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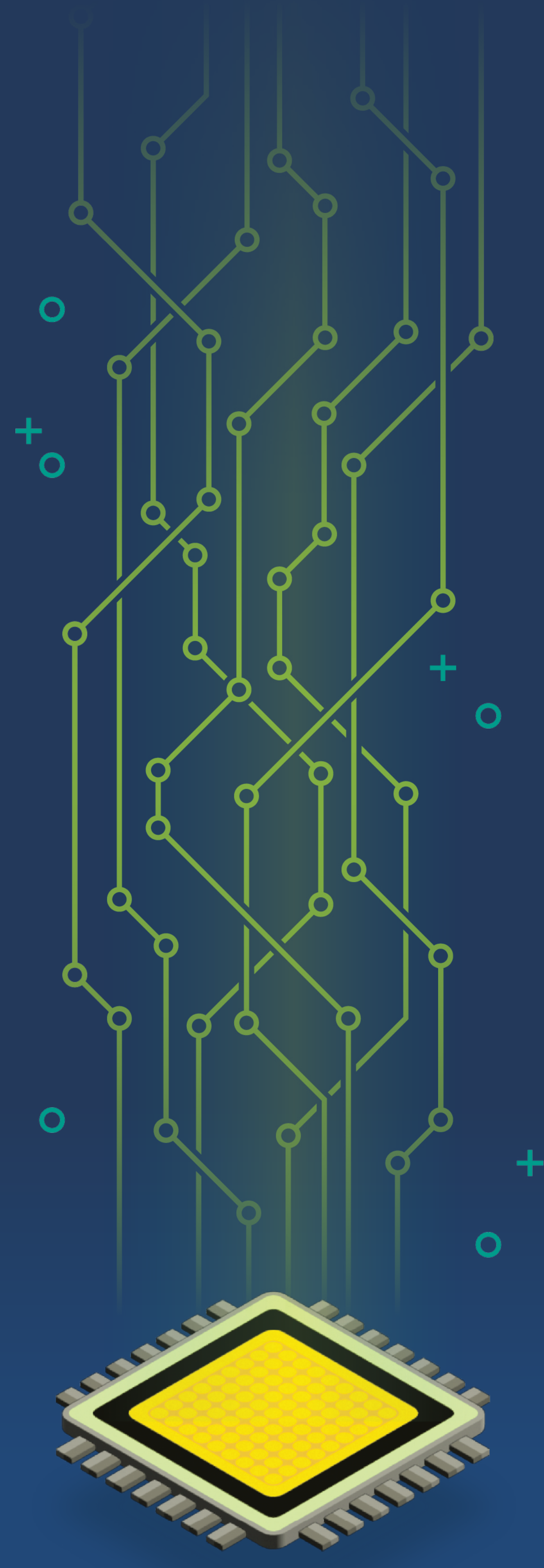
Strengthening US–Mexico Semiconductor Supply Chains

Opportunities and Challenges in the Nearshoring Agenda



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INTRODUCTION

Semiconductors are a vital sector of the global economy and a fiercely contested geopolitical battleground. The shortages that wracked supply chains at the height of the COVID-19 pandemic revealed how central "chips" are to modern life by sending shockwaves through nearly 200 downstream sectors as diverse as automobiles, consumer electronics, and household goods, contributing to the destabilizing global surge in inflation.[1] Despite the current cyclical downturn, the industry is expected to increase overall capacity output at an unprecedented level and is predicted to reach $1 trillion in sales by 2030 as a consequence of megatrends, including the rise in remote working and demand for electric vehicles (EVs).[2] Further, both leading-edge and legacy chips are essential not only for all major defense systems, from fighter jets to satellites, but also for the next-generation technologies expected to determine the future of warfare, such as artificial intelligence (AI) and quantum computing.

