starting to develop its own solar resources, and the Plan Sonora is the

[11] 62.3% combined cycle, 11.8% thermoelectric and 0.8% turbogas

[12] The estimated photovoltaic power output ranges for the respective states are as follows: Baja California Sur 4.94-5.56 kWh/kWp, Baja California 4.86–5.66 KWh/kWp, Sonora 4.84-5.48 kWh/kWp, Chihuahua 4.71-5.51 kWh/kWp (ESMAP 2019)

cornerstone of this development. The Plan Sonora is a development plan of the federal and state governments focused on developing green growth-related opportunities. A key component of it is the development of a solar PV park in Puerto Peñasco, northern Sonora. The plans aim for an installed capacity of 1,000 MW. While the final date for the whole plant is set at 2028, the first 120 MW came online in 2023.

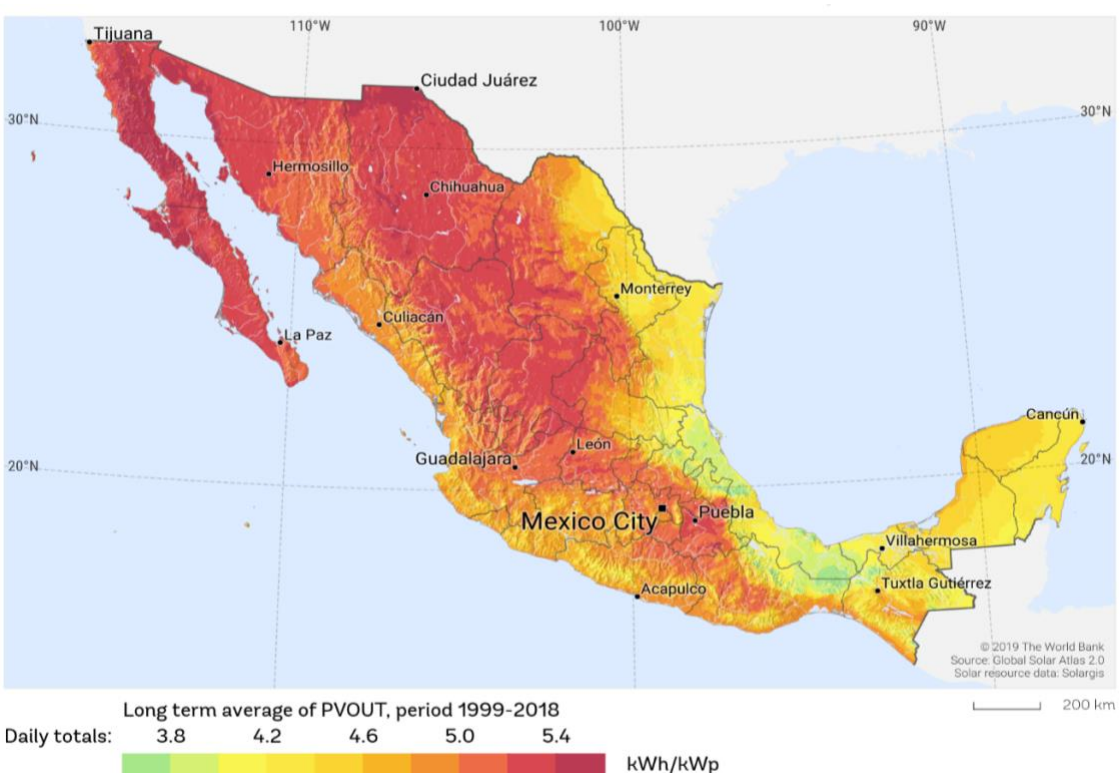
The concerted effort by the CFE to develop more solar power in Sonora through the Plan Sonora opens opportunities for future energy-intensive activities in the state. Increased solar capacity in Sonora may make it more viable to attract energy-intensive activities in the state as firms seek to power their processes with renewable energy. The Plan Sonora also explicitly aims to develop scientific parks which are supposed to be fully supplied by green electricity. However, many of these plans are still in an early phase and many details remain unclear. The potential to spur economic activity in the state through more solar power is there but the success will rely on the implementation.

Currently, the lack of distribution infrastructure is holding back new investments that could make use of Sonora's electricity advantages. Interviews with local businesses have revealed that the lack of sufficient distribution infrastructure limits the entry of new businesses. They are either constrained to locate in few areas with sufficient distribution infrastructure or cannot set up new facilities altogether. Several industrial parks have no or very limited electrical distribution capacity left that could supply new business entrants.

Electrical distribution infrastructure appears to be lagging in the country overall, with this issue being particularly pronounced in Northern Mexico. A survey of firms in industrial parks (BBVA 2024) highlights the lack of investment in transmission and distribution as a primary concern. This challenge is especially acute in Northern Mexico, where surging demand has exacerbated existing infrastructure limitations. Consequently, the problem is not confined to Hermosillo but represents a broader

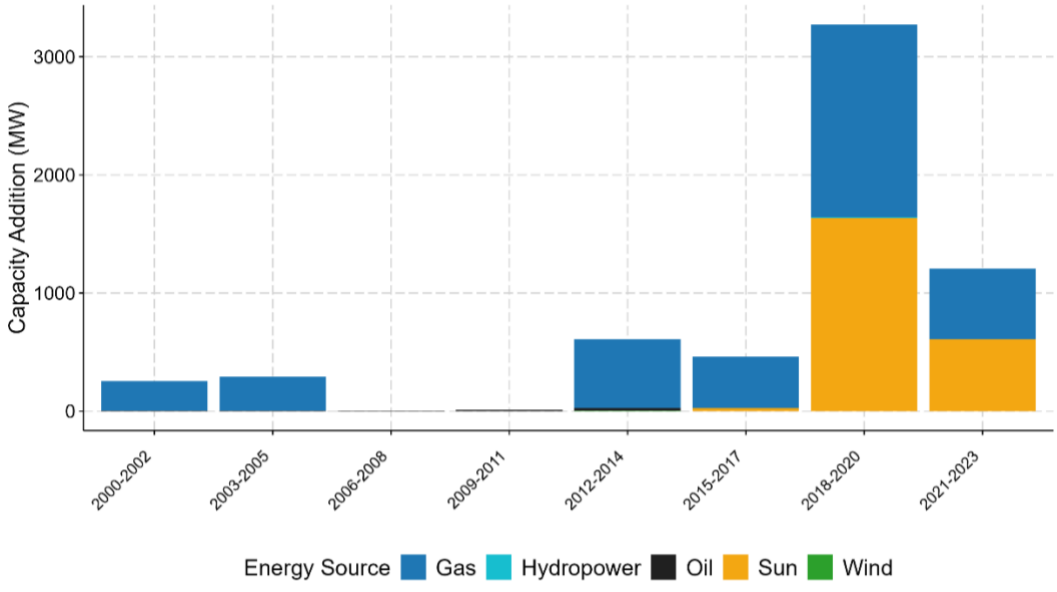
constraint on investment across the region. While this broader context does not diminish the severity of the issue for the city, it underscores its systemic nature.

Figure 31: Photovoltaic Power Potential in Mexico



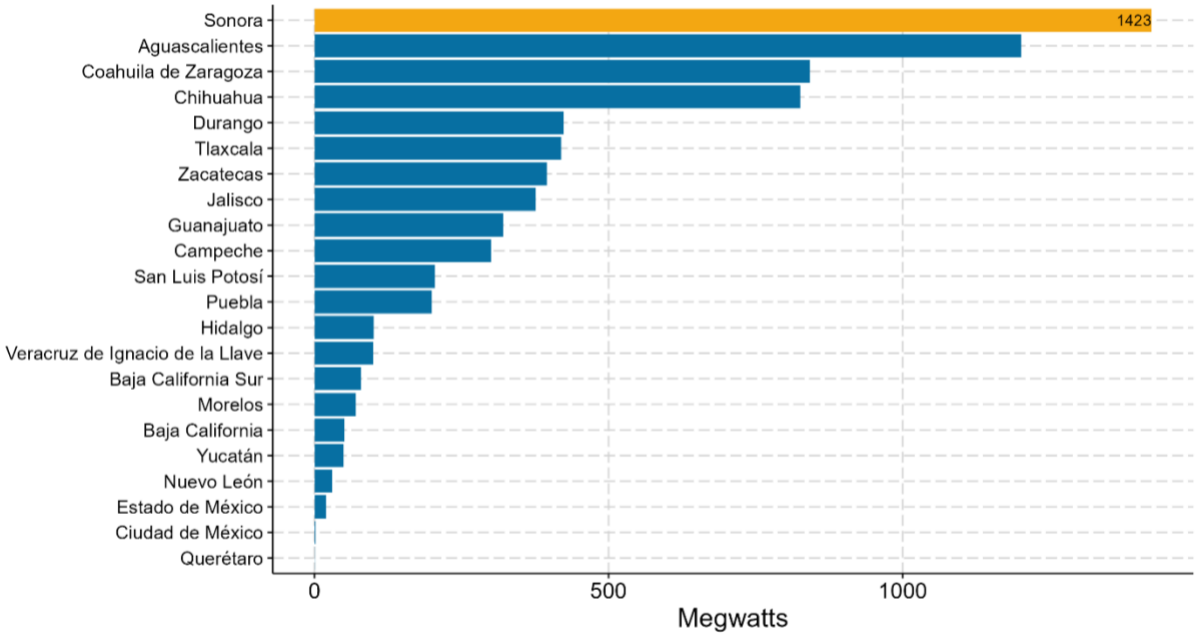
Source: ESMAP 2019

Figure 32: Electricity Generation - Capacity Additions in Sonora



Source: Comisión Reguladora de Energía (CRE)

Figure 33: Solar PV - Installed Capacity (2023)



Source: Secretaría de Energía 2024

4.3.4 Diagnostic testing

The previous sections have detailed the functioning of the power market of Mexico, its changes over time and how the generation mix of both Mexico and Sonora have evolved. The previous growth diagnostic uncovered several signals that indicated that the supply of electricity may have prevented new businesses from entering and Hermosillo from diversifying. This section will test to what extent electricity has constrained the growth of companies and industries in Hermosillo in the recent past. The electricity system changed significantly in the period since the last diagnostic, and new data is available to understand whether this impacted the extent to which electricity was a constraint for growth and diversification in Hermosillo.

4.3.4.1 Prices and Quantities

In analyzing the extent to which electricity may be a binding constraint to growth in Hermosillo, the dynamic of prices and quantities of electricity consumed by the city and its economy can be telling. If the electricity supply is a binding constraint to growth we would expect to see high prices and low quantities of electricity consumed. The price being high would indicate that demand exceeds supply and the relatively low quantity would be indicative of the missing supply. While it is important to keep in mind that this is a regulated market, the structure of the market does allow for insights in this context. The electricity wholesale market shows the prices of electricity on the day ahead, as well as the intraday market within Mexico. While the price of energy is determined for the whole national interconnected system through merit order dispatch, the congestion and transmission charges vary and thus determine the locational marginal prices.

4.3.4.1.1 Price Analysis

Hermosillo has among the lowest prices in Mexico on the wholesale electricity market. Over the year of 2023 the average monthly electricity price on the day ahead wholesale market was consistently below the 25th percentile in Hermosillo (Figure 34). As this is driven by low congestion charges, it is likely a reflection of the large generation capacity in the state itself, making it less costly to transmit power to the final consumer as well as potentially transmission infrastructure that is in relatively better conditions in Hermosillo. As this is the price that exists on the wholesale market, the entities that face it are large industrial consumers that choose to purchase power on this market (i.e., qualified users – as seen in Figure 2) and qualified suppliers (i.e., retail suppliers). It is, therefore, not reflective of the price faced by customers that contract with the CFE.

The tariffs offered by the CFE in Hermosillo are on the lower end of the distribution within the Mexican electricity market, but the differences are less pronounced. The CFE separates the country into twelve different regions for which it offers varying tariffs to its customers. Hermosillo is part of the *Noroeste* (Northwest). Its industrial consumers face a fixed monthly cost that is middle of the pack (Figure 35) but the variable cost of electricity, which depends on the kWh consumption, is among the lowest

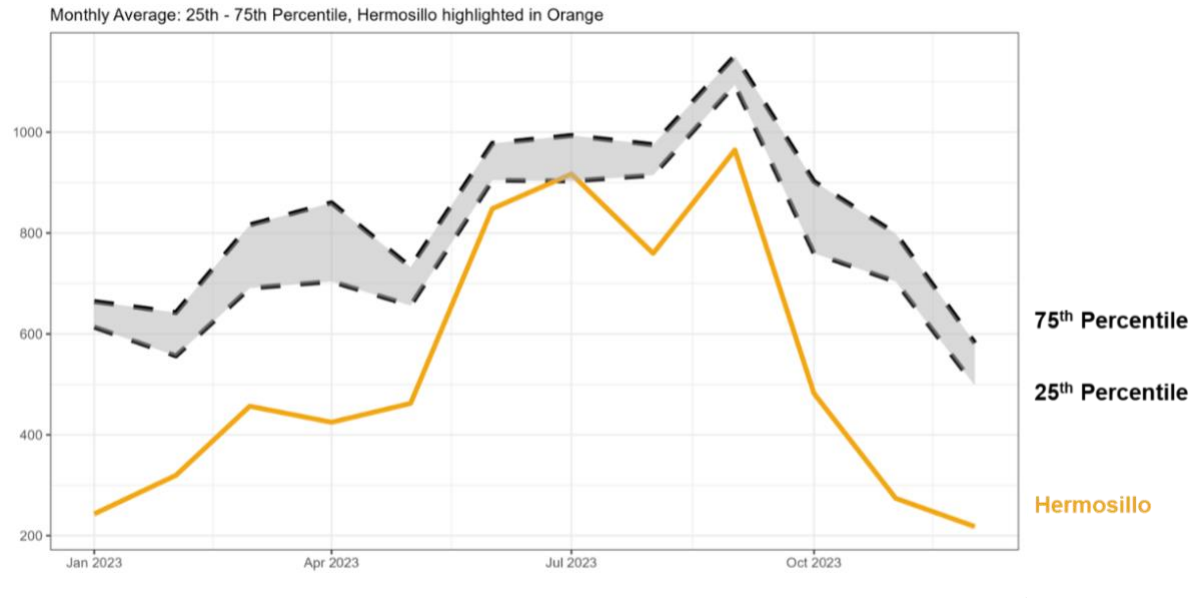
in the country. Together with the low wholesale market prices both price signals indicate that businesses in Hermosillo should not be constrained by electricity relative to the rest of the country.

Hermosillo has a larger price advantage on the wholesale market than it does through CFE tariffs. This indicates that companies may benefit from contracting with private providers. While the tariffs offered by the CFE in the Northwest region are lower than in other areas, the difference is not very large. However, the electricity prices on the wholesale market in Hermosillo are significantly lower than in many other areas of the country. This is due to the excess generation capacity in Sonora. Anecdotally, we have heard that many companies in Hermosillo have been hesitant to source electricity from private providers. This may be due to perceived legal uncertainty stemming from the policy objectives of the federal administration as well as a lack of information and coordination.

The absence of electricity outages indicates a low "shadow price" and provides additional information indicating that the availability of electricity is not a constraint in Sonora. As this is a regulated market, we can look at a "shadow price" of electricity, a signal beyond the regulated prices. In this context, we look at electricity outages. The reliability metrics SAIFI & SAIDI show that Sonora's service region is not impacted by outages much[13] (CRE, 2023). Similarly, an analysis of Google keyword searches between 2019 and 2024 reveals that Sonora has had the third lowest searches for these terms over that period of all Mexican states. This indicates that power outages are a smaller issue in Sonora than they are in other states of Mexico.

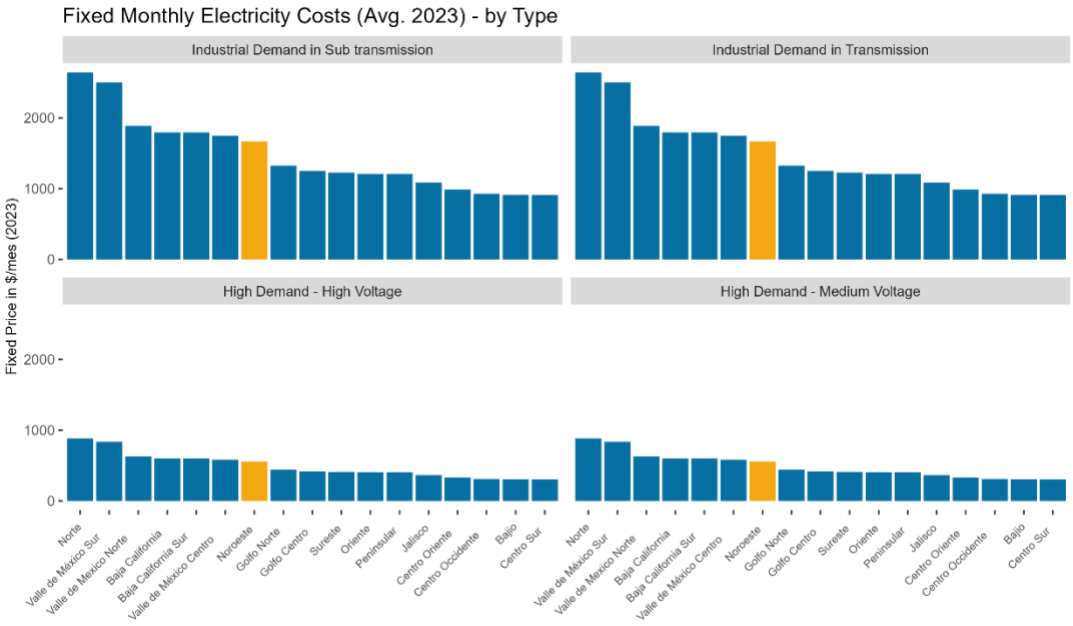
[13] In 2022 the SAIFI for the Northeast service region was 0.42 and the SAIFI was at 18.02. Therefore, a customer experienced on average less than half an outage per year with an average duration of 18.02 minutes. The only region that seems to have had significant problems was the Southeast (SAIFI: 0.63, SAIDI: 42.1)

Figure 34: Electricity Wholesale Market Prices – 2023



Source: CENACE 2023

Figure 35: Electricity Tariffs by Region from the Comision Federal de Electricidad (CFE) in 2023



Source: Comision Federal de Electricidad 2023

4.3.4.1.2 Quantity Analysis

Hermosillo had the second-highest electricity consumption per capita in the peer group after Mexicali in 2023 (

Figure 36**).** This fact is largely driven by very high residential electricity consumption in the summer. Both Hermosillo and Mexicali experience very high temperatures during the summer which increase electricity consumption due to the usage of air conditioning. The consumption patterns in Hermosillo as well as in Mexicali and Monterrey show this seasonal demand clearly. The seasonal variation in electricity consumption can also be seen for businesses that are contracted through the various commercial tariffs. This includes most local businesses, as the industrial tariff option is only applicable for companies with a very large electricity demand – only 949 companies had CFE's industrial tariff nationwide in 2023.[14] The decrease in electricity consumed from Hermosillo's industrial sector after Jun 2023 stems from the number of companies contracted with the CFE in this tariff class decreasing from 6 to 5. This could be due to this company choosing to switch to a private electricity provider, which would not show up in this data as it only covers clients of the CFE.

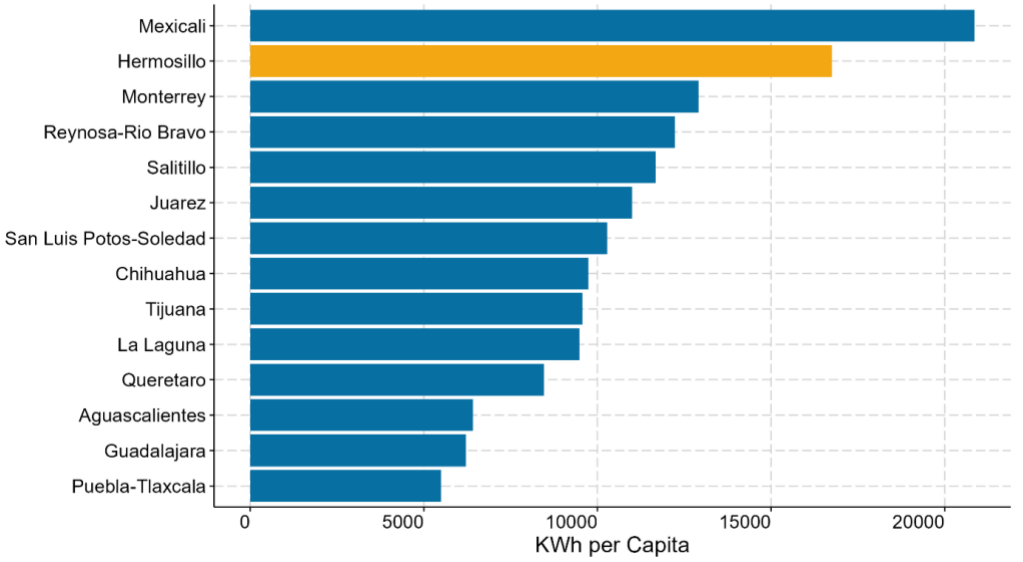
The electricity consumption of Hermosillo's private sector is in line with that of its peers. To ensure that the comparison is not impacted by the heightened demand during summer months, we restrict the analysis to the period January to May.[15] In that respect, the electricity usage of Hermosillo's businesses in the commercial tariff is slightly below the median for the group relative to the size of the city (Figure 38). However, Hermosillo ranks similarly to peers such as San Luis Potosi-Soledad, La Laguna, Aguascalientes, Chihuahua, Guadalajara, and Puebla-Tlaxcala. Regarding electricity usage from users in the industrial tariff group, Hermosillo is slightly above the median, with Mexicali and Saltillo having the largest industrial electricity consumption relative to their population

[14]

[15] From June to November onwards the electricity consumption of households in Hermosillo is significantly higher than for this period unlike for peers, indicating that air conditioning usage is driving this consumption.

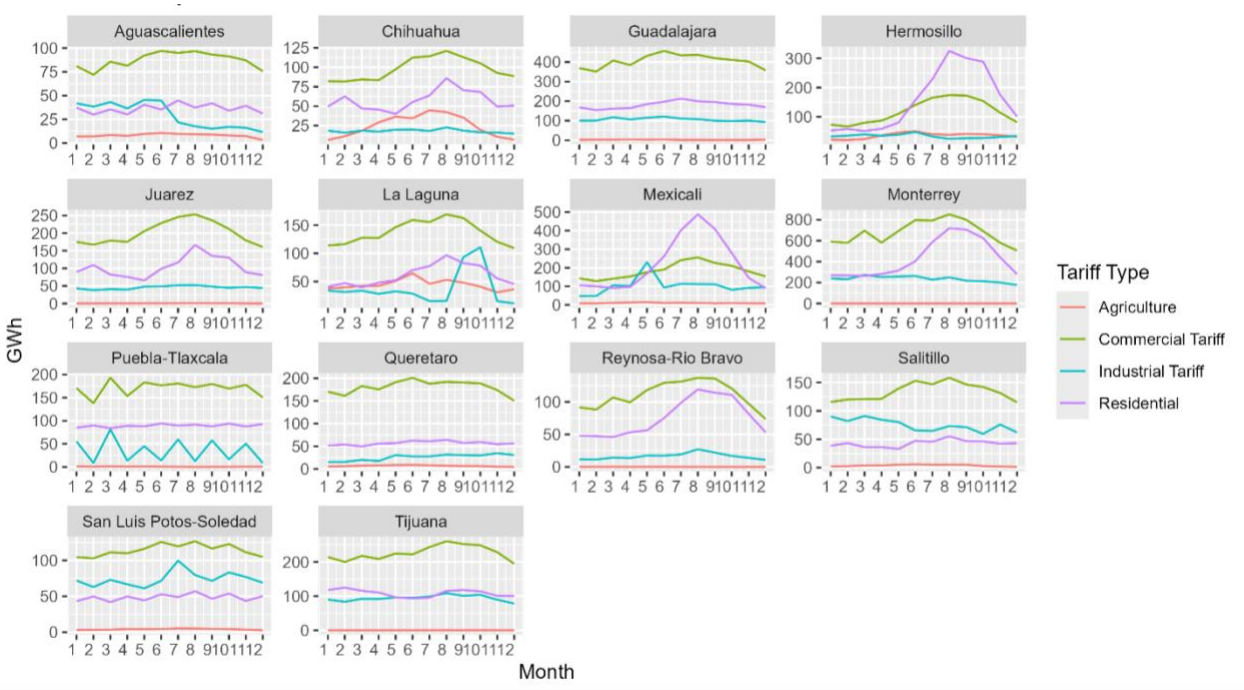
size. However, in terms of average electricity consumption per user Hermosillo ranks second highest for the industrial users within the peer group (Figure 39). This reflects Hermosillo having only a few (7) companies contracted in this tariff class, but these companies have a very high electricity consumption. It is important to note again that these results are restricted to CFE customers only. Some patterns may differ with the extent to which the contracting with private electricity suppliers differs significantly across cities.

Figure 36: Total Electricity Consumption per Capita (2023)



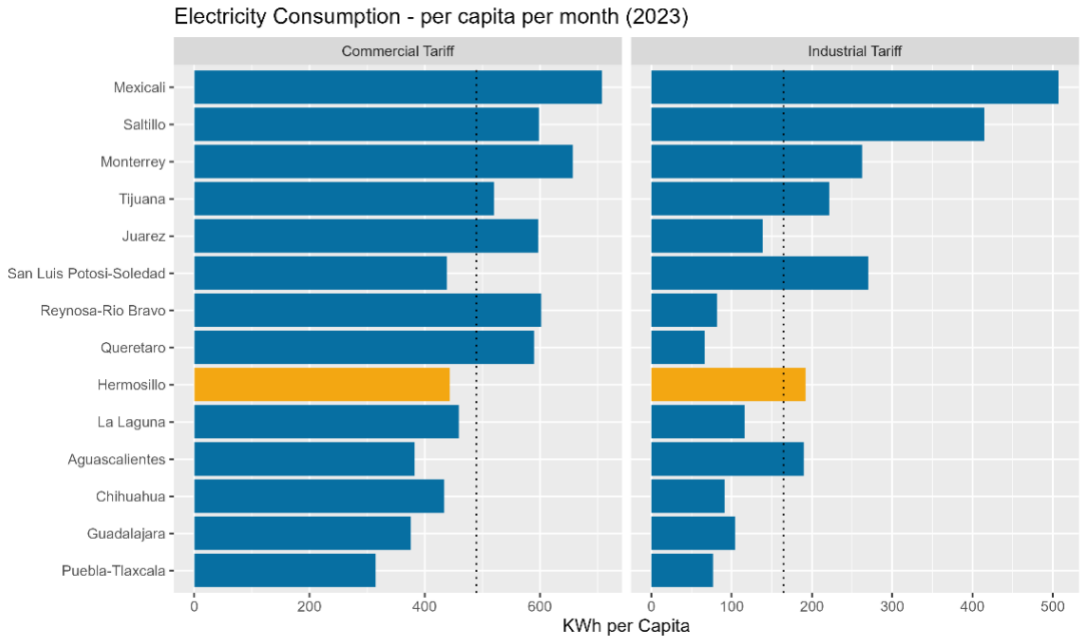
Source: Comisión Federal de Electricidad

Figure 37: Electricity Consumption by Month in 2023



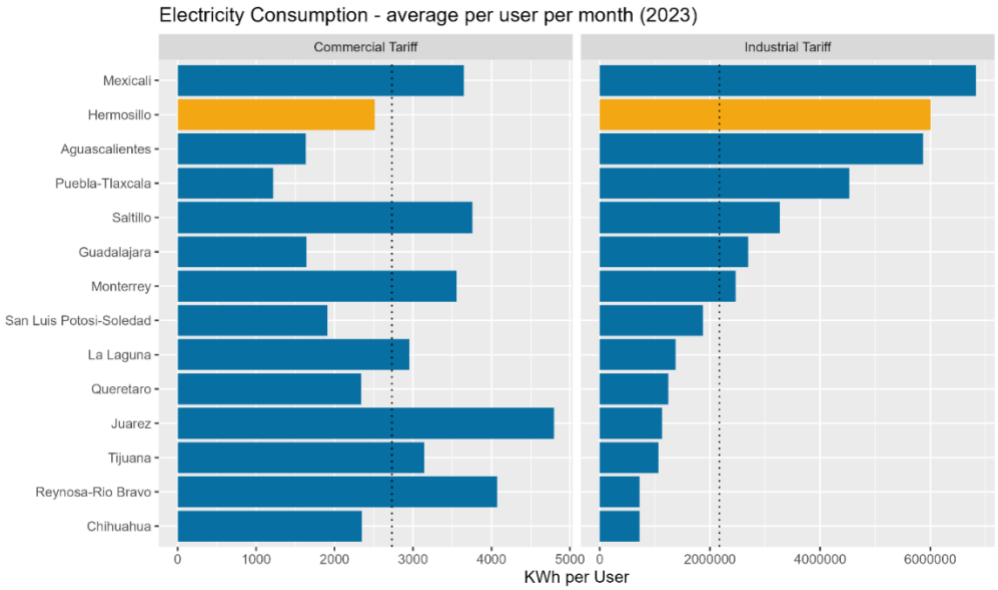
Source: Comisión Federal de Electricidad

Figure 38: Average Monthly Electricity Consumption - per capita



Source: Comisión Federal de Electricidad. Note: Restricted to January to May 2023.

Figure 39: Average Monthly Electricity Consumption - per user



Source: Comisión Federal de Electricidad. Note: Restricted to January to May 2023.

4.3.4.2 Camels and Hippos – Electricity Intensive Industries

A further analysis that can inform how electricity may impact the economy of Hermosillo is the extent to which electricity-intensive industries are present and growing in its economy. To do so, we distinguish between *price-sensitive and quantity-sensitive* industries with respect to electricity. These concepts are defined as follows:

- *Price Sensitive Industries:* The top 20% of industries in terms of electricity expenditures as a share of their intermediate consumption
- *Quantity Sensitive Industries:* The top 20% of industries in terms of electricity expenditures per firm

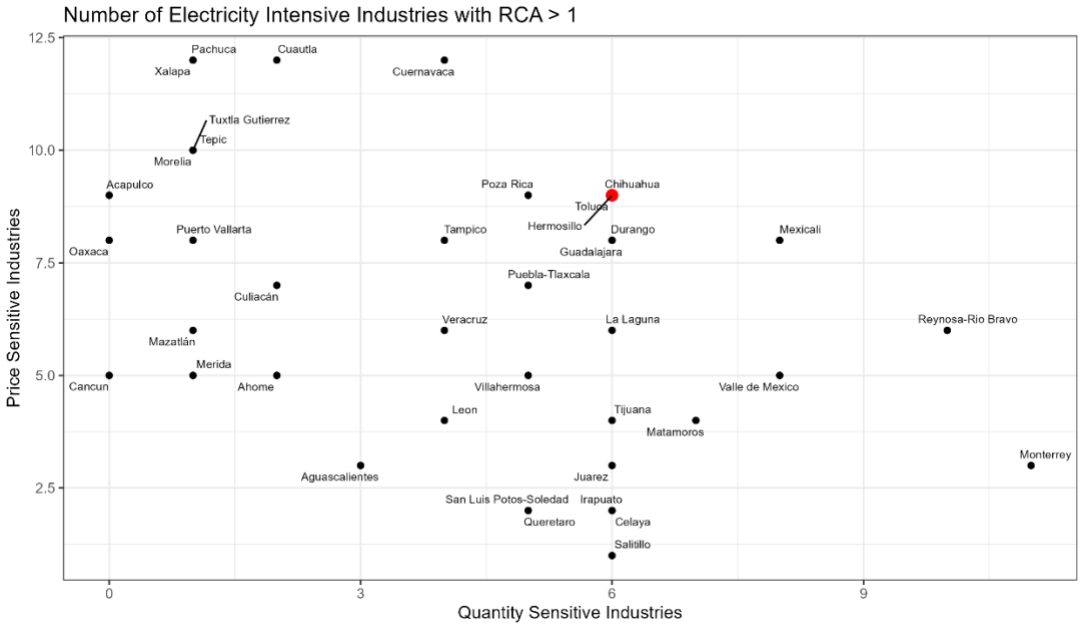
The idea behind this approach is that the dynamics may vary. A price-sensitive industry may be impacted more strongly by small price changes but may not require large quantities of electricity, whereas a quantity-sensitive *industry* will require larger quantities of electricity to be readily available.

Hermosillo has a revealed comparative advantage in several price- and quantity-sensitive industries, indicating that electricity did not constrain them from establishing in Hermosillo. As Figure 40 shows Hermosillo is among a few cities that have a strong presence both in price as well as quantity sensitive industries. Industries that are an important driver of this dynamic as they are both *price and quantity sensitive industries* and have a strong presence in Hermosillo are mining, mining-related services as well as manufacturing of computers and other electronic equipment. The fact that Hermosillo has a relatively high presence of industries in both dimensions is a further indication that electricity is unlikely to be constraining the economy. If electricity was a constraint, we would expect these industries not to be present in Hermosillo or to be struggling to grow.

***Price-* as well as *quantity-sensitive* industries have experienced growth rates that are similar to those across the rest of Hermosillo's economy.** If electricity was a binding constraint to growth, we would expect industries that are more intensive in the use of this factor to have a worse growth performance than the rest of the economy. The

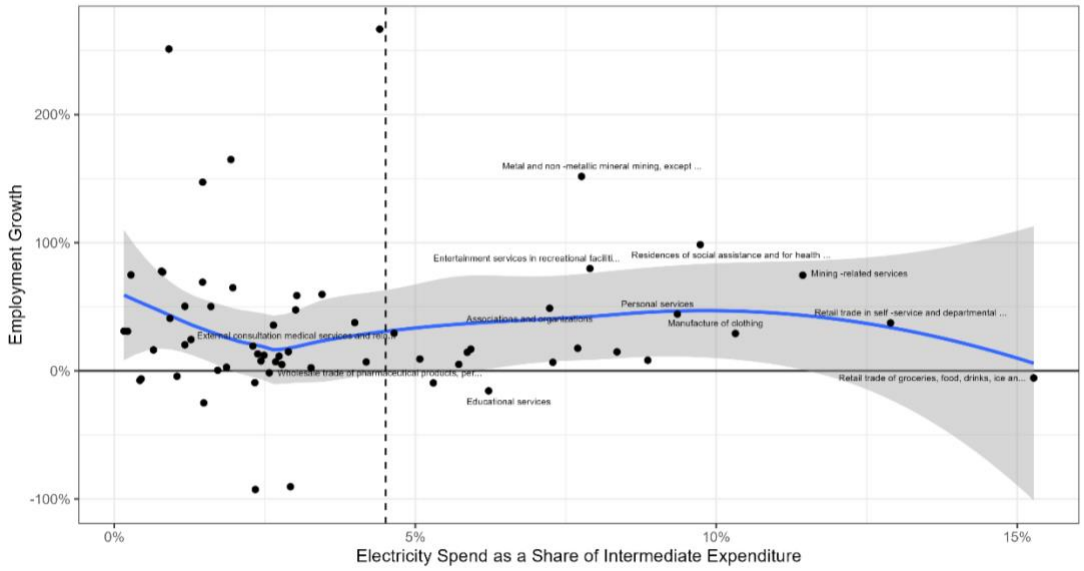
analysis shown in Figure 41 and Figure 42 indicate that both, *electricity price and quantity sensitive* industries have been growing similar to the rest of the economy in terms of employment. That the growth performance of these industries is in line with the rest of the economy is an additional indicator that electricity does not seem to have been a constraint in Hermosillo in recent years.

Figure 40: Presence of Electricity Intensive Industries



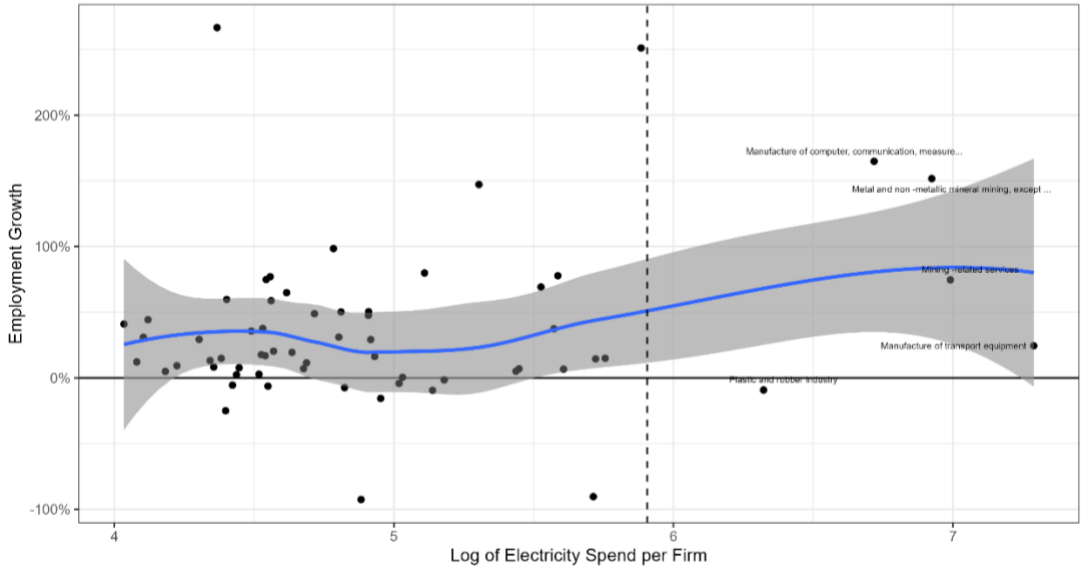
Source: Own calculations based on Comisión Federal de Electricidad.

Figure 41: Employment Growth of Electricity Price-Sensitive Industries in Hermosillo (2014 – 2019)



Source: Own calculations based on Comisión Federal de Electricidad.

Figure 42: Employment Growth of Electricity Quantity Sensitive Industries in Hermosillo (2014 – 2019)



Source: Own calculations based on Comisión Federal de Electricidad.

4.3.5 Key Takeaways

The analysis has shown that currently, electricity does not seem to be a binding constraint to growth in Hermosillo but that the lack of distribution infrastructure presents a challenge. The analysis of electricity prices shows that both the wholesale prices as well as industrial tariffs in Hermosillo are among the lowest in the country. Similarly, the "shadow price" of electricity outages shows that Sonora does not face constraints in the reliable provision of electricity. Hermosillo's private sector electricity consumption is also in line with that of peers. Moreover, Hermosillo has a revealed comparative advantage in a number of electricity intensive industries both in terms of *price-sensitivity* and *quantity-sensitivity.* These industries have also grown at similar rates to the rest of Hermosillo's economy, indicating that it is unlikely that electricity has been a binding constraint. However, insufficient distribution infrastructure has held back more firms from locating in Hermosillo. While this is a widespread issue in Northern Mexico it is limiting the extent to which Hermosillo can benefit from its electricity advantage.

The development and utilization of solar energy in Sonora presents a significant growth opportunity to attract investment in the future. Given Sonora's good solar resources, it can leverage this to attract economic activity, which puts a premium on access to low-carbon electricity. While the state saw a lot of private investment and development of solar plants between 2018 – 2023, the state is now taking a much more active role in developing new solar capacity. The "Plan Sonora" with its target to develop 1 GW of new solar capacity in the state can be an opportunity to attract industrial activities from companies which put a premium on accessing green electricity. The success of this will not just depend on developing the solar capacity but also on factors such as having sufficient transmission capacity in place, available land and sufficient workforce. Additional factors will depend on the needs of specific companies and industries which can be revealed through public – private interactions and coordination.

The access to low-cost and low carbon electricity could be a source of comparative advantage in Hermosillo. To take advantage of low electricity prices in Hermosillo, companies may explore to contract with private electricity providers. Hermosillo's comparative advantage of having excess generation capacity and cheap solar power is reflected much more on the wholesale market than in the tariffs of the CFE. Making use of this advantage, therefore, requires contracting with private electricity providers. This is an option for companies with large electricity consumption (i.e. qualified users) as well as for industrial parks that can bundle the demand from their companies. However, this does not yet appear to be happening much in Hermosillo. It may require bridging information gaps about these opportunities and coordinating within the private sector to make this happen.

4.4 Water

In the 2018 growth diagnostic, water was proposed as a potentially binding constraint to economic diversification. At that time, Economic Units reported relative dissatisfaction with the prevention of leaks, and only 35% felt water was affordable relative to 50% nationally. Industrial and Commercial water prices had seen a substantial increase over the previous year, and legal disputes over the Independencia Aqueduct contributed to further uncertainty over water delivery to Hermosillo. The economic census of 2014 showed that economic units were less water-intensive than comparators on average. Thus, the combination of factors leading to uncertainty over water supply, dissatisfaction with water costs and leakages, the unavailability of new water from Hermosillo's aquifers, coupled with the observation that the industrial sector used less water than expected warranted the raising of water as a potentially binding constraint in 2018.

Updated data now suggests that water has not been a binding constraint for economic growth. Many of the factors highlighted in the previous report remain true

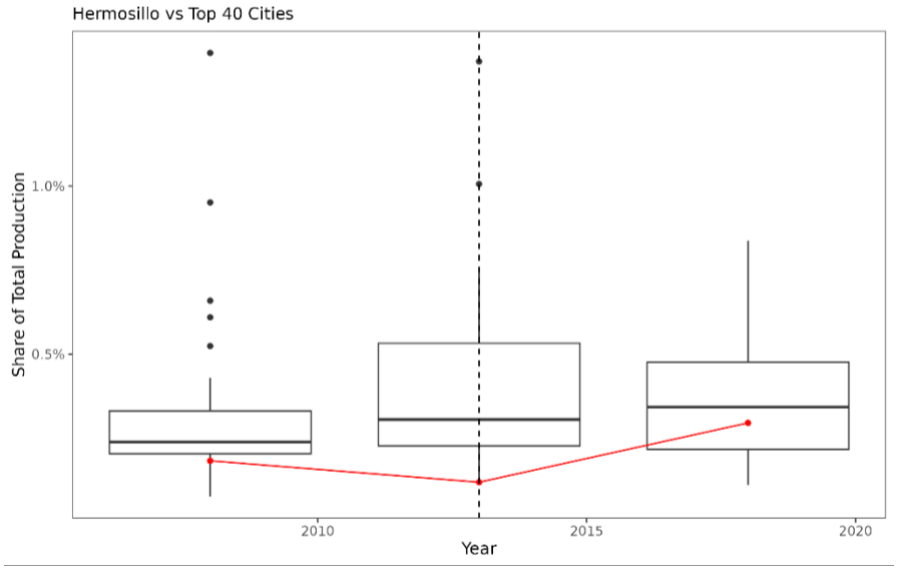
today, and water remains a central concern for Hermosillo. Economic units continue to report dissatisfaction with the prevention of leaks and with the cost of water (Figure 47). However, the updated economic census of 2019 indicated that the economy became more intensive in its water use, bringing it back within expected bounds for water use in its economy (Figure 43), compared to similar cities. Furthermore, satisfaction with the provision of water services moved from 54.2% in 2016 to 73.4% in 2020, according to The National Survey on Regulatory Quality and Government Impact on Enterprises (ENCRIGE). It would appear that the Independencia Aqueduct was successful in alleviating water stress for businesses in Hermosillo. Analysis conducted using the updated economic census also reveal the relatively high presence of water intensive industries in Hermosillo. These industries exhibit similar growth patterns as the rest of the economy, implying they are not especially constrained. These facts cause us to conclude that water has not been a binding constraint to economic growth between 2014-2019.

Anecdotal evidence suggests water may be binding for housing expansion today. Conversations with housing developers in the city revealed that there is difficulty obtaining water permits for new construction. The water utility, Agua de Hermosillo, confirmed the creation of a 'trust fund', whereby additional payments from developers would unlock permits for new growth. The utility uses the money to undertake infrastructure improvements which help reduce leakages and recover water, so that it may be allocated to the new construction. It will be important to monitor water for housing and real estate, as housing shortages can drive up prices, which would need to be compensated by increasing wages, which in turn hurts economic competitiveness.

At the same time, current water usage in Hermosillo is unsustainable. Underground extraction far exceeds aquifer recharge rates, which implies the stock of fresh water is decreasing. The lack of knowledge about the stock of underground water resources means there is no certainty on how long these extraction rates can continue. Achieving sustainable water use would put pressure on all sectors - agricultural, industrial, and residential – as it would decrease the supply of water from underground. To address this,

we propose improving pricing mechanisms for residential and agricultural users to allocate water more efficiently while also ensuring the needs of vulnerable populations are met.

