Journal of the International Society for the Systems Sciences | 69th Meeting of the International Society for the Systems Sciences, Birmingham, UK.
Wilby, J., Makar, J. and Smith, G. eds.

THE SEMICONDUCTOR INDUSTRY AND ITS ECONOMIC, POLITICAL, AND SOCIAL IMPACT IN MEXICO

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Abstract
Mexico has a limited participation in the global semiconductor value chain, which restricts its technological and economic development, despite having favorable strategic conditions. This problem, characterized by the interaction of industrial, educational, political and economic factors, requires a systemic approach to understand its complexity and identify integrated and sustainable solutions. The fundamental reason for the study is to explore the opportunities and challenges for the development of the semiconductor industry in Mexico, with an emphasis on its economic, political, and social impact, as well as its installed capacities, value chain, and the strategies needed to strengthen its participation in the international context.
The present study uses documentary and analytical research methodology. The general approach is descriptive and explanatory, with the objective of analyzing the impact of the semiconductor industry on the Mexican economy through the study of macroeconomic, historical and technological indicators.
The results are to explore the opportunities and challenges that Mexico faces in its consolidation process as a key player in the global semiconductor industry.
Propose strategic lines of action aimed at strengthening the national semiconductor ecosystem, through effective articulation between the governmental, industrial, and academic sectors.
Develop specialized talent in technology, increase the competitiveness of Mexican companies through knowledge transfer and promote global training programs in the semiconductor value chain.

Keywords
Semiconductors, Industry, Technologies, Economy, Politics

1 | Introduction

In recent years, the technological industry has undergone significant transformations, with semiconductors standing out as a key driver of social and industrial change. These advancements have led to the emergence of new companies, jobs, professions, and innovative technological products that have profoundly influenced people's lives across the globe.
Semiconductors, the tiny chips that enable modern technology, play a crucial role in various applications. They ensure the safe operation of automobiles, support advanced medical and pharmaceutical equipment in saving lives, and empower military radar systems to detect threats efficiently.
The term *semiconductor* generally refers to materials that have the ability to both conduct and insulate electrical currents. However, in the technological context, it also applies to the highly sophisticated products manufactured from these materials, commonly known as "chips" or "electronic circuits."

2 | Methodology

This research adopts a qualitative and exploratory approach to comprehensively understand the factors influencing the development of the semiconductor industry in Mexico. Given the complexity and evolving nature of this sector, a methodological strategy based on scientific literature review was selected, focusing on academic, institutional, and governmental sources at both national and international levels.
The research process was structured into four sequential phases, aimed at building a systemic vision of the phenomenon:

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- **Phase 1 – Theoretical, Political, and Social Framework Review:** Academic publications, institutional reports, and relevant public policies were collected and analyzed to establish the conceptual, political, and social foundations framing the semiconductor industry within the Mexican context.
- **Phase 2 – Historical Background Exploration:** A critical review of historical sources and specialized reports was conducted to identify key milestones and transformations that have shaped global technological evolution and their connection to Mexico.
- **Phase 3 – Economic Growth Analysis:** Economic databases, sectoral studies, and specialized literature were examined to describe the current and potential impact of the semiconductor industry on Mexico's development.
- **Phase 4 – International Trade Assessment:** Trade reports, international agreements, and analyses from organizations such as the OECD, the Mexican Ministry of Economy, and the Bank of Mexico were reviewed to understand the dynamics of exports, imports, and regional integration.

The collected information was analyzed through thematic coding, allowing the identification of recurring patterns, causal relationships, and gaps in existing literature. This qualitative approach facilitated the construction of contextualized interpretations aimed at generating informed strategic recommendations.

3 | Results

As a result of the study, strategic recommendations are proposed for the design of public policies, the strengthening of the business ecosystem, and the development of specialized talent, all of which are essential for positioning Mexico as a key player in the global semiconductor value chain.

3.1 | Theoretical Framework

Solow (1956) argued that technological progress enhances production relations and drives economic productivity. Grossman and Helpman (1995) identified a positive relationship between international trade and technological learning, emphasizing the role of trade openness in facilitating technology transfer and strengthening intellectual property rights. Entrepreneurial acumen plays a critical role in innovation, as it enables the transformation of external knowledge into increased productivity and operational efficiency (Nelson & Winter, 1982).