Given its importance, the industry's sudden emergence as a focal point of the United States–Mexico relationship comes as little surprise. For the US, semiconductors are at the forefront of a bipartisan effort spanning multiple presidential administrations to increase supply chain resilience in critical sectors. The Biden administration, motivated by pandemic bottlenecks and the deteriorating US–China relationship, is aggressively promoting semiconductor reshoring and "friend-shoring" while simultaneously working to undermine China's ability to import, manufacture, and export leading-edge chips. The CHIPS and Science Act (CHIPS Act, 2022), a paradigm-shifting bill featuring $52.7 billion in subsidies and incentives, aims to revitalize domestic fabrication after the US global share plummeted from 37 percent in 1990 to 12 percent in 2022.[3] US officials hope that Mexico, despite its limited existing industry footprint, can play an essential role in their attempted global industrial restructuring by offering a viable alternative to China and supplementing Taiwan and other key partners in coproduction.

For Mexico, the CHIPS Act presents an immense opportunity. Mexico is benefiting from growth in inbound foreign direct investment (FDI) across manufacturing sectors fueled by demand for reliable and tariff-free access to the United States. The prospect of integrating into US semiconductor supply chains holds particular promise by presenting Mexico with a potential foothold in an innovative, high-growth industry that would create good jobs, increase prosperity directly and through positive spillover effects, and advance national technological ambitions—all central goals of President Andres Manuel

López Obrador's government. The development of North American semiconductor supply chains would moreover help increase the competitiveness and resilience of Mexico's leading, chip-intensive sectors, including autos and auto parts, aerospace, information and communications technology (ICT), and electronics, all of which suffered amid pandemic-related shortages.

There are nevertheless significant barriers that, if left unaddressed, will derail the US and Mexico's shared ambitions for a regional semiconductor ecosystem. The industry, attracted by the reduced risk of supply chain disruptions and geopolitical conflict, is actively exploring Mexico as a potential source of high-skilled yet lower-cost labor close to US-based investments and North American end users. Investment, however, remains on hold pending more information and decisions on incentives and costs, programs to meet specialized workforce needs, and commitments to improve the broader investment climate. The window to act is rapidly closing because semiconductor investments are capital- and time-intensive, with firms today in the middle of infrastructure planning cycles that may span a decade. Mexico and the US risk missing out on this generational opportunity and, with it, a pivotal chance to improve the bilateral relationship.

This paper, which is among the first on this critical yet understudied topic, assesses the current landscape and outlines a path forward in combination with the Institute's recent publication on the North America Semiconductor Conference. The first section offers a primer on semiconductor supply chains. The second section traces the origins of demand for North American semiconductor reshoring and reviews bilateral cooperation to date. The paper then delves into an in-depth consideration of the supply chain segments commercially viable for relocation to Mexico before detailing the barriers restraining investment. Finally, the paper offers policy recommendations for the Mexican and US governments, industry, and academia, including:

- executing a targeted recruitment strategy focused on back-end-of-line manufacturing that increases cost transparency and capitalizes on synergies with North American end users;
- taking immediate actions to bend the cost curve, including coordinated Mexican federal and state incentives packages and binational workforce development programs;
- committing to medium-term actions that will increase investment prospects, including border infrastructure projects, customs modernization reforms, regulatory harmonization, and security cooperation; and
- exploring creative ways to bolster collaboration, such as joint investment roadshows, technical assistance programs, export and project financing, and a binational R&D lab.

BREAKING DOWN THE SEMICONDUCTOR SUPPLY CHAIN

Semiconductors are miniaturized electronic circuits layered on thin silicon wafers. Single chips can pack billions of nanometer-sized transistors on material measuring a few square centimeters.

Although more than 30 types are produced, chips can be classified into three categories: logic; memory; and discrete, analog, and other (DAO). Logic chips, such as microprocessors and microcontrollers, process data and serve as the “brains” of computing. Memory chips, the most common of which are dynamic random-access memory (DRAM) and NAND memory, store the information required to perform computations. DAO chips transmit, receive, and transform information.

Semiconductors manufactured at smaller “nodes” are generally more powerful, with leading-edge chips currently measuring three to five nanometers (with 5 nm approximately equivalent in size to 10 atoms). Mature nodes nevertheless remain critical to key sectors, including autos and defense electronics, and smaller nodes have fewer benefits for DAO chips used for functions such as power management, sensor readings, and communications.