Figure 43: Water Spending as a Share of Production, Over Time



Source: INEGI Economic Census

4.4.1 Water in Mexico – Context and Developments

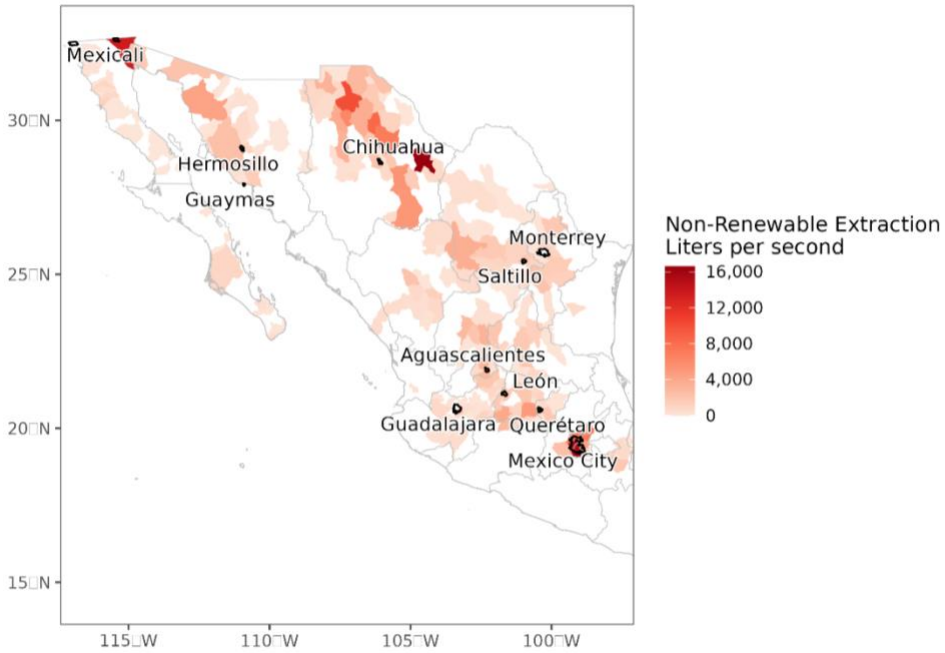
Water is managed at the federal, state, and local levels. The 1992 Water Law in Mexico establishes the modern legal framework for water management across the country. The National Water Commission (CONAGUA) manages water at the federal level, where it develops national water policies and strategies, water concessions, and large-scale water infrastructure projects and coordinates with state and local governments on water issues. In between, the state manages the implementation of water policy within its jurisdiction, state level infrastructure, and the coordination of municipal water utilities and sanitation services. Municipal and local governments are responsible for providing water supply and sanitation in urban areas, managing local water infrastructure, and implementing water conservation measures at the community level. While municipal utilities provide water for industrial, commercial, and domestic

use, individuals and businesses may also apply to CONAGUA for a water concession directly.

Water concessions from CONAGUA form the foundation of water allocation in Mexico. A water concession is a permit granted by the government that allows the holder to use and exploit a specific volume of national water resources for a certain period of time. CONAGUA distributes concessions to individuals, businesses, and government water utilities for both surface and underground water in aquifers. Different uses of water get different prices under the current regime. Notably, agricultural users do not pay for the amount of water extracted within the concession limits (CONAGUA, 2010), and are the largest user of Mexico's water.

Much of Mexico faces water stress. Many of the largest cities of Mexico pull their water from aquifers that are over-exploited (Figure 44), and recent droughts have reduced the supply of water (ISciences, 2024; NASA Earth Observatory, 2021). According to government data, more than 70% of the country is dealing with some level of drought (Barrera & Garrison, 2024). These droughts have been caused by both lower rainfall levels and higher temperatures, which lead to increased evaporation (ibid.). Climate models project both a hotter and drier climate that will contribute to increased water stress for much of the country (The World Bank Group, 2023). Figure 44 uses data from CONAGUA's "Sistema Nacional de Información del Agua" to visualize the aquifers in which the extraction of water exceeds the stated recharge rate. The figure illustrates a pattern of stress on aquifers in the north of Mexico, as well as in the most populated areas.

Figure 44: Unsustainably Extracted Aquifers, Mexico 2023



Source: CONAGUA

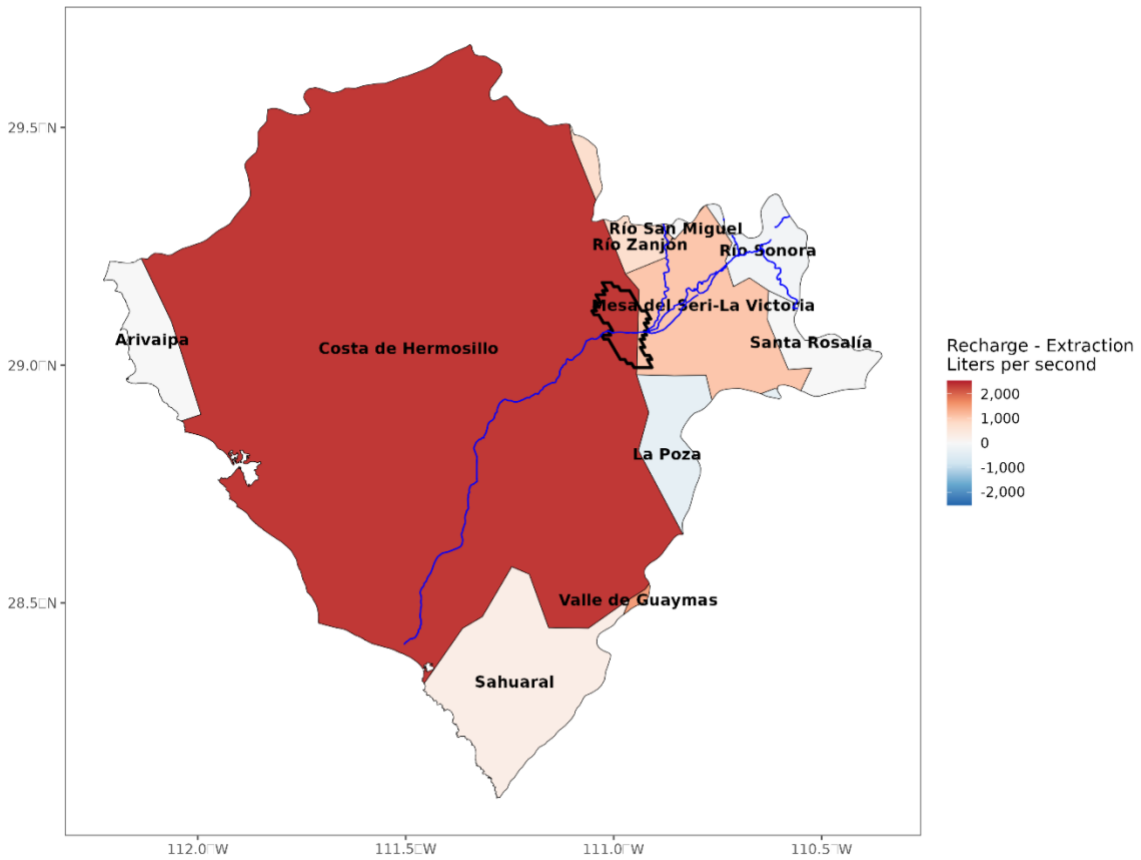
Water management is an active area of policy reform and legislation, reflecting the urgency of the nation's water scarcity challenges. A reform enacted on May 8, 2023, targeted the mining industry, imposing stricter reporting obligations to ensure more sustainable water usage and reduce environmental impact (Jones Day, 2023). These reforms highlighting a shift towards securing water for essential human needs first**.** Drought conditions were relevant in the recent Mexican elections (Oré & Carrillo, 2024), and President Claudia Sheinbaum has aims to improve water governance in the agricultural sector by reforming the National Water Law and a potential investment of 20 billion pesos per year (Barrera & Garrison, 2024). This includes reviewing existing water concessions, cracking down on illegal use, updating irrigation technology and revamping CONAGUA (ibid). While many specifics of the remain unknown, it is clear that climate change, water scarcity and use of water in agriculture is a central issue for policy makers.

There is uncertainty regarding a potential freeze on further water concessions in the north, where water scarcity is most acute. In February of 2024, President López Obrador had proposed the prohibition of new water concessions in areas of low water availability, as well prioritizing water for domestic and personal consumption (Duran, 2024). The proposed freeze could be a major constraint as Mexico seeks to take maximum advantage of the recent wave of nearshoring as supply chains shift out of China. The hurdles faced by Tesla regarding their investment in Monterrey demonstrate the extent to which water security is a relevant issue that will have to be addressed by cities as they continue to push for economic opportunities for their citizens**.**

4.4.2 Water in Hermosillo – Key Considerations

Hermosillo, like many Mexican cities, uses more water than it has. The municipality consumes all its surface water resources, and the city's major aquifers have been and continue to be overexploited. Of the 10 Aquifers that overlap with the municipality, only two are listed as having available water - La Poza and Rio Sonora (CONAGUA, 2023). The balance of Hermosillo's aquifers are visualized in Figure 45. Aquifer balances are measured as the recharge rate minus the extraction rate, and it shows that the major aquifer of Hermosillo – Costa de Hermosillo – is being extracted faster than it is being recharged at a rate of more than 2,000 liters per second. The outline in black shows where the city boundaries are, according to the Global Human Settlement Layer, and how it overlaps with various aquifers. Historically, there have been reports of saltwater intrusion into the wells of farmers near the coast, and the water shortages were so severe in the late 1990s and 2000s that the city had to implement the 'tandeos' and ration water across the city.

Figure 45: Map of Hermosillo's Aquifer Water Balance, 2023



Source: CONAGUA

Historically, water availability has been increased through infrastructure investments. In 2008, the El Molinito aqueduct was built to provide additional water to the city of Hermosillo, and just two years later another intervention was necessary to provide more water for the city. The Independencia aqueduct was completed in 2013 and brings water 125 kilometers from the El Novillo Dam on the Yaqui river to the city. The aqueduct is highly controversial and faces ongoing resistance from the Yaqui tribe. A 1937 treaty, upheld by a 2013 federal Supreme Court ruling, had guaranteed the Yaqui people 50% of the rivers water (Climate Diplomacy, 2010). However, the Yaqui people claimed they were not properly consulted in the construction of the project, which they fear will exacerbate water scarcity. The tribe filed for legal protection repeatedly, but construction continued (Pablos, 2017). Consequently, protests and highway blockages were organized which obstructed the construction and economic

activities of the region (ibid). The state and the Yaqui people have yet to reach a formal resolution to their dispute (Climate Diplomacy, 2010). Nonetheless, today the aqueduct supplies about 20% of the water to the city. Political resistance to this form of expansion demonstrates that it is costly to mobilize new water resources for Hermosillo in this way. And, despite the construction of the aqueduct, the city finds itself again close to the limit of its water consumption as evidenced by the difficulties in granting water permits for new housing construction.

4.4.3 Diagnostic Testing

Water can limit the economic success of a city through multiple channels. Water scarcity can restrict the competitiveness of companies located in the city because of a relatively high price of water or a lack of availability. Water can also limit economic competitiveness through a real estate channel, whereby water unavailability would limit the growth of new housing, industrial parks, or other construction. A constraint on new housing supply would push up housing prices and thus put pressure on wages to respond in order to attract workers, which in turn can make the industry less competitive. Naturally, limits on the expansion of industrial parks would also constrain industrial growth. Finally, water scarcity can operate through an 'amenity' channel, whereby policies like water rationing act as a dis-amenity that makes the city less attractive for a potential migrant to locate in given the level of real wages. Potential migrants would then require a higher wage - or lower housing prices - to compensate for the decrease in living standard associated with living in the city.

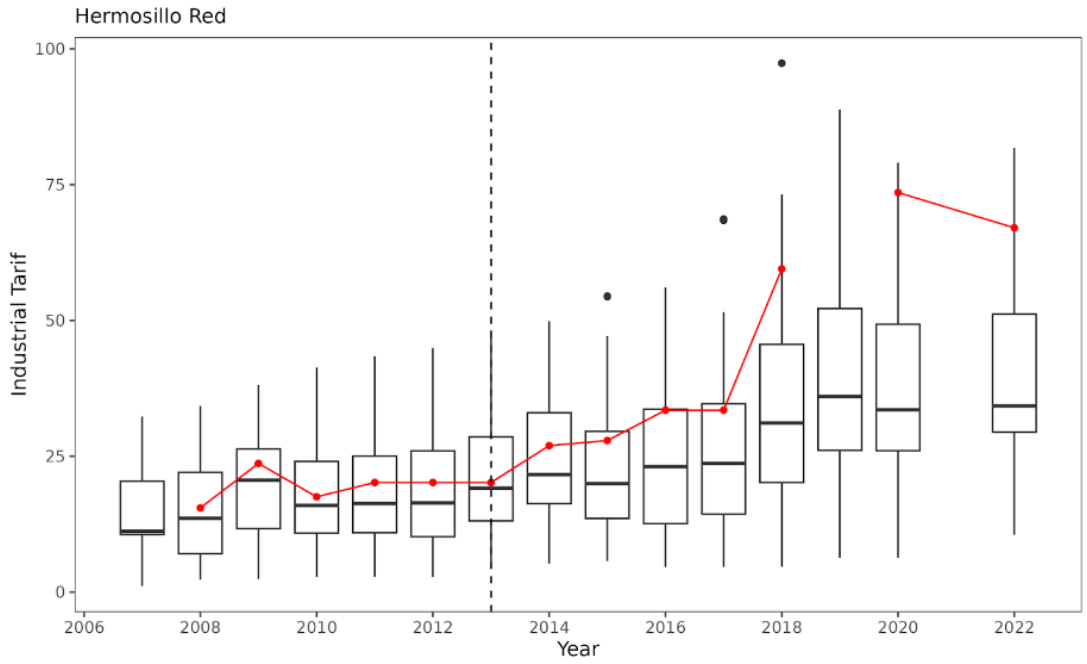
This section will evaluate to what extent water has constrained the growth of companies and industries in Hermosillo in the recent past. The diagnostic tests primarily investigate water as a direct input into economic activity, examining the relationship between types of industries, their water spending, and their competitiveness in Mexico compared to similar and aspirational cities. Housing is investigated in detail in Section 4.7, but here we provide some anecdotal evidence from our interviews with

officials in the city regarding the role of water in housing and industrial real estate expansion. The role of water as an 'amenity' is not directly explored.

4.4.3.1 Testing Prices

The scarcity in the quantity of water, driven primarily by Agriculture and Domestic use, has resulted in a high price for Industrial use in Hermosillo. After the 2013 water law was implemented, the formula for the water price is set at the hydrological basin level, and the base price of water reflects the level of water availability in the basin it is drawn from (Guerrero García Rojas et al., 2019). We observe water prices increasing dramatically after the implementation of this law, with further spike in 2018, for both commercial and industrial use. The high price observed for industrial use reflects the scarcity in water availability. It's important to note that here we are comparing water prices for water from CONAGUA, and not from the water utility.

Figure 46: Industrial Water Tariffs



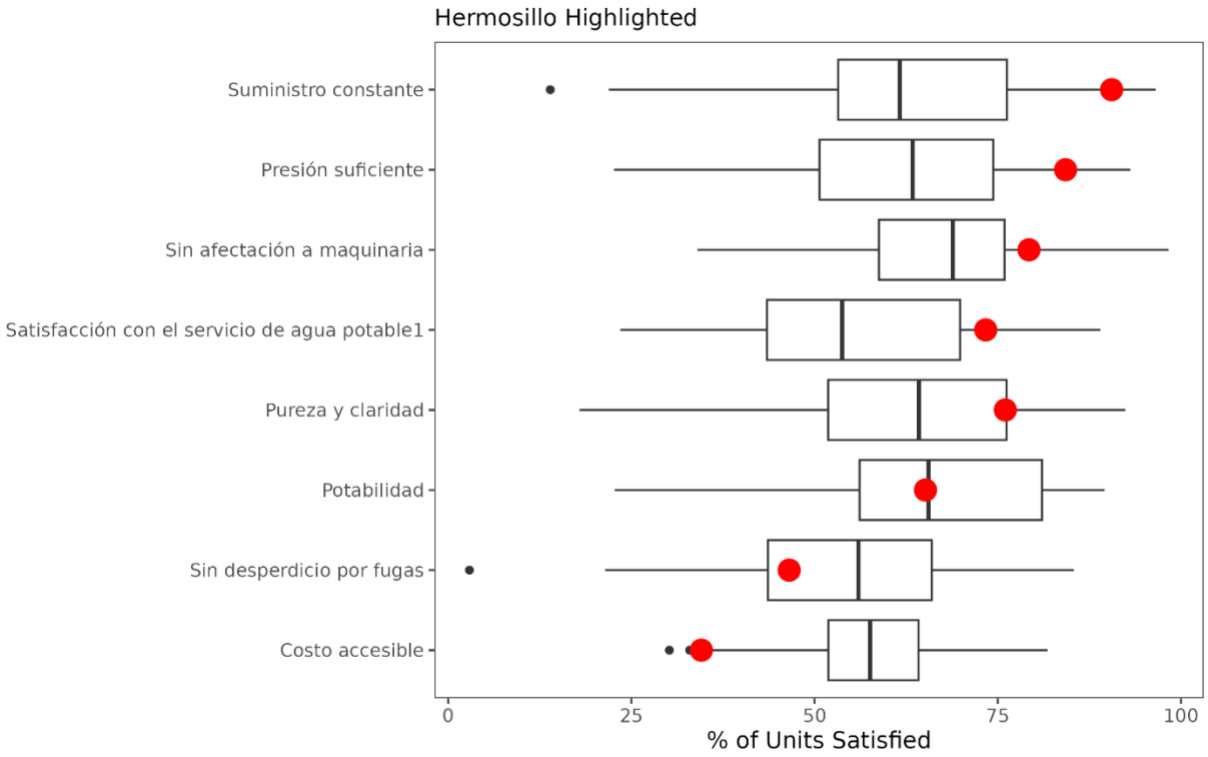
Source: CONAGUA

However, the biggest users of water do not pay a high price. It is worth noting that Agriculture does not pay for water unless the user exceeds their allocated amount.

Furthermore, Agricultural users receive subsidies on electricity for pumping the water from the ground, meaning even the ‘shadow’ price of water – the price of pumping – is set artificially low. The price for water for domestic use is also at about the median rate. When we take into consideration that many residential users either don’t have a water meter, or it no longer functions, it further builds the case that residential users don’t pay a high price for water. Thus, for the two largest uses of water, the price is not high.

No ‘shadow’ price is observed in the form of water rationing. Often, prices for goods provided by the state do not reflect their true social value as they are not subject to competitive market forces. As this is the case for water in Hermosillo, we look for a ‘shadow’ price, or an additional signal beyond price to indicate its economic value. In this context, we check for quantity rationing. Since price does not fluctuate to balance supply and demand, it may be that quantities play the balancing role. This is known as rationing. If this were the case, we would observe intermittent and unreliable water delivery service. However, based on responses to a quality-of-service survey run by INEGI, we observe no rationing of water. In fact, we observe complaints related to water wastage due to leaks in the system - a complaint backed up by a high potable water per capita consumption rate. The figure below visualizes the responses to the water satisfaction survey relative to all other municipalities surveyed.

Figure 47: Satisfaction with Water (2020)

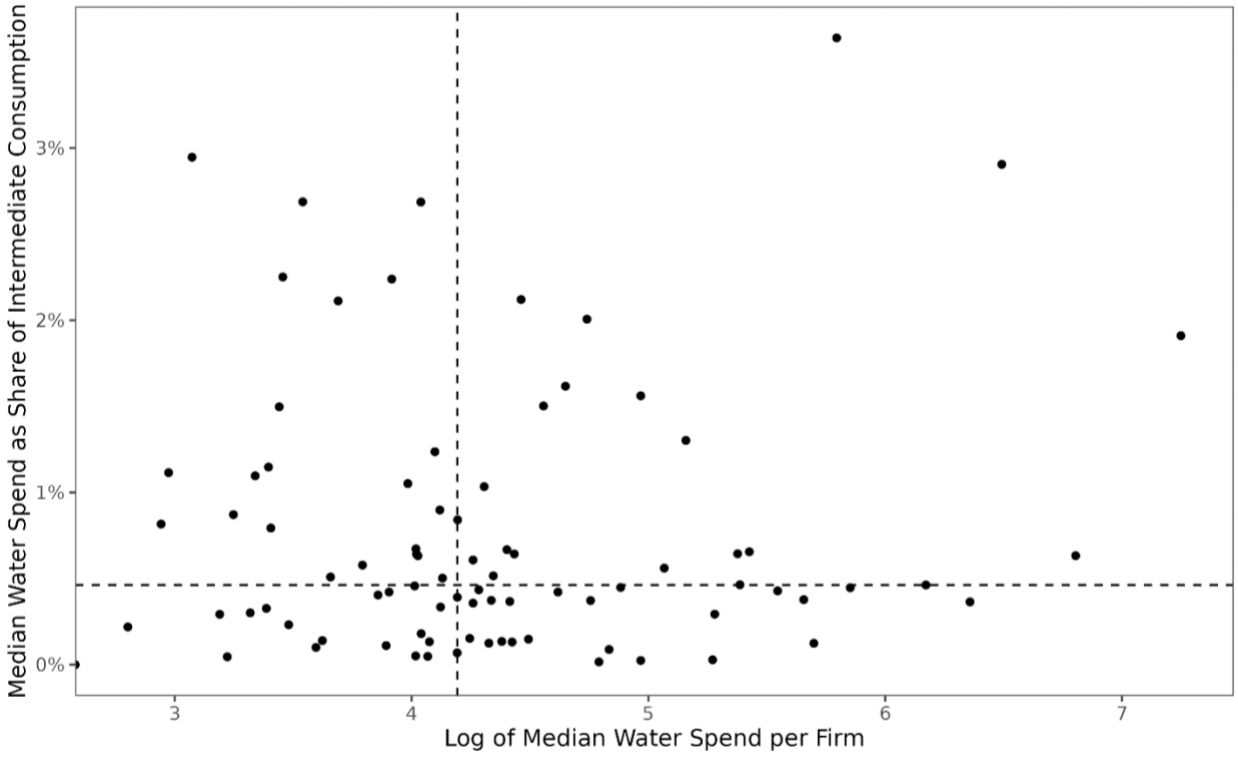


Source: ENCRIGE 2020

4.4.3.2 Testing Camels and Hippos

Despite the high industrial and commercial water prices and the shortage in quantity, we observe that water intensive industries are present and performing in Hermosillo. We define water intensiveness in two ways: industries where water expenditures make up a high share of its intermediate consumption (*price sensitive*), and industries that typically consume a large quantity of water per firm (*quantity sensitive*). We analyze both groups independently because we observe that industries that require large quantities of water often have water as a low share of their intermediate consumption, while several industries that have water as a high share of intermediate consumption consume relatively small amounts of water. This is illustrated in Figure 48 below.

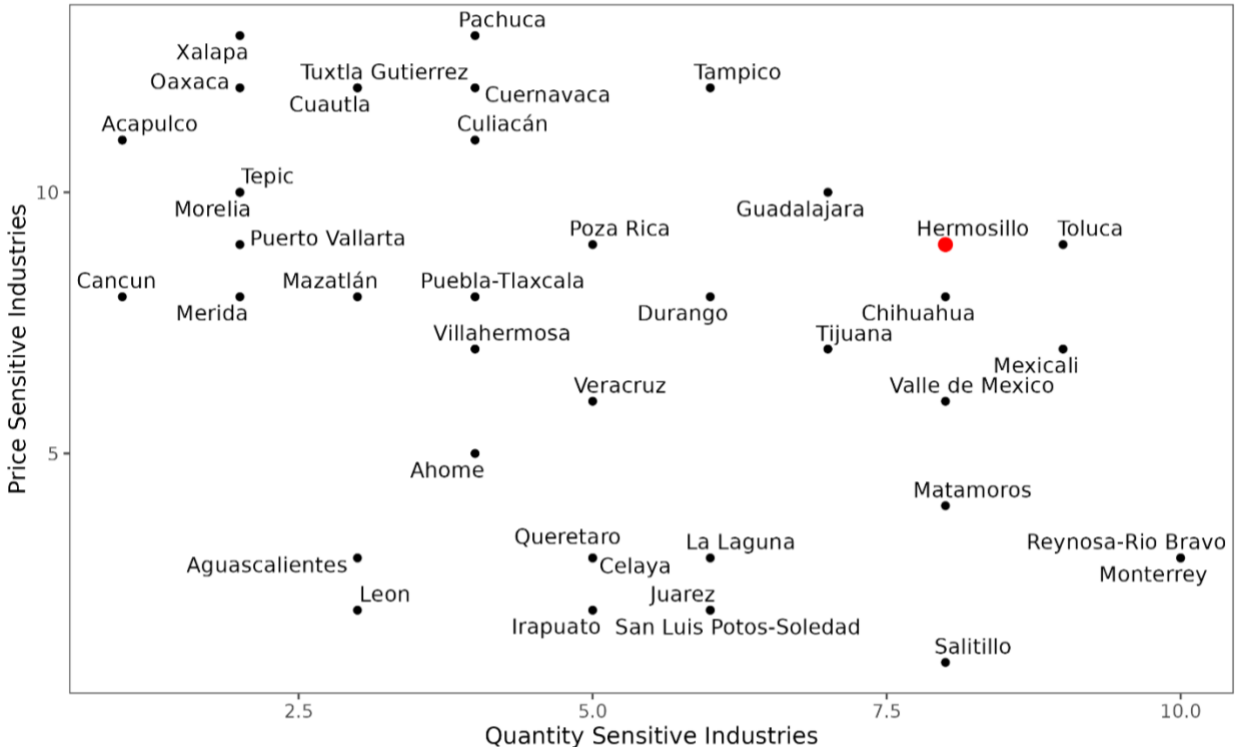
Figure 48: Water Intensity, Price Sensitive vs Quantity Sensitive Industries



Source: INEGI Economic Census 2019

We observe that both price and quantity sensitive industries are present in Hermosillo. Hermosillo has 9 industries with a revealed comparative advantage (RCA) out of the top 18 most price sensitive. It also has a revealed comparative advantage in 8 out of the 18 most quantity sensitive industries. The city performs comparatively well on both these metrics against other cities in Mexico, as illustrated in Figure 49 below.

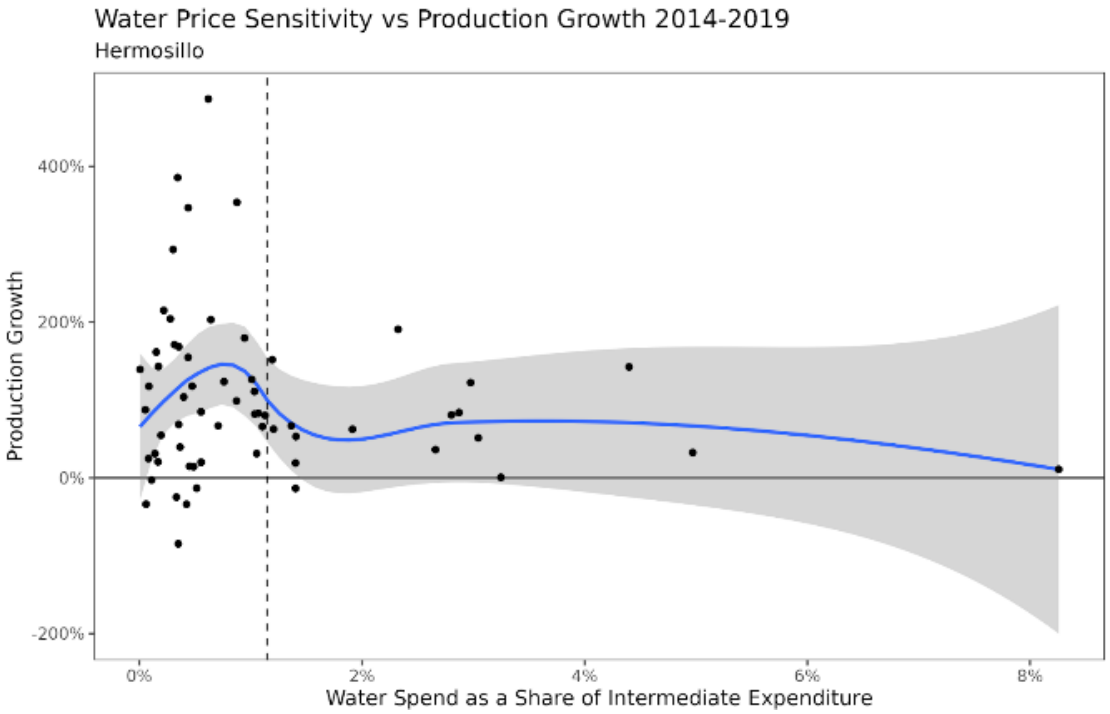
Figure 49: Number of Water Intensive Industries with RCA > 1



Source: Own Calculations from INEGI Economic Census 2019

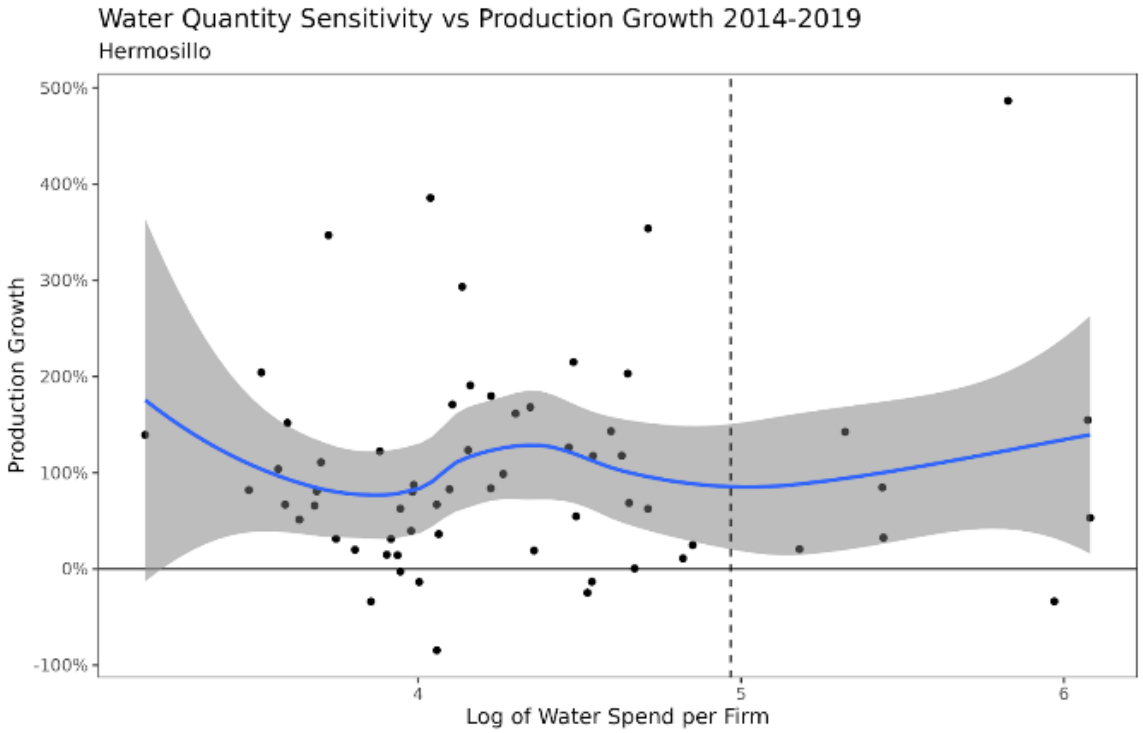
These industries have mostly grown normally relative to the rest of the city. We find no clear pattern indicating that industries that are more sensitive to water prices, or to water quantity, have grown differently than other industries in the city. We would expect this to be the case if the water shortages were binding for their growth. Together with the fact that such industries are heavily present in Hermosillo, it gives evidence that water has not been binding for the economic growth of the city.

Figure 50: Water Price Sensitivity vs Production Growth, 2014-2019



Source: INEGI Economic Census 2014-2019

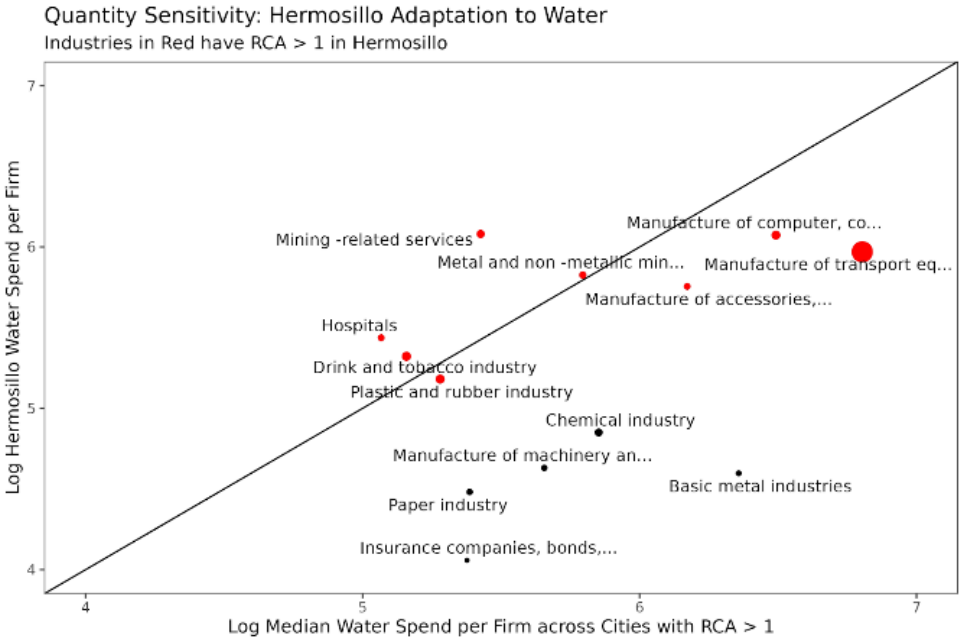
Figure 51: Water Quantity Sensitivity vs Production Growth, 2014-2019



Source: INEGI Economic Census 2014-2019

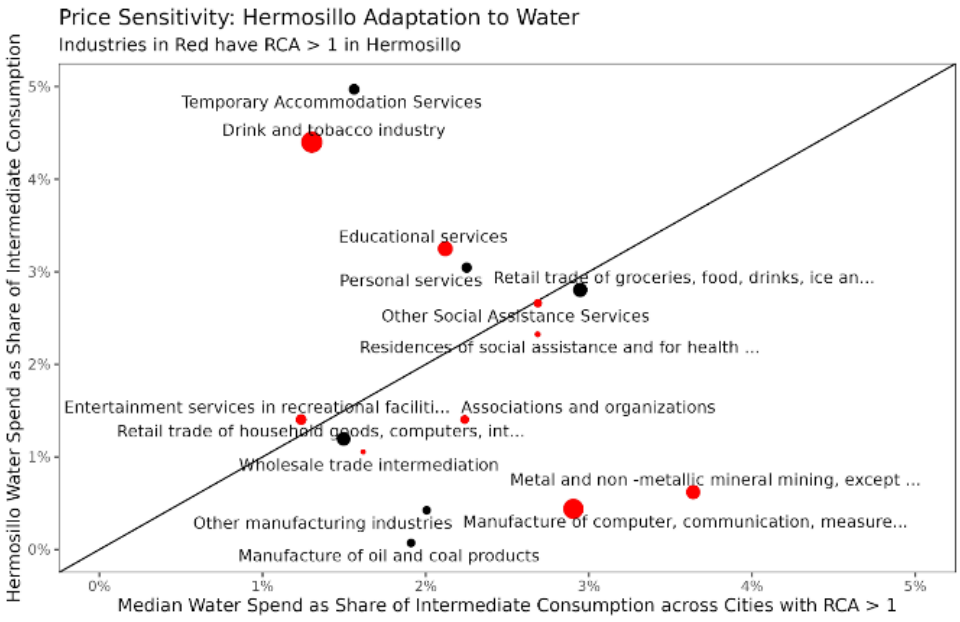
We observe no consistent pattern in industry adaptation to a water constraint. We have identified industries as water-intensive based on their average characteristics across Mexico in areas where they have an RCA > 1. However, it may have been the case that these industries in Hermosillo had somehow adapted themselves to use less water while still being competitive, and thus acted differently than the average case. However, when comparing water quantity - proxied by total water spending - and water expenditures as a share of intermediate consumption, we find no clear differentiation on average. We illustrate this in the Figure 52 and Figure 53 below, which show no clear pattern of deviation from the 45 degree line.

Figure 52: Quantity Sensitivity: Hermosillo's Adaptation to Water



Source: Own Calculations from INEGI Economic Census 2019

Figure 53: Price Sensitivity: Hermosillo's Adaptation to Water



Source: Own Calculations from INEGI Economic Census 2019

We conclude this section with a comment on housing. As noted earlier, water can act as a constraint on the economy through a real estate channel. If there is not enough water to approve new housing construction, or the construction of new industrial parks, it can put pressure on overall economic growth of the city.

Anecdotal evidence suggests that water has the potential to become a binding constraint for housing expansion in Hermosillo. In meetings with municipality leaders during May 2024, it was reported that Housing Developers have difficulty in getting water permits for new construction. When we followed up on this with Agua de Hermosillo, the water utility, we learned that to alleviate this issue, a 'trust fund' had been created where housing developers pay an additional cost to the water utility in order to unlock housing permits. Agua de Hermosillo, in turn, can use those funds to invest in water efficiency improvements, such as micro metering, which will reduce losses and create new water that can be allocated to the new construction. These signals suggest that as demand for new housing construction rises, water becomes binding for the expansion of the city, and in turn the water utility is bound by a financial constraint. If Hermosillo were to overcome its "trailing growth" challenges and catch up with fast-

growing cities, the city would need to solve its water issues. The expansion of industrial and residential real estate would be essential in this process, but current signals indicate that water infrastructure and management could limit that expansion.

4.4.4 Water usage, economic growth & sustainability

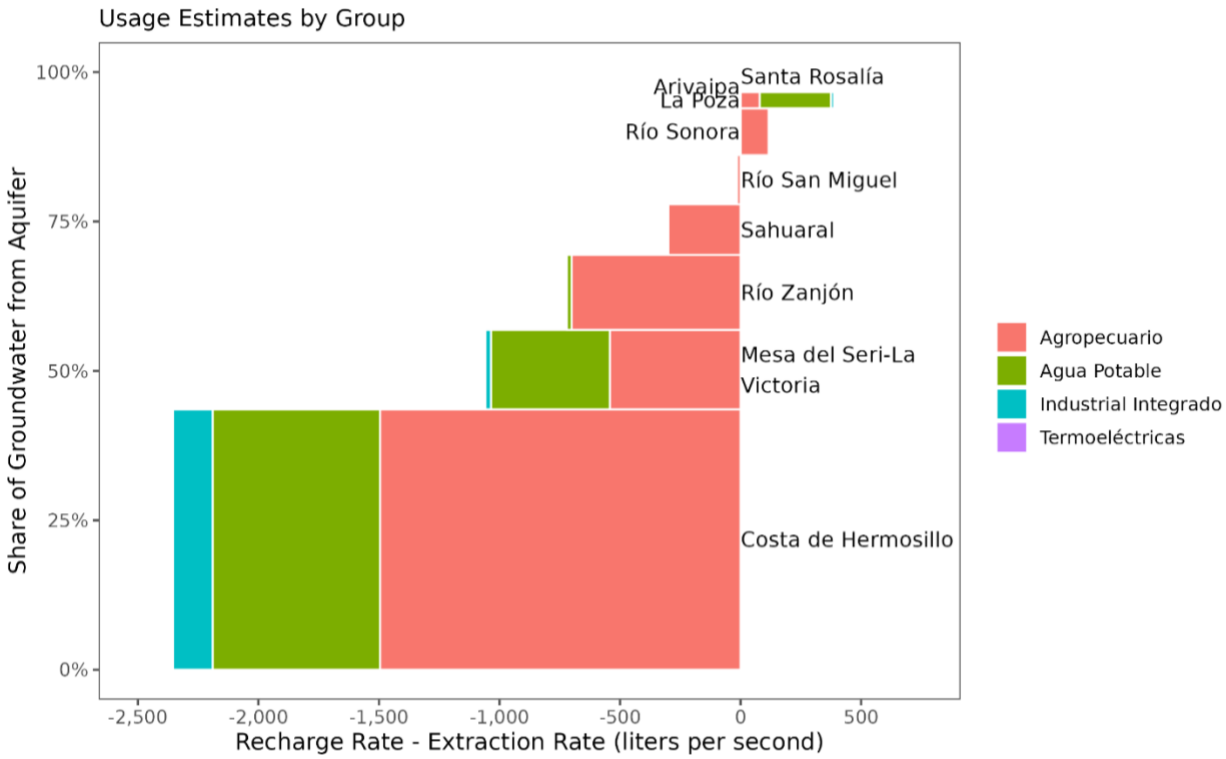
While water availability in Hermosillo has not hindered economic growth in the recent past, the current unsustainable water usage patterns could lead to significant constraints in the future. Data from CONAGUA makes it clear that underground water extraction is continuing at a pace that far exceeds their recharge rate. At the same time, there is no clear, recent understanding on the stock of total water resources in the major aquifers. If freshwater stock exists for the next one hundred years at the current extraction rates, for example, it can contribute to a time-inconsistency problem whereby agents today have no incentive to switch to sustainable extraction because the costs will be borne by future generations. Bringing water use within sustainable bounds, without expanding water supply from other sources, would create availability pressure on users throughout the municipality – agricultural, industrial, and residential. In this section, we propose improving the price mechanism for both residential and agricultural users so that water be allocated to its most socially desirable uses, and thus support growth within sustainable bounds.

To support sustainable growth, water policy should both expand the supply of water and reallocate water to its most socially desirable uses. Expanding water supply will no doubt continue to be important in supporting growth, especially as economic growth and population growth tend to move together in spatial equilibrium (see Section 2.3). The scope for engineering solutions in expanding the water supply without increasing aquifer withdrawals has been much discussed, ranging from reducing water losses in distribution to expanding wastewater recycling schemes (Pineda Pablos & Navarro Navarro, 2023). However, the expansion of water supply without commensurate action to address the lack of incentives for appropriate use will mean that water can continue to be used inefficiently for activities of limited social value. More

fundamentally, without improving incentives, economic growth would rely more on expanding water supply instead reallocating water from low to high productivity uses. This seems a dubious strategy in the Sonoran Desert, where water is a precious and finite resource. Therefore, this section focuses on policies to improve water reallocation in Hermosillo.

There is significant scope for reallocating water to more efficient use, as both households and the agricultural sector are not exposed to water prices. In the municipality of Hermosillo, according to the 2022 CONAGUA REPDA database, 64% of water concessions are used for “Agropecuario”, while 33% go to “Agua Potable”, leaving about 2% for “Industrial Integrado”. Using data from CONAGUA we visualize the estimated breakdown of water usage at the aquifer level in Figure 54 below. Each bar is sized based on the share of Hermosillo’s water that comes from the aquifer, and its height shows the net extraction rate. Across all major aquifers, agriculture is the largest user, with drinking water as the second largest. Since agriculture does not pay for water within their concession limits, and only half of households are attached to a working meter (Pineda, 2024), roughly 80% of Hermosillo’s aquifer water is not exposed to a functioning water price. Thus, the typical market mechanism that would allocate water to its most productive use is not in place, in a context where water resources are severely constrained.

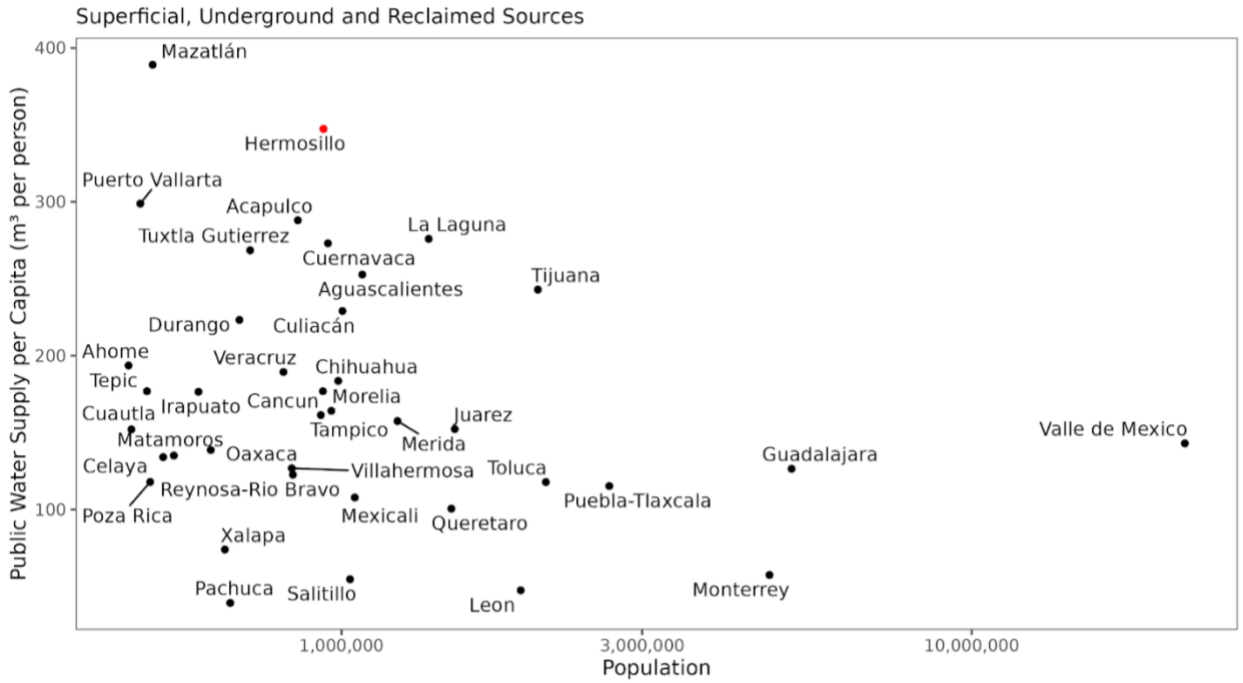
Figure 54: Hermosillo Aquifer Water Balance 2023



Source: Own Elaborations from CONAGUA Sistema Nacional de Información del Agua

Hermosillo is especially inefficient in its use of public water per capita. Figure 55 visualizes estimates of the public water used per capita in the most populated commuting zones in Mexico. This figure shows that Hermosillo has a remarkably high public water usage per person, using 3.5 times more than peer cities like Queretaro and Aguascalientes. This finding is consistent with the observation that economic units in the city are frustrated with water leakages and is one of the key priorities of Agua de Hermosillo. Expanding micro-metering can help identify sources of leaks, both within households and in the water delivery infrastructure, and is an intelligent policy that should continue to be pursued.

