Submission date: 15-Jan-2024.

Candidate No.: 275982

Word Count: 1990

FROM ICE TO EV

Science, Technology, and Innovation: Markets, Firms and Policies

Contents

Introduction

The automotive industry in Mexico has undergone a remarkable evolution since the inception of NAFTA, now known as USMCA, in 1993. This transformation has been instrumental in shaping the country's economic landscape, particularly in the specialization of key sectors like automotive, electronics, and aerospace manufacturing. The impact of this agreement on Mexico's economy is profound, with the GDP and per capita income experiencing significant growth. Such economic expansion reflects not just quantitative progress but also deep-seated structural changes within the Mexican economy. The growth in manufacturing capacity has been paralleled by Mexico's integration into the North American regional market, especially with the United States, its principal trading partner. This integration has positioned Mexico as a crucial player in the global automotive industry, marked by a substantial export orientation and an increasing focus on fulfilling the demands of its largest trading partner. Mexico should capitalize on the electric vehicle transition that is happening globally.

Specialization in vehicle manufacturing

Since the signing of the NAFTA -now, USMCA- in 1993, Mexico has capitalized on trade to specialize itself particularly in the automotive, electronics and aerospace industry. Since the agreement, GDP has boomed [see Figure1] (World Bank, 2023).[1] Growth in manufacturing capacity has been accompanied by Mexico's economy integration into the North America's regional market, particularly the US, its largest trading partner.

According to the United Nations Conference on Trade and Development (UNCTAD, 2023), by 2022, a striking 78% of Mexico's exports were directed to the USA, underscoring the degree of economic interdependence between the two countries [Figure 2]. Automotive manufacturing has emerged as a cornerstone of Mexico's export economy. In 2023, automotive products accounted for a remarkable 33% of Mexico's total exports [Figure 3]. The country's role as a major player in the global automotive industry

[1] Figures can be seen in appendix.

is further highlighted by its status as the world’s seventh-largest passenger vehicle manufacturer, producing 3.5 million vehicles annually (INEGI, 2023a).

The export-oriented nature of this industry is evident, with 88% of vehicles produced in Mexico being exported, of which 76% are destined for the United States. The evolution of Mexico’s vehicle production has mirrored shifts in the USA’s economic demand. From a predominance of light passenger vehicles, which constituted 70% of Mexico’s vehicle production in 2005, there has been a notable shift towards the production of bulkier vehicles such as SUVs and pickup trucks, that now account for 80% [Figure 4] (INEGI, 2023a).

Competitive advantages: capitalizing on U.S. expanding market and nearshoring

The strategic adaptation of Mexico’s automotive production to these trends underscores the country’s responsiveness and ‘dynamic capabilities’ to the evolving regional market dynamics and its role in fulfilling the demands of its largest trading partner (Winter, 2003). The boom in manufacturing, and the subsequent relocation of production facilities to Mexico can be attributed to several key advantages that make the country an attractive destination for developed nations' industries (Baldwin, 2012):

- **Geographical proximity:** Mexico's close integration with the United States, underpinned by shared territorial borders, significantly reduces transportation costs, time, and movement. By leveraging its proximity, Mexico can become a strategic hub for companies looking to streamline their logistics and distribution processes Government of Mexico (CEPAL, 2022).
- **Labor costs:** A primary factor driving investment and manufacturing relocation to Mexico is the comparatively low labor costs. As of October 2023, the average hourly wage in the US for transportation equipment manufacturing stood at $38, while in Mexico, it was just $2.65 (U.S. Bureau of Labor Statistics, 2023; INEGI, 2023b). This translates in cost savings enabling them to maintain competitive pricing while managing production expenses.

- **Specialised workforce:** Mexico has established a competitive edge in global manufacturing, evidenced by a skilled and specialized workforce (BBVA, 2022). This level of expertise enhances Mexico's appeal as a manufacturing location, offering companies access to a labor pool.
- **Intra-industry trade:** Mexico's role in intra-industry trade is highlighted by the fact that intermediate goods account for up to 80% of its imports [Figure 4]. This trade structure allows companies to optimize their production costs while maintaining high standards of quality and efficiency.