Although astonishingly complex, modern semiconductor supply chains can be divided at a high level into seven discrete segments:[4]

1. **Research and Development:** R&D drives progress across the other six segments and includes precompetitive, exploratory, competitive research, and prototyping.

2. **Design:** Design involves determining how chips should operate (specification), creating a schematic model and physical layout of chip components (logic and physical design), and ensuring the design operates as intended (validation and verification).

3. **Electronic Design Automation (EDA) and Core Intellectual Property (IP):** EDA and IP are essential components of chip design. EDA is specialized software used to design

semiconductors, and core IP refers to the reusable architectural building blocks licensed by design firms to form their chip layouts.

4. **Fabrication:** Fabrication, which occurs in advanced manufacturing facilities ("fabs"), is the process of printing integrated circuits from the chip design onto wafers that will each contain anywhere from hundreds to hundreds of thousands of chips.

5. **Assembly, Testing, and Packaging (ATP):** ATP is the process of cutting a finished wafer into separate chips, mounting each chip on a frame with wires that connect it to external devices, enclosing it in a protective casing, and testing it to ensure correct operation. Following ATP, chips are distributed for device assembly and integrated into products purchased by customers.

6. **Semiconductor Manufacturing Equipment (SME):** SME captures more than 50 categories of specialized equipment used for fabrication and ATP. Lithography tools, among the most complex and capital-intensive components of fabrication, are used to carve patterns on wafers by directing ultraviolet light that interacts with photoresist chemicals.

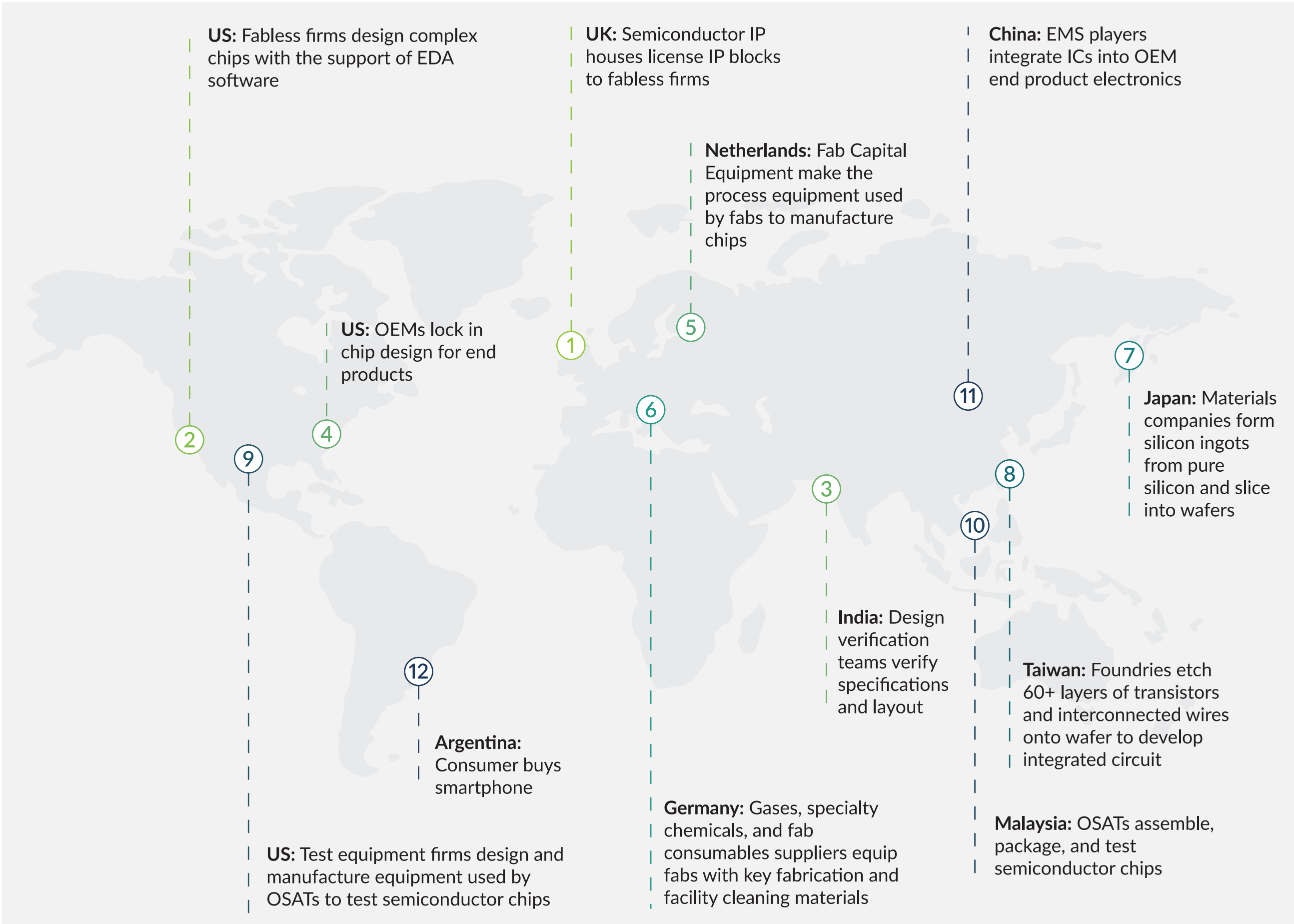
7. **Materials:** Both fabrication and ATP require hundreds of materials and specialty chemicals, many of which also require advanced technology to produce.