Figure 55: Estimated Public Water Usage per Capita (2023)



Source: CONAGUA REPTA, 2023; INEGI, 2020

Reforms that focus on improving water delivery infrastructure are impactful and necessary. Over-extraction from the main aquifers by Hermosillo in 2023 totals to about 186 Hm^3, according to data from CONAGUA in 2023. If Hermosillo were to bring its public water per capita consumption level to 148 m^3 per person, or roughly at the same level as Valle de Mexico and Villahermosa, it would reduce the required public supply enough to cover the over-extraction from the aquifers if all other variables were held constant. If it were to reach the level of Queretaro, it would save an estimated 230 Hm^3 of water, roughly 45 Hm^3 more than the amount needed to balance underground water withdrawals. However, according to this data, only 79 Hm^3 are pulled from underground sources for public use. If this amount were brought to zero, over-extraction would continue at over 100 Hm^3 per year, due to the extraction rate from the agricultural sector. To make increased efficiency in public water distribution result in reduced aquifer withdrawals, one would need to find ways to supply additional surface or recycled water to farmers in return for reduced pumping rates.

Table 3: Withdrawal and Recharge Rates by Aquifer

Aquifers in the Hermosillo Municipality

Aquifer	Recharge (hm^3)	Withdrawal (hm^3)	Net (hm^3)	Situation
Costa de Hermosillo	275.2	348.92	-73.72	Sin Disponibilidad
Mesa del Seri-La Victoria	73.0	106.52	-33.52	Sin Disponibilidad
Río Zanjón	77.8	100.52	-22.72	Sin Disponibilidad
Sahuaral	58.6	68.05	-9.45	Sin Disponibilidad
Arivaipa	15.2	14.99	0.21	Sin Disponibilidad
Santa Rosalía	11.8	11.23	0.57	Sin Disponibilidad
Río San Miguel	65.3	62.26	3.04	Sin Disponibilidad
Río Sonora	66.7	61.96	4.74	Con Disponibilidad
La Poza	33.8	21.56	12.24	Con Disponibilidad

Source: CONAGUA, 2023

Table 4: Water Usage in the Hermosillo Municipality

Grouped Water Usage in the Hermosillo Municipality

Water Usage	Underground	Reclaimed	Superficial	Total
Abastecimi	79.20	86.04	160.00	325.24
Agrícola	474.85	1085.40	11.18	1571.42
Ecológico	0.00	0.00	0.00	0.00
Hidroeléct	0.00	1.26	0.00	1.26
Industrial	5.50	0.66	0.00	6.16
Termoeléct	0.36	0.00	0.00	0.36
Total	559.91	1173.36	171.18	1904.44

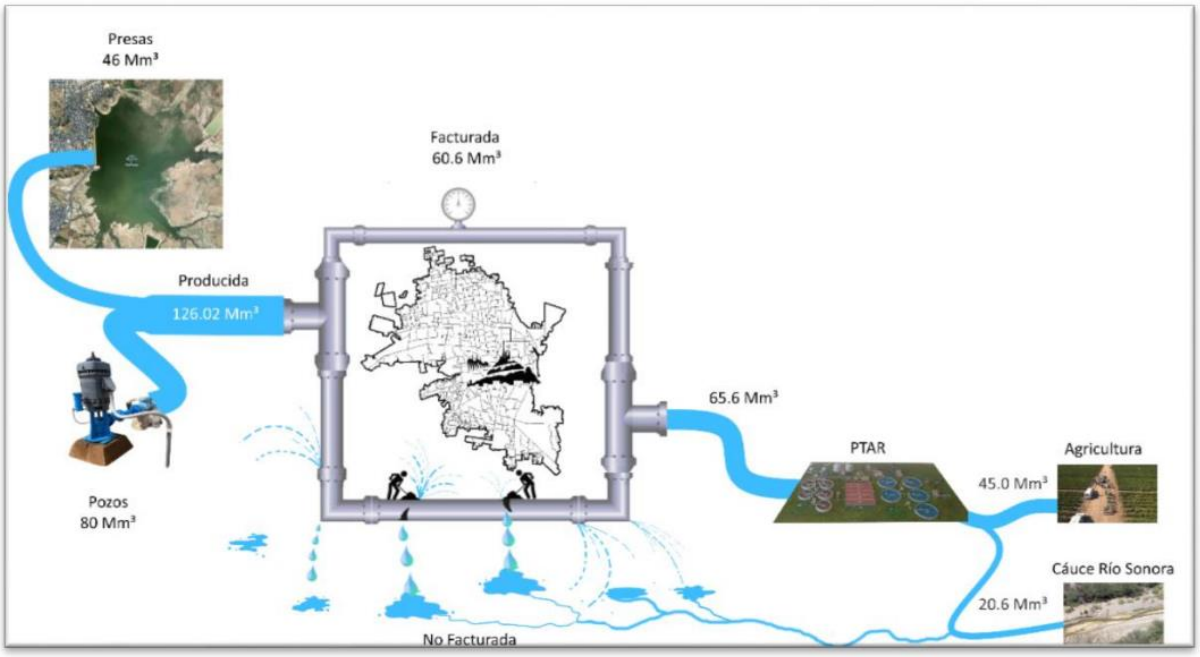
Source: CONAGUA, 2023

Current municipal water policy is rightly focused on expanding micro metering. Agua de Hermosillo's focus on expanding micrometers, which measure the usage of water at the household level, is a particularly efficient policy because it simultaneously enables the identification of physical water leaks in distribution infrastructure and

exposes households to the cost of their water consumption. It can therefore alleviate the constraint on new housing growth in the near term as well. As households are exposed to the cost of water delivery, they can modify their water consumption practices accordingly and allow for more efficiency in water allocation. Furthermore, it will mobilize much-needed revenue to close the operating deficits of the municipality, which further enables infrastructure and service delivery improvements. Leaks are a significant problem in Hermosillo, as visualized by Pineda Pablos and Navarro Navarro in Figure 56, almost equal in size to measured water. As households become accurately measured, it becomes possible to quantify the size of leaks in between the telemetry station midway through the distribution network and the end households. This enables triage and prioritization of large leaks within the distribution network, putting the city on a path to sustainable water usage.

As metering is expanded, it will be important to provide social protection for households who may find water unaffordable for their basic needs. Water is a human right, and schemes that increase the cost of water - which is required when the resource is precious - must take into consideration their distributional impact. Provisions to protect vulnerable households will be essential to support an aggressive expansion of water metering. Without such considerations, the metering policy can meet substantial social opposition which threatens the transition to sustainable water usage.

Figure 56: Water Flow in Hermosillo (2022)



Source: Elaborado por Elena Pineda y Luis Alan Navarro con base en datos de Agua de Hermosillo y con graficos de https://www.vecteezy.com/free-vector/gas Gas Vectors by Vecteezy.

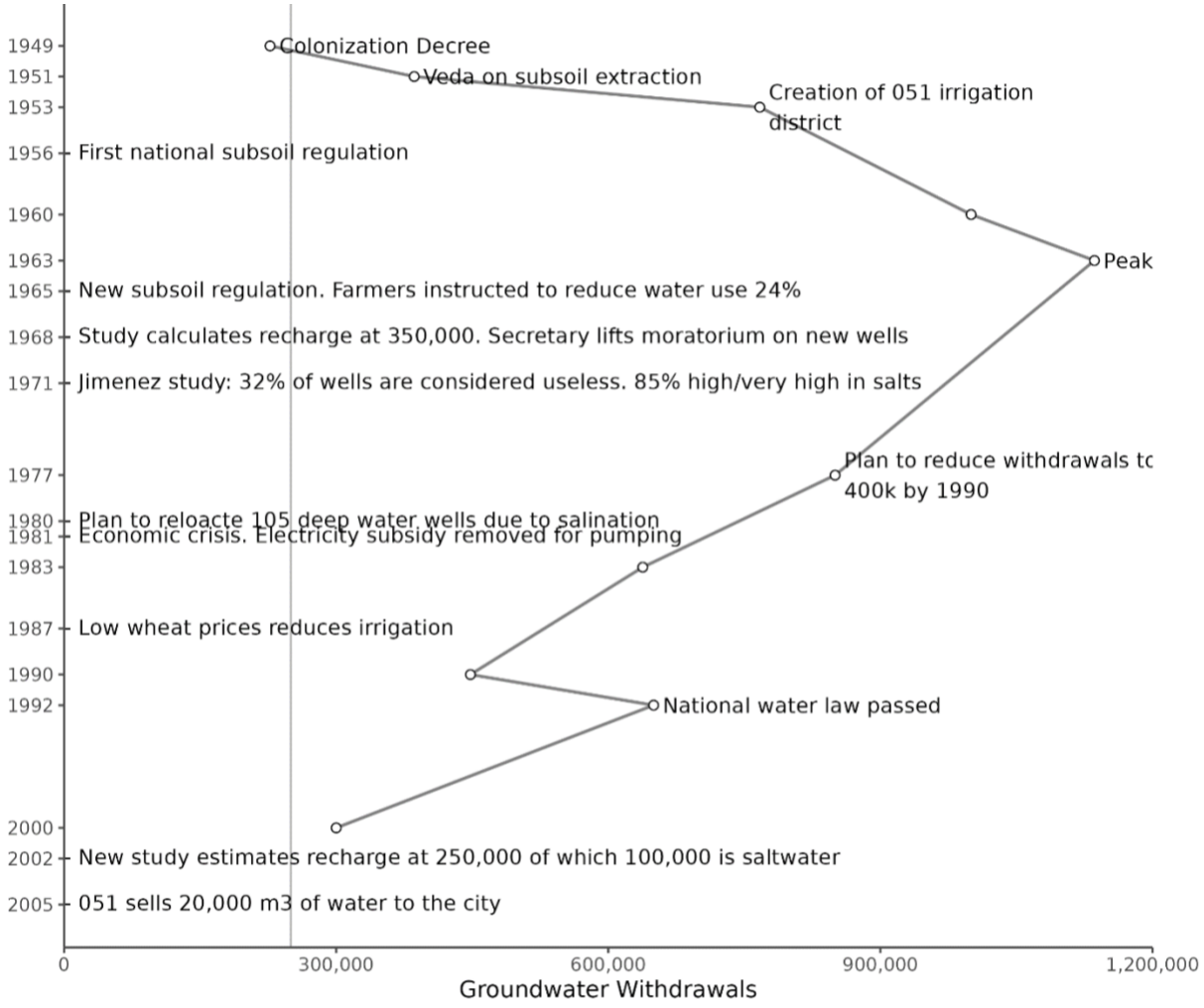
However, improving water delivery efficiency is not enough to resolve Hermosillo's water issues in the long term. In a static analysis, mobilizing additional water through improved efficiency can indeed bring Hermosillo closer to sustainable aquifer withdrawal rates. However, this analysis assumes all other variables are constant. In reality, water demand continues to grow as the city grows, both for industrial and housing needs. Currently, additional water mobilized through resolving leaks is allocated to new housing projects. This is evident in the design of the Agua de Hermosillo 'trust fund', through which additional capital given by housing developers awaiting water permits is used to expand micrometers, which in turn mobilize additional water, and thus unlocks the water permit for the housing developer. While it remains an impactful and critical policy directive, this example illustrates that improved efficiency today unlocks additional growth in Hermosillo, not necessarily reducing aquifer withdrawals to sustainable rates.

Policy gaps remain in addressing water for Agricultural use. 64% of Hermosillo's aquifer water concessions are for agricultural use. This water comes at no cost, and its pumping is further subsidized through discounted electricity rates. These water

concessions, pricing schemes, and the electricity subsidies received for pumping are all regulated by federal law and managed through CONAGUA. The municipality therefore has few formal policy levers it can affect to incentivize efficient water usage by its largest water user.

There are still opportunities to coordinate with the Agricultural sector. The *Asociación de Usuarios del Distrito de Riego No. 051* (ASUDIR 051) is a well-organized entity that manages the water concessions among farmers of the Hermosillo Coast. Historically, the 051 Irrigation Unit has been able to reduce its groundwater withdrawals from a peak of over 1,000,000 m^3 in the early 1960s to now about 358,000 m^3 in 2022 (CONAGUA, 2024; Moreno, 2012). Direct coordination between the group and the city has occurred in the past, as in 2005, when the association sold 20Mm^3 of water to the city at a cost of 140 million pesos (Moreno, 2012). Figure 57 below visualizes the water withdrawals of the Costa de Hermosillo aquifer from 1950 to 2005, showing significant historical events next to the water withdrawal levels over time. It shows a large spike in withdrawals after the 1949 Colonization Decree, and then a gradual decrease until 2005 as falling water levels and saltwater intrusion drove farmers and regulators to improve management of the underground resource. Ultimately, the record since 1949 demonstrates that Hermosillo has the capacity to coordinate and reduce water withdrawals.

Figure 57: Timeline of Groundwater Withdrawals in Hermosillo



Source: José Luis Moreno, 2012

The objective of such coordination should be to ensure sustainable groundwater withdrawals are achieved. This will require reductions in total withdrawals. The decision remains as to how those reductions should be allocated, between agriculture and the city, both today and over time. Under a typical market scenario, a reduction in supply would result in an increase in price, forcing users to modify their consumption and become more efficient in the use of the input. On the part of the city, expanding micro metering lays the foundation for incentivizing responsible water use by households and achieving full cost recovery for water distribution infrastructure. Improved efficiency could be achieved in agriculture, for example, through increased investment in irrigation technologies or a change in crop selection to ones which provide

more value for a given amount of water consumed. A 2012 study by (Salazar Adams et al., 2012) estimated that 90% of the current agricultural value could be produced with 33.4% of the water resources through a change in cropping patterns. In lieu of a pure price mechanism, quantity reductions or rationing could be undertaken, but would need to be updated periodically as water demand and supply changes over time. One way in which a quantity reduction could be executed is if the city again purchases water rights from farmers, as it did in 2005.

4.4.5 Key Takeaways

Hermosillo, like many Mexican cities, uses more water than it has. The municipality consumes all its surface water resources and the city's major aquifers are overexploited, implying that the stock of fresh water is decreasing. The lack of knowledge about the stock of underground water resources means there is no certainty on how long these extraction rates can continue.

In the 2018 growth diagnostic report, water was proposed as a potentially binding constraint to economic diversification. At the time, economic units reported relative dissatisfaction with the prevention of leaks, and only 35% felt water was affordable relative to 50% nationally. Industrial and commercial prices had seen substantial increases over the previous year, and legal disputes over the Independencia Aqueduct contributed to further uncertainty over water delivery to Hermosillo. The 2014 economic census showed that economic units were less intensive in their use of water than comparators on average.

However, updated evidence suggests water has not been binding for economic growth in the recent past. Satisfaction with the provision of water services improved from 54% in 2016 to 73% in 2020 (ENCRIGE). The updated 2019 economic census indicates that the economy became more intensive in its water use, bringing it to levels comparable with similar cities. Crucially, this data also reveals the relatively high presence of water intensive industries in Hermosillo, which have been competitive and

growing similarly to the rest of the economy. This evidence causes us to conclude that water has not been a binding constraint to economic growth between 2014-2019.

Anecdotal evidence suggests water may be binding for housing expansion today. Conversations with housing developers in the city revealed that there is difficulty obtaining water permits for new construction. Behind this difficulty is a water utility, Agua de Hermosillo, which is struggling with a financial constraint that prevents it from making investments which will reduce leakages and recover water. It will be important to monitor water for housing and real estate, as housing shortages can drive up prices and affect economic competitiveness.

Efforts to grow the economy without bringing water extraction within sustainable bounds could lead to an eventual crash. Reducing aquifer withdrawals would put pressure on the economy through a reduction in water supply, but an improved price mechanism for residential and agricultural users would help Hermosillo's water be allocated to its most socially desirable use. We estimate that roughly 80% of Hermosillo's water does not face a functional price today. Without this incentive system, economic growth is forced to rely more on the continual expansion of water supply than the reallocation of water from low to high productivity uses. On the residential side, the expansion of micro-metering is a particularly efficient policy as it both exposes users to prices and helps identify leaks in the distribution system. On the agricultural side, federal regulatory constraints demand more creative coordination between the city, farmers, and CONAGUA to arrive at a solution which reduces withdrawals. The historical record since 1950 in this regard demonstrates Hermosillo's remarkable capacity to conduct this coordination successfully.

4.5 Human Capital

Human Capital is not a binding constraint to growth. On the contrary, it continues to be one of Hermosillo's major assets. Compared to peers, the city's population has a high prevalence of high school, bachelor's, and doctorate level graduates. The city also has relatively high university enrollment rates, and its student's career choices are

skewed toward applied and hard sciences. Furthermore, we find returns to schooling are either not significantly different than in the rest of Mexico, or significantly lower than them, depending on the level and type of education. The migrant wage premium is insignificant in Hermosillo too. These facts suggest the labor market is not having trouble finding educated Hermosillenses. Similar to what was first noted by Barrios et al. (2018), we found that incomes in Hermosillo are still comparatively high, but that these differences are not explained by education or experience. The following subsections delve deeper into Hermosillo's human capital, its universities, the returns to education in its labor market, and the premiums paid to incoming migrants.

Hermosillo is the epicenter of Sonora's university system. The city is home to *Universidad de Sonora* (UNISON), the Technological Institute of Hermosillo (ITH), and a local campus of *Tecnológico de Monterrey*. UNISON first opened in Hermosillo in 1942 and has since expanded into 5 additional campuses, currently educating approximately 45 thousand students in 120 undergraduate and 50 postgraduate programs. ITH opened in 1975 and is currently a breeding ground for the engineers of Hermosillo's manufacturing sector. It has 12 undergraduate programs, 4 master's degrees, and a doctorate in engineering. ITH has 8 sister technological institutes in other parts of Sonora. *Tecnológico de Monterrey*'s Hermosillo campus opened in 1983, and currently has around a thousand students and 9 undergraduate degrees. It has another campus in Sonora, but the main one is in Hermosillo.

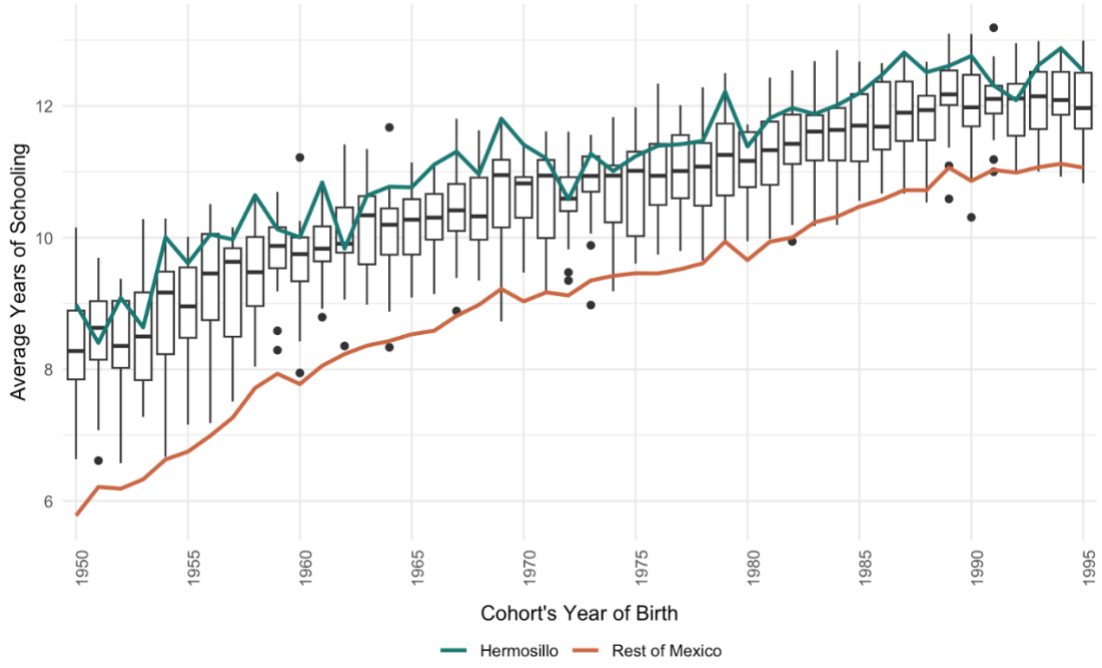
4.5.1 Diagnostic Testing

We performed three tests to diagnose if human capital was a binding constraint to growth in Hermosillo, based on Santos & Hani (2021). First, we observed whether the quantity of skilled human capital was abnormally low and found that was not the case. Then, we tested if the labor market was paying significantly high premiums for some types of education as a proxy for labor shortages and found no evidence of them. Finally, we tested if the market was having to pay high premiums to attract labor from abroad and found no evidence of such a migration premium in Hermosillo.

4.5.1.1 Testing Quantities

The population of Hermosillo has historically been highly educated. Due to a strong primary and secondary education system, and the early foundation of UNISON, Hermosillenses of all age cohorts have more years of schooling than the rest of Mexicans, on average. Figure 58 describes the average years of schooling per cohort for Hermosillo, its peers, and the rest of Mexico. Hermosillo and the rest of Mexico are shown as colored lines, while the distribution of peers is graphed as yearly box plots. Compared to its peers, Hermosillo tends to be above the 75th percentile in most cohorts. This is true for older, middle-aged, and younger cohorts.

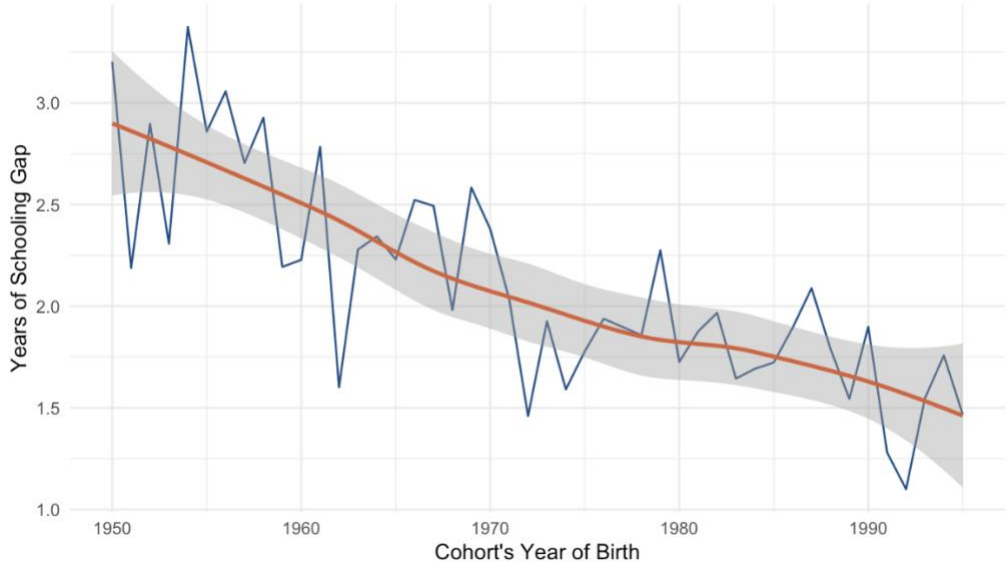
Figure 58: Years of Schooling by Age Cohort



Source: Author's calculations based on Censo de Población y Vivienda 2020 and INEGI. Note: Box plots represent the distribution of peers, while the two lines represent Hermosillo and the rest of Mexico

The gap between Hermosillo's level of education and that of the rest of Mexico has been shrinking. Cohorts born in 1950 average around 3 years of schooling more than the rest of Mexico, but this gap has now halved to 1.5 for those born in 1995, as education in the country catches up to Hermosillo's standards. This dynamic is visualized by Figure 59.

Figure 59: Schooling Gap Between Hermosillo and the Rest of Mexico, by Cohort



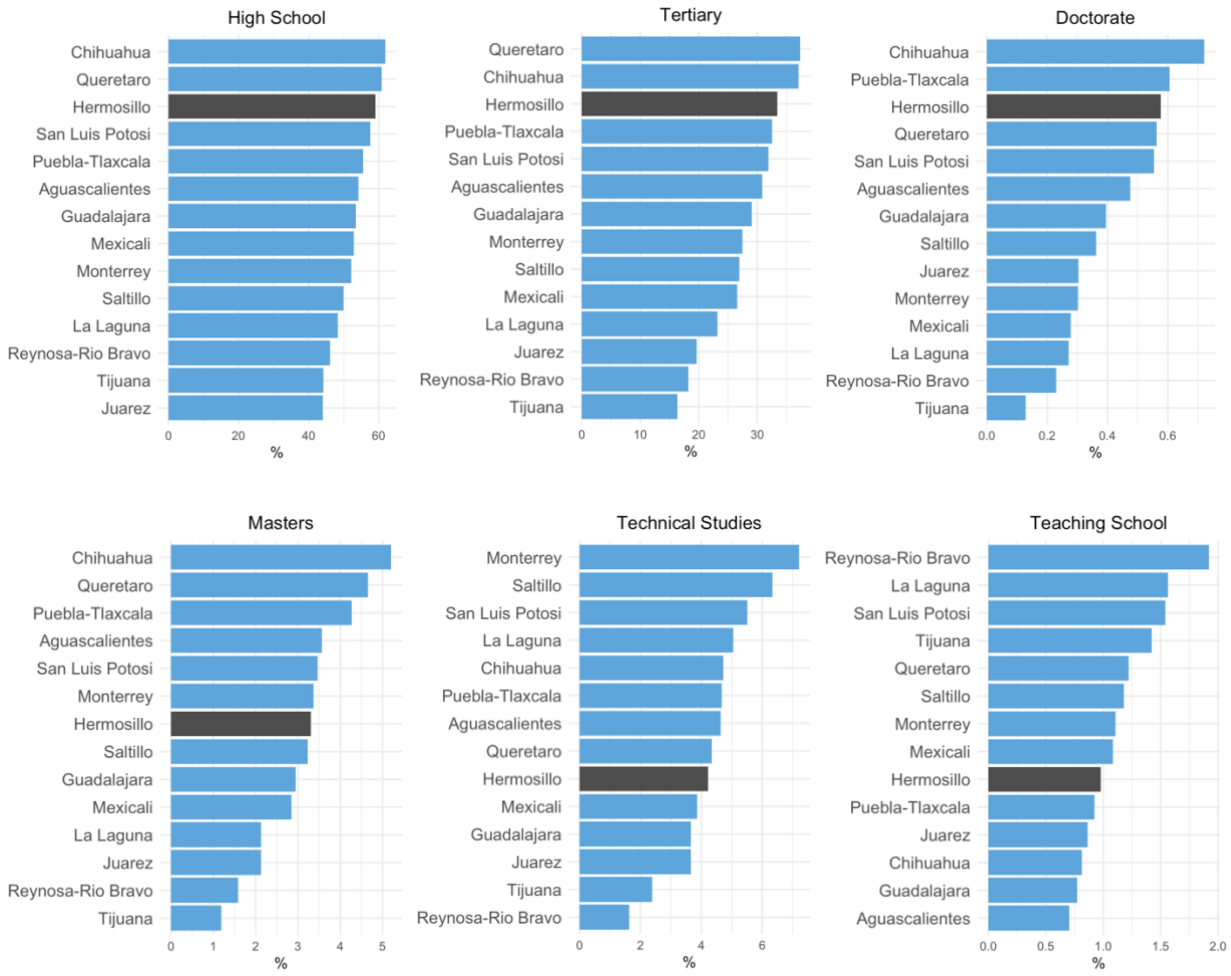
Note: Shaded area represents confidence interval. Source: Author's calculations based on Censo de Población y Vivienda 2020 and INEGI.

Hermosillo's education system is robust at the basic and university level. Over 90% of the working-age population has completed primary and secondary education, and almost 60% completed high school. For the purpose of this analysis, the working age population was defined as those between 25 and 60 years old. We know from Figure 58 that younger cohorts have more years of schooling, so previous figures should not be misconstrued as current completion rates. Comparatively, the prevalence of high school degrees is high in Hermosillo (Figure 60). The same can be said for tertiary degrees and doctorates, which are held by 33% and 0.8% of working age Hermosillenses, respectively. Broad university education is a distinguishing factor between Hermosillo and border maquila-intensive cities such as Tijuana, Reynosa, Juarez, or Mexicali.

Some types of degrees are less abundant (Figure 60). This is the case for master's level education, technical studies, and those from teaching schools (*Escuelas Normales).* Schooling for teachers is more popular in cities like Reynosa, La Laguna and Tijuana, where going to a university is less common. Technical studies are programs oriented towards labor force preparedness. They tend to be developed in coordination with labor-intensive firms, and last one or two years. Students usually have the option of

going through 2 or 3 more years of education after their technical studies to earn a university degree. In the context of nearshoring, incoming multinationals benefit from locating in cities with versatile technical study systems, where new and tailor-made programs can be structured months before the start of their operations. The underwhelming prevalence of master's and technical study degrees in Hermosillo could be worrying.

Figure 60: Share of Working Age Population with Completed Studies, by Type (2020)



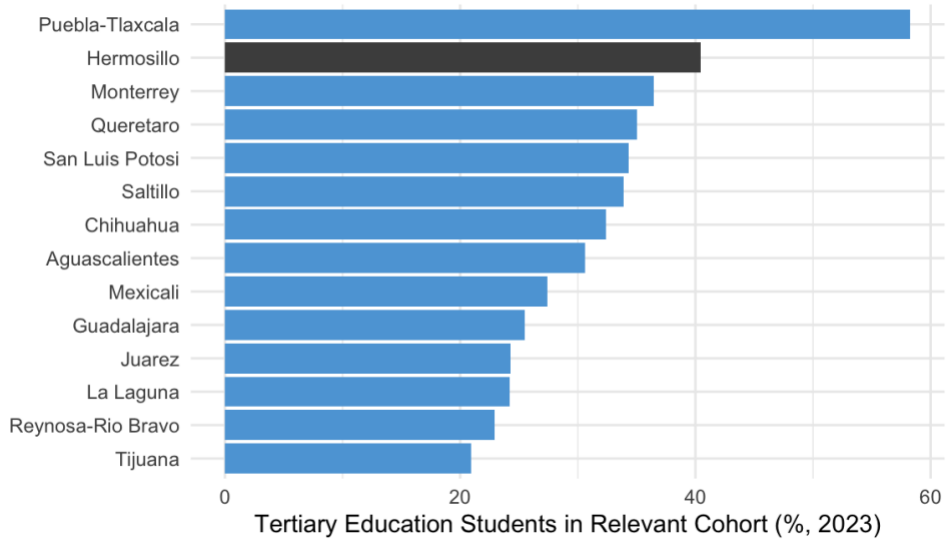
Source: Author's calculations based on Censo de Población y Vivienda 2020 and INEGI. Note: Working age population was defined as those between 25 and 60 years old.

Hermosillo's university education is high across most broad career categories. Compared to its peers, Hermosillo's stock of university graduates is higher than average

all across the board, except in “arts & humanities”. Notably, the population share with degrees in “Natural sciences, mathematics, and statistics” is more than double that of the average peer. In absolute terms, the largest differences in population shares are in “Business administration” and “Social sciences & law”. However, these last two majors seem to have fallen out of fashion with today’s youth, which have shifted their career choices compared to the average in Hermosillo.

Current university enrollment rates are high for Hermosillo, but not for greater Sonora. 40% of college-aged Hermosillenses are currently enrolled in higher education. This is the second-highest rate among peers, as shown in Figure 61. However, the same is not true for Sonora, which has a tertiary enrollment rate slightly below the Mexican average. This means that excluding Hermosillo, university enrollment in Sonora is much lower than the Mexican average, and young Sonorans may look to migrate to Hermosillo to complete their studies.

Figure 61: Current University Enrollment Rates

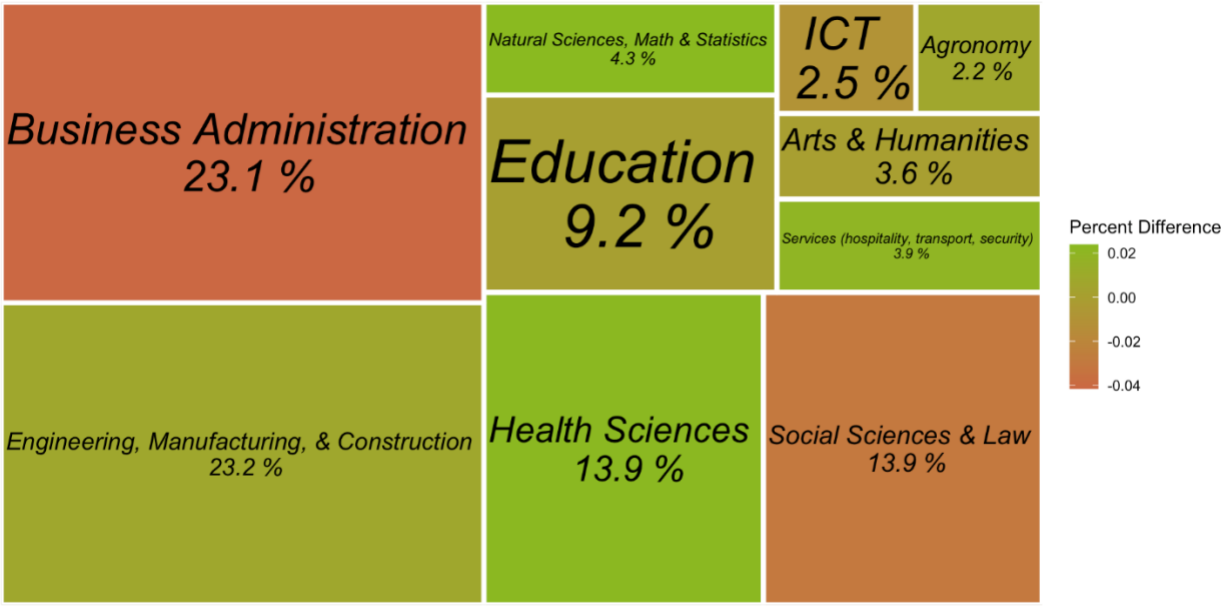


Source: Author’s calculations based on data from ANUIES, and Censo de Población y Vivienda 2020 *(INEGI). Note: Relevant cohorts consist of individuals aged 18 to 23 years old within in each commuting zone.*

Young students tend to enroll in STEM majors. Although “business administration” and “social sciences & law” are the most overrepresented degrees in Hermosillo’s working age population compared to peers, they are now the two most

underrepresented majors for currently enrolled students (Figure 62). “Information and communication technologies” are also underrepresented among current students. In contrast, degrees in “health sciences” and “natural sciences, mathematics, and statistics” are overrepresented in Hermosillo’s universities today. Hermosillenses are also slightly more likely to choose careers in services, engineering, and agronomy compared to peers.

Figure 62: Hermosillo's University Graduates by Major, Compared to Peers (2023)



Source: Author’s calculations based on data from ANUIES, and Censo de Población y Vivienda 2020 (INEGI). Note: The size of boxes is determined by the share of students who graduated from each major in Hermosillo in 2023. The color of each box is determined by their degree of over or underrepresentation as a share of degrees in Hermosillo, compared to the average share of that degree among peer cities. This is measured in percentage point differentials.

4.5.1.2 Testing Prices

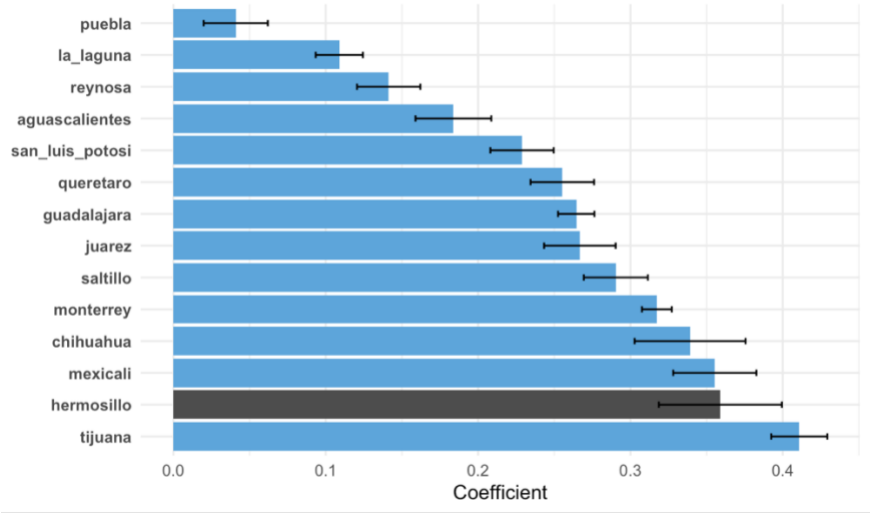
The 'Testing Prices' section serves to determine whether educated workers are in short supply compared to market demand. **A highly educated workforce and elevated enrollment rates in tertiary education – with a bias towards STEM – are** insufficient **conditions to rule out education as a constraint**. This subsection analyzes labor market prices to see if demand is higher than supply for some education levels, types, or degrees. If human capital was a constraint, we would expect to observe high

premiums locally. If not, there would be no evidence of relative shortages, and the market would presumably be meeting demand endogenously.

We used Mincer-type regressions to model city-level premiums for different education levels and majors. The two main regression models are visualized in the following three Figures. The first model is a standard Mincer regression. We use the natural logarithm of income as the dependent variable. Independent variables include years of experience (and years of experience squared), every level of education as a dummy (except for preschool and below, which are assumed as the baseline), interaction terms between each selected city dummy (Hermosillo and its peers) and specific degrees (tertiary, master's, doctorate, and technical studies), and controls (gender, race, and ethnicity). The second model differs in three ways: We exclude dummies for levels of education and add years of schooling instead. We add dummies for 10 broad major categories and interact them with an Hermosillo dummy. Lastly, peer dummies are excluded. For both regressions the sample was restricted to individuals between 25 and 40 years old, as we are concerned with measuring proximate returns to schooling.

The finding that Hermosillenses earn a high income regardless of their level of education is robust. Under multiple specifications, Hermosillo's baseline income coefficient is positive and higher than that of most peers, which is consistent with Barrios et al. (2018). This means that controlling for education, Hermosillenses earn a higher income than most of their peers and the rest of Mexico's average. Figure 63 compares the baseline coefficients from the first model.

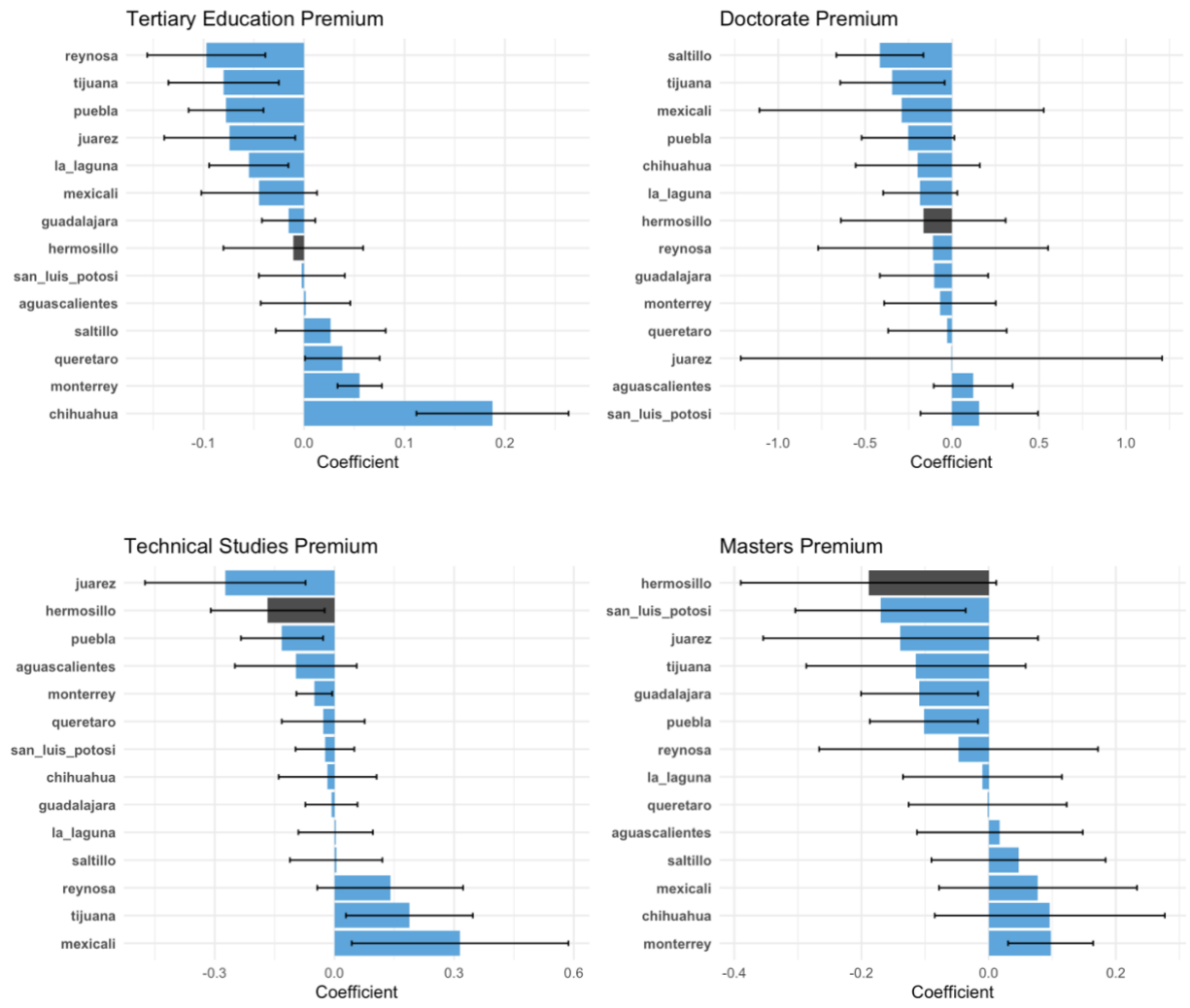
Figure 63: Baseline Location Coefficient from Mincer Regression, by city (2020)



Note: Bands represent confidence intervals at the 95% threshold. Source: Author's calculations based on Censo de Población y Vivienda 2020 *and INEGI.*

Returns to schooling are either statistically indistinguishable from those in the rest of Mexico or significantly lower than them, which is a strong indication of human capital not being a binding constraint for economic growth. The first model estimates distinct coefficients for the returns to each degree in the rest of Mexico and those are assumed as the baseline coefficient for a given degree. In addition, we estimate an interaction coefficient between those degrees and a dummy for Hermosillo and each of its peers. These interaction coefficients represent the deviation of returns to that degree in each location from those in the rest of Mexico. If these were significantly higher in Hermosillo, that would suggest the city is having to pay high premiums to attract missing talent. As shown in Figure 64, all four coefficients are lower for Hermosillo than for the rest of Mexico. Some are not statistically distinguishable, and others are indeed significantly lower. This means that the labor market is not undergoing extraordinary pains to hire workers with these characteristics, at least compared to Mexican standards.

Figure 64: Returns to Education in Hermosillo and Peers by Level, Compared to the Rest of Mexico (2020)

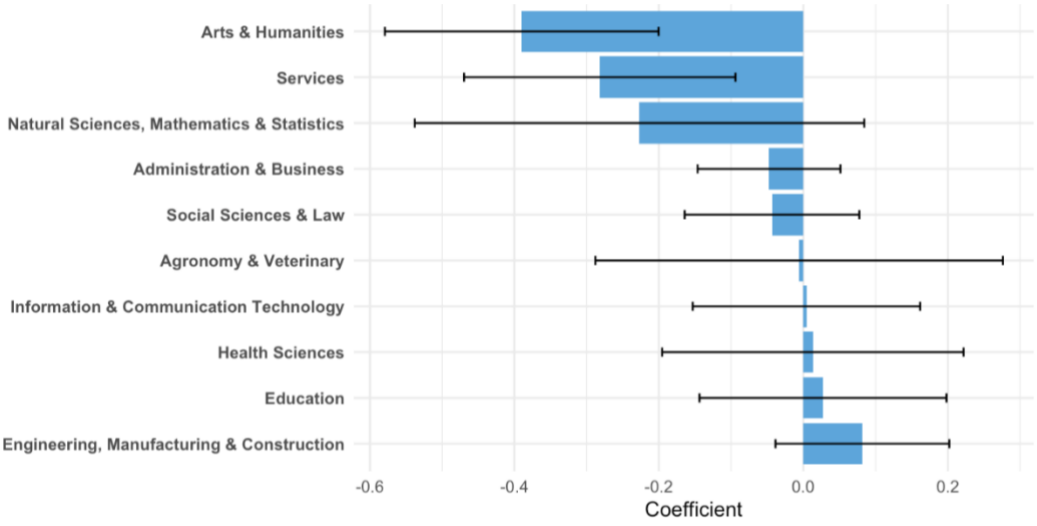


Source: Author's calculations based on Censo de Población y Vivienda 2020 and INEGI. Note: Bands represent confidence intervals at the 95% threshold.

Hermosillo's labor market is unlike that of border cities or Monterrey. Border cities such as Mexicali, Tijuana, and Reynosa pay relatively lower premiums for tertiary education and higher premiums for technical studies. Monterrey, Chihuahua, and, to some extent also, Saltillo are on the other end of the spectrum, paying higher premiums for both tertiary education and master's degrees. Hermosillo does not fit neatly into any of those groups. It does not pay extraordinary premiums for any level of education, on average.

Disaggregating returns to higher education by concentration also shows no evidence of labor shortages. The second model tests whether returns to higher education are significantly different from the rest of Mexico, depending on the major of concentration (Figure 65). Again, no premium is significantly higher than in the rest of Mexico, and returns are substantially lower in the case of "services" and "arts & humanities". Natural sciences, mathematics, and statistics also have a very low premium, albeit with quite a wide confidence interval.