There has been an important shift in vehicle demand and Electric Vehicles (EVs) are surging within important markets such as China, Europe, and the US, mainly [Figure 5]. Mexico should get ahead of the curve and transition from ICE manufacturing to EV manufacturing. To effectively capitalize on the expanding U.S. demand for EVs and the ongoing global shift in supply chains, Mexico must orchestrate a coordinated transition that leverages its competitive advantages while embracing environmentally responsible practices. This transition entails a strategic shift towards becoming an environmentally friendly manufacturing hub, which aligns with global trends towards sustainable production.

Simultaneously, Mexico's established dominance in automotive manufacturing, coupled with its ability to exploit economies of scale, can be a pivotal factor in reducing the costs of EVs domestically. Such a reduction would not only make EVs more accessible to Mexican consumers but also contribute significantly to lowering road transport CO_2 emissions, aligning with broader environmental goals.

Nature of the industry: Unlocking the path dependency of internal combustion engine and capitalizing on the advantages developed to further profit and maintain position.

Automotive industries are often categorized as typical Chandlerian firms (Teece, 1993), characterized by their large scale, capital intensive, vertical integration, and complex managerial hierarchies. This classification is aligned with Pavitt's Taxonomy, where they are placed in the scale-intensive spectrum (Pavitt, 1984).

These firms are defined by their large-scale production and capital-intensive technologies, focusing on standardization and mass production, and capitalizing on increasing returns, such as economies of scale, learning by doing, adaptive economies and network economies (Unruh, 2000; Arthur, 1989).

Economies of scale

In the automotive industry, characterized by Chandlerian, scale-intensive firms, economies of scale play a crucial role, particularly in Mexico's 37 major manufacturing plants. This principle allows for cost-effective large-scale production, reducing unit costs and enabling competitive pricing for vehicles like the Nissan Versa and GM Aveo, a benefit not available to smaller firms or newcomers.

However, the focus on ICE vehicle production has led to operational inertia, complicating the shift to electric vehicles (EVs). Challenges include lower after-sale revenues for EVs, significant investments in existing ICE lines, uncertain EV market acceptance, and risks associated with the need for critical minerals (Corradi et al. 2023). The "path dependency" phenomenon (Rosenbloom et al., 2019) suggests that early choices can strongly influence future directions.

Nevertheless, existing manufacturing infrastructures provide a strategic avenue for transitioning to EV production. Overcoming financial and operational hurdles could enable companies like Ford, with its Mustang Mach-E in Puebla, and JAC, with the EJ7, to leverage economies of scale in EV production. This shift, mirroring industry trends like Audi's Q5 PHEV and Tesla's Nuevo León gigafactory (Corradi et al. 2023), points to a significant move towards adapting scale-intensive operations for efficient EV production.

Learning economies

The automotive industry's prowess in manufacturing internal combustion engine (ICE) vehicles is a culmination of extensive experience and honed expertise. With an average of 83 thousand employees in vehicle manufacturing plants (AMIA, 2023), these companies have developed a deep proficiency that extends beyond manufacturing techniques to include design, materials usage, logistics, quality control, and crucially, adapting to consumer needs through practical experience. This expertise, coupled with continuous improvements aligning with Lean Manufacturing -Toyota Production System- and Six Sigma principles, has led to enhanced product quality, efficiency in production, and cost reductions.

However, this specialization has also resulted in path dependency, presenting challenges in transitioning to electric vehicle (EV) manufacturing. The established processes and 'rules of thumb' that have been ingrained in ICE vehicle production create perceived hurdles in adopting new technologies like EVs, as noted by Lovins (1998). The focus on process innovation for ICE vehicles, primarily aimed at cost reduction and efficiency enhancement, adds to this complexity.

Despite these challenges, the wealth of knowledge and experience in ICE vehicle production could be a significant advantage in the shift to EV manufacturing. The learning economies within these firms suggest that the skills, techniques, and processes cultivated for ICE vehicles are adaptable to EV production. While some aspects of EV manufacturing will require new learning and innovation, the foundational expertise of these companies provides a solid base for this transition.