Front-end-of-line manufacturing (fabrication) is more sophisticated and capital-intensive than back-end-of-line manufacturing (ATP), which nevertheless requires significant investments in specialized facilities. Integrated device manufacturers (IDM) such as Intel and Texas Instruments (TI) handle design, fabrication, and ATP internally. IDMs compete most directly with "fabless" semiconductor companies, a model pioneered in the 1980s and 1990s. Fabless firms design and sell chips but outsource fabrication to "foundries" such as the Taiwan Semiconductor Manufacturing Company (TSMC). Then, their chips are delivered to outsourced semiconductor assembly and test (OSAT) firms such as Amkor for ATP.

The rise of the fabless/foundry model, in combination with the small size and weight of chips, contributed to the remarkable geographic dispersion of semiconductor supply chains in recent decades (see Figure 1 for a stylized representation). During manufacturing, products may cross international borders more than 70 times over the course of up to 100 days.[5]

This dispersion, however, is combined with extreme geographic specialization that creates numerous vulnerabilities and chokepoints. The US, where semiconductors were pioneered in the 1950s, leads in R&D-intensive activities, including EDA, IP, and chip design. Front- and back-end manufacturing, however, are heavily dominated by Taiwan, South Korea, and China. All advanced logic fabrication is currently located in Taiwan and South Korea, as well as 75 percent of total wafer fabrication.[6] Taiwan and China additionally account for more than 60 percent of global ATP capacity.[7] The US, by contrast, retains no cutting-edge fabrication capacity and only 10 percent and 3 percent of global fabrication and ATP capacity, respectively.[8]

FIGURE 1: THE GLOBAL DISPERSION OF SEMICONDUCTOR SUPPLY CHAINS



Source: *Milken Institute (2023), based on Syed Alam et al., Accenture (2022),* https://www.accenture.com/_acnmedia/PDF-172/Accenture-Semiconductor-Value-Chain-Report.pdf*, p. 17*

THE DEMAND FOR 'MADE IN THE AMERICAS'