Figure 65: Returns to Higher Education in Hermosillo by Major, Compared to the Rest of Mexico (2020)

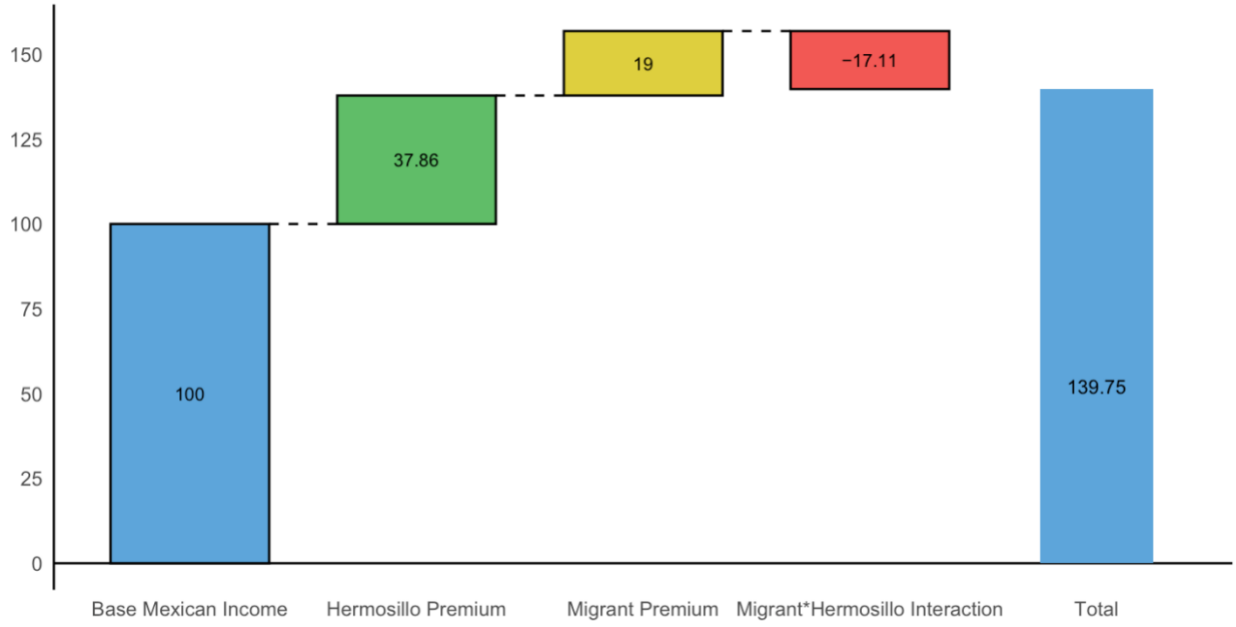


Source: Author's calculations based on Censo de Población y Vivienda 2020 and INEGI. Note: Bands represent confidence intervals at the 95% threshold.

4.5.1.3 Testing for Agents Attempting to Overcome the Constraint

Places that are constrained by human capital tend to pay a premium to attract it from elsewhere. Santos & Hani (2021) describe the example of Panama, where firms attempting to bypass their labor shortages were paying an average premium of 47% to foreign migrants. For this particular test, we define migrants as those who reported living in different cities between 2015 and 2020. This includes internal migration as well as foreign migrants and Mexican return migrants. On average, the migrant wage premium in Mexico was 19% in 2020.

Figure 66: Migration Premium in Hermosillo (2020)



Source: Author's calculations based on Censo de Población y Vivienda 2020 and INEGI. Note: This figure visualizes the results of a regression where income was also controlled by years of schooling, experience, gender, and ethnicity.

The migrant wage premium in Hermosillo is insignificant. As shown by Figure 66, Hermosillo's migrant premium is 17.1 percentage points lower than that of Mexico. Put differently, the labor market only pays incoming migrants 1.9% more than locals, on average. However, based on the standard error of this estimate, it is not statistically distinguishable from zero. This is not the case for some of Hermosillo's peers. For example, the coefficient for Aguascalientes is slightly positive, meaning the point estimate for its migrant premium is higher than the Mexican average. Querétaro, Puebla, San Luis Potosi and Chihuahua also have coefficients that are not significantly different from the Mexican average. This is another sign that Hermosillo's firms are not having to overcome a human capital constraint.

4.5.2 Key Takeaways

Human Capital is a strength of Hermosillo. Hermosillo's workforce is highly educated, including older and younger cohorts. The city has a relatively high rate of high school and university graduates. Tertiary school enrollment rates continue to be one of the highest compared to peers, and students are disproportionately choosing careers in mathematics, science and engineering. Hermosillo also hosts a relatively high quantity of professionals with PhDs, which produce substantial academic publications with above average citation rates (further detailed in section 4.6.1).

Diagnostic tests show no signs that human capital could be a binding constraint to growth. Returns to education are not high in Hermosillo for Mexican standards or compared to its peers. We do not find significantly high premiums even after disaggregating by type of degree or major of concentration. Furthermore, firms are not paying significantly high premiums to attract human capital from outside of the city. In fact, this premium is statistically indistinguishable from zero in Hermosillo.

4.6 Innovation

Firms and research institutions in Hermosillo have innovative capabilities. However, the private sector is disengaged from the formal innovation process. Businesses in Hermosillo frequently tinker with their pre-existing technology, which is a sign of capabilities for in-house marginal innovations. As previously argued in Section 4.5, the education of Hermosillo's population and the city's university system are considered to be major strengths. This university system has evolved into a successful ecosystem for academic publications that could potentially be leveraged for collaborative innovation projects with the private sector. However, this is not occurring in the present. Hermosillo's patenting activity is low and has historically occurred among innovators un-affiliated to the productive sector. Companies also have low levels of investment in R&D and low employment in patenting occupations, which naturally has translated into poor outcomes in the generation, registration and commercialization of new proprietary technologies. This section dives into Hermosillo's innovation capacity by

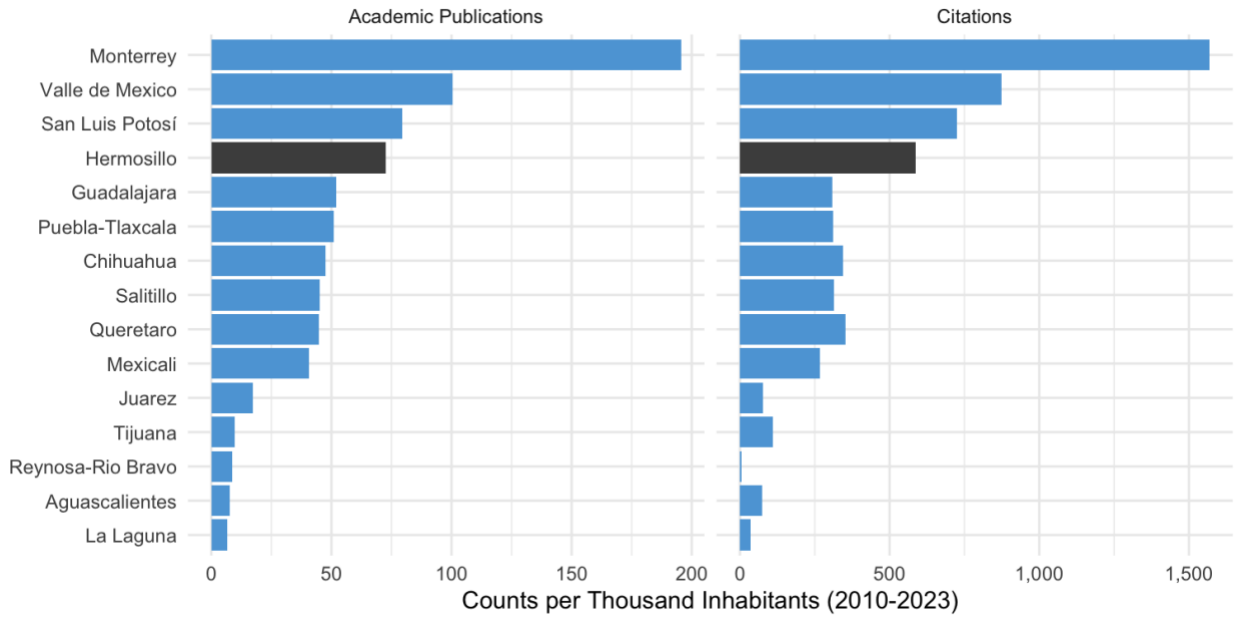
analyzing academic publications, patent registration, and within-firm technological improvements.

4.6.1 Academic Publications

Academic and patenting capabilities are correlated. Hausmann et al. (2023) finds that places tend to diversify into patent technology classes that are related to fields in which they publish academic papers. The distribution of scholarly publications is less geographically concentrated than that of patents. Hausmann et al. (2023) observe international convergence in the diversity and complexity of academic publications, which means that although developing countries have not caught up in terms of economic growth with the developed world, they are doing so in terms of academic publications. Further, the study shows a significant correlation between the complexity of a place's academic publications and its GDP per capita growth rate over the following two decades. International evidence shows that the degree to which a place produces scientific publications is a strong predictor of future economic growth. In addition, testing with vector autoregression models we find that – at least before reforms were introduced in 2019 – there was a significant correlation between publications and patents within the sample of Hermosillo and its peer cities. This correlation holds with a lag of 4 to 6 years, depending on the regression specification.

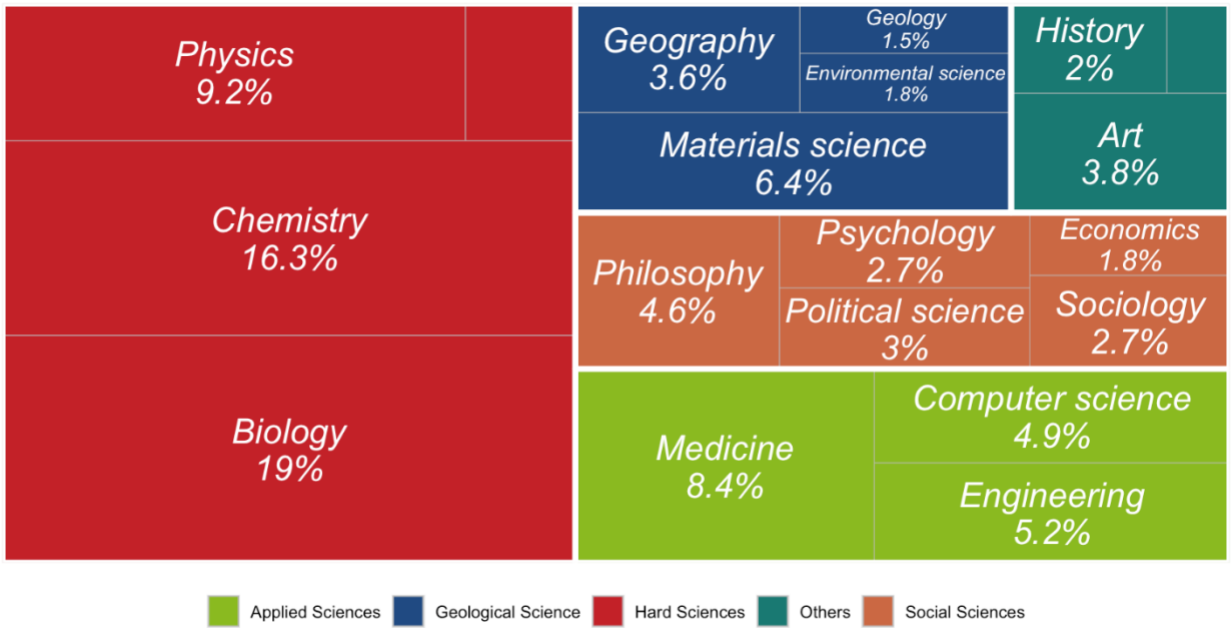
Hermosillo has developed a successful ecosystem of academic publications. It is in the 99th percentile among Mexican cities in terms of number of academic publications, citations and authors involved, and was among the 10 best performers in all three metrics during 2023. The city has over a hundred research institutions and around three thousand academic paper authors. Figure 67 shows cumulative per capita academic publications and citations since 2010 for Hermosillo and peers. Besides a high degree of publications, an above-average rate of citations per publication indicates high quality. A decomposition of publications by field is also visualized in Figure 68.

Figure 67: Academic Publications, Authors, and Citations per capita (2010-2023)



Source: Author's calculations based on data from Open Alex, consolidated by Hausmann et al. (2023).

Figure 68: Hermosillo's Academic Publications by Field (2023)



Source: Author's calculations based on data from Open Alex consolidated by Hausmann et al. (2023), and Censo de Población y Vivienda 2020 from INEGI.

4.6.2 Intellectual Property

Hermosillo's patenting performance must be understood in the context of Mexico's innovation ecosystem. Innovation policy and financial support were historically channeled through the National Council for Science and Technology (CONACYT), which provided funding for scholarship programs, housed various trusts supporting research institutions, provided research grants to members of the National System of Researchers (SNI), and supported research institutions and innovative firms through the Innovation Stimulus Program (PEI). It also conducted useful innovation surveys following OECD guidelines.

CONACYT underwent drastic reforms, raising the vulnerability of Mexico's innovation. Its budget was first cut by a third from 2015 to 2018 in nominal terms. Under the new administration, CONACYT then endured structural reforms and further budget cuts. The PEI and innovation surveys were scrapped in 2019, and the trusts that financed research institutes were eliminated in 2020. In 2023, new reforms centralized research support under the direction of public officials, who now decide what is considered a priority area, and exclusively fund public sector organizations. Mexico's federal goal of spending 1% of GDP on innovation was eliminated, and the council was relabeled to CONAHCYT. Thus, there is currently limited support for innovation from firms, universities and research institutes in the private sector. There are also limited scholarships for the education of future innovators in private universities.

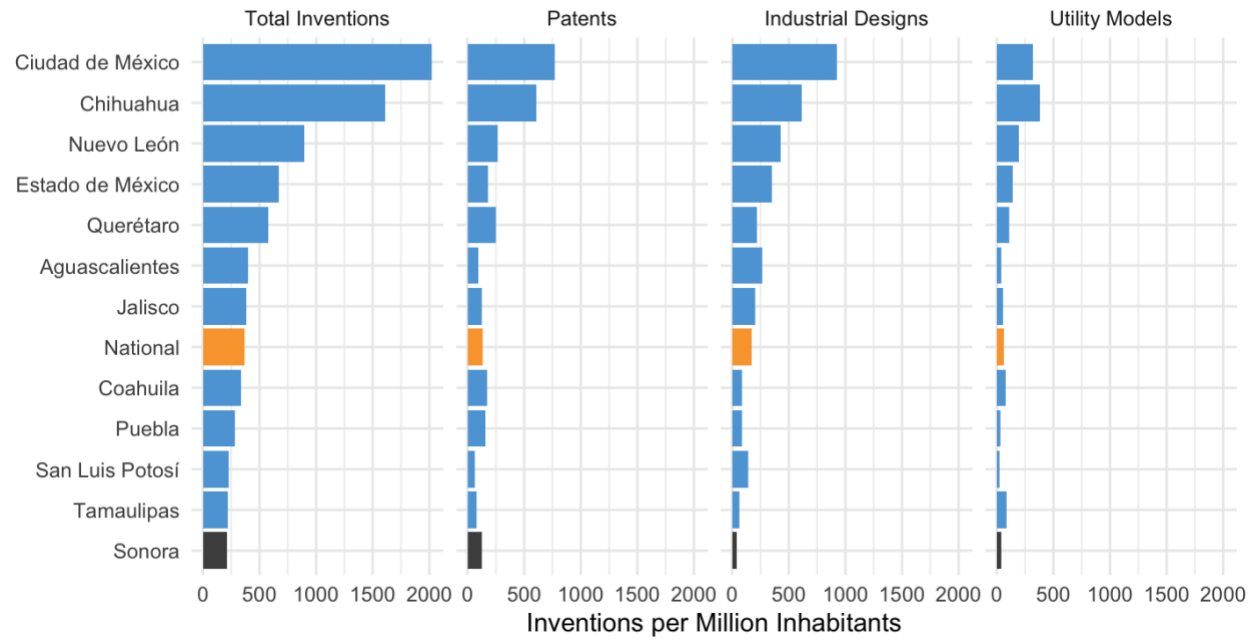
Hermosillo should leap from publications to innovation and patents, but its research institutions have not been able to do so. Following reforms to CONACYT, there needs to be a more symbiotic relationship between the research community and firms. The Technological Institute of Hermosillo (ITH) already has a link-up council or *Consejo de Vinculación* coordinating joint projects with the productive sector. However, this council mostly focuses on joint labor force training programs instead of technological research and development. Sonoran universities have not readjusted after the withdrawal of CONACYT, and still have no alternative internal mechanisms in place

to structure joint research contracts and receive funding from private firms. This constitutes a missed opportunity, given that Hermosillo's academic community has consistently published well-cited research in fields that are related to local industrial activity.

The Mexican Institute for Industrial Property (IMPI) offers federal protection for patents, utility models, industrial designs, and integrated circuit designs. Patents are an intermediate step in the process of inventing a new marketable idea, so they represent a valuable – albeit imperfect – resource for assessing the absence or existence of innovative capabilities in a given location. Utility models are a simpler alternative to patents. The novelty requirement and examination process of these innovations is not as stringent, and they offer protection for shorter periods. Industrial designs are mostly aesthetic protections to shapes and patterns, and integrated circuit designs are similar but associated to semiconductors.

Sonora accumulated the fewest applications to IMPI per capita among peer States in the 2010-2023 period. Figure 69 shows accumulated intellectual property applications to IMPI per million inhabitants by type of invention, for a selected group of Mexican States. Integrated circuit designs are not included in the figure because Sonora filed zero applications, because there is no semiconductor design activity in the State. Sonora performed below the national average in all categories and was especially poor on industrial designs.

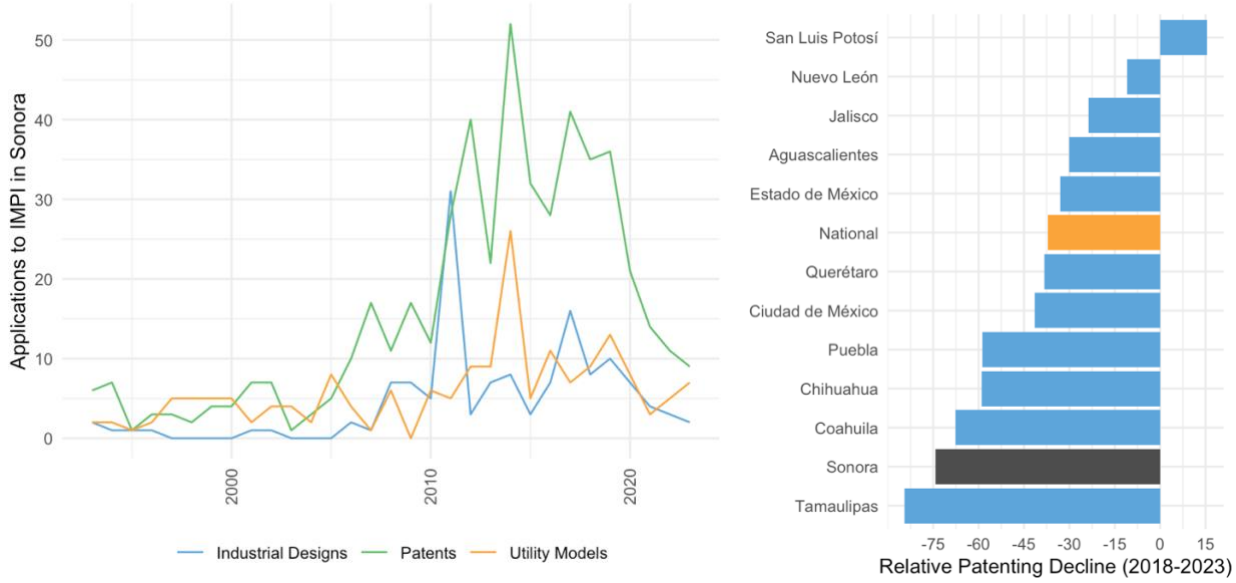
Figure 69: Accumulated Innovations per capita by State (2010-2023)



Source: Author's calculations based on data from IMPI and Censo de Población y Vivienda 2020 from INEGI.

Sonoran patents, industrial designs, and utility models all followed a pattern of sharp decline after reforms to Conacyt in 2019. Data from IMPI suggests that Sonora's innovative ecosystem was particularly reliant on the programs and funding sources that were quickly eliminated by the new administration of CONACYT (PEI and research institute trusts). The left panel from Figure 70 shows how all types of inventions in Sonora experienced slight increases in 2019 before contracting in 2020. The most significant contraction occurred in patent registration (which was reduced by 75%, 2019-2023). The right panel from Figure 70 shows that peer States experienced similar contractions in patenting after 2019, but Sonora stands out by its magnitude. For some reason, Sonora proved less resilient than States such as San Luis Potosi, Nuevo Leon, Jalisco, and Aguascalientes. In contrast to intellectual property, Hermosillo's academic publications were more robust and showed no signs of contraction following reforms to CONACYT.

Figure 70: Evolution of Locally Registered Innovations



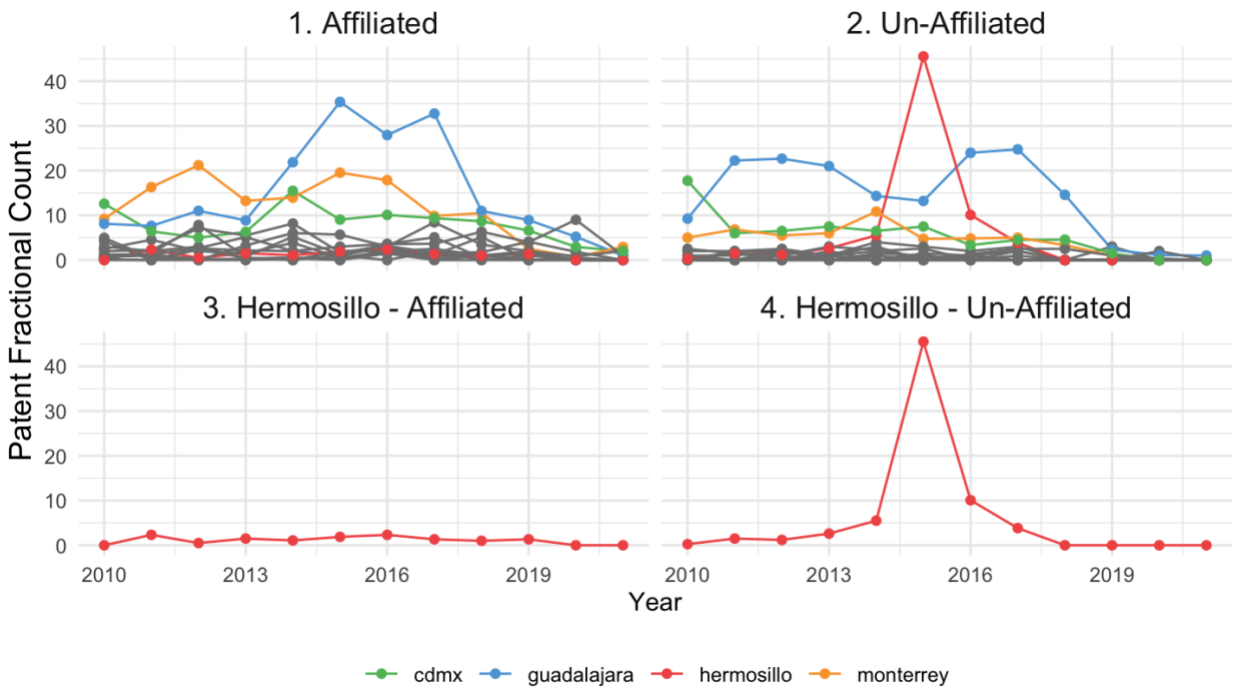
Source: Author's calculations based on data from IMPI.

Most of Hermosillo's patents were not affiliated with any research institute, university, or firm. The European Patent Office's Patent Statistical Database (PATSTAT) provides standardized data on global patenting activity. It includes patents registered at the international and national level for over 80 countries. We merged PATSTAT with REGAPAT, and OECD dataset that links each patent to the address of its authors. The merged data was used to identify patents where at least one author belongs to Hermosillo or its peer cities, assigning them patent fractional counts under standard methodology. From 2010 to 2021, Hermosillo ranks fourth among peers in patent fractional counts after Guadalajara, Monterrey, and Mexico City. However, 84% of Hermosillo's patents are assigned to an individual instead of a research institute, university, or firm. This odd pattern is not observed in other peer cities, except for Aguascalientes. These unaffiliated patents are observed to have a higher rejection rate from the European Patent Office, implying subpar quality. When accounting only for the patents that are affiliated with an organization, Hermosillo is among the worst performers, with only 14 patent fractional counts from 2010 to 2021. In contrast,

successful patenting cities such as Guadalajara, Monterrey, and Mexico City accumulated 179, 135, and 94, respectively.

Over half of the patents of authors from Hermosillo in the past decade were filed in 2015 and had an unaffiliated assignee. The fact that most patents were filed in 2015 is odd and only involved unaffiliated patents. As shown by Figure 71, patents affiliated to firms or research institutions were almost inexistent in Hermosillo, and zero unaffiliated patents have been registered since 2018. From 2018 to 2021, only 2.3 patent fractional counts are associated to the city. These factors point to the existence of limited patenting capabilities in Hermosillo even before reforms to CONACYT and raise questions about the nature and quality of unaffiliated patents.

Figure 71: Patent Fractional Counts from Patstat in Hermosillo and Peer Cities



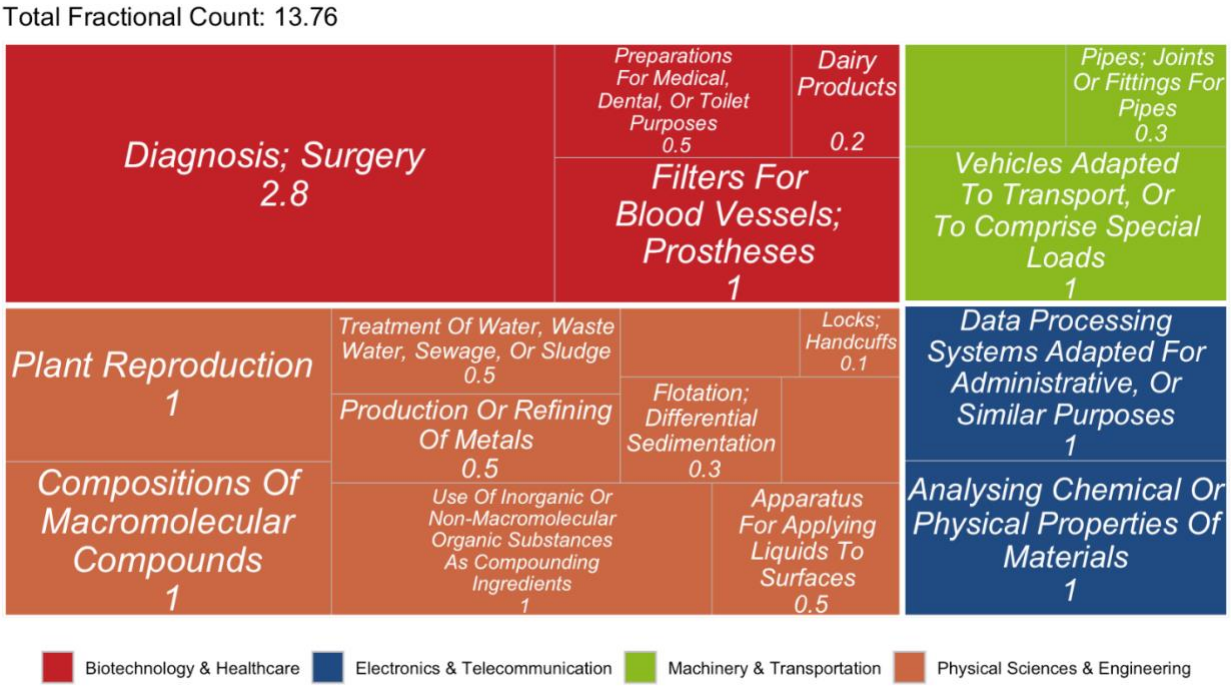
Source: Author's calculations based on data from PATSTAT.

Hermosillo's unaffiliated patents are more diverse than its affiliated patents. Hausmann et al. (2023) find that the diversification and development of patenting and academic publication capabilities are path-dependent. This means that if innovators

manage to diversify their patenting into different technology classes, they are likely to be similar to the technologies they had already developed in the past. The paper also shows that the technology classes in which a region develops patents are correlated to the region's revealed comparative advantage in the export of related products. Over the past decade, Hermosillenses, associated with firms, universities, or research institutes, developed patents in 19 technology classes (Figure 72). Those unaffiliated to any institution patented in 60 technology classes (Figure 73).

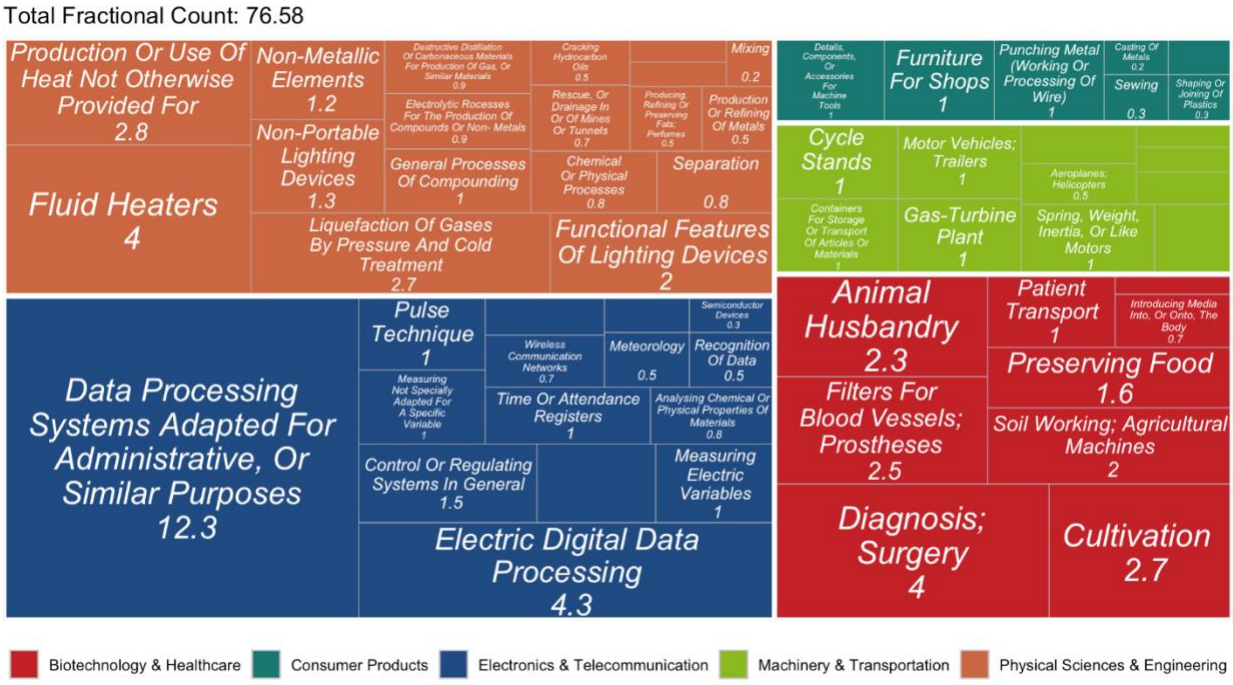
Despite the dubious quality of some of Hermosillo's patents, data suggests there are embryonic capabilities that could be leveraged by the private sector. We estimated the degree of industrial overrepresentation by location, conditional on the composition of their patents. This resulted in a measure of co-location between patents and industries across cities in Mexico. Among the 19 technology classes where patents had an institutional affiliation in Hermosillo, we found associations with the automotive, aerospace, machinery, chemicals, plastics, metals, water treatment, and agriculture sectors. Hermosillo should build from these capabilities to improve innovation outcomes.

Figure 72: Hermosillo's Affiliated Patents by Technology Class (2010-2021)



Source: Author's calculations based on data from PATSTAT.

Figure 73: Hermosillo's Un-Affiliated Patents by Technology Class (2010-2021)

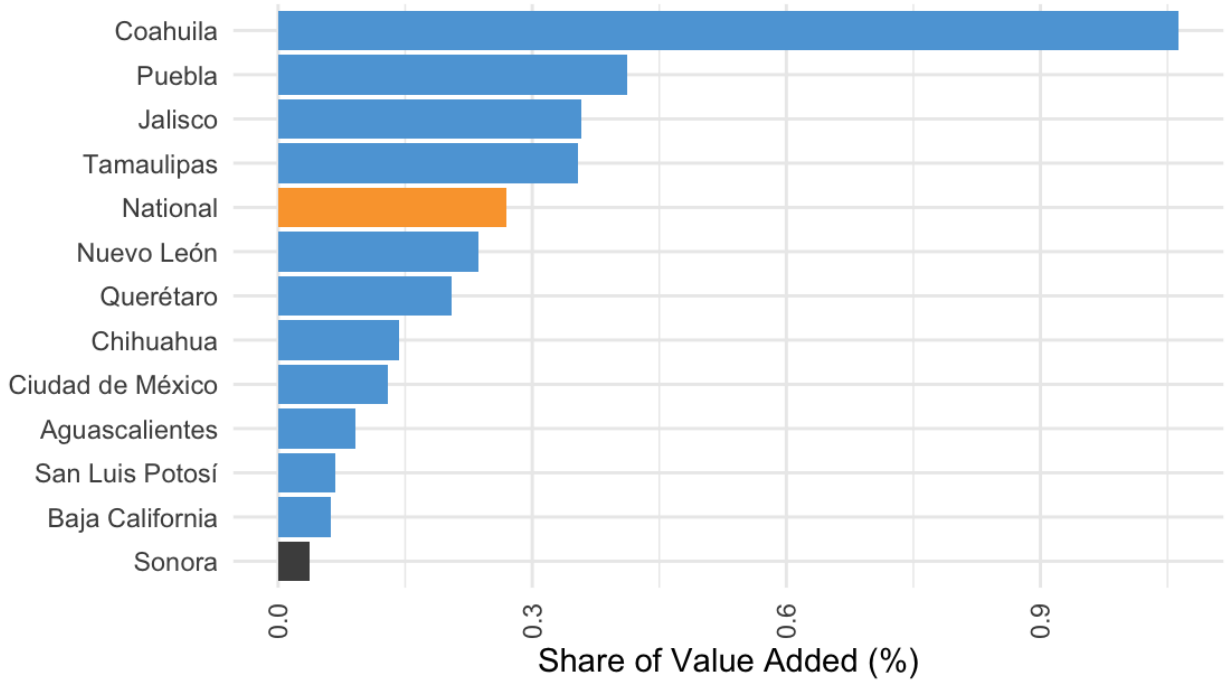


Source: Author's calculations based on data from PATSTAT.

4.6.3 Within-Firm Innovation

Sonora's large firms make few investments in research and development, given their value added. From 2016 to 2018, large firms invested over 1% of their value-added on R&D in Sinaloa, Guanajuato, and Coahuila. In Sonora they only invested 0.04% of their value-added, as shown by Figure 74 This is less than a sixth of the national average, and it helps explain Sonora's low levels of patenting. If investment is low because expected returns to R&D are also low, then further research would be required to understand why. Otherwise, this represents a missed opportunity for firms to collaborate with Sonora's and Hermosillo's capable academic sector and use its human capital.

Figure 74: R&D Spending by Large Firms as a Share of their Value Added (2016-18)

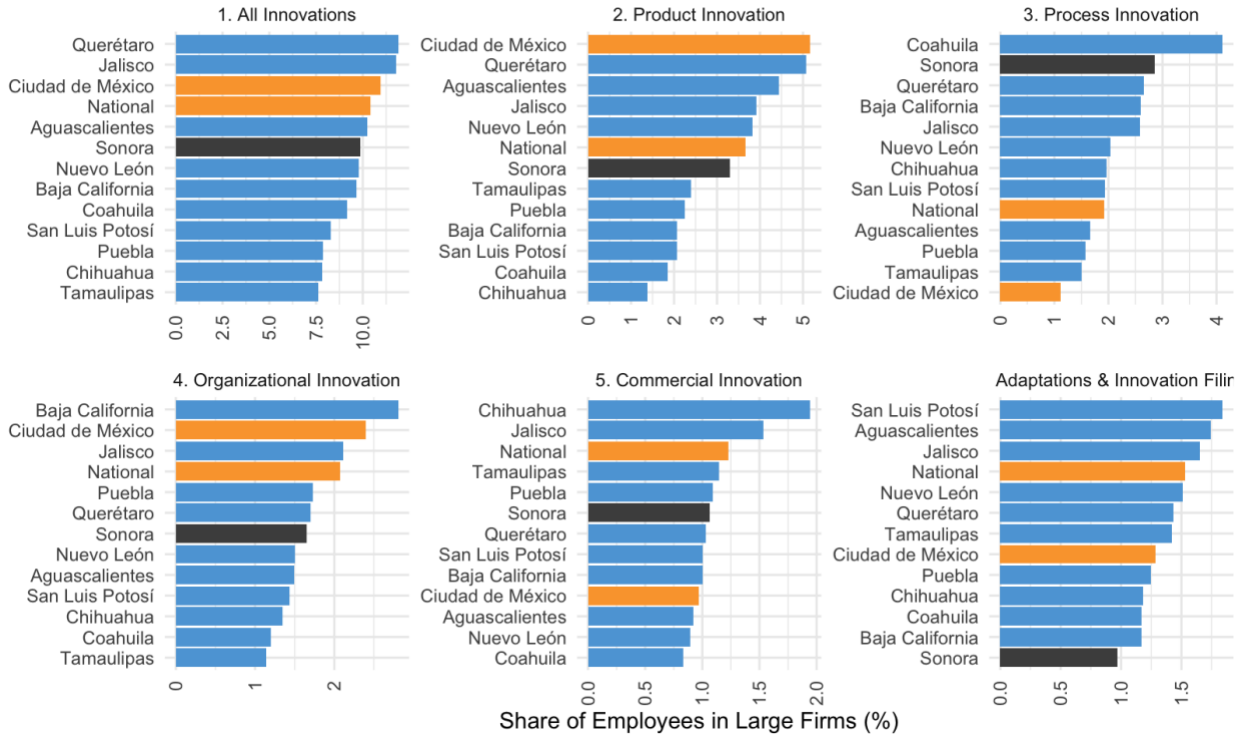


Source: Author's calculations based on Economic Census 2019, INEGI.

Sonora also devotes few human resources to most types of innovation, except for innovation focused on marginal improvements to productive processes. We can infer firms' innovation priorities by the occupational distribution of their employees. For example, as shown in Figure 75, large firms in Mexico City disproportionately employ product innovators and organizational innovators but deprioritize process innovators. They design new products and improve the administrative efficiency of complex organizations. These activities tend to be closer to management, further from the operational manufacturing process and are consistent with Mexico City's high concentration of headquarters. By contrast, the local subsidiaries of Sonora's large multinationals are more involved in core productive processes than in high-level business and organizational decisions. In Figure 75, Sonora is distinguished by its high share of employment in process innovation and its low share of workers on innovation encoding (dubbed "Adaptations and Innovation Filing"). The encoding of adaptations and innovations is used either for internal record-keeping or for the future registration of

intellectual property. This low priority given to innovation filling is consistent with Sonora's poor corporate patenting performance.

Figure 75: Employees Engaged in Innovation within Large Firms (2018)



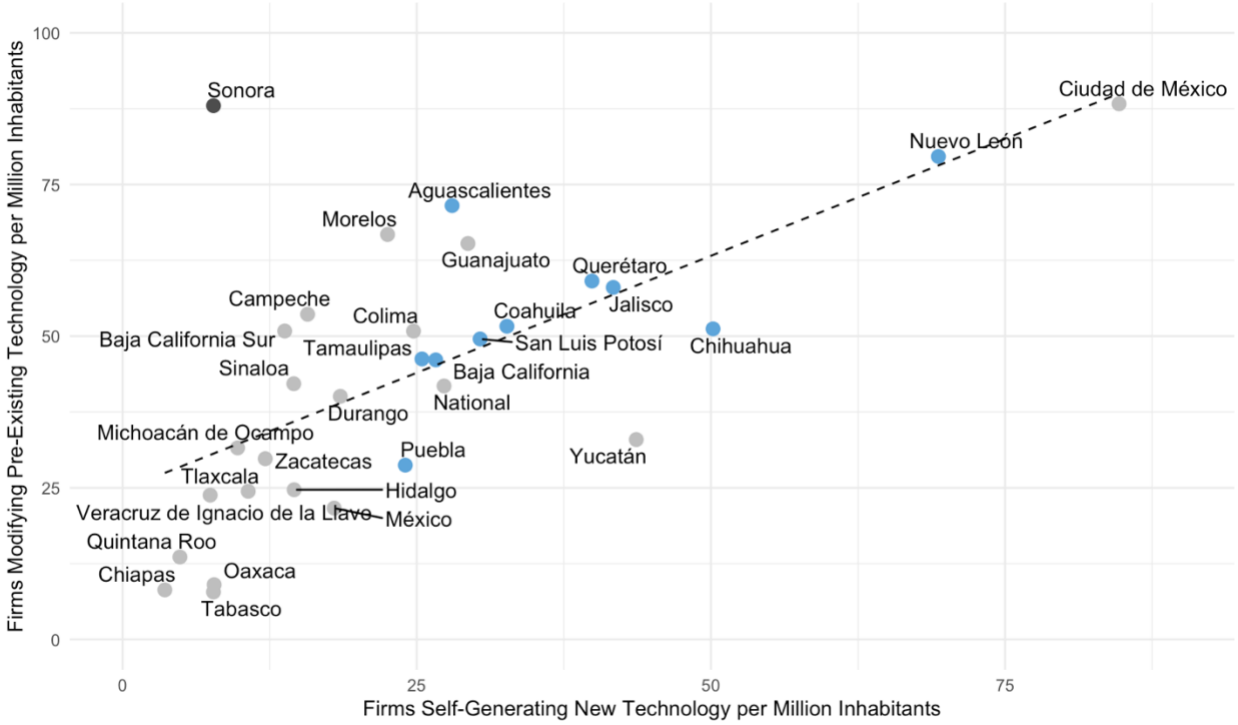
Source: Author's calculations based on Economic Census 2019, INEGI.

Sonora outperforms peer states on process innovation. Many Sonoran firms have the capacity to make frequent marginal improvements to the technology they use, which implies a certain degree of know-how embedded in the local human capital. Instead of just buying and using equipment off the shelf, firms can tinker with it to improve it or adapt it to local situations. This can be observed in the proportion of employees occupied in process innovation in Figure 75, and the number of firms that reported frequently modifying their technology in Figure 76. Sonora also has the second-highest rate of modification to acquired licensed technologies in Mexico.

However, companies rarely generate new innovations from scratch. disproportionately few firms report frequently leveraging their employees' knowhow to create new innovations or commercialize them through licensing and patenting. This

means that while Sonora is the second-best performer in process innovation, it is also the worst performer among peers in new or marketable innovations. These deductions are based on the ESIDET survey from CONACYT, which was discontinued after its 2017 edition, so they may not be as representative of the present. However, given Sonora's post-2019 patenting performance, ESIDET's 2017 data might overestimate how many firms frequently generate patentable or commercializeable innovations.

Figure 76: Firms Reporting Frequent Innovations, by Type of Innovation (2017)



Source: Author's calculations based on ESIDET 2017 (CONACYT), and Censo de Población y Vivienda 2020 (INEGI). ESIDET was discontinued after the 2017 edition. Note: Peers shown in light blue.

4.6.4 Key Takeaways

Hermosillo demonstrates innovation potential. The city is host to a thriving academic ecosystem, ranking among the top 10 for Mexican cities on academic publications, number of research authors, and citations. Firms in Hermosillo also have the know-how to make regular marginal improvements to their acquired technology and devote human resources to doing so. Local innovation could become a source of economic dynamism

and help Hermosillo be less reliant on FDI as a source of diversification. A successful local innovative ecosystem may also attract potential foreign investors looking to settle in Hermosillo.

However, Hermosillo has failed to reach its innovative potential. Hermosillo's firms underinvest in the research and development of innovations, which results in poor patenting outcomes and low diversification dynamism. It fuels a self-perpetuating cycle of disconnection between researchers and firms who may decide to do their R&D elsewhere. Academic publications were correlated with future affiliated patenting in the sample of Hermosillo and its peer cities before reforms to CONACYT in 2019. However, this relationship did not hold for Hermosillo in particular, so something may have prevented the leap from coming to fruition.