From a policy perspective, basic economic theory characterizes technology as applied knowledge in production—encompassing information related to products, processes, and applications (Reddy & Liming, 1990). Markus and Tanis (2000) broaden this definition to include essential production-related information, while Afriyie (1988) describes technology as a subsystem integrating knowledge, technical support, and physical capital.

Economically, innovation involves product design improvements, the launch of new products, or the adoption of novel methods. These processes may be driven by industrial policies or market signals aimed at improving productivity and fostering economic growth.

3.2 | Mexican economy in semiconductors

Mexico could experience accelerated growth in the semiconductor sector due to nearshoring (an outsourcing strategy in which a company transfers part of its production to third parties located in nearby countries with similar time zones). This strategy involves the construction of new plants and contributes to the country's economic growth.

Within the framework of the USMCA, Mexico has been identified as having the opportunity to design, train, assemble, and package semiconductors.

Behavior of the electrical and electronic industry in Mexico. In Mexico, only 0.08% of economic units in the manufacturing sector are dedicated to semiconductor manufacturing.

The electronics industry has experienced very favorable development over the past decade, transitioning from a domestic-oriented industry to a competitive industry whose production is primarily destined for export.

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The semiconductor industry and its economic, political, and social impact in Mexico

The electronics sector generates almost 0.2% of the national Gross Domestic Product and approximately 330,000 direct jobs. Between 2015 and 2022, cumulative Foreign Direct Investment in this sector reached more than $9 billion, and annual exports exceeded $85 billion (Concamin, 2024).

The products with the largest share of Mexican exports are audio, video, computers, cell phones, and measuring instruments, among others. Currently, the global market for this sector is estimated at approximately $537.028 billion USD, but in five years, it could reach $664.053 billion USD, representing a 4.34% Compound Annual Growth Rate (CAGR) growth rate per year.

In Mexico, more than 3,500 companies are involved in the electronics sector. In 2024, according to the Ministry of Economy, the electronics sector could grow between 2.5% and 3.5% (CLELAC, 2024).

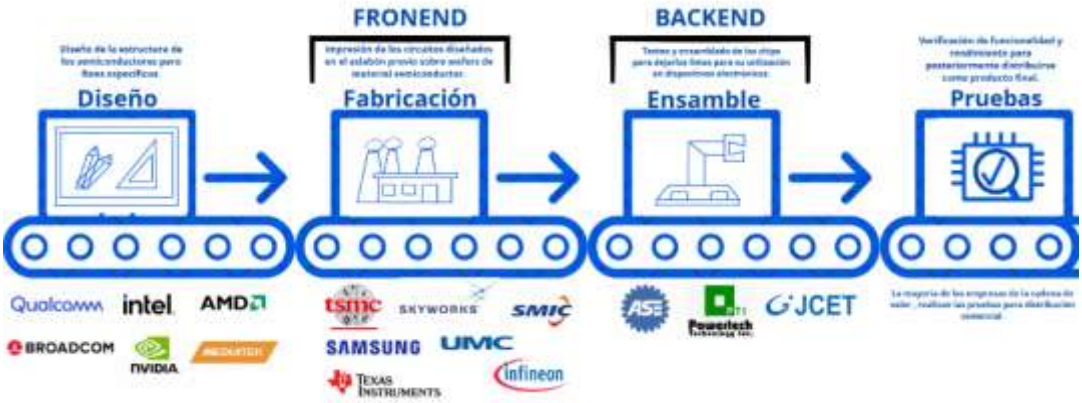
3.3 | Incorporation into the semiconductor value chain

Mexico's participation in the electronics sector was achieved thanks to the introduction of the maquiladora system in the 1960s, the North American Free Trade Agreement in 1994, and the liberalization of trade in the sector's production chain in 2002. This sector has evolved due to the high global demand and its capacity to meet the needs of this market.

In Mexico, there are currently 26 public research centers and 20 universities and technological institutes that offer various electrical engineering and related fields. In the semiconductor sector, Mexico has 150 high-level researchers specializing in semiconductors and system structures. Mexico has been studying integrated circuits for 35 years (SE, 2022).

The semiconductor value chain has four central links: design, manufacturing, assembly and testing.