Two major shifts disrupted decades of US government and industry acceptance of growing foreign reliance: the aforementioned COVID-19 pandemic supply chain disruptions and intensification of US-China geopolitical tensions. China, which in 2019 accounted for 60 percent of global semiconductor demand, established ambitious goals for its domestic industry more than two decades ago and more recently set an objective to meet 80 percent of domestic demand through domestic production as part of the "Made in China 2025" strategy.[9] The industry has fallen short of these goals, remaining behind the leading edge and highly dependent on foreign technology but nevertheless gained significant global market share, particularly in ATP and legacy chip fabrication. In 2022, the Semiconductor Industry Association (SIA) found that Chinese firms had recorded rapid revenue increases across all supply chain segments and predicted its industry could capture upwards of 17.4 percent of the global market within three years.[10] Equally significant for US officials are growing fears of a Chinese invasion of Taiwan, which fabricates more than 90 percent of the most advanced chips designed by US semiconductor firms.[11]

In response, the US is pursuing a "protect and promote" strategy intended to arrest Chinese progress and boost domestic production.[12] The Biden administration, building on the Trump administration's Section 301 tariffs and use of Entity Listings and Foreign Direct Product Rule restrictions, unveiled additional extensive export controls in October 2022 that severely restrict China's ability to access advanced semiconductors and subsequently convinced the Netherlands and Japan—the two global leaders in advanced SME—to follow suit. Alongside these executive actions, the US Congress passed the CHIPS Act in December 2020 and appropriated funding to execute it through the CHIPS and Science Act in August 2022 to increase supply chain reliability, enhance international competitiveness, and reduce reliance on China. The legislation appropriated $39 billion in manufacturing incentives, including $2 billion for legacy chips used in automobile and defense systems; $13.2 billion in R&D and workforce development; and $500 million for international ICT security and semiconductor supply chain activities (see Table 1). The act additionally established a 25 percent investment tax credit for US-based capital expenses for semiconductor and SME manufacturing and imposed strict guardrails prohibiting investment in China by recipient firms for 10 years and limiting technology transfer.

TABLE 1: THE CHIPS FOR AMERICA FUND

Program	Appropriation
Department of Commerce (DOC) Manufacturing Incentives	$39 billion
DOC Research and Development	$11 billion
Department of Defense Microelectronics Commons	$2 billion
International Technology Security and Innovation Fund	$500 million
Workforce and Education Fund	$200 million

Source: *Milken Institute (2023), using data from CHIPS Act of 2022, Pub. L. No. 117-167, Div. A (2022)*

The CHIPS Act is catalyzing a seismic restructuring of the global chip industry by unleashing a deluge of US-based investment and firing the starting gun in a new global race to bolster chipmaking capacity. In the US, more than 35 companies had pledged nearly $200 billion for projects across 16 states as of January 2023.[13] One industry report released in 2020 estimated that a government investment comparable to the CHIPS Act would increase the US share of global production to 14 percent by 2030.[14] In response, the European Union and Japan have moved rapidly to develop their own competing incentive packages. This initial success, and the response it has spawned, have shifted US attention toward domestic implementation and the international partnerships required to enhance resilience.

Within this macro context, the US and Mexico have taken important steps toward deepening semiconductor cooperation over the last two years. In September 2021, Biden and López Obrador announced the creation of a semiconductor supply chains working group as part of the relaunched High-Level Economic Dialogue (HLED).[15] Building on this foundation, the US and Mexico are working closely with Canada to enhance trilateral cooperation on semiconductor supply chain resilience. The three governments committed at the January 2023 North American Leaders' Summit (NALS) to work with the private sector and academia to identify investment locations, pursue a pilot project to determine the feasibility of nearshoring semiconductor manufacturing inputs, and map regional semiconductor supply chains. North American officials, following up on a bilateral event hosted by Mexico in August 2022, reaffirmed their shared commitment during the trilateral North America Semiconductor Conference in Washington DC in May 2023 and agreed to make the semiconductor industry a key priority of the new North American Ministerial Committee on Economic announced during the event.

These deliverables come alongside extensive efforts organized by the private sector, universities, and Mexican states, an Inter-American Development Bank (IDB) nearshoring initiative, and discussions between Biden and López Obrador on Mexican incentives.[17] Multiple leadership changes in the *Secretaría de Economía*, however, have slowed progress due to the loss of institutional knowledge.[18] Implementation remains limited, and no new Mexican investments have been announced at the time of writing.