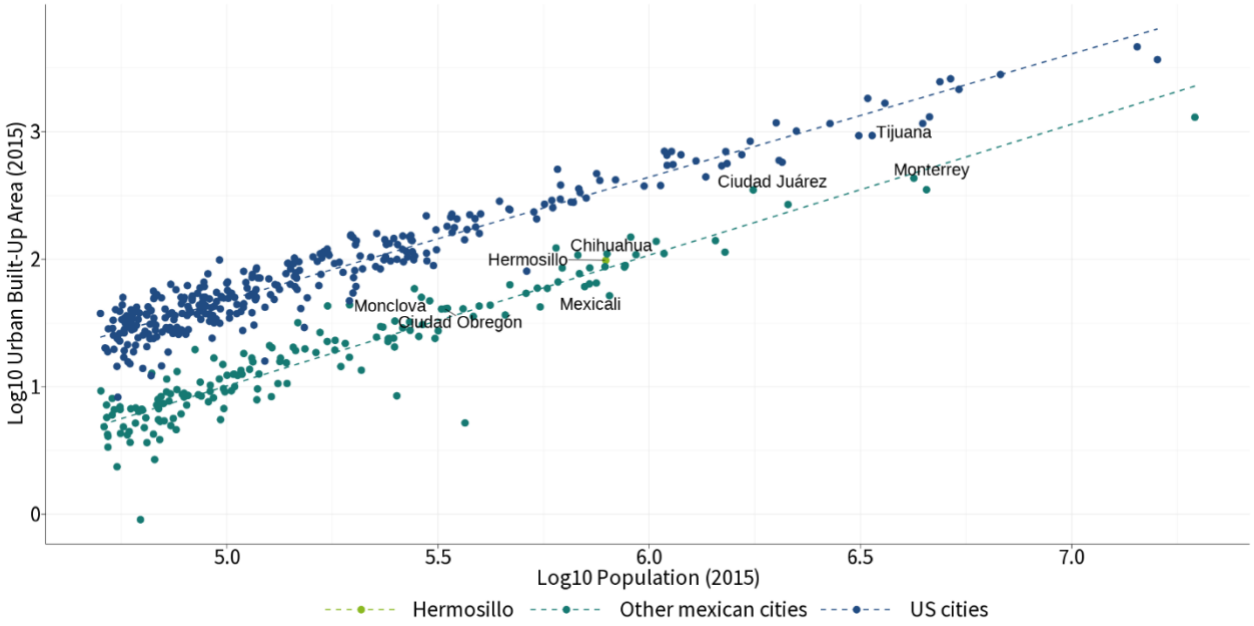
The withdrawal of funding from CONACYT also damaged Hermosillo's innovation ecosystem, which did not readjust to the new market conditions. Hermosillo should leap from academic publications to patents by seeking new funding sources and collaboration from industrial partners. To do so, research institutes and universities must set up internal structures for collaborative ventures and demonstrate to firms that doing R&D in Hermosillo can be profitable.

4.7 Urban Dynamics

In this section, we analyze Hermosillo's urban dynamics, specifically in terms of its housing and transportation. In the first part of this section, we analyze Hermosillo's urban form and how its shape affects how housing is developed and the transportation costs that workers incur. Then, we analyze housing, where it can be seen that, while it has not been a constraint in the past, the faster growth of housing prices in the city suggests that they could become an issue for the city's competitiveness in attracting investment and talent. Finally, we look into the problems of Hermosillo's transportation system, where the inefficiencies associated with it have translated into higher labor costs for firms due to them overcoming the constraint by providing private transportation to their workers.

Hermosillo has been described as a city that is as sprawl as an American city; however, the built-up area shows that it looks like many other Mexican cities. Hermosillo looks like an average Mexican city that does not stand out in its urban expansion, even compared to other northern cities in Mexico. Other Mexican cities that share urban areas with American cities in the South look more sprawl (e.g., Tijuana, Monclova, and Ciudad Juárez). Furthermore, Hermosillo's urban density is more compact than that of similar-sized cities in the North of Mexico, such as Saltillo, Chihuahua, and Mexicali.

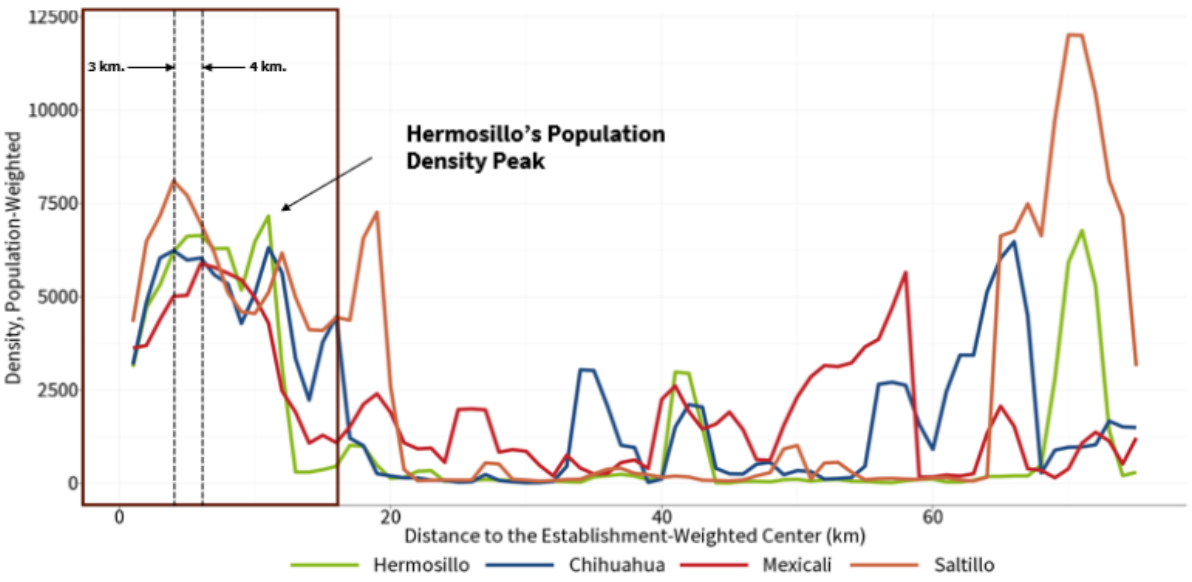
Figure 77: Urban Built-Up Area and Population: American and Mexican Cities



Source: Global Human Settlements Layer (2023).

Despite the city's compactness, the population density in Hermosillo peaks farther from the business center than in other northern cities. A zoning policy that has prevented the appearance of mixed-used residential areas has resulted in "workplaces being located on opposite sides ends from most of the working-class housing areas" (Inter-American Development Bank, 2018). This directly impacts transportation costs for firms, workers, and the municipality while negatively affecting the inclusion of low-income workers in the city.

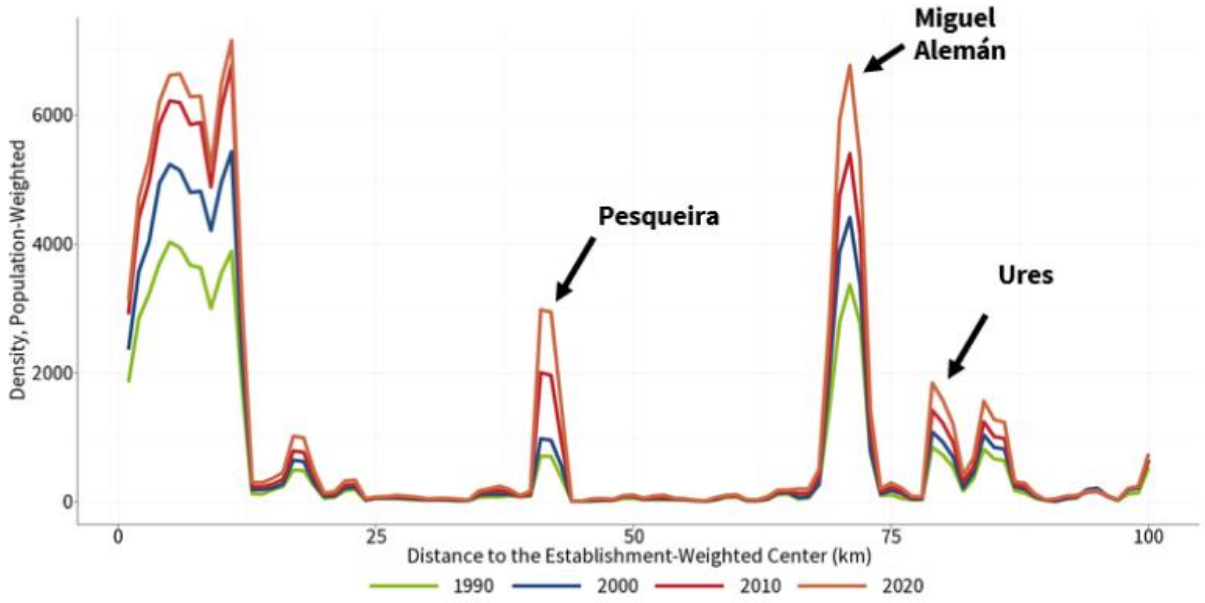
Figure 78: Population Density to the Business Center: Hermosillo vs. Peers



Source: Own calculations based on Dun & Bradstreet (2023) and Global Human Settlements Layer. Note: The variable is population-weighted density.

Between 1990 and 2010, Hermosillo experienced significant growth in density within its city boundaries, but this growth slowed down remarkably between 2010 and 2020. Since 1990, all the growth in the density within the city has been concentrated within 13 kilometers of the city center. Just outside this boundary, there has not been any significant urbanization, which cannot be explained by the city's topography or the dam's presence. Despite the slow growth in density within the boundaries of the city, there has been significant growth in nearby towns that are smaller and more informal, such as Miguel Alemán, Pesqueira, and Ures.

Figure 79: Population-Weighted Density to the Business Center: 1990 to 2020



Source: Own calculations based on Dun & Bradstreet (2023) and Global Human Settlements Layer.

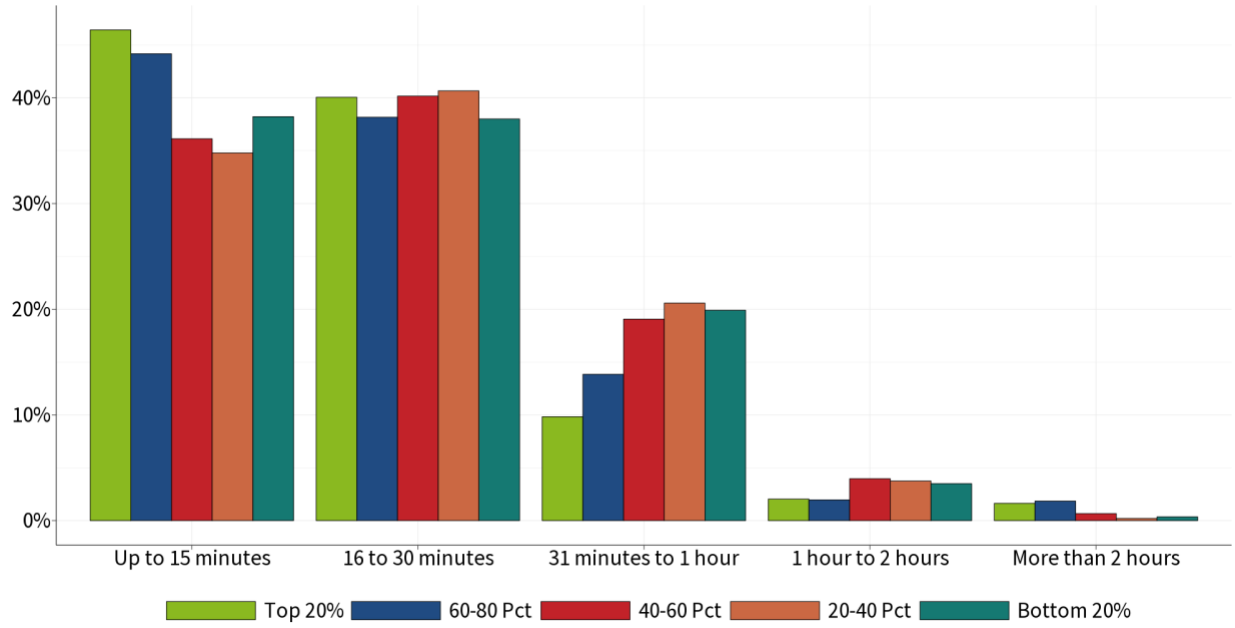
The urban form of Hermosillo and how it has evolved over time raises questions about housing prices and the city's urban and suburban transportation policy. Between 2010 and 2020, the city's population density grew at a significantly slower pace than other nearby towns, which could have two explanations: these towns experienced a significant productivity boost that allowed them to increase their population size in a relatively short time period, or these towns act as satellites of Hermosillo where people live and commute to work which could be a reflection of lower housing prices in these places and restrictions to the housing supply within the city boundaries the main urban area of the municipality. Disentangling both requires an analysis of its housing market and the commuting costs that workers who live in non-urban areas experience.

The distance between jobs and workers within the city and the growth of smaller towns on the outskirts increase the importance of its transportation networks for labor market efficiency. These urbanization patterns coexist with poor public transportation infrastructure across the city and its nearby towns. This has led private entities to set up their private transportation systems (Bermudez et al., 2019). This has become a more prominent issue in the city, as surveys report that commuting times

have increased since 2020 and that the use of public transportation (UNE Sonora) has declined from 35.4% in 2019 to 13% in 2023 (Hermosillo, ¿Cómo Vamos?, 2024). Workers have shifted to other types of transportation, such as vehicles privately arranged by their employers and rural trucks that move them into the city.

The lack of infrastructure for public transportation has led to higher transportation costs for low-income workers in urban areas and rural workers commuting to the city. Rural workers in the municipality of Hermosillo who work in the city experience significantly higher commuting times due to the distance to the city center. Other urban workers in low-income areas of the city experience significantly higher transportation times, as they must rely on UNE Sonora (which is reported to have high waiting times), bicycles, or transportation privately arranged by their employers.

Figure 80: Commuting Times by Income Level for Urban Workers



Source: Own calculations based on Censo de Población y Vivienda de México 2020.

4.7.1 Diagnostic Testing: Housing

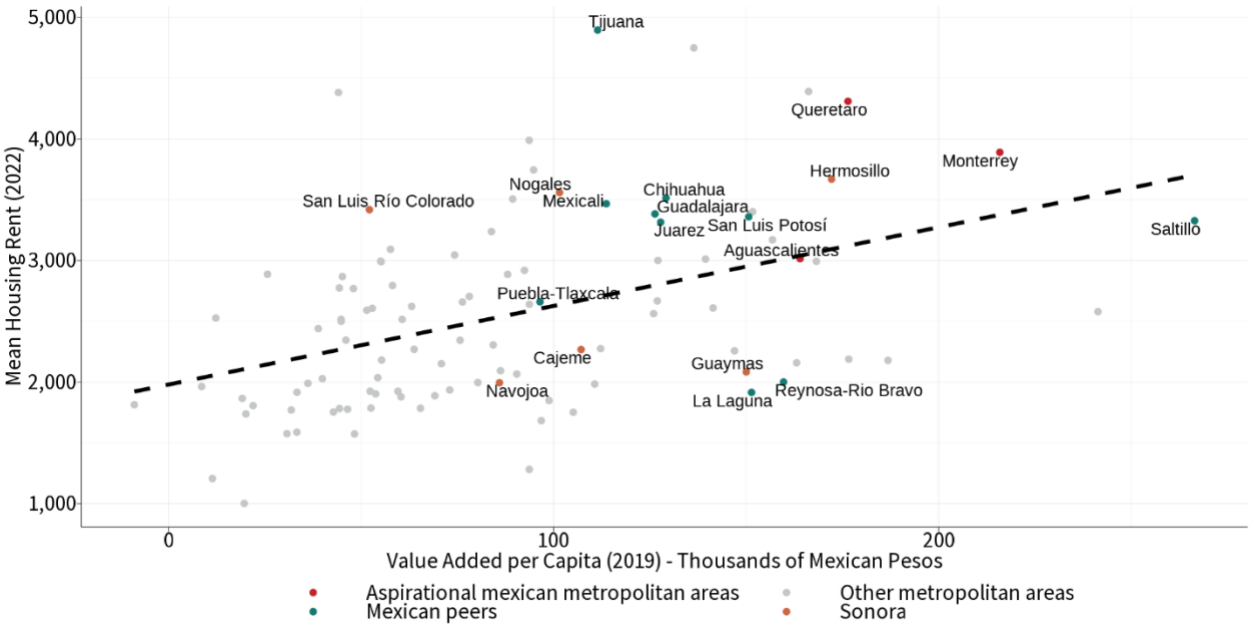
Hermosillo faces significant challenges in its housing market, characterized by relatively high rental prices and rapid increases in housing costs that outpace wage growth. This situation is driven by factors such as employment growth, positive net migration, and constraints on housing supply. While the city's housing market has adapted to past migration flows, recent trends suggest it may become a limiting factor for future economic growth. The rising costs and limited availability of housing, particularly for low-income households, have led to the emergence of informal settlements and increased commuting from nearby towns. These factors highlight the interconnected nature of housing, transportation, and economic growth in Hermosillo.

4.7.1.1 Prices and Quantities

Compared to other cities in the north of Mexico and its peers, Hermosillo has relatively high housing rental prices. Mean housing prices[16] in Hermosillo are relatively high compared to their expected level, given the GDP per capita. Still, they remain lower than aspirational peers such as Monterrey and Querétaro and at a level similar to that of Chihuahua, Saltillo, and San Luis Potosí. Since Hermosillo is a net receiver of migrants, this is probably offset by higher levels of wages in the city, but it raises questions surrounding the heterogeneity in housing prices for different levels of income in the city. Other places in Sonora that are net senders of migrants, such as Cajeme, Guaymas, and Navojoa, have among the lowest renting prices, likely reflecting higher disamenities and lower wage levels.

[16] These are prices for a two-bedroom housing unit, which is the median size of a house in Mexico.

Figure 81: Renting Prices in Hermosillo (2022) and Value Added per Capita (2019)



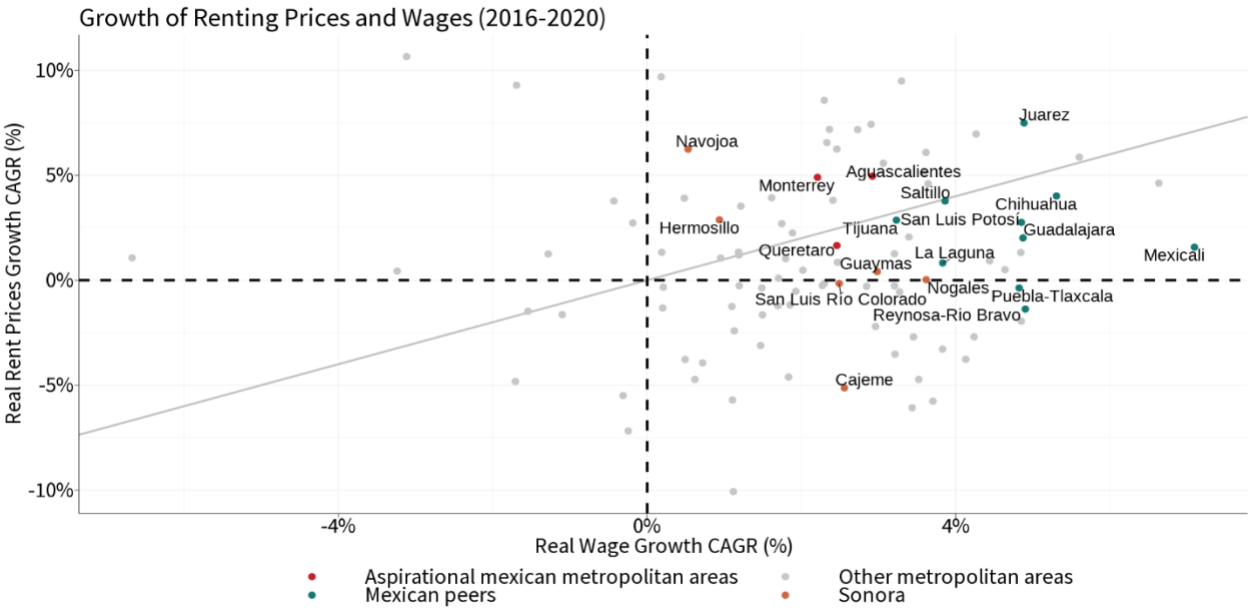
Source: Own calculations based on Censo Económico (2019) and Encuesta Nacional de Ingresos y Gastos de los Hogares (2022)

However, between 2015 and 2020, Hermosillo experienced a rapid increase in its real housing prices that is not fully explained by an increase in real wages but by increases in employment. This increase in housing prices is in line with other growing cities in Mexico, but Hermosillo ended up having slower growth in real wages than in rent prices, similar to Monterrey or Aguascalientes (

Figure 82). This implies that, over time, workers in Hermosillo have experienced losses in their disposable income, at least when controlling for housing costs. Other manufacturing cities, such as Querétaro or Chihuahua experienced faster real wage growth which allowed its workers to experience bigger real income gains. Other places like Ciudad Obregón or Reynosa-Río Bravo experienced declines in their real housing prices, which is explained by the availability of land and housing units. The growth of housing prices in Hermosillo could be explained by the increases in employment in the city (Figure 83) and the positive net migration, as the demand for the new units by workers and household probably outpaced the capacity of the housing market to

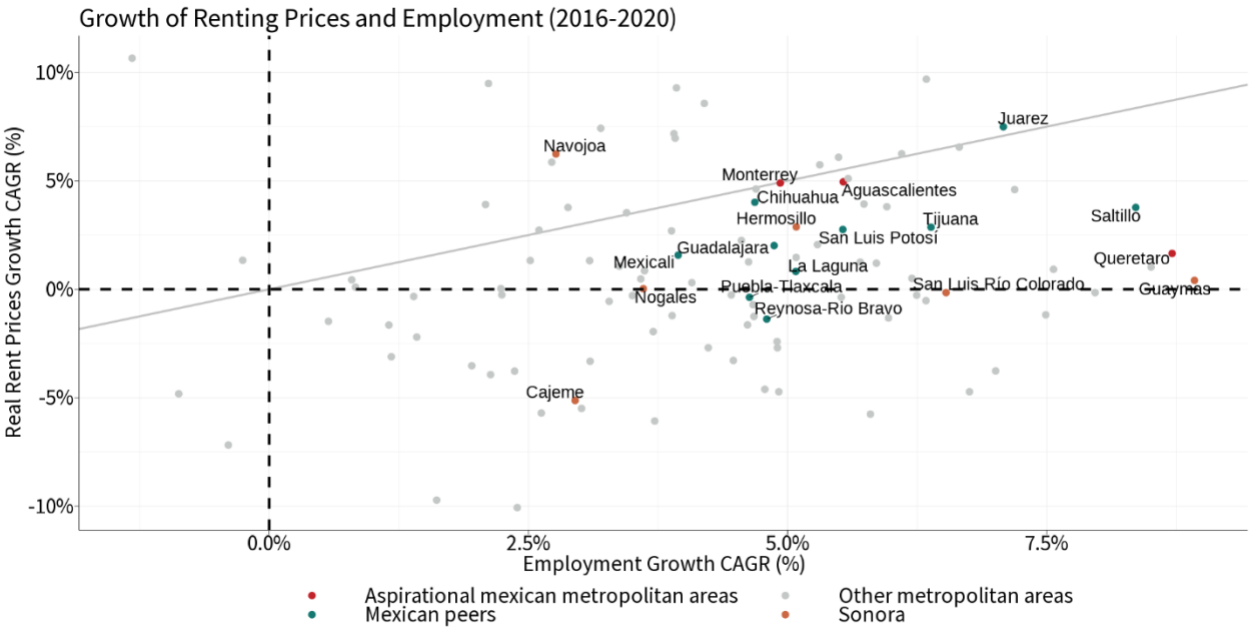
respond. This translates into a housing market that does not have enough units to keep up with the new population and results in higher housing costs.

Figure 82: Growth of Renting Prices and Wages (2016-2020)



Source: Own calculations based on Censo de Población y Vivienda de México 2020. and Encuesta Nacional de Ingresos y Gastos de los Hogares (2016-2020)

Figure 83: Growth of Rent Prices and Employment (2016-2020)



Source: Own calculations based on Censo de Población y Vivienda de México 2020. and Encuesta Nacional de Ingresos y Gastos de los Hogares (2016-2020)

While housing supply seems to have adapted to migration flows experienced in previous years, housing could become a binding constraint for economic growth in the future as housing prices increased rapidly in 2023. Hermosillo's housing prices increased more rapidly than in peer cities during 2023 and the first quarter of 2024 and faster than the Mexican average (Figure 84). This is signaling two things: a city that is growing and is facing increases in demand and a housing market that is currently unable to supply the necessary housing units to accommodate the workers that city needs. This is evidenced by and Registro Único de Vivienda - SNIIV (2024)

, where it can be seen a steep decline in the available housing inventory of the city that outpaces most of its peers in the same time period.

Figure 84: Change in Housing Prices and Housing Inventory (2023-1Q 2024)

Source: Own calculations based on Indice SHF Precios de Vivienda (2024) and Registro Único de Vivienda - SNIIV (2024)

Infrastructure investment costs and construction regulations limit the growth of the supply of low-income housing. The lack of water availability and the low availability of new housing is pushing the city's urban planners to require developers to acquire water well rights from national regulators and to develop the necessary infrastructure to perforate those wells. This has a significant impact on the construction costs of new developments, as CANADEVI reports that this adds 13% to the total cost, and it can take up to 8 months to get necessary approvals and permits. Additionally, other city regulations and restrictions imposed by its public transportation system also raise the costs of construction, as serving the market can mean increasing the number of parking spots or increasing the square footage of the housing units.

In addition to the housing costs problems, a reduction in housing financing could be impacting disproportionately lower-income households. In May 2021, INFONAVIT made changes to the types of housing units that the institution would finance by requiring them to be near certain amenities, such as access to schools or employment, which effectively limited the areas where new housing could be developed, especially inside Hermosillo. While the policy is meant to encourage the construction of denser developments near the city center, it increases the costs of land within the current urban areas of the city. It discouraged the horizontal expansion of new housing in the outskirts of the city where lower-income housing was typically placed. This, in combination with low land-value taxes and increased housing costs for developers, is leaving a gap in the housing market for lower-income households that are being overcome in different ways.

4.7.1.2 Agents overcoming the constraints

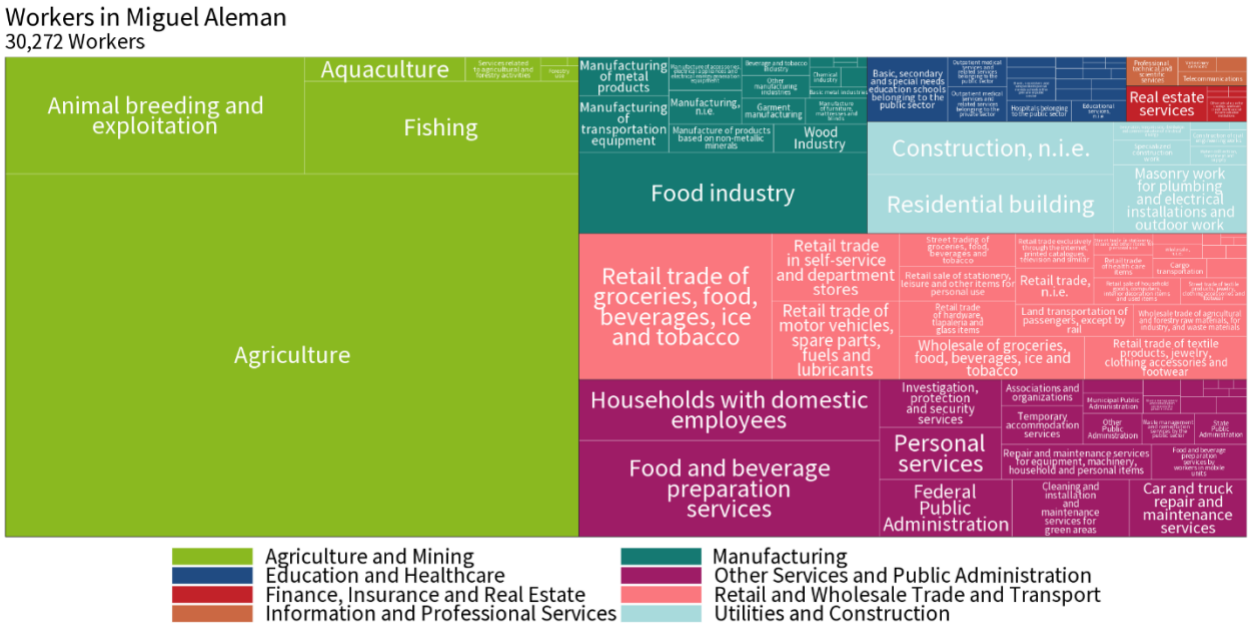
The limits to legal urban expansion in Hermosillo and the higher cost of housing have led to the establishment of informal settlements around the city. In Hermosillo, there are currently 33 irregular settlements, commonly referred to as "invasiones" (Sol de Hermosillo, 2023). These settlements are characterized by a lack of basic services such as potable water, electricity, sewage systems, and paved roads. They tend to be

located in the north and west of the city where fewer formal developments could limit its expansion; however, they also pose a challenge for the city and its firms as these settlements have poor access to transportation networks, which increases the costs of their participation in the local labor market.

Similarly, workers have been settling into Miguel Alemán to overcome the constraints of the low-income housing supply. Miguel Alemán is a town 60 kilometers to the west of Hermosillo, which has typically housed a significant part of the municipality's agricultural production. Its growth in population in recent years (2010-2020) and the industries where its workers participate (

Figure 85) are indications of a town that is becoming an important part of Hermosillo's workforce. Interviews with private firms in the city also point in this direction, as one of the firms said that as many as 120 workers lived and commuted every day from the town. Since January of 2023, there is a public transportation route provided by UNE Sonora that operates from 5am to 4pm and helps workers commute into the city.

Figure 85: Workers that live in Miguel Alemán by Industry



Source: Own calculations based on Censo de Población y Vivienda de México 2020.

Workers and households moving to these places bring Hermosillo's transportation system to the forefront. As informal settlements and towns like Miguel Alemán become home to a significant portion of the workforce, the existing transportation infrastructure faces increased pressure. The lack of efficient and reliable transportation options from these areas into the city exacerbates the challenges for workers and the private sector. The economic integration of these workers will depend on a combination of housing and transportation policies to improve their productivity and the overall economic growth of the city of Hermosillo.

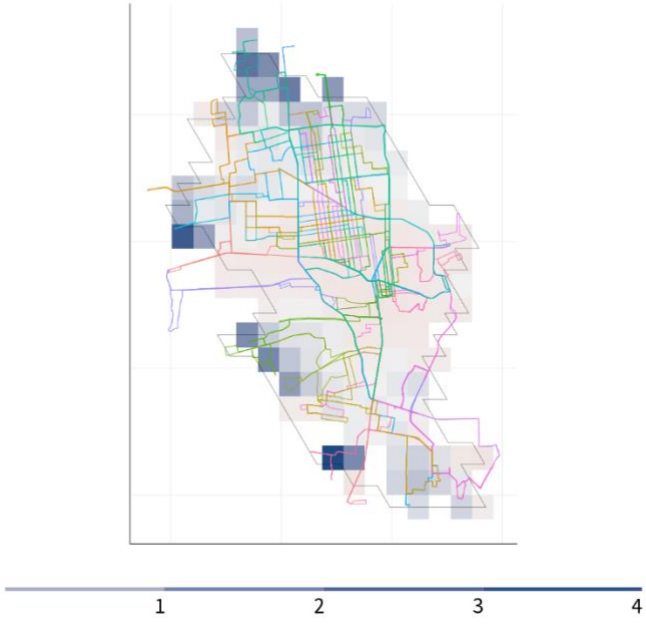
4.7.2 Diagnostic Testing: Urban Transportation

Hermosillo's urbanization patterns and centers of economic activity make a functional transportation system a key factor in its economic growth. The city's north and west regions are predominantly characterized by low-income housing, where many residents live in informal settlements or underdeveloped areas with limited access to roads, transportation networks, and jobs in the vicinity. On the other hand, the southern part of the city and its center are the main poles of economic activity. An

efficient transportation system that bridges this divide is critical for workers to access better-quality jobs and for firms to tap into a larger pool of talent for their operations.

Using public transportation to move from the north to the south of the city is costly in terms of time and money. Hermosillo's current bus network consists of more than 20 bus lines with limited coordination between the city and the state in its design and operation. The coverage of these lines tends to be more limited in places where there are fewer jobs per person (Figure 86) and where population growth has been concentrated in the last few years. The commute in public transportation for a worker living in the north and working in the south can take up to 3 hours. This worker will probably have to switch lines up to 3 times and pay 8 pesos every time they board a bus, significantly increasing the shadow price of labor.

Figure 86: Population per job by square kilometer and public bus network



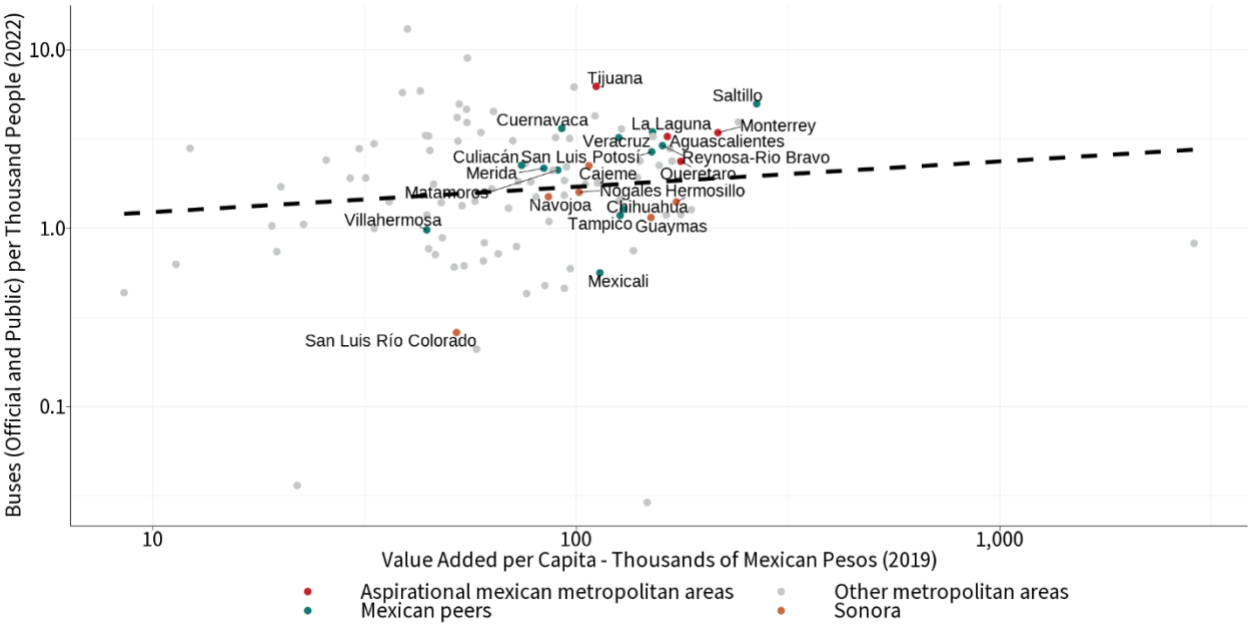
Source: Own calculations based on Global Human Settlements (2023) and Dun & Bradstreet (2023); IMPLAN. Note: Each square represents one square kilometer , where a darker blue means that there are fewer jobs available inside those areas per population living in them. These areas coincide with the areas less covered by public transportation.

4.7.2.1 Quantities and Prices

Compared to peers, Hermosillo is at the lower end of the distribution regarding the number of buses per capita but remains relatively close to the Mexican average.

Hermosillo has buses per capita that are similar to peers like Chihuahua and Tampico and at the same levels as other cities in Sonora, except San Luis Río Colorado (Figure 87). This is probably a reflection of statewide transportation policy, as the government of Sonora and through UNE Sonora design and operate bus routes. While the number of buses is likely not the main cause of the limitations of the current transportation system, it probably plays an important role in the delays reported by the users of the system and the shift towards other means of transportation (Hermosillo, ¿Cómo Vamos?, 2024).

Figure 87: Buses per Thousand People vs. Value Added per Capita

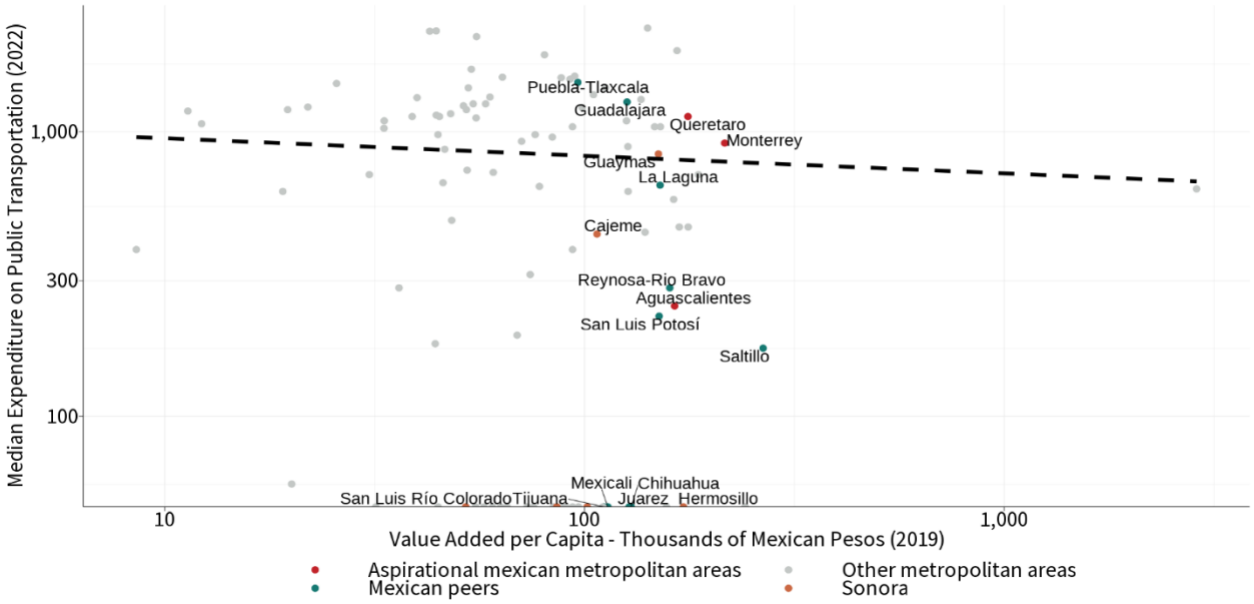


Source: Own calculations based on INEGI; Censo Económico (2019).

The median person in Hermosillo spends almost nothing on public transportation, which results in a city with one of the highest transportation expenditures in Mexico. Hermosillo's median person spends almost nothing on public transportation, similar to other northern cities such as Tijuana, Mexicali, or Chihuahua (Figure 88). This is likely a result of two things. First, readily available access to motor vehicles comes with the presence of transportation manufacturing inside the city, which helped shape the city's urban form (Bermudez et al., 2019). Second, a transportation system does not properly respond to the needs of its users when commuting to their places of work. The

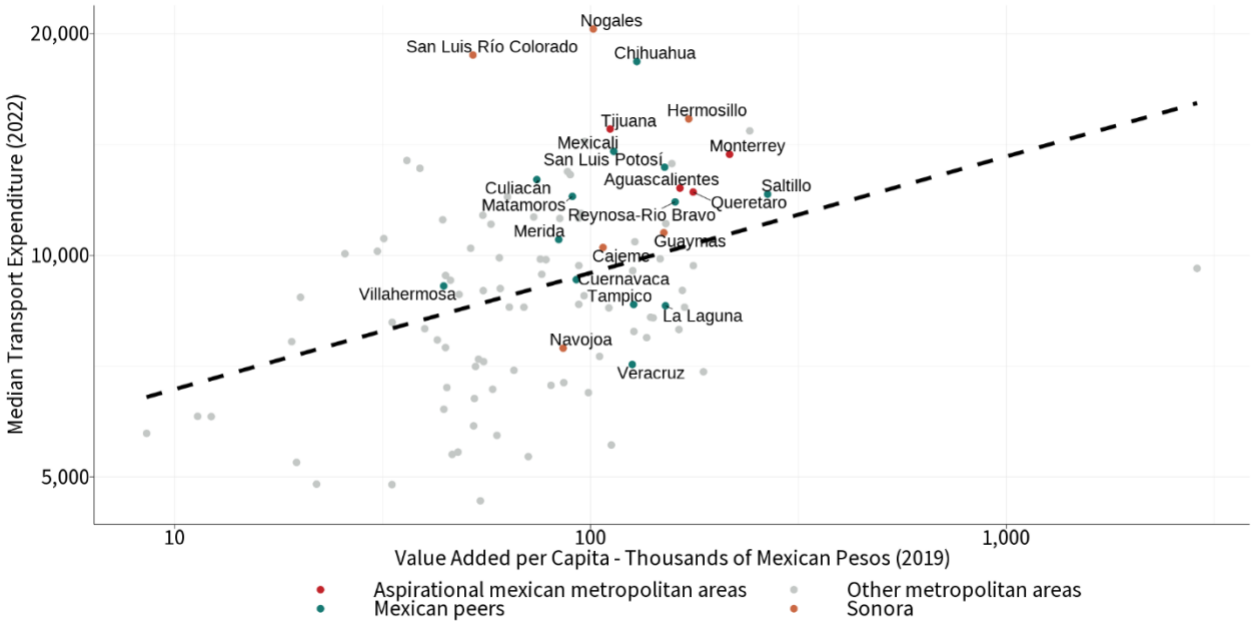
result is that workers and firms shift to other forms of transportation, such as firms that provide private transportation for personnel and workers buying cars to commute to their workplaces.

Figure 88: Median Expenditure on Public Transportation (2022)



Source: Own calculations based on Encuesta Nacional de Ingresos y Gastos de los Hogares (2022); Censo Económico (2019).

Figure 89: Median Expenditures in Transportation (2022)

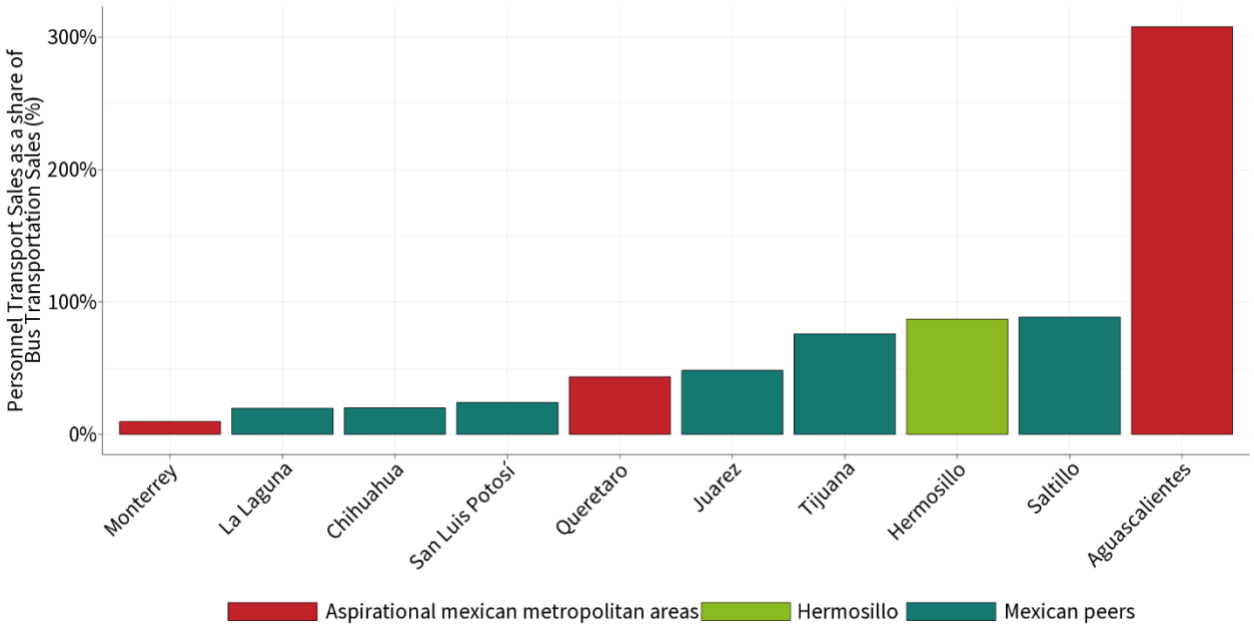


Source: Own calculations based on Encuesta Nacional de Ingresos y Gastos de los Hogares (2022); Censo Económico (2019).

4.7.2.2 Agents overcoming the constraints

Firms provide private transportation to the workplace as part of their benefits package to guarantee that workers will come. Due to the high commuting costs that workers face, many firms have shifted to offering private transportation to their workers to bring them to their workplaces and back to their homes. In these cases, the personnel transportation firms design routes and pick-up points depending on the location of the workers. A proper public transportation system would increase the efficiency of the operations given its scale and the city-wide optimized routes. Hermosillo has one of the highest shares of sales for personnel transport as a share of bus transportation sales, only surpassed by other manufacturing centers like Aguascalientes and Saltillo (Figure 90).