This transition is not merely about adopting new manufacturing techniques but involves reapplying and modifying existing knowledge to meet the demands of EV production. The firms' inherent learning economies could enable a smoother and quicker adaptation to EV technologies, leveraging their established competencies to navigate the complexities of this technological shift.

Policies and Consumer Preferences

As outlined by Freeman (1995), the drive for innovation hinges on the coordination of various institutional factors, ranging from policy frameworks to consumer preferences and behaviors. The adoption of electric vehicles (EVs) is currently hampered by high initial costs and concerns like "range anxiety." Breetz (2018) and Cullenward (2020) categorize EVs within the diffusion phase of the adoption curve, emphasizing the need for coordinated policies. These policies should aim to expand EV deployment, thereby increasing the economies of scale in manufacturing, enhancing performance through experiential learning, and ultimately reducing costs.

The slow adoption rate of EV technology, as argued by Breetz et al. (2018), is partly due to the political landscape, which has not fully supported the acceleration of EV adoption. This lack of support, as Everett Rogers noted, results from the absence of key characteristics like trialability, observability, and relative advantage in the EV market. Current government policies have tended to favor the entrenched Internal Combustion Engine system, potentially leading to an "irreversible lock-in" (Urry, 2007) if unaddressed.

Therefore, it is crucial to advocate for a unified and robust effort to expedite the adoption of EV technologies. This push should not only focus on overcoming current barriers but also aim to capitalize on the transformative process. By implementing strategic policies and fostering a conducive environment for EV growth, there's an opportunity to transition towards more sustainable transportation systems. This necessitates a paradigm shift in both government policy and industry practices to ensure that the potential of EV technology is fully realized and integrated into the broader automotive ecosystem.

Package of proposals		
Actors	**Objective of the Incentive**	**Policy or Incentive**
Manufacturers	Encourage the production of EVs	Tax credits for EV production; Subsidies for R&D in EV technology; Grants for setting up or upgrading facilities to manufacture EVs.
Suppliers	Promote the development of EV components and infrastructure	Tax incentives for suppliers of EV components; Funding for research in battery technology and other EV-specific parts; Incentives for establishing charging infrastructure.
Consumers	Increase the adoption of EVs among the public	Tax rebates or exemptions for EV purchasers; Subsidies for home charging equipment; Reduced registration and road taxes for EV owners; Public awareness campaigns about the benefits of EVs.

Government	Accelerate adoption of EV and production industry	Incentives to consumers that address high upfront costs of EVs; incentives to residential charging station installations; gradually leave gasoline subsidies and focus on cleaner energies.

Source: Of my making with data sourced from Secretariat of Foreign Relations, 2023; Sheldon, 2022; Zhou et al., 2016.

Conclusion

Mexico's competitive advantages — geographic proximity to the US, lower labor costs, a skilled workforce, and a role in intra-industry trade — have been pivotal in this evolution. However, the burgeoning demand for EVs presents new challenges and opportunities. Transitioning from ICE to EV manufacturing requires leveraging Mexico's established manufacturing dominance and economies of scale while embracing sustainable practices. This shift promises not only to maintain Mexico's competitive edge but also to reduce domestic EV costs and CO_2 emissions, aligning with global environmental objectives.

The automotive industry's nature, characterized as Chandlerian and scale-intensive, underpins its potential for this transition. Firms' large-scale production capabilities, combined with their learning economies and adaptability, are instrumental in navigating the path from ICE to EV manufacturing. Coordinated policies addressing both production and consumer preferences are essential to expedite this shift, ensuring Mexico remains at the forefront of the automotive industry's evolution.