IDENTIFYING THE MEXICAN ADVANTAGE

Despite this cooperative infrastructure, Mexico faces an uphill climb to integrate meaningfully into US semiconductor supply chains. Entering any new sector poses major challenges. The qualities that led to the semiconductor industry's geographic concentration in the first place—high capital intensity, extreme specialization, deep technical complexity and related demand for skilled workers, and the benefits of scale and co-location—further complicate this task. Prioritization based on commercial viability is essential for success.

To date, Mexican officials have expressed interest in recruiting a range of supply chain segments. Two prospects, however, stand out based on Mexico's existing footprint, US supply chain gaps, and Mexico's competitive advantages: (1) ATP/OSAT facilities, and (2) ATP materials such as printed circuit boards (PCBs), substrates, lead frames, and bond wires. Mexico, by focusing on the back-end-of-line, can position itself as an alternative for firms looking to diversify Asia-centric supply chains. If successful, a back-end ecosystem can serve as a platform to expand into upstream inputs and higher-value segments as well as to recruit downstream end users, including device assemblers.

Existing Capacity

Mexico's existing back-end manufacturing footprint, albeit small and geographically dispersed, offers a starting point on which to build. Foreign firms currently operate four back-end facilities in northern border states and the Bajío region. Texas Instruments, which manufactures DAO chips for the industrial, automotive, and personal electronics end-markets, has run an ATP facility in Aguascalientes since 1984. Skyworks, a DAO manufacturer specializing in chips that enable wireless communications, maintains two facilities in Mexicali, Baja: one for assembly services and a second for test and finishing services. Infineon Technologies, a German DAO manufacturer, commenced operations in Tijuana in 2001 and, in 2018, announced a commitment to invest $40 million to expand production capacity.[19]

Overall, Mexico's exports of integrated electronic circuits (HS 8542) and diodes, transistors, and similar semiconductors (HS 8541) were just under US$3.5 billion and US$615 million in 2021—small fractions of global output and in sharp contrast with imports of $21.9 billion and $3.4 billion, respectively.[20]

Mexico's supplier network holds significant promise but is also more challenging to map, especially at the second and third tiers. Texas Instruments, for example, relies heavily on local components manufacturers to meet the needs of its Aguascalientes facility. Nearly half of its several hundred suppliers are in Mexico, and approximately half of those are located in Aguascalientes. More generally, Mexico's success in components manufacturing opens the possibility that existing contractors and subcontractors may be capable of expanding product lines or pivoting to semiconductor materials—a potential growth opportunity for states such as Jalisco, which is home to a vibrant technology cluster. Gaining an improved understanding of this ecosystem and disseminating that information to potential investors will be essential for both realizing Mexico's ambitions to recruit new ATP/OSAT facilities and meeting US competitiveness and resilience objectives.

US Supply Chain Gaps

ATP/OSAT and ATP materials also present the best opportunities for Mexico to benefit from the US semiconductor investment boom. The CHIPS Act is, at the end of the day, focused on reshoring semiconductor manufacturing to the US. This objective has fueled tensions with other US allies, including the European Union, with French President Emmanuel Macron going so far as to charge Biden with advancing policies "that will fragment the West."[21] Mexico, in sharp contrast, can capitalize on spillover effects from US subsidies and incentives by focusing on the areas that US officials have openly acknowledged are supply chain vulnerabilities but nevertheless not cost-competitive for reshoring.

The Biden administration's 100-Day Review of Semiconductor Manufacturing and Advanced Packaging, when read in tandem with the CHIPS Act and the Commerce Department's implementation plan, effectively offers Mexico and other interested countries a nearshoring blueprint.[22] The review identifies negligible US capacity in both ATP/OSAT and ATP materials as significant risks to supply chain resilience due to extreme reliance on foreign sources concentrated in Asia. According to one study, the US has only 3 percent of global ATP capacity and no commercially and technologically competitive suppliers of PCBs and substrates.[23] By contrast, 81 percent of global ATP capacity and 95 percent of substrate suppliers are concentrated in Asia, and 80 percent of global PCB production capacity is located in China alone. Most US-fabricated chips must, as a consequence, still be sent to China for back-end manufacturing.