Figure 90: Personnel Transport Sales as a share of Bus Transportation Sales (2019)



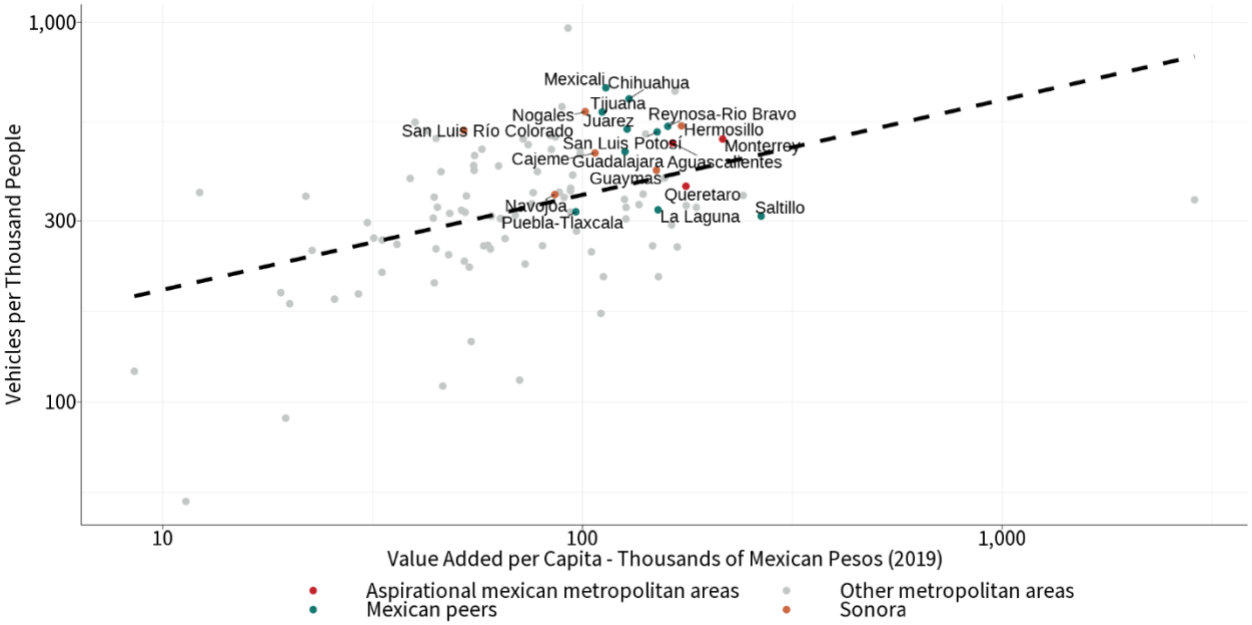
Source: Own calculations based on Censo Económico (2019).

The provision of private transportation might be a significant cost for the firms and could impact their margins and competitiveness, especially for SMEs. Personnel transportation firms in Hermosillo have one of Mexico's highest sales per capita, only surpassed by richer and more populated places such as Querétaro, Monterrey, and Tijuana. This reflects the higher costs that firms incur when hiring and offering benefits, as some report that it is one of the largest expenditure items in their financial statements after salary and wages paid to the workers. Increasing the competitiveness of the tradable sector in Hermosillo will require policies that improve coordination in the city's design and optimization of transportation routes.

Other workers decide to invest in cars to commute to their workplaces, which results in Hermosillo having one of the highest numbers of cars per capita in Mexico. Compared to peers, Hermosillo has one of the highest numbers of cars per capita in the country, comparable to other cities in the north, such as Tijuana, Mexicali, or Juárez, and higher than other Sonora cities in the south, such as Guaymas, Navojoa, and Cajeme. This is partially the result of higher income levels than in most of Mexico

but also the result of a shift in the mode of transportation of people in the city that has happened in the last 5 years, according to surveys (Hermosillo ¿Cómo Vamos?, 2023).

Figure 91: Private Vehicles per Thousand People (2022)



Source: Own calculations based on INEGI; Censo Económico (2019).

4.7.3 Key Takeaways

To fully take advantage of its economic potential, particularly regarding the recent near-shoring trends, Hermosillo must address critical constraints in its urban dynamics. As the city prepares to capture a more significant share of foreign investments coming from the near-shoring trends, the need for a more responsive housing market will require a combination of changes in regulations to accommodate the demand pressures that will come with new workers and new industries.

Hermosillo's urban form, while relatively compact, creates inefficiencies that could hinder its ability to capitalize on near-shoring opportunities. The spatial mismatch between residential areas and job centers increases transportation costs and commute times, increasing the costs of accessing jobs for both workers and firms. As the city prepares for growth, it must revisit its zoning policies to encourage mixed-use

development, thereby reducing commute distances, encouraging density around the main economic corridors, and enhancing labor market efficiency.

The housing market in Hermosillo faces significant pressure, with prices rising faster than wages, creating a mismatch between supply and demand. This challenge is particularly acute in the low-income housing segment. This pressure will likely intensify as new industries and workers are attracted to the area. To accommodate the new demand, Hermosillo needs to implement regulatory changes that streamline housing development processes and incentivize the construction of affordable housing using the policy tools controlled by the city and the state. Other significant impact areas for the housing market will require increased coordination with the national government and institutions like INFONAVIT.

The inadequacy of the public transportation system poses another significant challenge. With limited coverage, especially in recent growth areas and lower job density, the current system increases the shadow price of labor and could impede workforce participation. Hermosillo must prioritize substantial improvements to its public transportation infrastructure to attract and retain foreign investment, ensuring efficient connections between residential areas and emerging job centers. High transportation costs for firms providing private transportation and individuals resorting to car ownership could impact the city's capacity to attract near-shoring investments as it reduces the margins and competitiveness of their industries.

5 Diversification, Productive Capabilities & Economic Complexity

In this section, we analyze the productive capabilities of Hermosillo through the lens of economic complexity. We show that while Hermosillo's economy is diverse, its diversity lags in the manufacturing sector compared to its peer cities. We review the city's diversification, examining the dynamics of new and lost industries. Comparatively, Hermosillo has not added many sectors, whereas its peers have been more dynamic. The industries hosted by Hermosillo are not very sophisticated, painting an overall picture of a relatively low-complexity city. This low economic complexity limits Hermosillo's potential for economic growth and technological advancement.

5.1 A Brief Introduction to Economic Complexity

The theory of economic complexity posits that economic development is driven by the accumulation of productive capabilities. Economies, in general, do not get rich by specializing intensively in the production of the same products that they already produce. Quite the contrary: the true productive transformation and the secret of development lie in expanding the knowledge base and leveraging it to develop and become competitive in a greater diversity of goods. In turn, places that expand their productive capacities towards complex products—that require, in general, higher levels of knowledge—tend to grow faster. Rather than being commodity-driven, this is a decidedly human-driven approach to development. This is the theory of economic complexity.

Producing goods and services requires multiple inputs such as raw materials or labor, but also productive knowledge, or know-how, necessary to combine these elements (Hausmann et al., 2014)**.** Goods and services differ in the variety of productive knowledge required to be produced competitively. While some activities require little

know-how and few inputs, there are products and services that are extremely difficult to produce because of the specialized and specific skills required. It is these last products and services that we will classify as complex. This type of knowledge or know-how tends to be one of the main factors limiting the transfer of technology, and therefore the productive diversification of the world's economies. It is also the most difficult part of technology to transmit and teach, since it is only acquired through experience and practice. It resides, more than in books or manuals, in people's brains; the know-how required by most economic activities is acquired through experience and results from the collective combination of different capacities.

To better understand the concept of economic complexity, we can make an analogy between the productive capabilities of a city and the game of Scrabble. In the game, players arrange the letters on the available tiles to produce words. In the same way, companies (players) in a place bring together a variety of different capacities (letters) available in the local economy to create a product (a word). These capabilities include skills (e.g., chemical engineer, assembly line worker), infrastructure (e.g., electricity, water), supply chains, and public goods. Places with a limited range of capabilities (few letters) can produce a restricted range of low-value goods and services (words) (short words). As a place adds new letters (or capabilities), the number of words that can be created increases exponentially; words can get longer or become more valuable. Thus, making the most complex words requires the local availability of a wide range of letters. Departments differ in the variety of letters they have, so they differ in the models they can build with them. This plays out empirically: the most complex products are only produced in places with the most diverse capabilities. Economic development results from expanding these productive capacities towards the production of an increasingly diverse and less ubiquitous number of goods.

5.2 The Economic Structure of Hermosillo

The productive potential of Mexican cities depends on the existing capacities of their firms and industries. While capabilities or know-how are not directly observable, their quantity and diversity can be inferred from the goods and services a place can produce. With this goal in mind, we describe the productive landscape of Hermosillo and peer cities. We begin by examining the composition of industries, followed by an assessment of diversity, and conclude with an evaluation of the economic complexity of these cities.

We measure the composition and presence of industries in cities using employment data from the Mexican Population Census. This data offers several advantages (see Appendix 1 for a detailed discussion of data sources). First, it is statistically representative of many municipalities, which we aggregate to represent cities across states in Mexico.[17] Unlike other data sources, such as the Economic Census, this dataset does not censor observations, allowing us to gather data on many combinations of municipalities and industries. Second, using employment data allows us to measure the intensity of workers in each location more precisely than other data sources. Lastly, employment data from the Population Census enables us to assess both the diversity and complexity of cities by analyzing the occupations found in each city.

While diverse across industries and occupations, Hermosillo's employment rate is significantly lower in manufacturing than that of comparators. Figure 92 shows the composition of employment across industries in Hermosillo and comparator cities.[18] While manufacturing is the largest employer among peer cities, it accounts for a smaller

[17] We define cities following Atkin 2016. Cities are defined by combining municipios in the same Zona Metropolitan (as classified by INEGI) or where a significant number of commuters moved between them in the 2000 census. Commuting municipios are those where more than 10 percent of the working population reported commuting to a nearby municipio.

[18] In the figure illustrating the employment composition of comparator cities, we have aggregated employment data across various industries. This effectively represents a weighted average of Hermosillo's peer cities.

share of jobs in Hermosillo.[19] Compared to other cities, Hermosillo has a larger retail workforce. The data allows us to analyze employment by different occupations further. Figure 93 shows the composition of employment across occupations. The comparison with peer cities reveals two main differences. First, peer cities have a larger share of their workforce in professional occupations, such as accountants and technicians. Second, the proportion of workers in the category of operators, machinery, and assemblers (known as division 8) is significantly smaller in Hermosillo. Overall, these results confirm a known issue: among large cities in northern Mexico, Hermosillo has a low share of occupations and employment in manufacturing activities.[20]

Figure 92: Employment distribution across industries

a) Hermosillo

b) Comparators

Source: Own calculations based on Censo Económico y de Población.

[19] The composition of manufacturing employment is more concentrated in Hermosillo compared to its peer cities. **Error! Reference source not found.** in the appendix zooms in on the manufacturing sector, isolating it f rom other sectors, and showing this differential concentration more clearly.

[20] For instance, the description of dominant sectors in each wave of ENOE shows that Hermosillo ranks among the cities with the lowest share of manufacturing. See for instance page 30 in document "ENOE Primer trimestre de 2024, Principales indicadores laborales de las ciudades" https://www.inegi.org.mx/contenidos/programas/enoe/15ymas/doc/resultados_ciudades_enoe_2024_trim1.pdf

Figure 93: Employment distribution across occupations

a) Hermosillo b) Comparators

Source: Own calculations based on Censo Económico y de Población

5.3 Diversity, Economic Complexity & Economic Growth

A first step towards assessing Hermosillo's diversification patterns is establishing its diversity of industries. Diversification refers to the number of products a city, state, or country can produce. Ubiquity, on the other hand, refers to the number of places capable of producing a particular product. This requires first answering the question: Which industries are present, and which are absent?

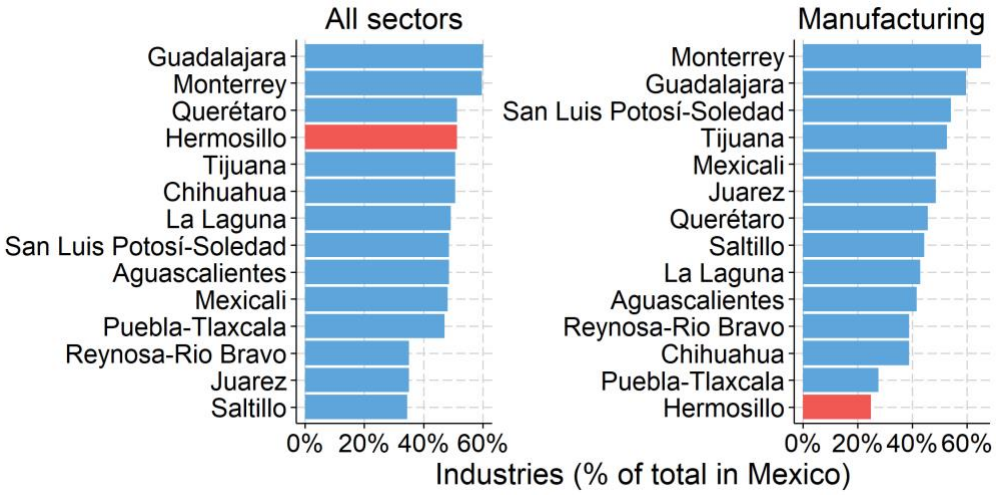
We follow established literature to define the competitive presence of industries, allowing us to assess cities' economic diversity more precisely. Specifically, we calculate the revealed comparative advantage (RCA), known as location-quotient (LQ) ratios.[21] RCA compares the share of employment in each industry within a city (the

[21] Comparative Advantage (CA) and Location Quotient (LQ) are equivalent measures of relative specialization. The concept of LQ was first introduced by Walter Isard in the 1950s (e.g. Isard 1956). Isard developed LQ as a tool to analyze the economic specialization of a region by comparing its industrial composition to that of a larger reference area, such as a country or state. The concept of Revealed Comparative Advantage (RCA) was introduced to economics by Béla Balassa in 1965. Balassa's RCA index measures the relative trade performance of individual countries in particular goods, helping to identify which goods a country exports more than the world average, thereby indicating its comparative advantage in those goods. Both measures, RCA and LQ, have been used as foundational tools for studying the comparative advantage of cities or countries (e.g., Glaeser et al., 1992; Porter, 2003; Hidalgo et al., 2007). See the appendix for the definitions and formulas used.

numerator) to the share of that industry in the country's total employment (the denominator). The larger this ratio, the stronger the sector's presence in the city. An industry is considered present, or a city is said to have a comparative advantage if this ratio exceeds one. This threshold indicates that the industry's share of employment in the city is at least as large as its relative importance in the country. By counting the number of different industries present, we can then compute the diversity of cities.

Hermosillo is a diverse city, but it lags in diversity within the manufacturing sector. Figure 94 shows diversity as the number of industries in which each city has a comparative advantage. The left panel shows diversity across all sectors, while the right panel focuses on manufacturing industries. Hermosillo ranks high in the distribution among peer cities when considering all industries, including retail and services. Its diversity is comparable to larger cities like Tijuana and Queretaro, and it is more diverse than other dynamic cities such as Juarez. However, the situation is concerning when we focus on manufacturing. Monterrey and Guadalajara are the most diversified cities, with relevant activity in over 60% of the manufacturing codes. Hermosillo is on the other extreme of the distribution, as the least diversified among its peer cities in this sector, with a presence in only 25% of the manufacturing industries of Mexico. Although Hermosillo has leading competitive manufacturing establishments in transportation equipment, such as the Ford plant, this analysis reveals that few other sectors contribute dynamically to its industrial diversity.

Figure 94: Hermosillo's Diversity vs. Peers (2020)



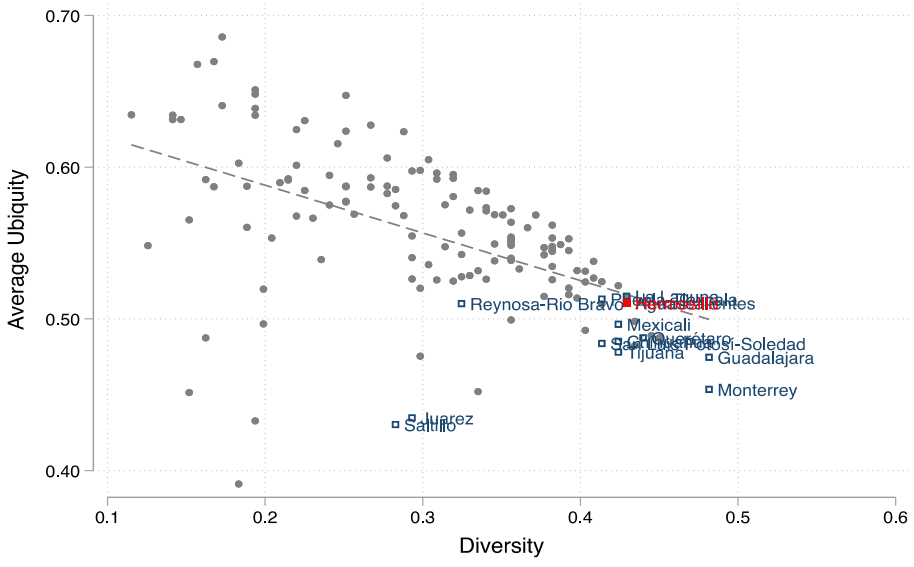
Source: Own calculations base don Censo de Población y Vivienda & DENUE. Diversity is measured as the proportion of the number of industries in the classification (N = 190 for all sectors, and N=72 for Manufacturing).

Cities with greater know-how are more diversified, while industries requiring more specialized knowledge are viable in fewer locations, making them less ubiquitous. The ubiquity of industries refers to the number of different cities in which they are established. The cities that hold more know-how should not only be more diversified but also capable of hosting less ubiquitous (i.e., more complex) industries. Research has demonstrated an inverse relationship between ubiquity and diversity, both at the national and subnational levels (states, departments, cities, or metropolitan areas within the same country).[22] Places with a greater concentration of know-how can produce a more varied and sophisticated array of goods and services (high diversity), which few other places can replicate (low ubiquity). Conversely, the places with low concentrations of know-how produce a limited variety of goods and services (low diversity), which many other places can also produce (high ubiquity).

[22] See Hausmann, Morales and Santos (2017) for the analysis of the provinces of Panama, Barrios et al (2018) for states in Mexico, Reynolds et al (2018) for the case of states in Australia, and Hausmann et al (2020). for Peru. Hausmann and Hidalgo (2009) were the first to show this inverse relationship between diversity and average ubiquity for countries.

In Mexico, the inverse relationship between diversity and ubiquity is clearly defined for its cities. Figure 95 presents a scatterplot of Mexican cities, illustrating the diversity of industries in each city as a proportion of the total industries in the SCIAN industrial classification on the horizontal axis and the average ubiquity of the industries present in each city on the vertical axis. We show nodes for the 150 largest cities (in gray), with selected comparator cities highlighted in blue and Hermosillo emphasized in red. Cities in the top left of the figure host a low number of very ubiquitous industries, indicating that these cities likely possess few capabilities, enabling them to support only a limited range of unsophisticated industries. Conversely, cities in the bottom right of the figure are more diversified, with industries that are less ubiquitous on average. The comparator cities selected for this report are concentrated in the bottom right, with Monterrey and Guadalajara leading in both high diversity and ubiquity. Juarez and Saltillo stand out in the figure; both exhibit lower diversity than their peers but have significantly lower average ubiquity than the fitted line suggests. The few industries these cities have specialized in are significantly less ubiquitous than those found in peer cities. As we will see, this has a substantial impact on their overall sophistication.

Figure 95: Diversity and ubiquity of cities in Mexico



Source: Own calculation based on Censo de Población y Vivienda 2020, DENUE

Economies vary in the complexity of their productive structures. As previously noted, one way to gauge this complexity is through the diversity of industries or products. However, diversity alone is an incomplete measure, as not all industries are equally sophisticated. Ubiquity can be used to measure industry sophistication based on the premise that only a few places—those with the highest levels of productive knowledge—can develop the most complex products and industries. Hausmann and Hidalgo (2009) proposed using diversity and ubiquity iteratively, a method known as the Method of Reflections, to refine these indicators for places and industries. This approach yields the Economic Complexity Index (ECI) for places and the Industry Complexity Index (ICI) for industries. These indices are important for economic development, as empirical evidence shows a strong correlation between them, per capita income, and economic growth potential (Hausmann et al., 2014).

Industries in Mexico differ greatly in terms of their complexity. Table 5 shows the Industry Complexity Index (ICI), highlighting the top and bottom 10 industries for brevity. The table includes the ICI, the percentile rank of each industry, and the total employment at the national level. The index is normalized to have a mean of zero and a standard deviation of one. At the top of the ICI ranking, we find the manufacturing of computers and other electronic equipment, followed by combustion engines and metallic products. Aerospace equipment, one of the growing industries in Hermosillo, is ranked 8th. Panel B shows the bottom 10 industries, which are primarily services generally associated with low levels of human capital. Interestingly, among the least complex industries, we find some sectors related to the public sector, which are significant employers in some small, lagging cities. Additionally, the drilling and exploitation of oil and gas are also associated with low complexity.

Table 5: Industry Complexity Rankings

Panel A) Top industries

scian	Descripcion	Complexity	Percentile rank	Employment (thousands)
3341	Fabricación de computadoras y equipo periférico	2.49	0.5	34
3336	Fabricación de motores de combustión interna, turbinas y transmisiones	2.32	1	19
3321	Fabricación de productos metálicos forjados y troquelados	2.29	1.6	32
3343	Fabricación de equipo de audio y de video	2.18	2.1	46
3353	Fabricación de equipo de generación y distribución de energía eléctrica	2.14	2.6	130
3334	Fabricación de equipo de aire acondicionado, calefacción, y de refrigeración	2.10	3.1	59
3345	Fabricación de instrumentos de medición, control, y equipo médico electrónico	2.00	3.7	29
3364	Fabricación de equipo aeroespacial	1.90	4.2	90
3352	Fabricación de aparatos eléctricos de uso doméstico	1.85	4.7	83
3342	Fabricación de equipo de comunicación	1.84	5.2	38

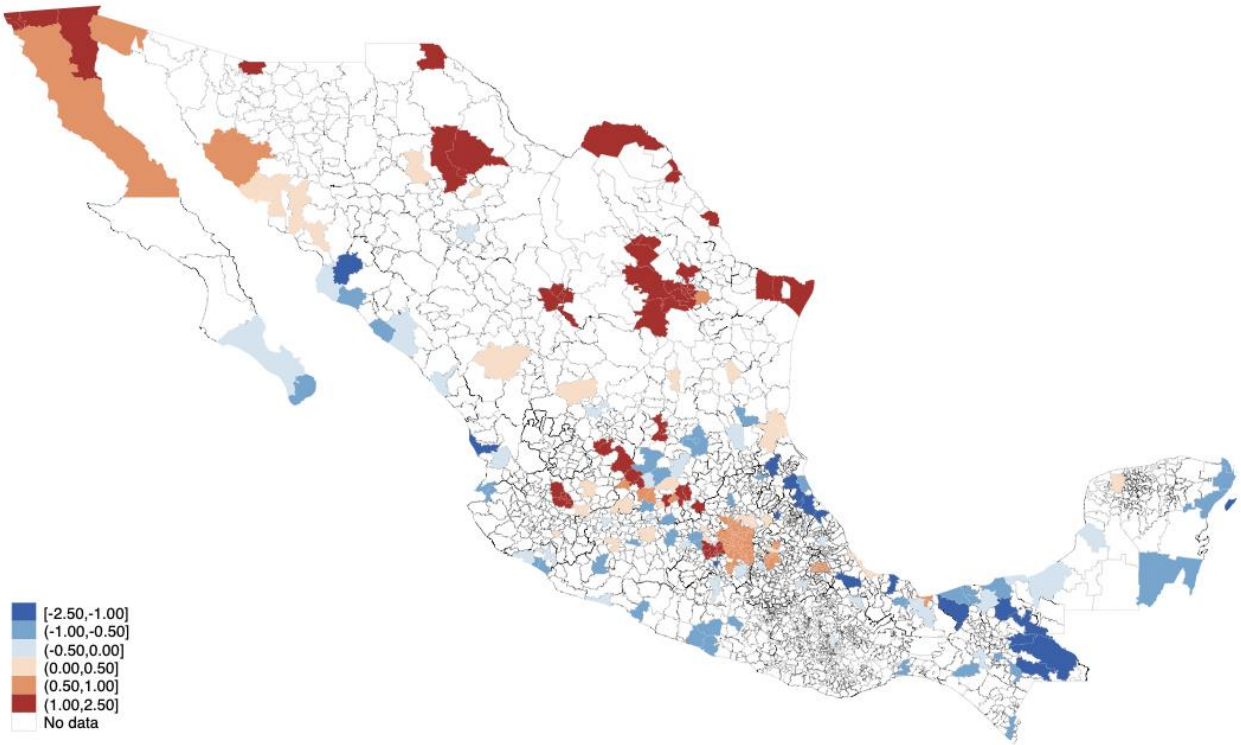
Panel b) - Bottom industries

scian	Descripcion	Complexity	Percentile rank	Employment (thousands)
7115	Trabajadores ambulantes en servicios de esparcimiento	-2.41	100.0	2
4370	Intermediación de comercio al por mayor	-2.18	99.5	9
5223	Banca de desarrollo, y fideicomisos del sector público	-2.18	99.0	4
6150	Servicios de apoyo a la educación	-1.99	98.4	5
7132	Venta de billetes de Lotería Nacional	-1.96	97.9	7
6122	Escuelas de educación técnica superior perteneciente al sector público	-1.86	97.4	8
2132	Perforación de pozos petroleros y de gas	-1.67	96.9	5
5321	Servicios de alquiler de automóviles, camiones y otros transportes terrestres	-1.67	96.3	13
6241	Otros servicios de asistencia social pertenecientes al sector privado	-1.61	95.8	14
4642	Comercio ambulante de artículos para el cuidado de la salud	-1.54	95.3	23

Source: Own calculation based on Censo de Población y Vivienda 2020, DENUE

There is considerable geographical variation in economic complexity across Mexican cities. Figure 96 provides a map illustrating the geography of economic complexity. While Table 52 focused on Hermosillo's peer cities for brevity, the map expands the selection to show the largest 150 urban areas in the country. The complexity index is color-coded, with darker blue representing low complexity and darker red indicating high-complexity cities. Northeast Mexico is generally more complex, but some of the most complex cities are also found in the center of the country. In contrast, the southern part of the country exhibits significantly lower economic complexity compared to the rest of Mexico. Hermosillo, located towards the northwest on the map, is depicted as moderately complex.

Figure 96: The geography of economic complexity



Source: Own calculation based on Censo de Población y Vivienda 2020, DENUE

Hermosillo's economic complexity is amongst the lowest in the peer group of cities and has not improved much in the past decade. Table 6 presents the ranking of the economic complexity of cities. The index measures the average complexity of the industries in a city, normalized to a mean of zero and a standard deviation of one. The table displays the complexity index and rankings for 2020, alongside the complexity index and rankings for 2010 for comparison. Additionally, the table includes data on the diversity and total employment of each city. Juarez tops the ranking with an economic complexity significantly higher than other cities, followed by Saltillo and Tijuana. Comparing 2010 and 2020 we see changes in the ranking of complexity, which is a result of the significant dynamism of cities in Mexico in the last decade. Among the top-ranked cities, only Juarez has maintained its 1st position since 2010. Hermosillo ranks 13th among the comparator cities, which is one position higher than its 2010 ranking. However, the value of the index is lower, suggesting that the change in ranking is

primarily due to a decline in Puebla's performance rather than an improvement in Hermosillo's. Notably, there is a significant difference between the economic complexity and diversity rankings, highlighting the relevance of sophistication differences between industries.

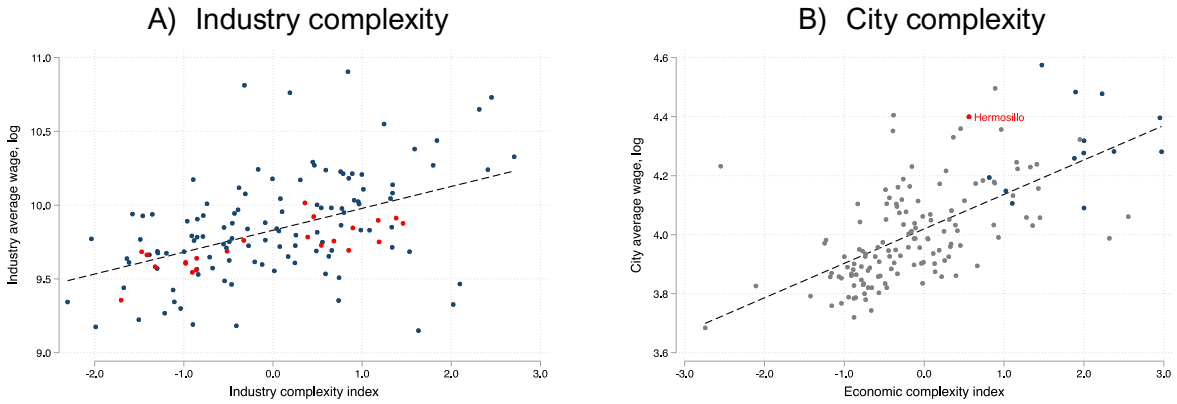
Table 6: Economic complexity of cities

	Complexity in 2020			Complexity in 2010			Diversity in 2020			Total
City	Index	Ranking	National percentile	Index	Ranking	National percentile	Percent	Ranking	National percentile	Employment
Juarez	2.94	1	0.01	2.16	1	0.01	0.21	12	0.53	773,941
Saltillo	2.77	2	0.01	1.87	4	0.03	0.19	14	0.65	487,532
Tijuana	2.16	3	0.03	2.10	2	0.01	0.27	8	0.17	1,104,493
Reynosa-Rio Bravo	2.14	4	0.04	1.75	6	0.05	0.2	13	0.63	425,415
Monterrey	1.98	5	0.05	1.96	3	0.02	0.34	2	0.01	2,347,239
San Luis Potosí-Soledad	1.79	6	0.06	1.34	10	0.11	0.26	11	0.21	644,542
Querétaro	1.67	7	0.07	1.73	7	0.07	0.29	5	0.09	801,382
Mexicali	1.64	8	0.07	1.62	8	0.07	0.26	10	0.21	540,835
Chihuahua	1.42	9	0.09	1.80	5	0.05	0.28	6	0.11	504,923
Guadalajara	1.32	10	0.11	1.61	9	0.08	0.34	1	0.01	2,670,906
La Laguna	1.02	11	0.15	1.17	12	0.14	0.26	9	0.19	643,837
Aguascalientes	1.01	12	0.16	1.30	11	0.12	0.31	3	0.03	541,447
Hermosillo	0.88	13	0.19	1.07	14	0.16	0.29	4	0.07	471,228
Puebla-Tlaxcala	0.79	14	0.21	1.17	13	0.15	0.27	7	0.13	1,318,746

Source: Own calculation based on Censo de Población y Vivienda 2020, DENUE

The Economic Complexity Index (ECI) informs a city's economic growth prospects. ECI reflects the amount of knowledge embedded in an economy's productive structure. Viewed this way, it is no coincidence that there is a strong correlation between complexity and income. Figure 97 illustrates this correlation for Mexico. Panel A shows the relationship between the Industry Complexity Index and the average wage paid by each industry in Mexico. As expected, a strong positive correlation exists with high-complexity industries paying higher salaries. Manufacturing industries are colored in red, and interestingly, these have a tighter relation with the trend.

Figure 97: Economic Complexity and Income (2020)



Source: Own calculation based on Censo de Población y Vivienda 2020, DENUE

Places tend to converge to an income level that aligns with their economic complexity. Panel B of Figure 97 shows the relationship between economic complexity and the average wage across cities, with peer cities shown in blue and Hermosillo highlighted in red. Once again, we find a strong positive correlation, indicating that higher complexity is associated with higher income per worker. The distance between a city's complexity and the regression line has been shown to predict future growth (see Hausmann et al., 2014). Cities above the regression line are "too rich" for the know-how they possess and, hence, tend to grow more slowly. Conversely, cities below the regression line have the potential, in terms of know-how, to be wealthier than they currently are and thus tend to grow more rapidly. In this sense, economic complexity is not just a symptom or an expression of prosperity; it is a driver.

Hermosillo has a relatively high wage level for its economic complexity. This result carries two implications. First, Hermosillo is expected to see other cities catch up to its relatively high-income levels. This finding is consistent with the fact that Hermosillo has been losing ground compared to peer cities in the past decade. Cities that expanded their productive capabilities beyond their current income levels, like Querétaro, experienced higher economic growth, thus increased income per capita. Hermosillo's wage levels were also high for its economic complexity in 2010, which shows that while the city experienced consistent economic growth, it has been relatively stagnant in terms of diversification. A second finding that stems from the relationship between

wages and economic complexity is that the main path for Hermosillo to catch up with peer cities is economic transformation. If Hermosillo aims to provide higher income levels for its workers, it needs to increase the sophistication of its industries, moving its position towards the right side in Figure 97.

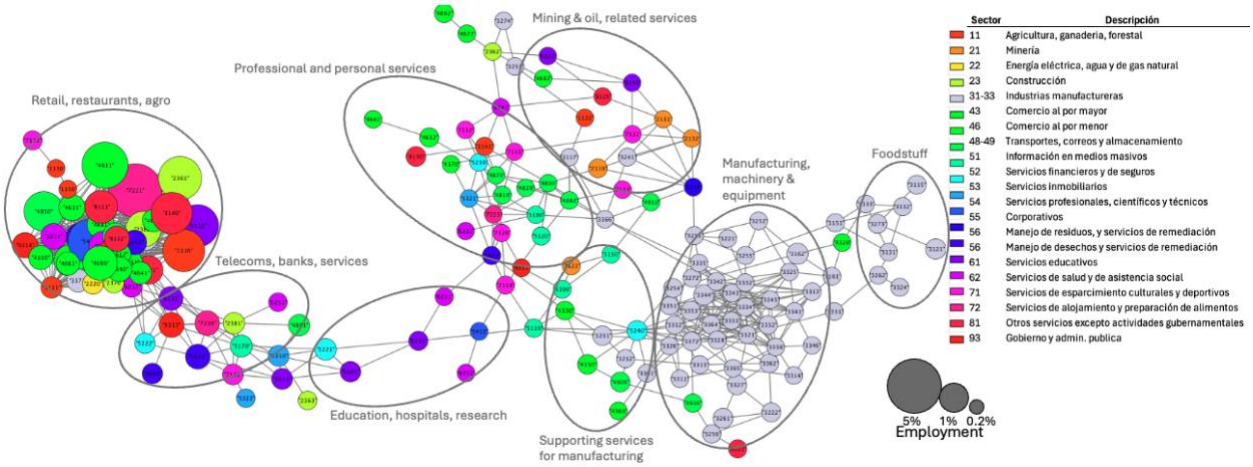
5.4 Diversification & Missed Opportunities

Places seldom diversify into new sectors that are vastly different from those that are already present in their economies. Although we cannot directly observe the distinct productive capabilities industries require, the co-location patterns of industries in places provide valuable insights. For instance, A place that produces garments like shirts will likely have the capability to make other garments like pants but not to establish an automotive industry. Similarly, the capabilities required to manufacture cars are closer to those required for producing trucks than those embedded in chocolate production. One way to empirically capture this intuition is to use employment, production, or export data to estimate the probability that industries are co-produced in a location. If two industries require similar capabilities, countries or cities with the necessary resources for one are also likely to produce the other.

The industry space of Mexico shows relevant insights for analyzing the diversification opportunities of cities. Figure 98 shows the industry space of Mexico, a network representing the inter-relationships between industries**.** To construct the industry space, we used data from the population census for 2010 and 2020, following previous research methodologies. We calculated the probabilities of co-hosting competitive industries using data from the largest 150 cities in Mexico. Each of the 190 nodes in the network represents an industry, with node size proportional to its share of total employment in Mexico. The largest node in the bottom-left of the figure is "Food and Beverage Preparation Services (SCIAN 7221)," accounting for approximately 5% of national employment. Industry nodes are connected by edges, indicating pairs of products often produced together. This is a simplified visualization of the technological

connections between sectors.[23] Broadly speaking, we observe eight groupings of industries. On the left side of the figure is a cluster primarily composed of retail, restaurants, and some agricultural sectors. Adjacent to this is a cluster of industries related to telecoms, banks, and other services, which are weakly connected to a nearby cluster of education, hospitals, and research. Towards the right side of the figure, there is a cluster of manufacturing industries, naturally split into two groups: one comprising industries that manufacture machinery and equipment and another one of food production. At the top of the figure are extractive industries related to mining and oil. The remaining industries are scattered throughout the network, mostly on the periphery.

Figure 98: The Industry Space



Source: Own calculation based on Censo de Población y Vivienda 2020, DENUE

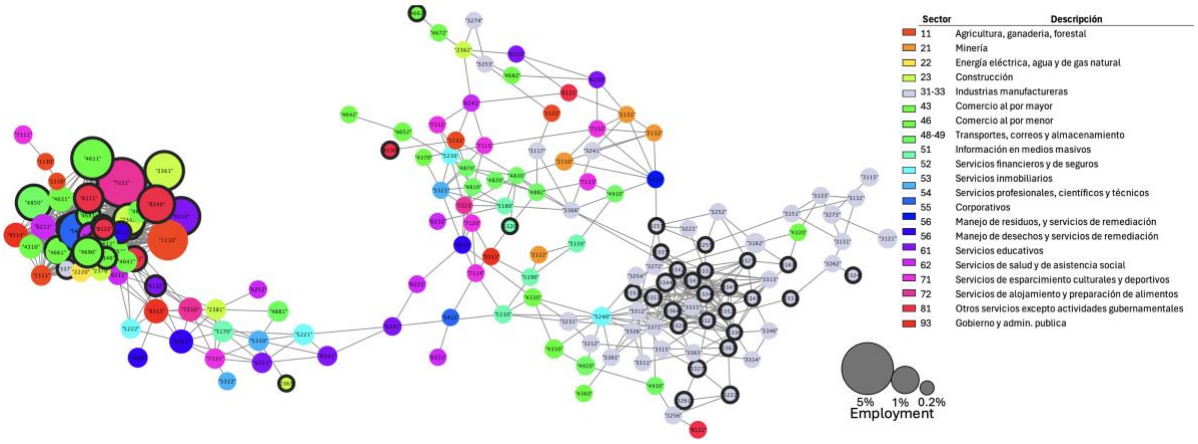
[23] The visualization simplifies industry relationships by focusing on the most relevant connections. Empirically, there is a chance of observing any pair of industries being co-produced. Instead of displaying all connections—which would result in a confusing "hairball" network—we restrict the number of edges and show the top 5% of the proximities between industries. Additionally, we excluded industry codes labeled as “industries not elsewhere specified,” as they are irrelevant for drawing meaningful conclusions. The connectivity of industries in the industry space indicates how related or shared their capabilities are, while the precise location of nodes is less informative. It is the links that illustrate the shared use of capabilities between industries. The position of the nodes is determined by a spring algorithm that equalizes the tension imposed by the different links on each node. Some industries, like those at the core of the manufacturing cluster, are highly connected to other industries, while others, like mining and oil, are poorly linked. This differential connectedness of industries will be important for subsequent analysis. The industry space is a representation of technological relatedness and can be used to highlight the industries that a city has mastered.

Hermosillo's industry space explains its low levels of economic complexity compared to peers like Juárez. Figure 99 illustrates this comparison, denoting the presence of cities in each industry with black circles over each industry-node.[24] Juarez, though relatively concentrated (as we saw in Figure 94), has a strong presence in two clusters: "retail, restaurants, and agriculture" and "manufacturing, machinery, and equipment.". The significant presence of Juarez in manufacturing, which includes some of the most complex economic activities (as indicated in Table 1), explains why Juarez is at the top of the economic complexity ranking. In contrast, Hermosillo shows a limited presence in the manufacturing cluster, highlighting its different economic focus. Further comparing Juarez and Hermosillo within the manufacturing cluster, Juarez has a large and central presence, with most industries having tight links to other industries. Hermosillo, on the other hand, is present in industries that appear less connected. Another observation is that Hermosillo, unlike Juarez, has a strong employment presence in the "Telecoms, banks, and services" cluster. This doesn't mean that these industries are completely absent in Juarez, but rather that manufacturing eclipses the relevance of these ancillary sectors as strong employers.

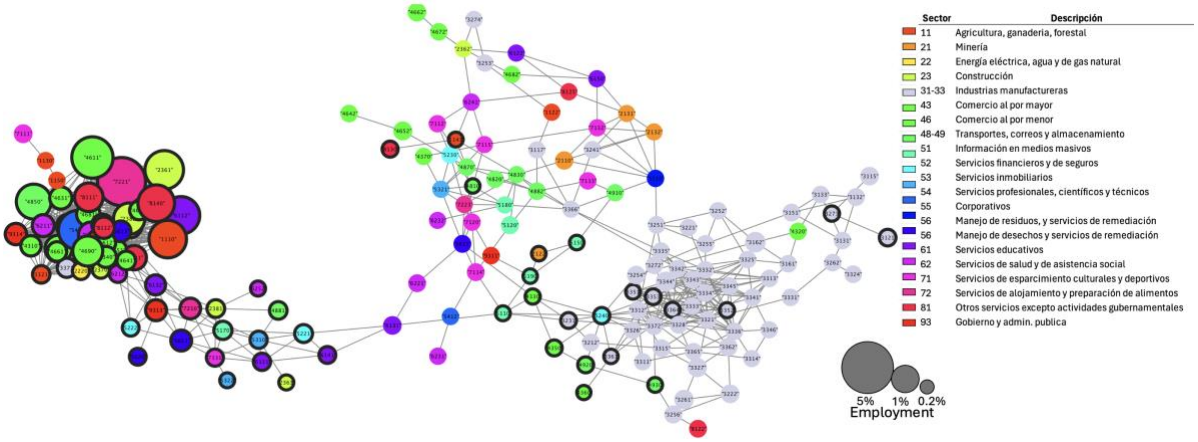
[24] **Error! Reference source not found.** in the appendix shows the position of the weighted-average peer c ity on the product space.

Figure 99: Juarez and Hermosillo on the Industry Space

Panel A: Juarez



Panel B: Hermosillo



Source: Own calculation based on Censo de Población y Vivienda 2020, DENUE

Box 2: Diversification in the Industry Space

Density in the industry space strongly predicts the diversification path of cities and countries. Past research has shown strong path-dependence in the industry space; places tend to develop new sectors close to where they have a dense agglomeration of industries with comparative advantage (see Hausmann et al., 2007). Conversely, industries are more likely to exit cities in a less dense part of the industry space. We can empirically test this implication by calculating the density in the industry space. Density is a city-industry measure of how closely an industry is surrounded by sectors usually found together.

In Table 7 we assess how predictive density is for the case of cities in Mexico. We report the results of regressions where the dependent variable is whether an industry that was not significantly present in the baseline period appears after ten years. We control for density and RCA in the baseline period, and in columns 2 and 4, we also control for city and industry fixed effects to account for any unobserved characteristics constant across cities or products over time. In columns 1 and 2, the estimate of density indicates that a one standard deviation increase in density raises the likelihood of an industry appearing by 14% and 13%, respectively. In columns 3 and 4, we present estimates for the disappearance of sectors. The estimates indicate that a one standard deviation increase in density reduces the likelihood of losing an industry by 9.4% and 9.1%, respectively. Overall, the results suggest that in Mexico, the appearance and disappearance of industries follow the path of the industry space.

Table 7: Density predicts the appearance and disappearance of industries

	New industry		Lost industry	
VARIABLES	(1)	(2)	(3)	(4)
Density	0.146***	0.130***	-0.094***	-0.091***
	(0.014)	(0.015)	(0.008)	(0.011)
RCA	0.178	0.268**	-0.006***	-0.012***
	(0.112)	(0.123)	(0.002)	(0.002)
Observations	2,105	2,091	6,928	6,928
R-squared	0.215	0.328	0.153	0.270
City FE	-	y	-	y
industry FE	-	y	-	y
Dep var mean	0.121		0.114	
Mean density	0.187		0.633	
SD density	0.175		0.287	

Robust standard errors in parentheses clustering by city and industry
*** p<0.01, ** p<0.05, * p<0.1

Source: Own calculation based on Censo de Población y Vivienda 2020.

To explore whether Hermosillo's diversification followed the pattern predicted by the

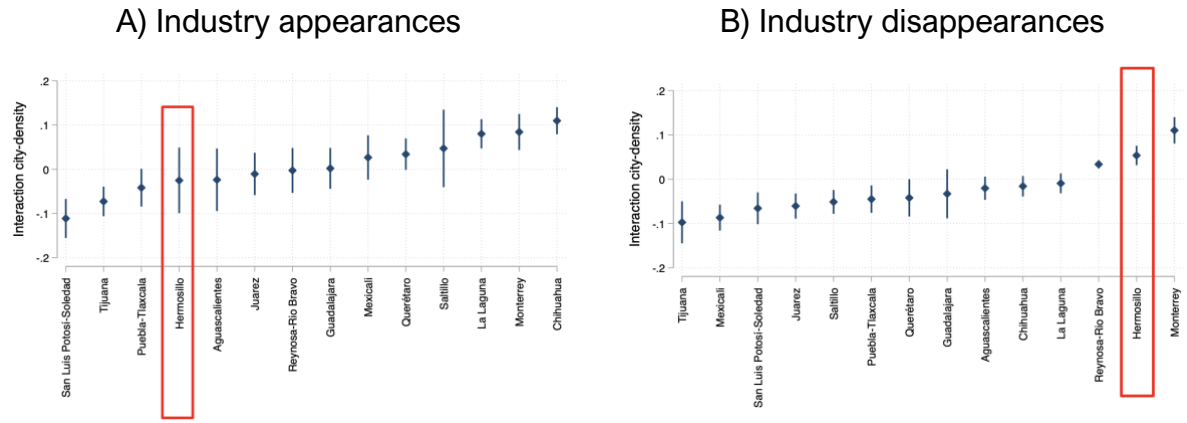
product space, we expanded the regression in Table 7 by interacting the density variable with a dummy for each city. Estimates of this interaction term indicate whether the industries that appeared or disappeared in each city align more or less than, on average, with the expected path in the industry space. For appearances, a positive coefficient suggests that a city's new industries are more closely related to their current competitive sectors than in the average town. Conversely, a negative coefficient indicates that new industries are less related to their existing position in the industry space. A similar interpretation applies to estimates for disappearances, although with the opposite sign. Figure 100 presents the results of these estimations, with panel A showing the coefficients for appearances and panel B for disappearances. The nodes represent the point estimate for each city, and the bars indicate the confidence interval of the estimated coefficients.