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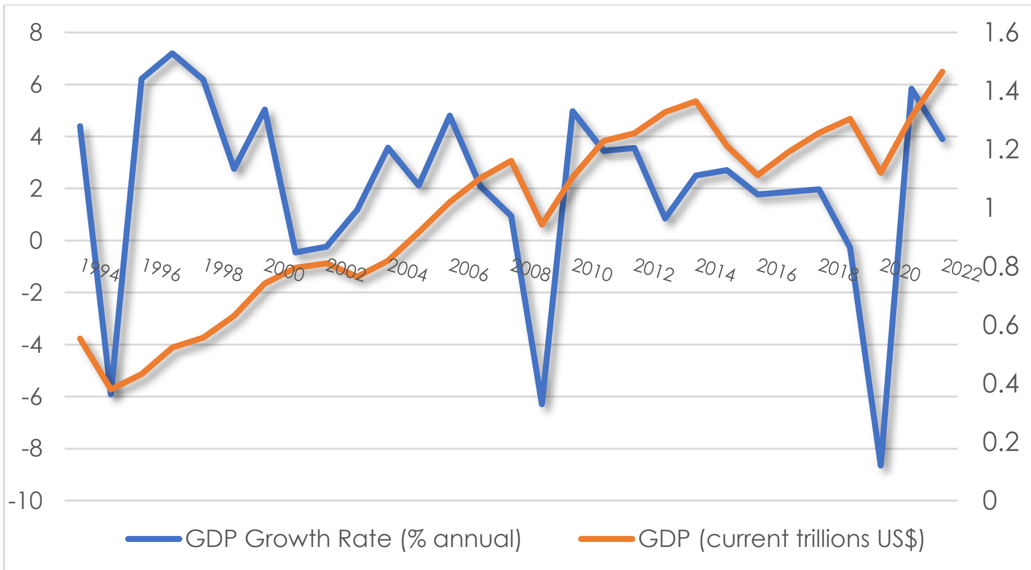
Appendix

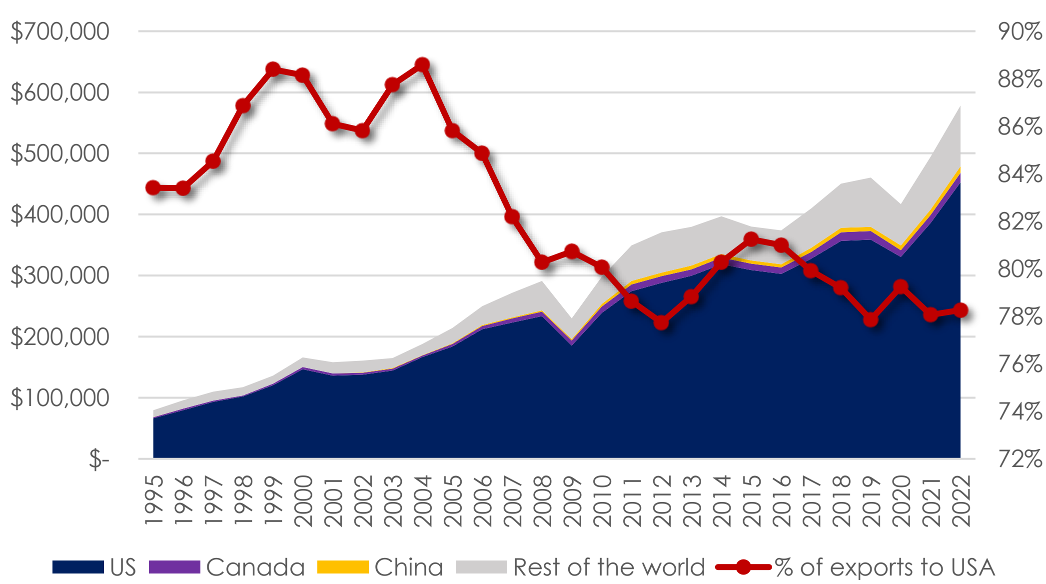
Figure 1. GDP growth post NAFTA



Source: World Bank, 2023.