However, US efforts to reshore back-end-of-line manufacturing are likely to focus almost exclusively on advanced packaging, which is a subset of traditional packaging that involves using novel techniques to put chiplets and/or more than one integrated circuit into one package. The CHIPS Act appropriates $2.5 billion to launch a National Advanced Packaging Manufacturing Program focused on R&D and allows, but does not require, the $39 billion in manufacturing incentives to be directed toward ATP. The implementation strategy includes a handful of references to back-end manufacturing but clearly establishes the expansion of fabrication and reinforcement of R&D leadership as the top priorities.[24] The US is likely to struggle to meet the back-end demands of the 23 new fabs and nine fab expansions already spurred by the CHIPS Act and, either way, will need to depend on partners to fill the remaining void in traditional ATP for mature and current-generation chips.

Competitive Advantages

Prioritizing the development of an ATP ecosystem would place Mexico in direct competition with Southeast Asian countries, including Malaysia and Thailand, that are also looking to capitalize on US–China technology competition.

Mexico, however, has several key advantages despite its limited footprint. The first is geographic proximity. The US and Mexico share a 2,000-mile border with 47 active land ports of entry. Proximity has not traditionally played a major role in shaping semiconductor supply chains due to the low cost of shipping chips. Supply chain disruptions and the growing complexity of back-end manufacturing, which increases the benefits of co-locating front- and back-end-of-line manufacturing, are changing this calculus. Nearly 40 percent of US fabs are located in border sites, including TSMC's new $40 billion production hub in Arizona and major Intel, TI, and Samsung projects in Arizona, New Mexico, and Texas (see Table 2).[25]

TABLE 2: SEMICONDUCTOR INVESTMENT IN US BORDER STATES, MAY 2020–JANUARY 2023

State	City / County	Company	Investment	Investment Type	Employment
Arizona	Chandler	Intel	$20 billion	New (2 fabs)	3,000
Arizona	Phoenix	TSMC	$40 billion	New (2 fabs)	4,500
California	Fremont / San Jose	Western Digital	$350 million	Expansion	240
New Mexico	Rio Rancho	Intel	$3.5 billion	Expansion	700
Texas	Taylor	Samsung	$17 billion	New	2,000
Texas	Sherman	Texas Instruments	$30 billion	New (4 fabs)	3,000
Texas	Richardson	Texas Instruments	$6 billion	Expansion	800
Texas	Austin	NXP	$2.6 billion	Expansion	800

Source: *Semiconductor Industry Association (2022)*

Mexico's second major advantage is the US–Mexico–Canada (USMCA) agreement, which makes Mexico the only US trade agreement partner targeting investment in back-end manufacturing. The USMCA, albeit imperfect, nevertheless secured preferential market access, modernized trade rules important to the semiconductor industry, and, by strengthening enforcement of labor and environmental rights, helped ameliorate political barriers in the US that had long impeded support for coproduction with Mexico. The SIA applauded a wide range of provisions in the agreement, including new disciplines on commercial cryptography and state-owned enterprises, stronger protection and enforcement of trade secrets, new digital trade rules, including a ban on forced localization, and a commitment not to impose customs duties or fees on digital products.[26] Further, some of the agreement's more controversial provisions, such as its strict rules of origin designed to incentivize North American production of autos and auto parts, could lead the automotive industry to push semiconductor companies to nearshore manufacturing as well.

Mexico's third, closely related advantage is that its deep economic integration with the US is concentrated in chip-intensive sectors such as autos and auto parts, aerospace, ICT, and electronics, which creates unique opportunities to benefit from cross-industry synergies. The North American auto industry, which accounts for one-fifth of global output, is a prime example. Pandemic-era chip shortages severely injured auto and auto-parts companies in both the US and Mexico, resulting in significant production shortfalls that led to tens of billions of dollars in lost revenue on both sides of the border, as well as devastating job cuts and shift reductions in Mexico.[27] Automakers are responding with efforts to secure their chip inventories, which are ballooning due to rising EV production and demand for advanced driver-assistance systems. General Motors, for example, signed a first-of-its-kind agreement with GlobalFoundries in February 2023 to guarantee access to US-manufactured chips.[28] The desire for resilience, in combination with the US Inflation Reduction Act's North American content requirements for EV subsidies, may intensify pressure on US fabs to turn to Mexico for back-end manufacturing.