Hermosillo's diversification patterns show that, between 2010 and 2020, the city developed industries that were closely related to its industry space. Panel A of Figure 100 shows that Hermosillo's new sectors followed density predictions, as is also the case of other cities ranging from Aguascalientes to Saltillo. Specifically, the coefficient is not statistically different from zero, indicating that the new industries followed the average pattern. In contrast, cities like San Luis Potosi and Tijuana managed to diversify into industries that were less connected to their productive capabilities. These cities experienced foreign investments in sectors that were not present beforehand, so they managed to do long jumps in terms of their diversification paths. In the other extreme of the distribution, cities like La Laguna, Monterrey, and Chihuahua, show a pattern of diversification where new sectors are more closely related to their existing industries than the average diversification path of Mexican cities. This reflects the fact that, in these cities, new ventures are likely to be sustainable and experience high growth.

In turn, the industries that Hermosillo lost were those less related to the city's existing industry space. Panel B of Figure 100 shows that for many cities, ranging from Tijuana to Queretaro in the figure, the coefficients are statistically negative. This

suggests that the industries that lost competitiveness in these cities were more strongly predicted by the industry space to have a higher likelihood of disappearing. In contrast, for Reynosa, Hermosillo, and Monterrey, we find statistically positive estimates, indicating that the industries that lost competitive advantage were less related to the existing industries in the city.

Figure 100: Differential industry-space density across cities



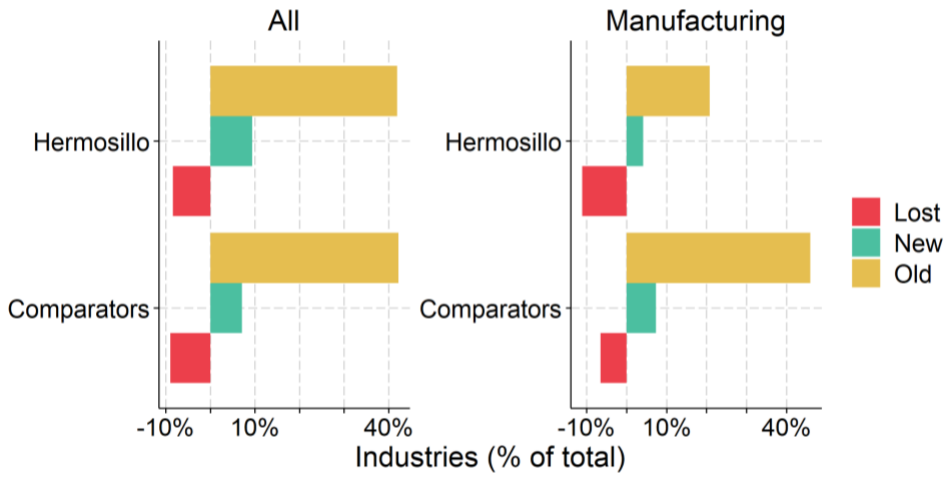
Source: Own calculation based on Censo de Población y Vivienda 2020.

Hermosillo's diversity of competitive industries has remained stable over time, indicating that the city hasn't diversified significantly. Figure 101 breaks down Hermosillo's diversification by classifying industries into three groups. The blue bar represents the diversity of industries in 2020. The gray bar shows industries that were present in 2010 (“old sectors”). The red bar shows the group of industries that are no longer competitive (“lost sectors”). The green bar shows sectors that were not previously competitive but have become so (“new sectors”). In order to achieve higher diversification, Hermosillo needs to add new sectors while maintaining current competitive industries.

Hermosillo’s diversification patterns are similar to those of peer cities when considering all sectors, but the city has underperformed in the manufacturing sector. Figure 101 highlights that Hermosillo has not developed new industries, particularly in manufacturing. Panel A shows that Hermosillo's overall diversification closely mirrors the average path followed by its peer cities. However, panel B tells a different story for the manufacturing sector. First, the proportion of industries with a comparative advantage is significantly lower than in its peers, as previously shown in Figure 94. More importantly, the number of new industries in Hermosillo is considerably lower than in its peers (shown in green). Comparing 2010 and 2020, Hermosillo has developed a comparative advantage in only two manufacturing sectors: “Manufacture of

electrical appliances for domestic use" (SCIAN 3352) and "Manufacture of electrical energy generation and distribution equipment" (SCIAN 3353).

Figure 101: Diversification Dynamics in Hermosillo Vs. Peers (2010-2020)

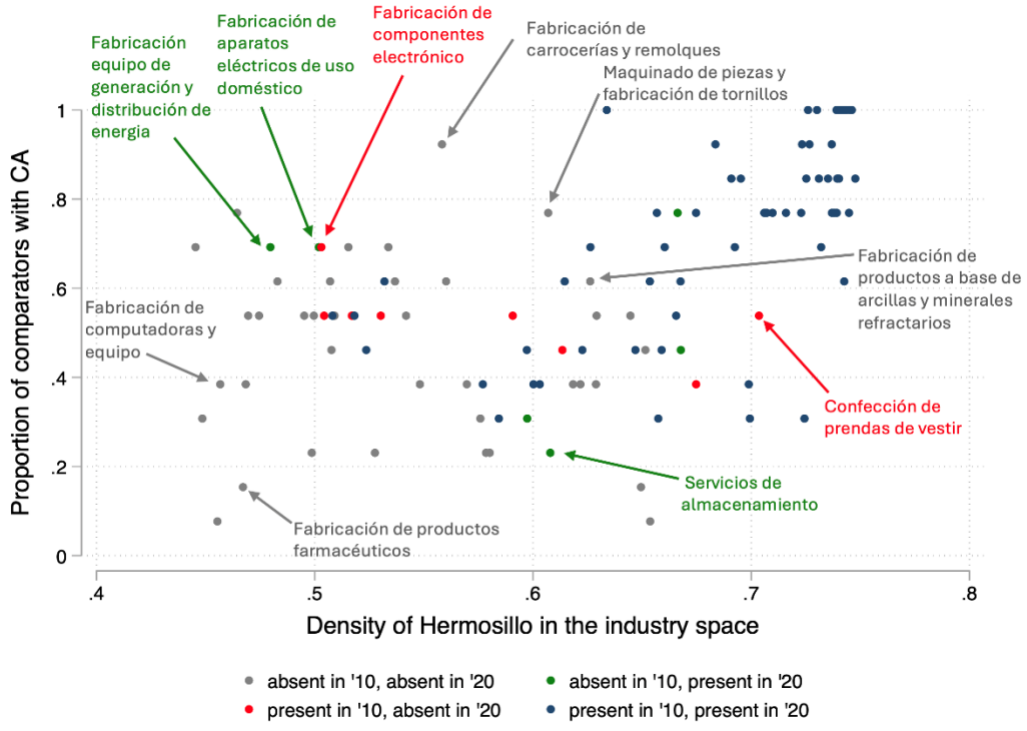


Source: Censo de Población y Vivienda & DENUE. This figure shows a decomposition of diversity in 2020 compared to 2010. Old Industries are industries that were competitive in 2010 and remained competitive in 2020; Lost Industries are those that were competitive in 2010 but are no longer competitive in 2020; New Industries are those that became competitive in 2020.

In the past decade, Hermosillo has had many missed opportunities that other cities managed to exploit. Figure 102 provides insights to support this statement. The horizontal axis sorts industries based on Hermosillo's density in the industry space, while the vertical axis shows the proportion of comparator cities that were competitive in each industry in 2020. Industries in the upper-right corner are closer to Hermosillo's capabilities (high density), but most peer cities already have a competitive presence in these sectors. Conversely, industries in the lower-left corner are far from Hermosillo in the industry space, and comparator cities do not have strong participation in these sectors. We classify industries into four categories based on their presence or absence in Hermosillo in 2010 and 2020 (see the color-coded legend in the figure). Some industries have been highlighted for reference. Interestingly, most blue nodes—representing industries that have consistently been competitive in Hermosillo—are located on the upper-right side of the figure. This indicates that these industries face strong competition from Hermosillo's peer cities. The figure also shows that sectors that lost competitiveness by 2020, shown in red, are negatively correlated with density.

Sectors absent from Hermosillo in both periods, shown in gray, are scattered throughout the figure. These sectors are the missed opportunities of Hermosillo, as they showed high density (close to the city's productive capabilities), and while other places managed to develop them, Hermosillo did not. For example, motor vehicle bodies and trailers are a part of the automotive value chain that Hermosillo could tap into and has not. Another missed opportunity is the manufacturing of screws, nuts, and bolts, a finding that is consistent with learnings from interviews with key stakeholders in Hermosillo. These highlighted the concern that Hermosillo and, more broadly, Sonora were lagging peers when it came to developing local suppliers, which, in turn, made the region less competitive in terms of input costs. The manufacture of metal parts was mentioned as a missed opportunity for local investors, as it is a crucial part of different value chains in Hermosillo. These sectors should be studied as potential opportunities for future diversification. In the following paragraphs, we provide some description, but we will dedicate a full report to growth opportunities.

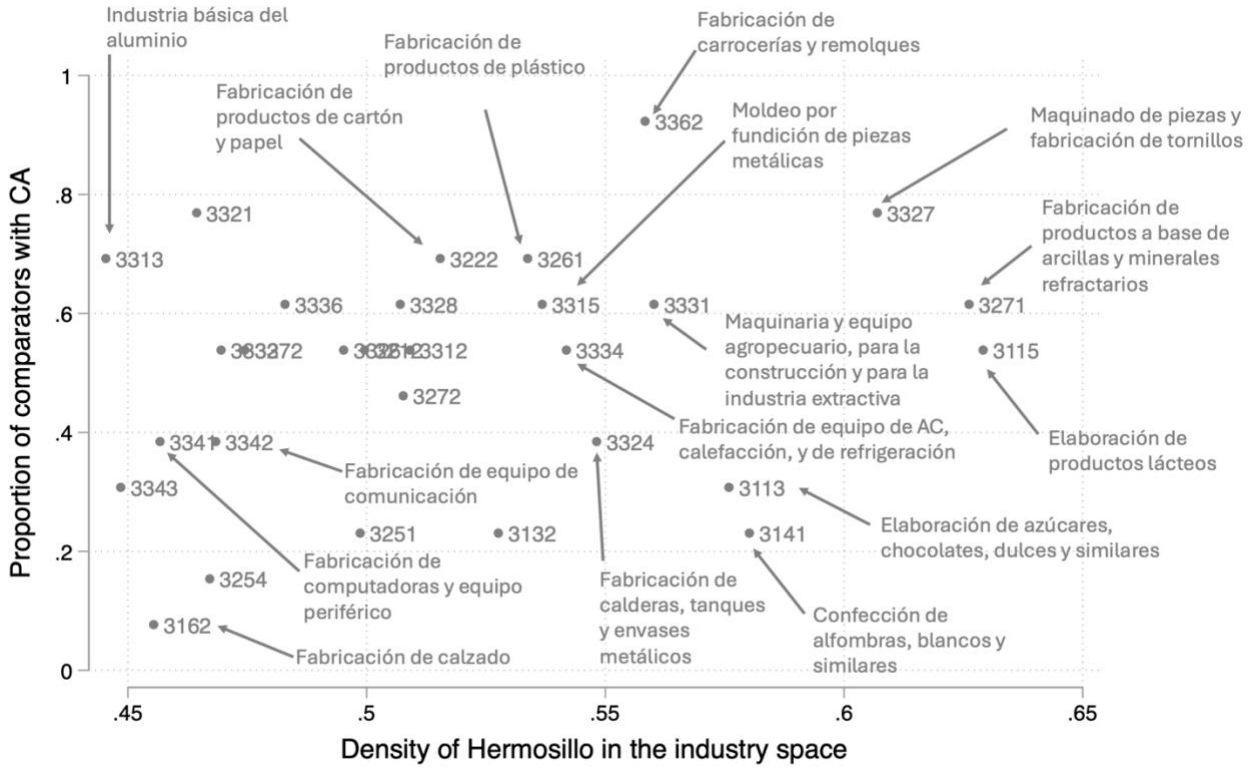
Figure 102: Competition in the industry space of Hermosillo



Source: Own calculation based on Censo de Población y Vivienda 2010 – 2020.

We can examine the missing manufacturing industries from Hermosillo more closely in Figure 103, focusing on the manufacturing industries shown in gray in *Figure 102*. Many of the high-density industries can be traced back to Hermosillo's strength in the automotive sector, such as 'Agricultural machinery and equipment, for construction and for the extractive industry (3331)' and, to a lesser extent, 'Casting and molding of metal parts (3362).' Given Hermosillo's extensive knowledge of manufacturing machinery, it is also surprising that other sectors, such as 'Manufacture of industrial and commercial air conditioning, heating, and refrigeration equipment (3334)' and 'Manufacture of boilers, tanks, and metal containers (3324),' are not more prominent. Interestingly, semiconductor—related industries— expected to experience a boom in nearby Arizona, USA—like 'Manufacturing of computers and peripheral equipment (3341)' and 'Manufacturing of communication equipment (3342)' do not have a large presence in peer cities.

Figure 103: Missing manufacturing industries

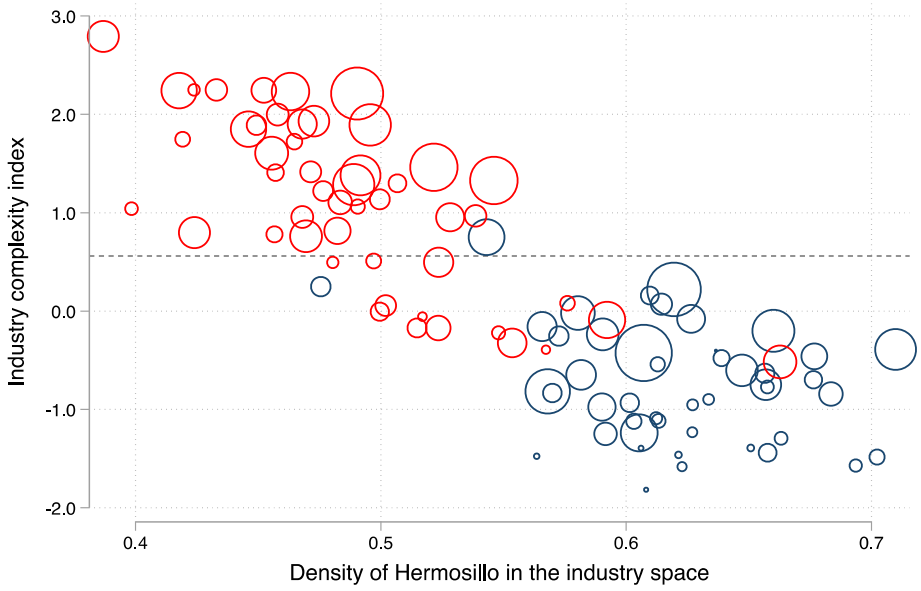


Source: Own calculation based on Censo de Población y Vivienda 2010 – 2020.

Hermosillo's most feasible opportunities are in low-complexity industries, while higher-complexity manufacturing industries are far from Hermosillo's capabilities. As shown previously, industries vary in complexity, highly correlated with higher income levels.

Figure 104 presents a scatter plot of industry complexity and the density of each industry in Hermosillo. Nodes are proportional to national employment, with manufacturing sectors highlighted in red. The horizontal dashed line indicates the current complexity of Hermosillo, so industries above the line are more complex. The figure highlights two key points. First, absent industries closer to Hermosillo's current capabilities (i.e., high density) are of low complexity. In other words, what is nearby is not particularly attractive. Second, manufacturing industries are particularly complex but far from Hermosillo's current capabilities. Developing or attracting firms in these sectors would pose a significant challenge.

Figure 104: Complexity and density of absent industries from Hermosillo



Source: Own calculation based on Censo de Población y Vivienda 2010 – 2020.

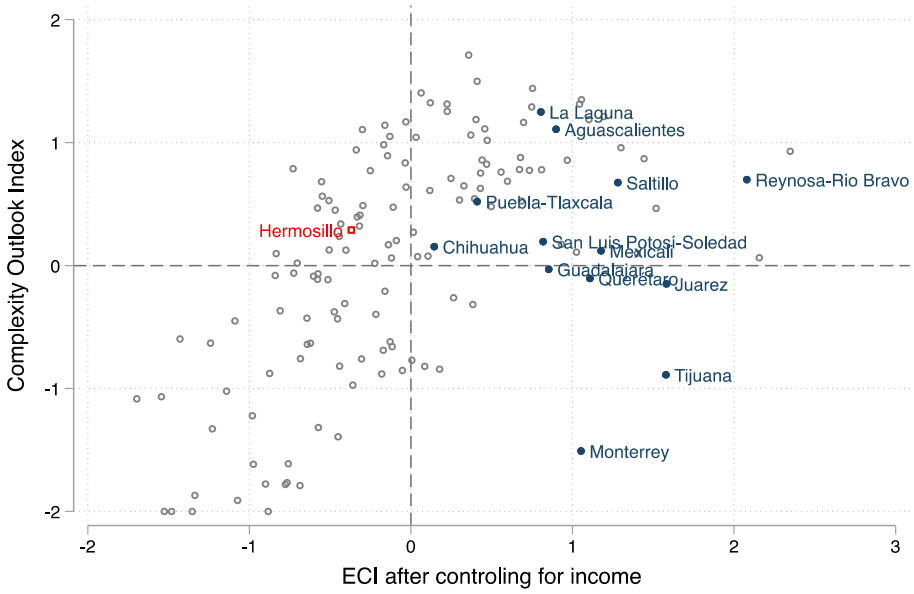
In a strategy for enhancing Hermosillo's economic structure through diversification, it's essential to consider productive capabilities (economic

complexity) and the ease with which they can develop new capabilities (complexity outlook). Cities face challenges based on their economic complexity and their position within the industry space. Some cities are well-positioned with industries close to many potential new industries, offering more opportunities for growth and diversification. Conversely, others have fewer options, starting with a limited number of industries in more peripheral and less connected parts of the industry space. The Complexity Outlook Index (COI) measures each city's position in the industry space, indicating the technological proximity between existing and potential industries. A high COI value results from nearby industries of high sophistication. Generally, COI is low for poor, undiversified cities but can also be low for rich, highly diversified cities with few missing industries. COI influences future growth and complexity increases, with cities and countries having a high COI tending to grow faster and increase their Economic Complexity Index (ECI) more quickly. The ECI and COI help position cities within a two-by-two matrix to identify strategic challenges, plotting know-how against current income and diversification opportunities. Cities with numerous nearby opportunities can diversify more easily and increase their complexity over time, while those with fewer opportunities face greater challenges.

The strategic setting of Hermosillo and its comparator cities is illustrated in Figure 105, which reveals four distinct cases. In the upper right quadrant, we find cities with sufficient know-how to be wealthier than they currently are and abundant diversification opportunities. These cities are poised for rapid growth due to both factors. This is the situation for most of Hermosillo's peer cities. In the lower right quadrant, cities possess ample know-how to be richer but face limited diversification opportunities, requiring them to optimize their existing assets. This describes Guadalajara, Juarez, Monterrey, Queretaro, and Tijuana—all diversified cities with expertise in various sophisticated manufacturing sectors. Cities in the bottom left need more know-how to become wealthier, but their poor positioning in the industry space makes it difficult for them to achieve this. Lastly, cities in the upper left quadrant of Figure 105 need more know-how to become more productive, but their position in the industry space makes it relatively

easy for them to acquire it by leveraging nearby diversification opportunities. This quadrant represents the challenge faced by Hermosillo, with many low-complexity opportunities to take advantage of. This reflects the fact that, in the past decade, Hermosillo lost ground compared to peer cities that managed to move to the right side of the figure. It also stresses the need for Hermosillo to strengthen its productive diversification path.

Figure 105: Hermosillo's Challenge of Diversification



Source: Own calculation based on Censo de Población y Vivienda 2020.

5.5 Key Takeaways

Hermosillo boasts a diverse economy but lags significantly in the manufacturing sector compared to its peer cities. While manufacturing is the largest employer in many comparator cities, Hermosillo has a higher proportion of its workforce in retail. Additionally, Hermosillo has fewer professional occupations, such as accountants and technicians, and a smaller share of workers in machinery and assembly roles compared to similar cities. This disparity highlights a need to boost employment in more skilled and manufacturing-oriented occupations to enhance the city's economic profile and competitiveness.

Hermosillo has not added new sectors to its economy, while other cities have been more dynamic in incorporating firms into industries previously absent. This stagnation may result from a combination of lacking certain productive capabilities and a less aggressive investment promotion strategy, as we will explain in the conclusion of this report. To remain competitive and foster economic growth, Hermosillo must enhance its capabilities and implement a more proactive strategy to attract diverse industries.

Hermosillo ranks low in economic complexity among its peer cities and has shown minimal improvement over the past decade. This stagnation results from the presence of industries that are ubiquitous and lack specialization. In contrast, peer cities have added more sophisticated industries, particularly manufacturing, increasing their economic complexity.

Hermosillo's low economic complexity limits its potential for high-income growth and technological advancement. The city is currently too wealthy for its expertise and production capabilities. Hence, Hermosillo's main road toward higher economic growth is through diversification. Particularly, Hermosillo needs to diversify into industries that increase its level of economic sophistication, bring higher skills, and expand into more productive activities.

Hermosillo faces the strategic challenge of increasing its economic complexity through diversification, particularly in manufacturing. Despite this challenge, Hermosillo's position in the industry space is relatively strong, with many related and sophisticated industries nearby. The city's existing capabilities provide a solid foundation for growth. To improve its economic structure, Hermosillo should focus on attracting and developing industries requiring higher know-how and technological sophistication, leveraging its current strengths to drive future advancements.

6 Conclusion: How to Accelerate Growth in Hermosillo?

Hermosillo is a city with proven economic potential that shows relatively low economic dynamism. Hermosillo has enviable assets to support stronger growth, including the city's excellent education institutions, abundance of skilled labor, and comparative advantage in energy generation. However, as we previously showed, the city has underperformed in terms of diversification into new manufacturing industries. Sonora's FDI levels are lower than those of the peer states, and the overall investment levels of the economy are also relatively low. Several peer cities have experienced exceptional investment and economic growth, especially foreign investment. How come a city that has managed to grow and become a relatively wealthy place cannot attract more investment? Why is it the case that Hermosillo has so many missed opportunities that others have been able to take advantage of?

If Hermosillo aims to increase economic growth by facilitating more investments in the future, it must solve its water, housing, and transportation issues. Housing and transportation could make wages uncompetitive for Hermosillo to attract labor. We argue that the city should revisit its zoning and building regulations, incentivize affordable housing, and improve its public transportation infrastructure to facilitate an efficient labor market where workers can access job opportunities without overwhelming commuting costs. Additionally, unsustainable water use could lead to water rationing, negatively affecting the city's amenities or even its capacity to host new industrial developments. Anecdotal evidence shows that water permits constrain the expansion of housing, which is a big problem if the city aims to increase job creation. To provide a higher quality of life for its residents, the city needs to solve these problems.

Innovation should also be part of Hermosillo's economic growth strategy. Hermosillo could use its human capital and strong research institutions to develop private-sector innovations and patents. Currently, local research institutions lack

effective internal mechanisms to structure joint research and innovation collaborations with firms. Innovation plays a crucial role in developing new manufacturing industries or products. Places that manage to develop local suppliers for the global supply chains they host tend to benefit from local innovation.

Another channel that Sonora and Hermosillo could explore to enhance its diversification strategy is developing an organized investment promotion and facilitation ecosystem. The landscape of investment promotion in Sonora includes different actors with competing interests. There are public-sector entities doing investment promotion in the same areas as former ProSonora, such as Consejo de Desarrollo (CODESO) at the state level, and others like Agencia Municipal de Desarrollo Económico (AMDE) at the city level. There are also private sector efforts, like Sonora Global EDC or the industrial parks. However, there is no systematic approach led by a single entity that coordinates the efforts of multiple actors trying to promote Sonora as a manufacturing destination. As a result, outcomes are suboptimal compared to places that managed to create coordination mechanisms for different private and public actors to work together toward promoting investment.

6.1 Investment Promotion & Public-Private Coordination

The public sector plays a leading role in facilitating and promoting foreign and domestic investments in Mexico and globally. The government is responsible for crucial areas for investment promotion, such as permits, infrastructure, or regulations. In Mexico, most of these responsibilities fall under the state governments. However, cities and municipalities might have control over relevant areas that can affect industrial development, such as zoning and building regulations. These policy areas can make a place stand out as an investment destination or become significant hurdles for potential investors looking for sites. In particular, water and electricity access could be a significant issue for manufacturing companies looking for sites in Mexico. Additionally, although state governments are fiscally constrained, they have some space for offering different types of incentives that can help convince potential investors. Finally, workforce

development is a crucial policy area where the government can play a defining role. For example, TSMC announced delays in establishing a semiconductor fabrication plant in Arizona due to local skills shortages during the first months of 2024 (Cheng, 2024, January 18).

The cases of Nuevo León and Querétaro offer insightful examples of the role the state governments play in investment promotion. Although it did not end up happening, the government of Nuevo León played an active role in convincing Tesla to build its next Gigafactory in its state. Key demands from Tesla were infrastructure improvements in electricity, water, and transportation. The state government addressed those needs by approving incentives worth $153 million (or 3.3% of the overall Tesla investment) that would go towards targeted investments in basic infrastructure for the plant, such as streets and water. The case of Querétaro's strategy for promoting investments in the aerospatial cluster is another noteworthy example. The state created the Universidad Aeronáutica en Querétaro (UNAQ) as a vital step in workforce development toward attracting the interest of the company Bombardier Aerospace back in 2005-2007.

The private sector also makes relevant contributions to the investment promotion process. The places that manage to attract investments, both from abroad and from the rest of the country, experience spillover effects from those investments. Sometimes, those effects can be problematic for local companies, such as when they experience competition in the demand for local talent. But most of the time, the effects are positive, as they contribute to regional clusters of skills and inputs and increase the attractiveness of a place as a labor market.. In some cases, the effects are direct. Industrial real estate developers, for example, tend to organize themselves to work on investment promotion for their industrial parks. Although in the case of other industries, the effects are more indirect, the local business communities tend to coordinate to help promote the region as an investment destination.

Public-private collaboration is essential for putting Sonora on the map for global investment decisions. In prosperous cities, the private and public sectors work together to attract investments from abroad because they both reap the benefits of new regional investments. In many cases, the private sector makes financial contributions, while the public sector works on facilitating permits, regulations, and incentives. The fact that Hermosillo and Sonora fell behind their peers in attracting FDI to develop new manufacturing industries shows that this is an opportunity for growth. Currently, two examples illustrate the need for better investment promotion and coordination in the industrial real estate development sector: the availability of industrial infrastructure (*naves industriales*) and the development of green industrial parks. In the case of *naves industriales*, investment promotion could help solve a chicken and egg problem where real estate developers do not seem to be investing in new industrial parks infrastructure due to perceived lack of demand. In contrast, manufacturing investors do not seem to invest in Sonora due to a shortage in *naves industriales*. In the case of green industrial parks, better public-private coordination could help Sonora leverage its underexploited comparative advantage in solar power for industrial development.

6.1.1 Naves Industriales

The industrial real estate sector in Mexico has seen outstanding growth since 2020. According to the *Asociación Mexicana de Parques Industriales Privados* (AMPIP), the number of industrial parks that joined AMPIP increased by 68% between 2020 and 2023. This translated into 60% more tenants (manufacturing firms operating in the industrial parks), 25% additional square meters, and 50% more jobs. Between 2022 and 2024, AMPIP members increased their investments in new and existing industrial parks by 85%. However, the development of new industrial parks is only surpassed by their demand. In 2023, the industrial park vacancy rate was only 2.2% nationwide (AMPIP, 2024). Although Sonora has several industrial parks and is developing new ones, the state is falling behind other locations, showing much greater dynamism. According to AMPIP (2024), 63% of the total industrial real estate market is in Monterrey, Juárez, Saltillo, Tijuana, and Reynosa. Only 2.4% of the industrial parks of AMPIP are in Sonora.

Sonora's industrial real estate sector faces a chicken-and-egg problem that could be solved by improving its investment promotion strategy. Mexico's industrial real estate sector has seen outstanding national growth since 2020, but this has not happened in Sonora. During interviews with local stakeholders in Hermosillo, the Growth Lab research team learned that one potential explanation for the low levels of industrial real estate development was that the demand for industrial real estate in Hermosillo is not high enough for developers to invest in new *naves industriales*. On the other side, potential investors might prefer to have industrial real estate move-in ready or, at least, consider a lack of industrial real estate projects as a negative sign that might reflect barriers to infrastructure like water or electricity. This results in a sort of "chicken and egg" problem where potential investors need to have readily available *naves industriales* while the developers need more demand from potential investors to take the risk of investing in new industrial parks. Hence, investment promotion could help solve this chicken-and-egg problem because there would be more direct demand for industrial real estate and more marketing for Sonoran industrial parks.

6.1.2 Green Industrial Parks

Sonora's excess solar power potential could be used to attract investments through "green industrial parks". Sonora has the largest installed solar power capacity in all of Mexico and the potential to develop much more. Additionally, it has an excess capacity for electricity generation as its capacity of 9.47 GW outstrips its maximum demand of 5.6 GW, leading to some of the country's lowest electricity wholesale market prices. As other parts of the country struggle with adequate electricity supply, Sonora's extensive availability of solar energy is a comparative advantage. Industrial parks could play a crucial role in leveraging this potential. They could potentially provide dedicated 100% renewable electricity to companies in their park by contracting with a private power supplier instead of the CFE. The main opportunity for a company to ensure a larger share of renewable energy in its mix is to contract with a private electricity provider. However, to do so, it must have a minimum demand of 1MW to classify as a "qualified user". Additionally, Industrial parks can bundle electricity

demand from companies in their park and act as a “qualified user” on their behalf. This allows them to enter into contracts with private electricity providers. The availability of green electricity should carry weight as many companies seek to reduce their emissions. To do so, Sonora has not yet fully taken advantage of this context. Interviews with renewable energy developers indicate room to attract energy-intensive activities with demand for green energy in Sonora, but this has not yet been done.

C**oordination failures and policy uncertainty have prevented the development of green industrial parks**. This opportunity remains untapped due to insufficient awareness and coordination. With excess electricity available and significant renewable generation capacity in the state, industrial parks could target electricity-intensive companies and offer to supply them with low-carbon electricity. The fact that this is not yet taking place is partly attributed to an information gap – existing industrial parks may not know enough about this opportunity. Interviews with renewable energy developers highlight that the absence of an industrial park association in Sonora has contributed to this gap. Another limiting factor is policy uncertainty due to the outgoing administration's policy objectives to strengthen the public sector's role and limit private sector participation. The new federal government might create larger policy certainty in the energy sphere if it becomes more open to private sector participation. This opportunity could attract significant new economic activity to Sonora and spur economic growth. Efforts to create an industrial parks association and potential changes in federal policy towards greater private sector participation present a timely chance to harness Sonora’s renewable energy potential, attract new businesses, and drive economic growth.

6.2 Policy Priorities

The growth diagnostic analysis included in this report identified strategic areas Hermosillo should prioritize to catch up with economic growth. As mentioned, these areas are investment promotion, water, housing, and transportation policies. Table 6 summarizes these policy priorities with strategic ideas on actions to approach them. While we consider that the policy priorities are essential for an economic growth

strategy for Hermosillo, the potential action areas are starting points that would benefit from a discussion with local policymakers and experts. Additionally, we identified relevant topics for strengthening Hermosillo's comparative advantages: promoting innovation by leveraging local human capital, capitalizing on Sonora's solar potential, and strengthening port and airport infrastructure. Table 7 describes them along with potential action areas as starting points. The first table summarizes the most pressing challenges identified in the report. The second table complements this by outlining specific policy initiatives to strengthen the city's competitiveness. These tables provide a strategic roadmap for policymakers, investors, and other stakeholders dedicated to driving Hermosillo's economic development forward.

Table 8: Policy Priorities and Potential Action Areas to Kickstart Economic Growth

Policy Priority	Description	Potential Action Areas
Improve Hermosillo's and Sonora's investment promotion strategy	Hermosillo is not on the map for global investment decisions like other cities in Mexico (Juárez, Tijuana, Querétaro, or Monterrey).	• Establish a single entity that streamlines investment promotion efforts in collaboration with public and private sector stakeholders.
Achieve sustainable water use	Hermosillo's water use is unsustainable, but higher economic and population growth would demand more water. Therefore, Hermosillo must decide how to allocate water to its most socially desirable use and weigh options to increase its water supply.	• Conduct geological studies of Hermosillo's aquifers, identifying their recharge rate, size, rates of salinization, and other relevant metrics. • Expand micro-metering at the household level in the city to raise funds for water utility and incentivize individuals to use water responsibly. • Coordinate with the 051 Irrigation District, relevant public sector entities, and agricultural users to achieve sustainable aquifer extraction rates and a better pricing mechanism for water usage. • Evaluate technical solutions to expand water supply, including desalination, wastewater treatment, recycling, etc.
Develop an efficient housing market that allows for higher urban density	The housing market in Hermosillo is struggling to meet demand, which creates friction for economic growth. Due to regulations, infrastructure investments, and land value prices, high construction costs have resulted in lower low-income housing construction and rapidly rising housing prices in the city.	• Launch a public-private team focused on housing and urban planning. • Review and reform housing regulations and policies that are increasing the cost of housing projects. • Review the land value tax ('impuesto predial') to encourage higher land use in the city center.
Improve the local transportation system	The urban form of Hermosillo and a dysfunctional public transportation system have resulted in high transportation costs. Higher economic growth puts more pressure on transportation systems, increasing costs for firms and workers and reducing the city's competitiveness to attract firms and talent.	• Launch a public-private team that forms part of the urban planning working group specifically dedicated to resolving the transportation system, including representation from the State government, the transportation workers, and the municipality.

Table 9: Policy Priorities and Potential Action Areas to Strengthen Competitiveness

Policy Priority	Description	Potential Action Areas
Promote local innovation	Hermosillo shows a shortfall in business innovations, start-ups, and patenting. Yet, the city's human capital is an asset for promoting innovation.	• Promote stronger collaborations between universities and the private sector focused on innovation. • Draft non-binding guidelines for establishing internal structures within universities and research centers to articulate and finance joint innovation projects with the private sector.
Leverage Sonora's renewable energy potential for the development of green industrial parks	The industrial real estate sector is not taking advantage of Sonora's solar potential due to a lack of coordination and policy uncertainty.	• Raise awareness among industrial park developers about the opportunity to access cheap, low-carbon electricity via private provision. A regional industrial parks association will be critical in this endeavor. It could also help to uncover other potential barriers.
Expand port and airport infrastructure	The Port of Guaymas has limited capacity to handle container shipments. Strengthening Sonora's port infrastructure would contribute to the region's relative cost competitiveness. In turn, Hermosillo's airport has a low number of international connections compared to peer cities. Promoting more of them would help the city's investment promotion efforts.	• Continue expanding the container capacity of the Port of Guaymas. • Establish a public-private team to promote more international connections in Hermosillo's Airport and solve any issues that prevent airlines from establishing new routes.

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8 Appendix

8.1 Mexican Data Sources for the Study of Economic Diversity

Various data sources can be used to estimate the presence of industries in Mexico. As a data-rich country, Mexico offers a wealth of information, though these sources may vary in terms of completeness and accuracy. This box discusses data options to describe cities' productive capabilities.

The first choice is between using export data and production or employment data. A challenge with using export data is that exports are often assigned to the location where firms are registered rather than where the economic activity occurs. For example, in the case of multi-plant companies, production could be incorrectly attributed to the firm's registered location rather than the actual site of economic activity. This discrepancy can lead to overestimating economic activity in large cities such as Guadalajara, Mexico City, or Monterrey, thus overstating their true productive capabilities. One way to address this issue is to use other sources of information to proportionally distribute exports. For instance, the 2017 Growth Lab study (Barrios et al., 2018) utilized data from the Mexican Social Security Institute (IMSS) to allocate exports proportionally to the municipality where the workers reside. Another problem with using export data is that it only records the final state of shipment, which under-represents areas involved in upstream stages of production. For example, in the case of car exports from Hermosillo, most engines used in these cars are produced in other states, particularly Chihuahua. Since export data do not indicate where each component was created, this can lead to an overstatement of production in Sonora and an underrepresentation of production in Chihuahua.

A second option is to use production or value-added data. In Mexico, the Economic Census (EC) is renowned for its quality and extensive coverage. Conducted every five years, the EC provides comprehensive data on production, value-added, and the general accounting of expenses and investments of establishments. Additionally, it

includes detailed information on workers. The high level of detail in the EC comes with the necessity to censor certain observations to prevent the identification of individual firms. For this study, we found that many observations (i.e., municipality-industry combinations) are censored. This censoring is a common issue, particularly in relatively small municipalities with sophisticated industries like Hermosillo.

A third option is to use employment data. One primary source is the National Survey of Occupation and Employment (ENOE), which is conducted frequently. However, ENOE lacks the high level of industry disaggregation required for our study. Despite its large sample size, ENOE has a notable disadvantage for our purposes: it struggles to be representative and adequately capture employment data across municipalities.

Our preferred employment data source is the Population Census, which offers several advantages. First, it is conducted nationwide every ten years using an extended or long-form questionnaire applied to 10% of the population, which is double the coverage of similar forms in most countries. This extensive coverage captures many industry-location combinations, even in small municipalities. Second, the Census records workers' occupations, which will be particularly useful for our upcoming report on growth opportunities.

However, a disadvantage is that the 2010 and 2020 Censuses used 3-digit codes to describe some industries, particularly in Manufacturing. For instance, the 3-digit code for "Transportation Equipment" (SCIAN 336) groups together sectors with varying levels of sophistication and requirements, such as "manufacturing of aerospace equipment" and "manufacturing of bodies and trailers" (SCIAN 3362). To address this issue, we supplement the Census data with information from the *Directorio Estadístico Nacional de Unidades Económicas* (DENUE). DENUE is a registry that provides basic information on every establishment in a municipality and describes employment using size brackets. We use this additional detail to enhance the granularity of our data on industries in the Manufacturing sector.

8.2 Migration Dynamics in Spatial Equilibrium: Mexico, Hermosillo and Peers

Mexico's spatial equilibrium dynamics can be analyzed using a gravity model approach. This model allows us to explore the determinants of migration flows between metropolitan areas in Mexico. The model utilizes data from the 2020 Households and Population Census, which captures individuals' location information in 2015 and 2020, allowing us to compute the migration flows from one metropolitan area to another. The census data also provides occupational codes, enabling us to categorize migrants into three skill levels: high-skilled, medium-skilled, and low-skilled. The basic equation for estimating the migration flows and their determinants includes variables such as distance, contiguity, and population of the origin and destination metropolitan area, as well as fixed effects for the skill level.

To better understand the factors driving these flows, we extend the model by incorporating additional variables that reflect wages, housing prices, and public safety. Extending the model to incorporate wage differentials, housing rent differentials, and violence rate differentials fits the spatial equilibrium framework because it captures the key factors influencing individuals' location decisions. In spatial equilibrium, people live and work in cities that offer the best economic opportunities, affordability, and quality of life. The gravity model reflects this by predicting migration flows based on the relative attractiveness of different cities along these dimensions. Wage differentials represent the economic opportunities available in each city, while housing rent differentials capture the cost of living and the supply and demand for housing. Violence rate differentials account for an important quality of life factor that can significantly impact location choices, especially in the context of Mexico, where crime and insecurity are major concerns. As an additional control, we are incorporating average maximum temperatures differentials to account for people's preferences of living in places with less extreme weather conditions.

The results from the gravity model allow us to explain the responsiveness of migration patterns to economic variables and living conditions across Mexican metropolitan areas. As shown in , an expected negative coefficient on distance shows the friction that greater distances pose on migration and the labor markets while the positive coefficient for contiguity shows that people are more likely to migrate to areas bordering their towns and cities of origin. The positive coefficients for population size at origin and destination point to agglomeration effects—larger cities send and receive more migrants, likely due to higher and more diverse demand for workers. As reflected by wage differentials, economic factors have a strong pull effect, indicating that individuals are drawn to cities with better earnings potential. Meanwhile, housing prices in the city of origin also exert a significant influence, captured by the negative and statistically significant coefficient on rent differential, which confirms that housing affordability plays a role in migration decisions. Public safety is shown as another factor: higher violence rates in the cities of origin increase out-migration. In comparison, lower rates in destination cities increase the rates of migration towards the cities.

Table 10: Gravity Model on Migration Flows in Mexico, basic specification

	(1)
Log of Distance	-0.651***
	(0.076)
Contiguity	0.737**
	(0.248)
Log of Population at Destination	0.847***
	(0.041)
Log of Population at Origin	0.912***
	(0.045)
Log of the Median Wage Differential	0.921***
	(0.093)
Log of the Rent Differential	-0.098*
	(0.045)
Log of the Violence Rate Differential	-0.149***
	(0.006)
Log of the Max Temperature Differential	-0.265***
	(0.056)
Observations	825,300
R2	0.687
Estimation	PPML
Origin FE	No
Destination FE	No
Skill-Level FE	Yes

** p < 0.1, ** p < 0.05, *** p < 0.01*

Higher wages tend to attract more migrants to cities with significant wage differentials. When a city experiences a productivity shock that raises wages, it draws migrants into the city. The city's population will grow if the housing supply is elastic and amenities are constant across space. This growth continues until real wages adjust and

the city reaches spatial equilibrium. When amenities are in decline, or the housing supply does not respond to its increased demand, then the population growth will decelerate, and real wages will compensate for the difference in amenities. In our model results, wage differences empirically play the most critical role in determining bilateral flows across cities.

Housing price differentials directly impact real wages and depend on the housing supply's responsiveness to productivity shocks. When productivity increases in a city, real wages typically rise, attracting more workers. If the housing supply is elastic, it can expand to meet the increased demand, stabilizing housing prices. This stabilization prevents real wages from falling further, as the cost of living does not increase with the influx of new residents. If the housing supply is inelastic, housing prices will rise sharply due to the increased demand, which will decrease the real wages. Therefore, the degree of housing supply responsiveness to productivity shocks plays a vital role in determining the population size of the city and its agglomeration. While rent prices are not the most significant factor in our model, the differentials have a moderate effect on determining outflows as they impact workers' real wages.

Amenities play an important role in determining wages across space, as workers would need to be compensated for disamenities or would be willing to accept lower wages for increased amenities. In our model, amenities are reflected in extreme heat temperatures experienced in different cities (temperature differentials) and by the relative safety of different cities, measured through the violence rates experienced in these cities. Other amenities could include the presence of restaurants, cultural activities or other types of entertainment services such as concerts. In general, bilateral flows tend to go to places that experience lower maximum average temperatures in Mexico and to places that experience lower violence rates. These amenities impact the real wages that need to be offered inside the cities to compensate or adjust these differentials: a higher maximum temperature means that workers would need to be paid more to compensate for the disamenities.

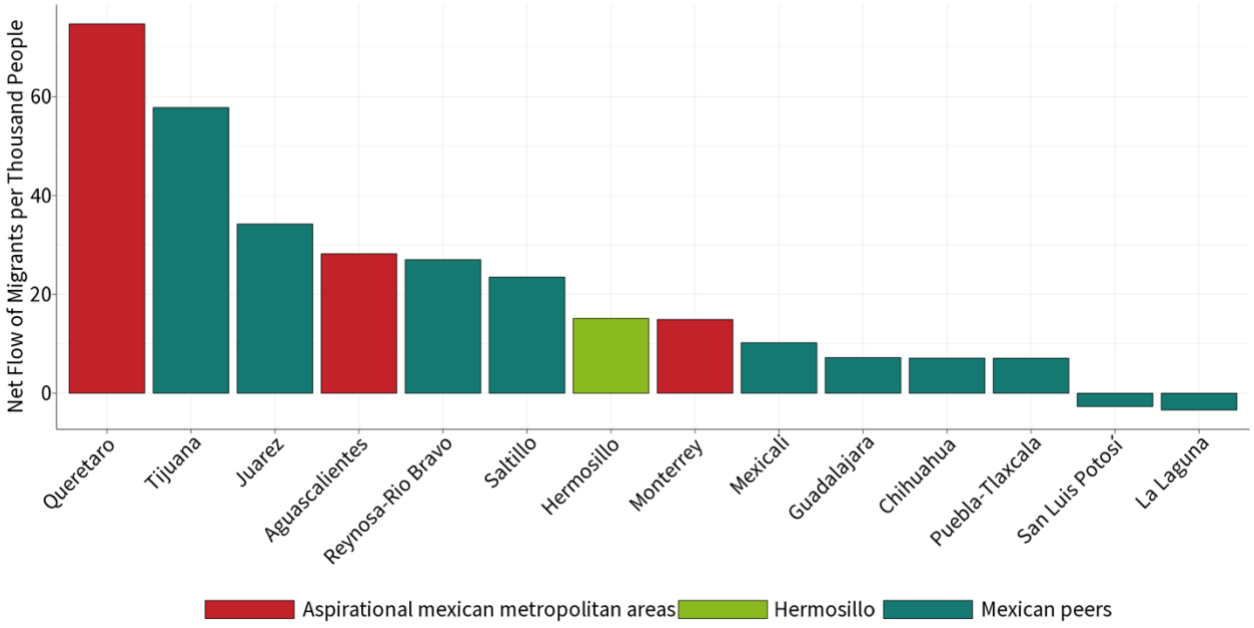
Hermosillo has experienced significant economic growth from the 1970s until the 2010s. Initially boosted by the Green Revolution and subsequent industrialization, Hermosillo has ranked high in relative wealth among Mexican municipalities, particularly in the automotive sector. However, post-2010, the city's growth trajectory has diverged from its peers, decelerating despite maintaining positive growth rates. The manufacturing sector, especially automotive, has been Hermosillo's economic cornerstone. In recent years, declining sector dynamism has been characterized by reduced job creation and limited industrial diversification. This deceleration, coupled with low domestic and foreign direct investment (FDI), has led to a "trailing growth" phenomenon where Hermosillo grows but lags behind more dynamic peer cities, such as Saltillo or Aguascalientes.