Figure 2. Mexico's exports 1995-2022

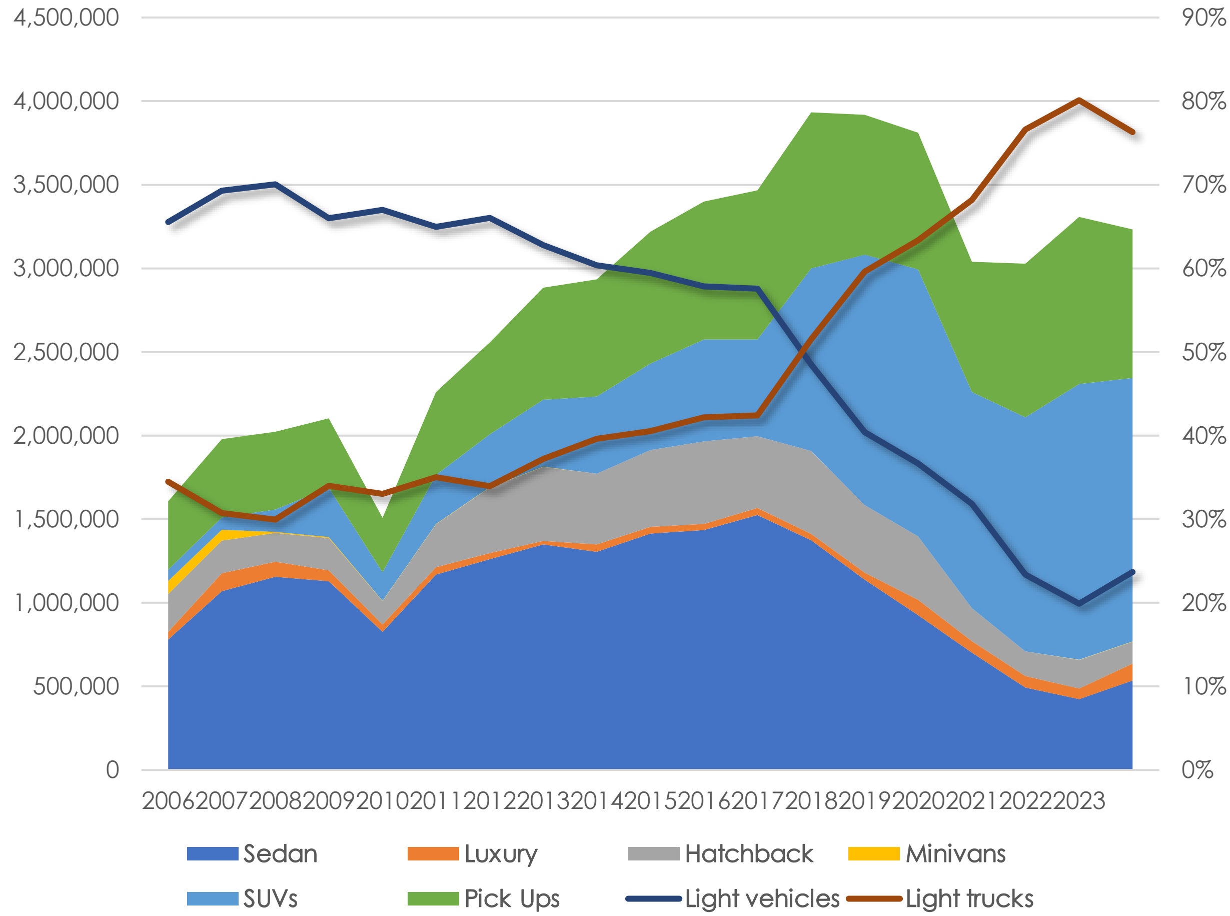
(US dollars at current prices in millions)



Source: UNCTAD, 2023.

Figure 3. Mexico adapts to US market

Production of passenger cars (2005-2023)