Exhibit 1. Key links in the semiconductor value chain



Semiconductor Design. In the design stage, the semiconductor structure is planned for specific purposes, such as electrical, thermal, and mechanical specifications for components. A mask is then created, which paves the way for circuit manufacturing. More than half of the research and development (R&D) expenditure is spent during this phase. Prominent design companies include Intel, Texas Instruments, Qualcomm, Nvidia, Broadcom, AMD, Mediatek, and others.

Semiconductor manufacturing (frontend). This process begins with semiconductor materials called "wafers" or silicon wafers, on which materials are deposited. The circuit design is then printed using lithography between hundreds and thousands of times. The wafer is then cut into individual chips, the final product. Prominent manufacturing companies include TSMC, UMC, Samsung, Texas Instruments, SMIC, Global Foundries, and others.

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Exhibit 2. Semiconductor manufacturing process

Semiconductor Assembly (Backend). Once the individual components have been obtained, they must be assembled into a single piece. This is the process of attaching the device to the board. Here, appropriate mounting methods must be chosen for the device, based on environmental conditions and performance requirements. For example, soldering, hermetic sealing, thermal management, shielding, and strain relief techniques must be used to prevent moisture, heat, radiation, and mechanical stress from affecting the device. Companies involved in assembly and testing include ASE, JCET, Amkort, Powertech, and TT.

Semiconductor testing. It is the process of verifying the functionality and performance of the device under different environmental conditions, thus certifying that the device complies with the specifications and standards of its application, for example, they must test the device to determine the temperature cycles, thermal shock, vibration, shock, pressure, humidity and radiation exposure, in addition, it must be characterized for parameters such as current and voltage curves, power dissipation, frequency response, noise and gain.

4 | Discussion

Mexico's participation in the global semiconductor value chain remains limited, restricting its technological and economic growth despite its favorable strategic conditions. This issue arises from the complex interaction of industrial, educational, political, and economic factors, requiring a systemic approach to identify integrated and sustainable solutions.

4.1 | Mexico’s Integration into the Semiconductor Value Chain

Mexico’s electronics industry began in the 1960s, facilitated by the maquiladora model. Its integration accelerated with the North American Free Trade Agreement (NAFTA) in 1994 and the liberalization of the sector in 2002, progressively incorporating the country into the global semiconductor value chain.

Today, Mexico hosts an institutional ecosystem supporting sector development, including business chambers, research centers, and industry associations such as CANIETI, INAOE, CINVESTAV, CIMAV, CICESE, NYCE, CNMN-IPN, CIDESI, and CNYN-UNAM. These organizations provide expertise in research, standardization, innovation, and talent development.

4.2 | Talent Development and International

Mexico’s Ministry of Economy has initiated agreements for technology transfer and specialized semiconductor workforce development, aiming to position Mexico as a regional hub for technological innovation. The strategy prioritizes three key areas:

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1. Talent development through specialized education and training.
2. Business strengthening via knowledge transfer and innovation programs.
3. Global training initiatives to enhance Mexico's competitiveness in the international semiconductor market.

5 | Conclusion

Mexico stands at a pivotal moment to position itself as a key player in the global semiconductor industry, driven by nearshoring strategies and the framework established under the USMCA. Although the country's current participation in semiconductor manufacturing remains limited, it holds a unique opportunity to expand its role through infrastructure development, talent training, and the implementation of supportive government policies.

Strategic leadership will be essential to ensure the effective implementation of initiatives such as the CHIPS and Science Act, as well as to generate investment incentives that strengthen the domestic semiconductor ecosystem. In parallel, enhancing education and training in STEM fields will be critical to developing a competitive and specialized workforce capable of driving technological innovation within the country.

International trade and the protection of intellectual property will serve as foundational pillars for industry growth, underscoring the importance of modern trade agreements and regulatory frameworks that promote fair competition in global markets. Furthermore, collaboration among universities, research laboratories, and industry partners will play a central role in advancing technological development and closing the gap between academic training and industrial needs.

With the right strategy in place—one that promotes investment, technological development, and international cooperation—Mexico has the potential to become a significant contributor to the global semiconductor value chain. The country's geographic location, trade agreements, and emerging talent pool collectively position it as a strong candidate to lead the development of the semiconductor industry in Latin America.

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