Compared to peers, the effects of this economic progress and ‘trailing growth’ can be understood through a spatial equilibrium lens. The economics of Hermosillo’s agglomeration is explained by the evolution of different variables, especially wages, housing prices, and population. When the city experiences growth in its productivity, it acts as an economic center that demands more workers, and depending on its wages and housing prices, it can do so. Wages would react to the new population growth by decreasing up to the point where it equalizes across space, considering the cost of housing and other amenities such as weather or safety. The city would experience population growth when the housing supply is elastic enough to accommodate the new workers who want to work there. Otherwise, lower-wage workers get priced out of housing, generating out-migration and compensating for the productivity shock.

Despite slower growth than peers in the 2010s, Hermosillo experienced a net positive inflow of migrants between 2015 and 2020. Compared to its peers, Hermosillo has attracted migrants but has performed worse than its aspirational peers like Tijuana, Queretaro, and Aguascalientes. This positive net inflow of migrants reflects Hermosillo's relative economic success in the five years between 2015 and 2020. At the

same time, it can also reflect differences in the amenities of the city compared to those cities where the migrants are originally from, as is the case with other places in the south of Sonora.

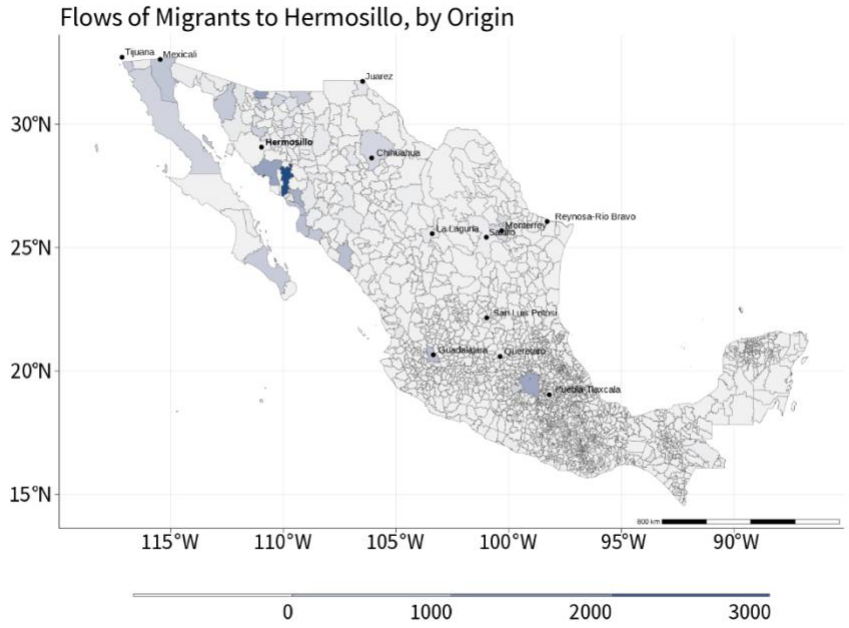
Figure 106: Net Flow of Migrants per Thousand People: Hermosillo vs. Peers



Source: Own calculations based on Censo de Población y Vivienda 2020.

Almost half of the people who migrated to Hermosillo come from metropolitan areas inside Sonora and relatively closer places than other Mexican peers. In Figure 107, it is shown that most migrants who arrived in the Hermosillo municipality between 2015 and 2020 came from nearby towns such as the city of Guaymas, Empalme (Guaymas), and Ciudad Obregón (Cajeme). These migrants were attracted by several 'pull' factors, such as higher wages and a lower rate of violence experienced in Hermosillo. At the same time, there were 'push' factors that negatively affected Hermosillo as a destination for migrants from all of Mexico, such as higher housing costs and an average of more extreme temperatures. This is especially true for cities in the south of Sonora that, even though they experienced less economic growth, received a significant portion of migrants from Hermosillo.

Figure 107: Map of Overall Flow of Migrants to Hermosillo by their Origin Metropolitan Area



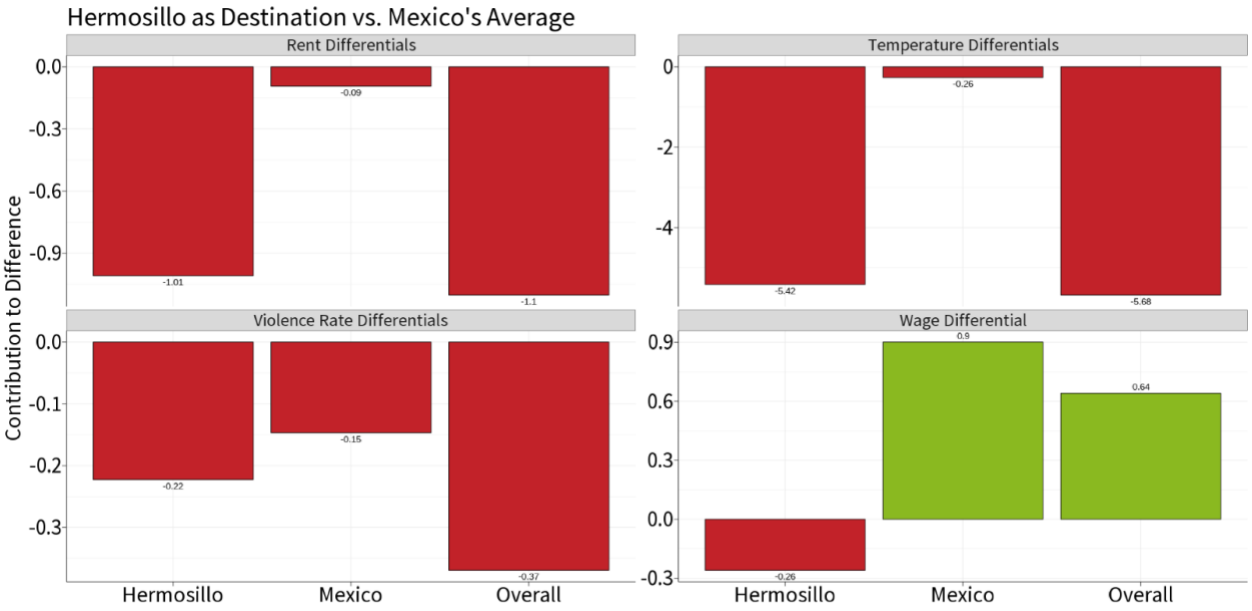
Source: Own calculations based on Censo de Población y Vivienda 2020.

Hermosillo has significant differences in the factors that explain its immigration compared to the rest of Mexico. Figure 108 highlights some of the 'pull' and 'push' factors determining people's movements towards Hermosillo. This figure shows the importance of different factors when explaining migration in Mexico and how Hermosillo differs from the rest of the country in each of these factors. Each coefficient is calculated using the model described above adding an interaction term with the city of Hermosillo as a destination to capture the difference of each factor concerning the Mexican average. The last bar of each panel in Figure 108 is the sum of both coefficients and gives the overall coefficient for the city.

On average, migrants who come to Hermosillo are less sensitive to wages than the Mexican average but more sensitive to violence, temperature, and housing prices. First, renting differentials between Hermosillo are significantly larger than in the rest of Mexico, suggesting that housing prices could act more as a 'push' factor driving people into Hermosillo or that Hermosillo's migration rate would be higher if its housing prices were lower. Second, violence in the cities of origin drives people towards Hermosillo

significantly more than the Mexican average. This is particularly important for cities in Sonora that experience higher rates of violence. Migrants coming into Hermosillo are less sensitive to wage differentials, which suggests that the positive net migration flows are compensated by amenities, such as improved public safety. Finally, the temperature differential is an important additional factor that acts as a disamenity for the city: the coefficient explains that migrants are more sensitive to the maximum temperatures experienced in Hermosillo. This can be explained by two factors: migrants that come to Hermosillo come from significantly hotter places, or migrants are less likely to come to Hermosillo from places that experience lower maximum temperatures across the year.

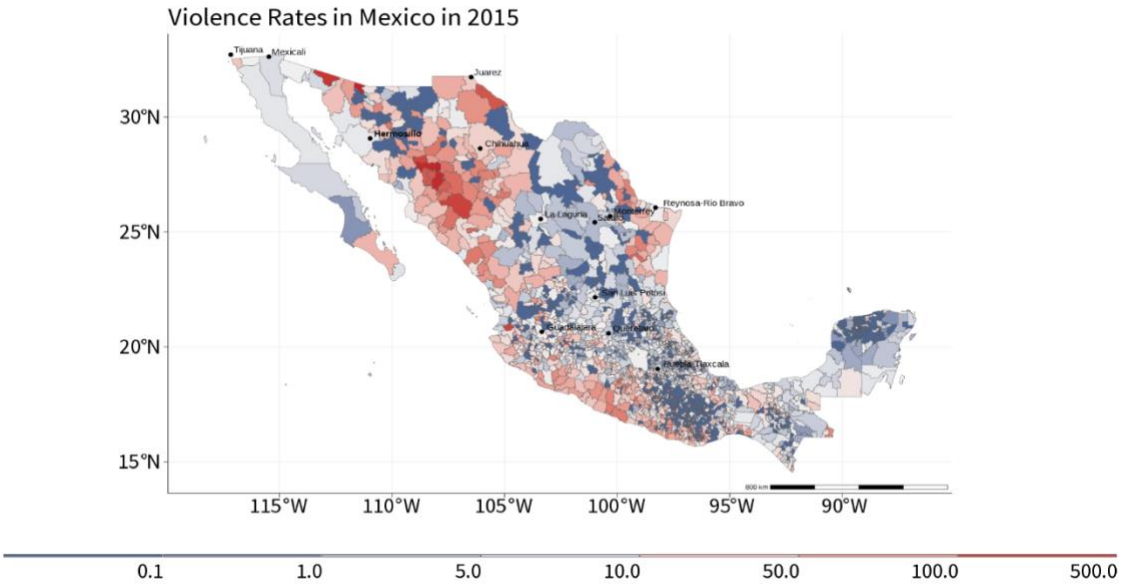
Figure 108: Coefficient in wages, rent prices, homicide rates, and maximum temperature in Mexico and interaction with Hermosillo as the destination.



An important asset for the city of Hermosillo is its lower violence rate compared to neighboring municipalities and some of the peer cities, reflecting its better public safety. The largest population centers around Hermosillo (Ciudad Obregon, Nogales, and Guaymas) have some of the highest rates of violence in Sonora (Figure 109), which ends up as a 'push' factor for migrants who would accept lower wages in Hermosillo because of the safety amenity. In general, safety as an amenity tends to play a larger role in Hermosillo than in the Mexican average, which is then reflected in a lower

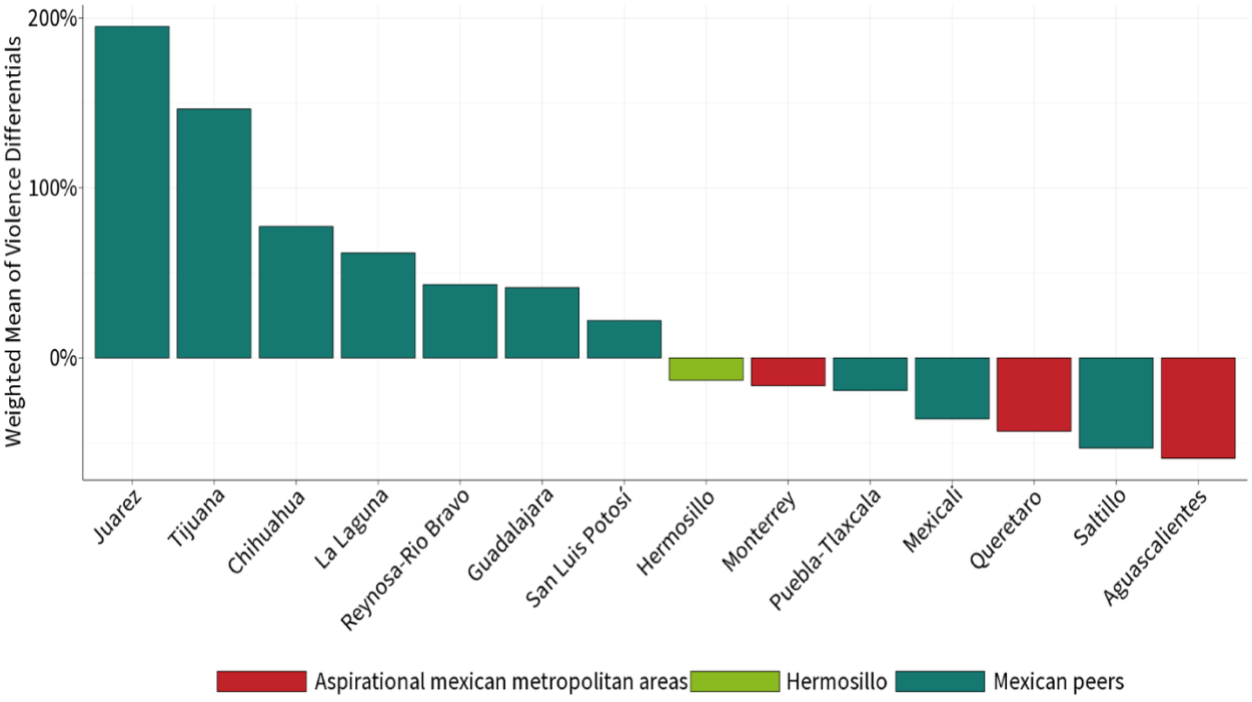
violence rate differential than in the origin of these migrants (Figure 110). While Hermosillo does not exhibit the lowest violence differentials across peers, it is one of the lowest when it is compared to the cities in the north of Mexico and close to the border with the United States.

Figure 109: Map of Mexico by Homicide Rates in 2015



Source: Authors' calculations based on Encuesta Intercensal de México 2015 and INEGI.

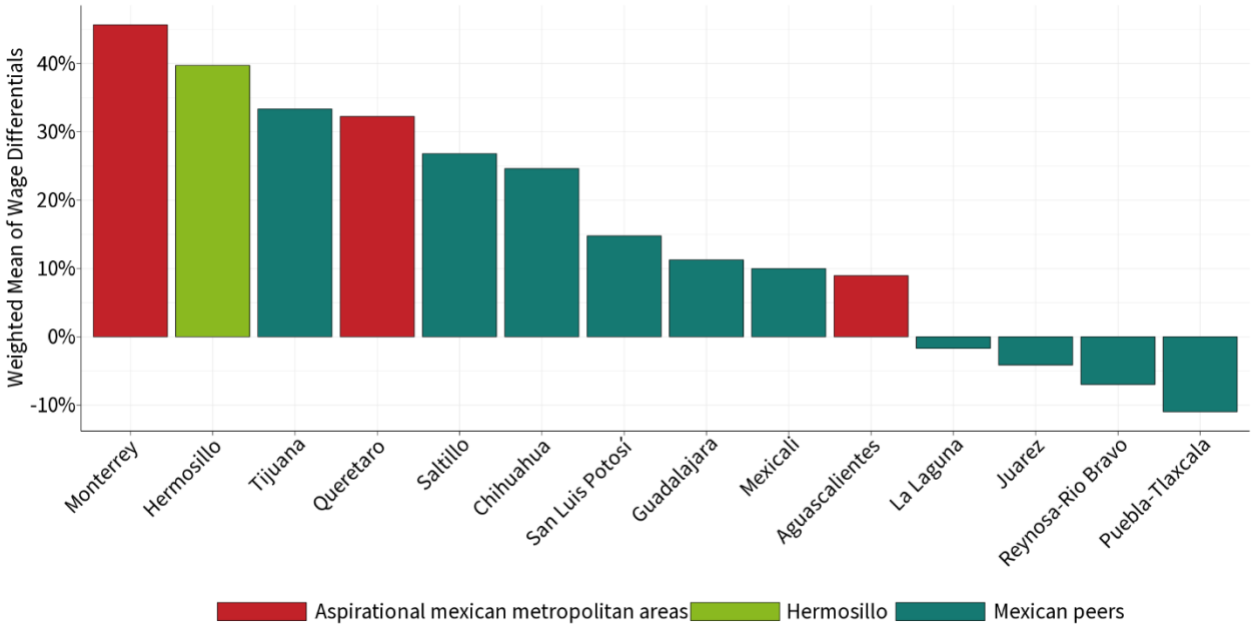
Figure 110: Weighted Violence Rate Differentials in 2015 from migrants' origins, Hermosillo vs. Peers



Source: Authors' calculations based on Encuesta Intercensal de México 2015 and INEGI.

Among peers, Hermosillo has higher wages in relation to the cities from which migrants come. Figure 19 indicates that Hermosillo offers relatively higher wages than other metropolitan areas. The higher wage differentials are explained by a city that has experienced high growth in the past and has remained relatively competitive in its wages, especially in comparison to where migrants are coming from. This is an important 'pull' factor for Hermosillo, despite being less important than in the rest of Mexico (Figure 111).

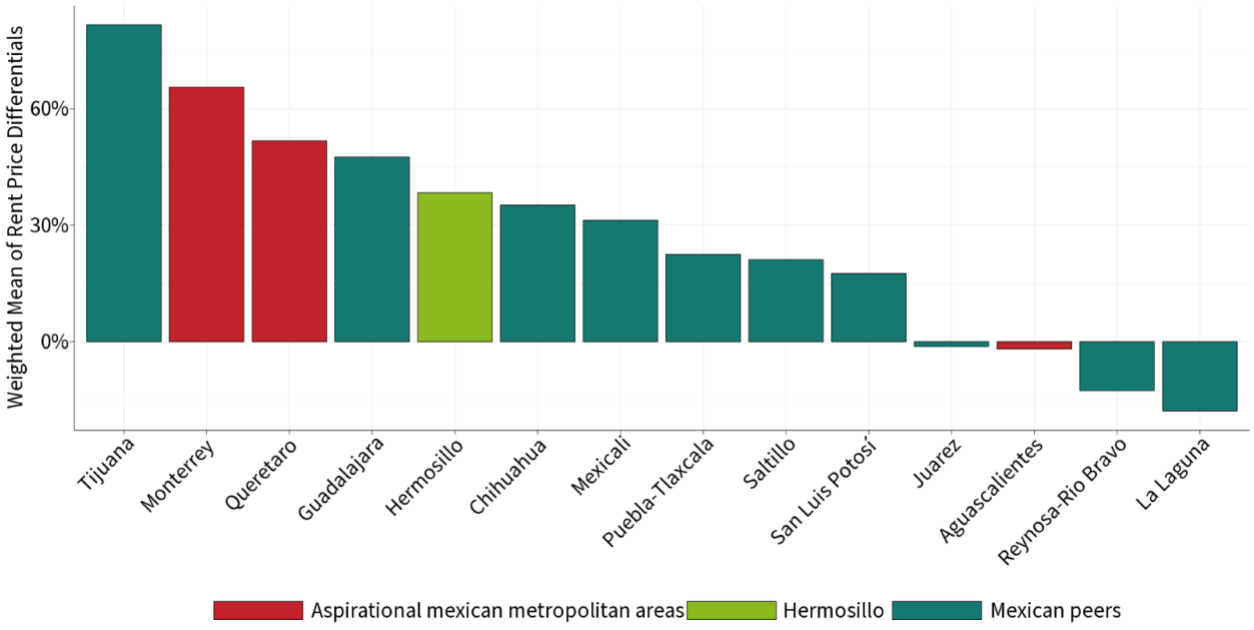
Figure 111: Weighted Mean of Wage Differentials: Hermosillo vs. Peers



Source: Own calculations based on Encuesta Nacional de Ingresos y Gastos de los Hogares 2016.

While rent differentials are relatively high, they are compensated by the wage differentials. In the context of rent price differentials (Figure 112), Hermosillo shows a moderate differential, below other large metropolitan areas such as Tijuana, Monterrey, and Querétaro. In aggregate, migrants coming to Hermosillo seem to experience moderate real wage increases as its wage differentials tend to be higher than its housing price differentials. The possibility of earning a higher real wage in Hermosillo, in combination with its public safety, plays an important 'pull' factor for the city when evaluating it using a spatial equilibrium lens.

Figure 112: Weighted Mean of Rent Price Differentials: Hermosillo vs. Peers



Source: Own calculations based on Encuesta Nacional de Ingresos y Gastos de los Hogares 2016.

Overall, Hermosillo's positive net migration can be explained by a positive real wage differential and higher levels of public safety. The city's economic growth in the past created job opportunities that offer relatively higher wages, as evidenced by the significant wage differentials. Despite the 'trailing growth' in the last few years, these wage differentials remained significant in determining migration flows between 2015 and 2020. While Hermosillo does experience higher housing cost differentials than some of its peers, the wage advantage tends to outweigh these increased living expenses, resulting in a net positive real wage differential for migrants. Additionally, Hermosillo has lower violence rates compared to many of the migrants' places of origin, particularly other major population centers in Sonora, such as Ciudad Obregon, Nogales, and Guaymas. This safety advantage acts as a significant 'pull' factor, as migrants would be willing to accept lower wages in the presence of this amenity.

So far, Hermosillo's continued economic growth has not been limited by housing or amenities. However, catching up with peer cities will require a combination of lower housing prices and stability in public safety. Higher economic growth in Hermosillo would pressure its housing market and wages through increased migration.

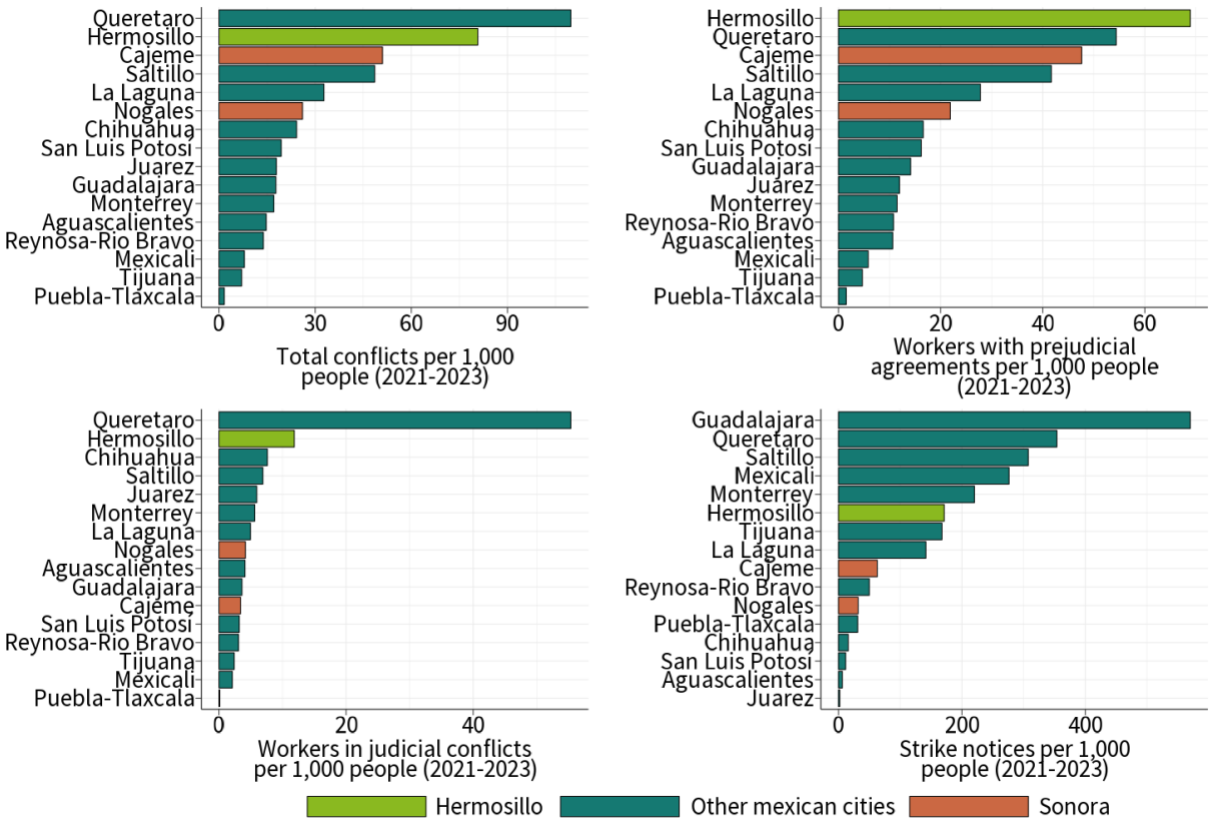
As the city's economy expands, it will likely attract more workers, potentially leading to increased demand for housing. This influx could drive up housing costs if there is insufficient housing supply. To maintain its attractiveness to migrants and sustain economic growth, Hermosillo must ensure its housing supply remains elastic enough to accommodate new residents without significant price increases. Simultaneously, maintaining the city's current advantage in public safety is crucial. Any deterioration in public safety could reduce this advantage and make the city less appealing, potentially slowing economic growth if wages cannot compensate for the loss of the amenity.

8.3 Labor Unions and Labor Conflicts

Labor conflicts in Hermosillo reflect a housing-constrained labor market where employers compete intensely for available talent. Due to housing constraints and urban planning failures that restrict labor market expansion, employers find themselves in intense competition for a limited pool of available workers, which especially affects those firms that rely the most on workers with lower wages. This can be seen in several forms in the relations within the labor market of the city, particularly in the frequency of labor conflicts, as well as in the strategies employers use to attract and retain talent, especially through added benefits.

Hermosillo shows a high rate of total labor conflicts per 1,000 people compared to other Mexican cities, second only to Querétaro. In the second panel of Figure 113, it can be seen that most of these conflicts are solved through pre-judicial agreements where Hermosillo exhibits the highest rate in all of Mexico, where other municipalities in Sonora like Cajeme and Nogales also show up high in the rankings. Despite this and a relatively high rate of judicial conflicts, Hermosillo shows a low rate of strike notices (‘emplazamientos a huelga’) which could be a result of institutional mechanisms working towards solving the conflicts before they get to a stage where it could end up being more costly both for the firms and the workers due to the stoppages in production.

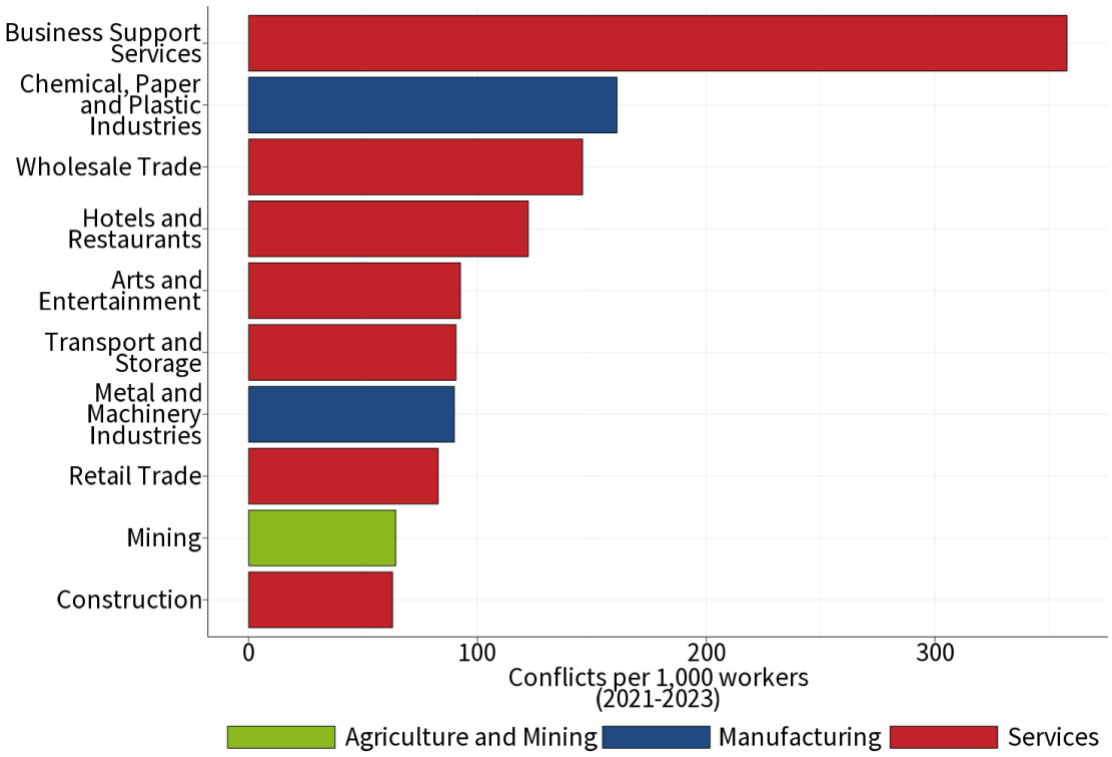
Figure 113: Labor conflicts in Hermosillo and peers (2021-2023)



Source: Own calculations based on Estadísticas sobre Relaciones Laborales de Jurisdicción Local

The sectoral distribution of labor conflicts reveals that business support services experience the highest conflict rate, which reflects a limited impact in export industries. This sectoral distribution suggests that labor tensions are more prevalent in non-tradable services rather than in the export sector, where firms might have more established labor relations practices and are able to compete on compensation with less impact in its competitiveness. Most of the labor conflicts are concentrated in industries such as Business Support Services, which include cleaning and maintenance of buildings, Wholesale Trade and Hotels and Restaurants (Figure 114). However, it is important to note that certain tradable industries still exhibit higher-than-average rates of conflicts albeit at a different scale than locally-traded activities.

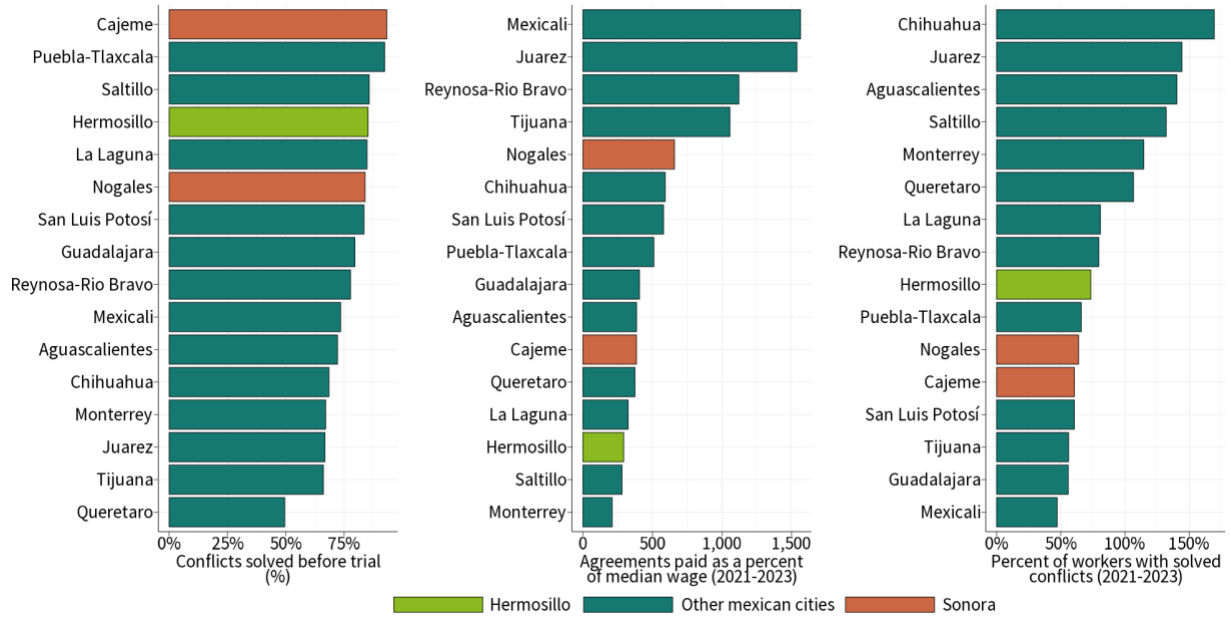
Figure 114: Conflicts per thousand workers by sector (2021-2023)



Source: Own calculations based on Estadísticas sobre Relaciones Laborales de Jurisdicción Local

Despite exhibiting high conflict rates, Hermosillo also has demonstrated remarkable institutional strength in the resolution of conflicts in the past few years. Around 75% of all labor conflicts in Hermosillo get solved before it gets to the trial phase, which is significantly higher than other cities with a high-rate conflicts, such as Queretaro that solve around half of them (Figure 115). Similarly, the median payout in the prejudicial agreements in Hermosillo tends to be significantly lower than in other cities (around 4 times the median monthly wage). The resolution of the labor conflicts and the prevalence of high rates in faster-growing cities like Queretaro suggests that the high prevalence of labor conflicts is not a constraint to economic growth in the city but rather a consequence of a labor market that is being constrained in its growth by other factors, such as housing availability.

Figure 115: Solved labor and agreements paid (2021-2023)

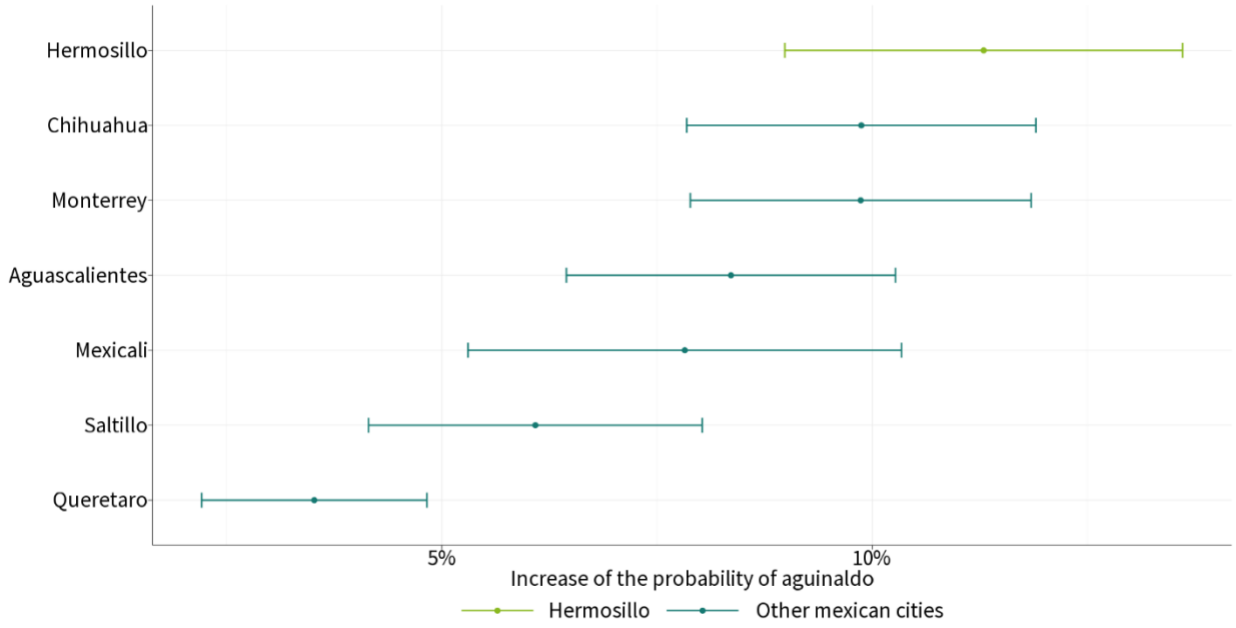


Source: Own calculations based on Estadísticas sobre Relaciones Laborales de Jurisdicción Local

The conflicts are likely a reflection of a tight labor market, which requires employers to compete for talent with higher labor benefits. When analyzing benefits of workers in the city, controlling for its economic composition[25], Hermosillo consistently shows up high in the rankings of having an increased probability of seeing certain labor benefits (end-of-year bonus, vacations, or profit-sharing). In Figures 116 to 118 in can be seen that Hermosillo is at the top of the cities consistently. This is despite being in the middle of the pack in the rates of prevalence of these benefits, when not controlled for the industries and the occupations in the city. This likely reflects the tight labor market that Hermosillo has consistently shown one of the lowest unemployment rates that declined to the lowest one in the last 25 years in December 2024 (BienInformado, 2024; Data México, n.d.).

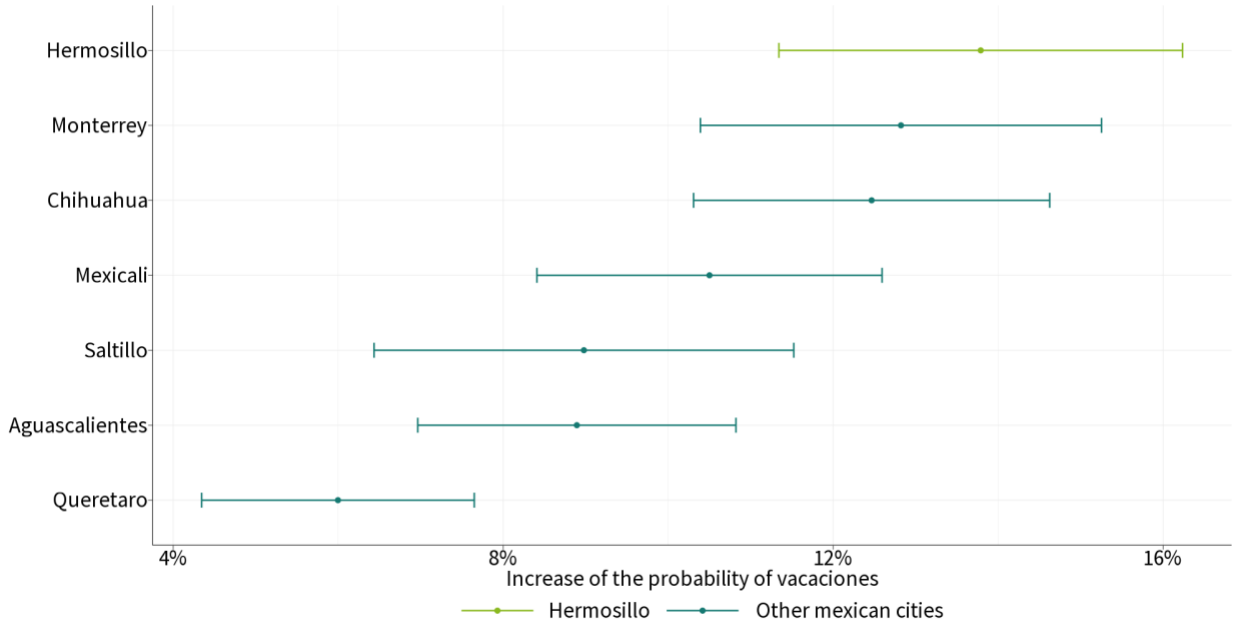
[25] When we talk about economic composition, we refer to controls and fixed effects on industries and occupations of the workers. The regression also includes Mincer controls such as age, experience and years of education.

Figure 116: Increase in probability of end-of-year bonus



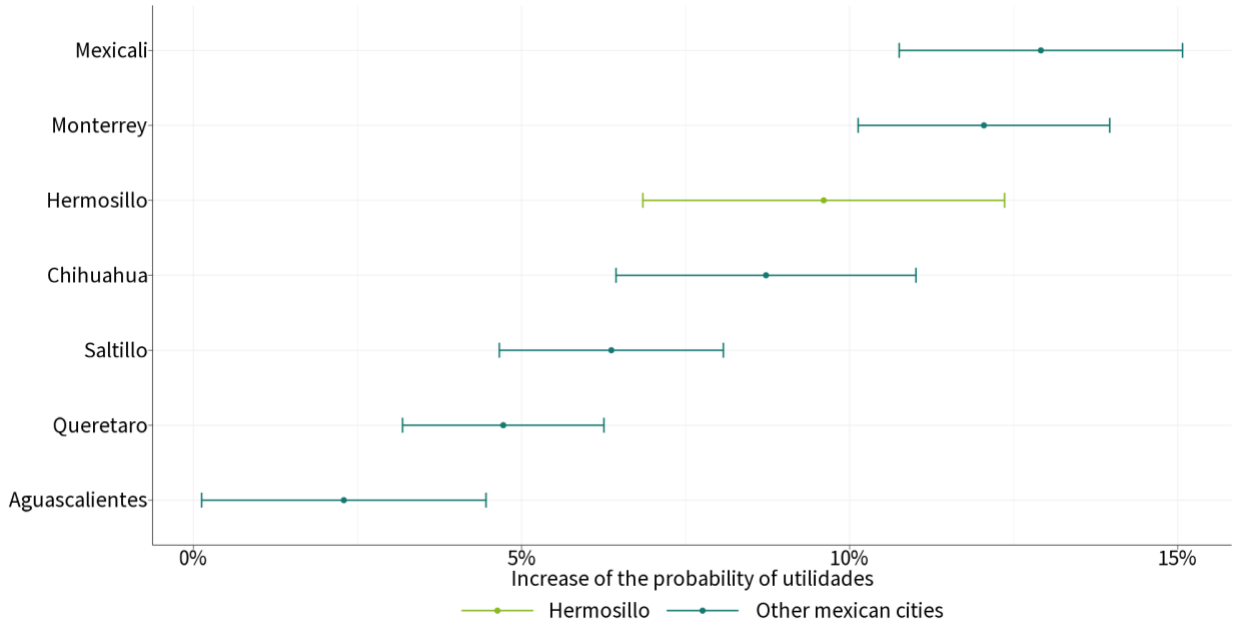
Source: Own calculations based on Censo de Población y Vivienda 2020.

Figure 117: Increase in probability of vacations



Source: Own calculations based on Censo de Población y Vivienda 2020.

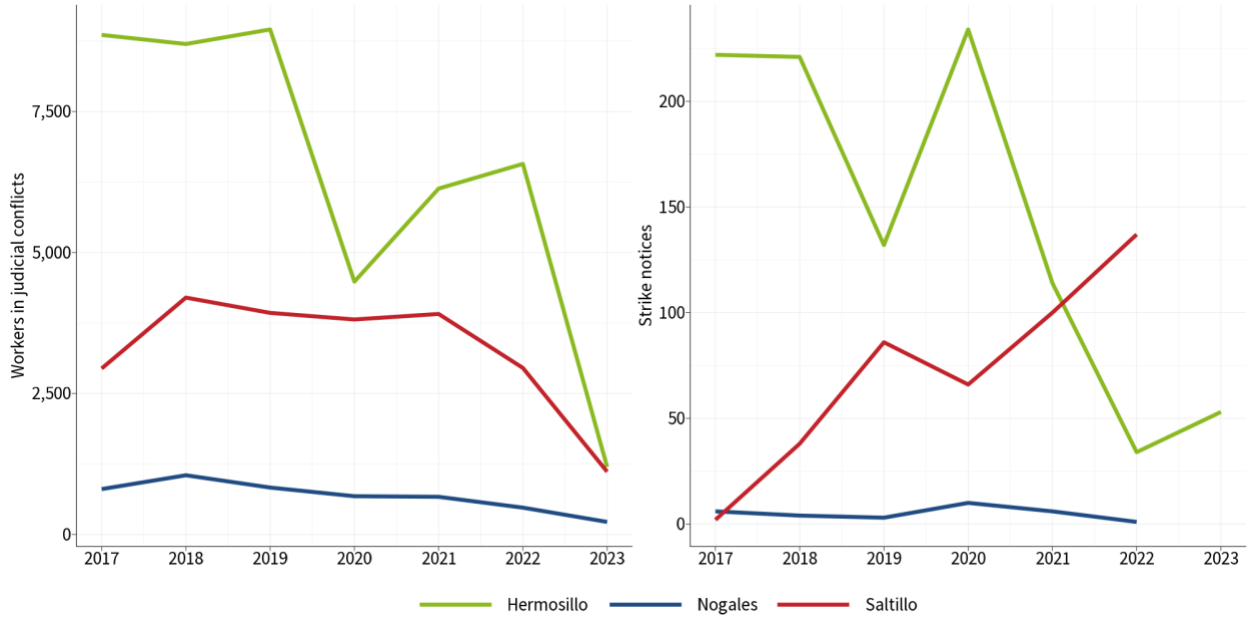
Figure 118: Increase in probability of profit-sharing bonus



Source: Own calculations based on Censo de Población y Vivienda 2020.

Despite still having high pre-trial conflicts, labor conflicts have been declining in the last few years, especially those that are longer and protracted, such strikes and strike notices. Judicial conflicts and strike notices have decreased significantly from 2017 to 2023, suggesting an evolution toward more efficient dispute resolution mechanisms (Figure 119). This trend indicates that while the pressure of a tight labor market continues to generate conflicts, these are increasingly being resolved through the institutional mechanisms that were created with the labor reform of 2019. The labor reform created mechanisms that promote conflict resolution and brought transparency to the union governance system, which has limited the power of labor unions to spark wider conflicts.

Figure 119: Number of Workers in Judicial Conflicts in Hermosillo, Nogales, and Saltillo (2017-2023)



Source: Own calculations based on Estadísticas sobre Relaciones Laborales de Jurisdicción Local

The complex dynamics of Hermosillo's labor market are more reflective of challenges in the growth of its labor market than labor unions and conflicts as a potential constraint to economic growth. While the high rate of labor conflicts might appear concerning, these are symptoms of a tight labor market rather than signs of dysfunction, as evidenced by the efficient resolution of conflicts and declining rates of protracted disputes. The combination of limited housing supply and employment growth creates a situation where employers must compete intensely for workers through higher benefits and wages, particularly affecting firms reliant on lower-wage labor. As Hermosillo positions itself to capitalize on nearshoring opportunities, addressing these housing constraints becomes crucial for enabling the city's economic growth potential.