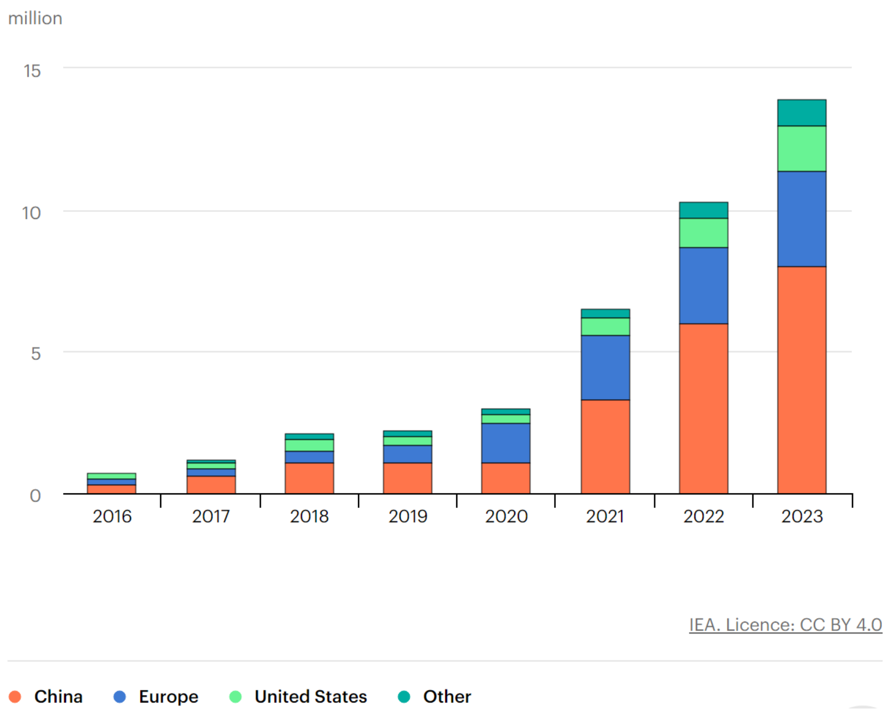


Source: INEGI, 2023a.

Figure 4. Manufacturing Exports and Intermediate goods Imports

Source: IMCO, 2023.

Figure 5: Electric Car sales



Source: IEA, 2023.

Figure 6.

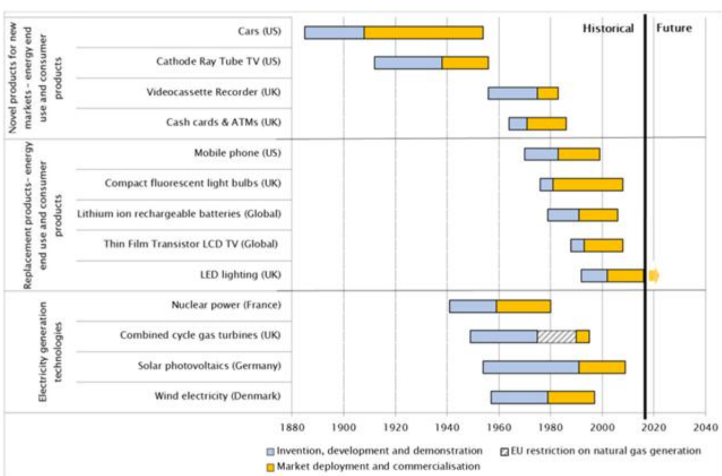


Fig. 6. Historical timelines by product / technology category.

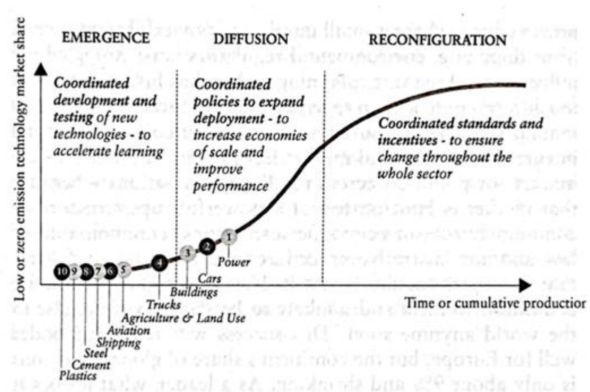


Figure 1.2 The state of decarbonization technology by sector
Source: Redrawn with permission from David G. Victor, Frank W. Geels, and Simon Sharpe, "Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action," Energy Transitions Commission and Brookings Institution (2019), based on assessments of technological development that rely heavily on the work of the Energy Transitions Commission (*http://www.energy-transitions.org/*).

Sourced from: Cullenward et al. (2020) and Gross et al. (2018).