Future Prospects

Mexican officials have expressed a strong desire to attract higher value-added activities in addition to back-end manufacturing, pointing to Intel's Guadalajara Design Center as proof of competitiveness. Opportunities may emerge in the future but are likely to be sparse in the short term, given US comparative advantage and heavy CHIPS Act spending in R&D-intensive segments.

Mexico may nevertheless have the chance to break into other areas. One option worth exploring, albeit as a second-tier priority, is that of the raw materials, chemicals, and gases used in semiconductor manufacturing. Mexico, for example, produces or has the capacity to produce many of the critical minerals used by the semiconductor industry, including graphite, lead, selenium, and manganese.[29] The industry, however, has expressed serious concern over the government's nationalization of lithium reserves, which may slow a shift toward regional sourcing. Critical mineral processing and refinement, furthermore, continue to be dominated by China, which reduces the resilience benefits until alternatives come online.

The semiconductor industry also relies heavily on chemicals and gases captured as byproducts of other industries, which Mexico may be able to provide, given its manufacturing prowess. These should also be granted lower priority, given the limited positive spillover effects and industry efforts to replace environmentally damaging inputs such as hydrofluorocarbons.

Device assembly, although not typically recognized as part of the semiconductor supply chain, presents a more intriguing prospect. As with ATP, Chinese dominance in device assembly compounds US resiliency challenges by reproducing dependencies at the final stage of production. Foxconn, the world's largest contract electronics manufacturer, and other Taiwanese tech suppliers, including Pegatron, Quanta Computer, Compal Electronics, and Inventec, are already increasing their capacity in Mexico to meet growing demand and, in response to client requests, reflecting the power of end users.[30] Mexican integration into semiconductor supply chains would only increase this investment inflow.

THE BARRIERS TO DEEPER INTEGRATION

Major barriers remain despite these advantages. The East and Southeast Asian countries that currently dominate back-end manufacturing have decades of experience working with the semiconductor industry and are already home to well established microelectronics ecosystems. Countries, including China, benefit from intangibles derived from deep industry embeddedness in their economies just as much as they do from human capital and high levels of direct and indirect support.[31] In Taiwan, for example, the semiconductor industry's revenues constitute about 15 percent of GDP and account for one-third of local stock market capitalization.[32] From an industry viewpoint, this scale offers leverage that ensures a strong voice in governance.

There are also serious, tangible impediments, some of which the Mexican government is already working with industry to assuage. The first of these revolves around the closely interlinked issues of cost competitiveness and data availability. The high capital intensity of semiconductor production makes the industry one of the most heavily subsidized in the world. Incentives designed to bend the cost curve are therefore widely recognized as a prerequisite for a seat at the table, even in the comparatively less capital-intensive back-end segments that Mexico should be targeting. For Mexico, well designed incentives packages from the federal government and states will also help solve a coordination challenge: In an industry that benefits from co-location, companies are more likely to "jump together" than alone. Reports indicate the federal government was developing a targeted incentives package to present to semiconductor firms in late 2022. Officials, however, appear to have subsequently changed course and are currently pitching the industry on opportunities created by the Plan Sonora and Interoceanic Corridor, which are López Obrador's two signature economic development initiatives. If enacted, targeted federal incentives would supplement the state packages that some governors have been pitching privately to industry since last year.[33]

Equally significant, however, is low visibility into the total cost of ownership (TCO)—a modeling challenge stemming from the industry's limited existing presence in Mexico. One industry analyst examining the costs of reshoring ATP cites Intel data estimating costs of $650 million–$875 million to relocate its ATP facility from China to another country, as well as Amkor data estimating initial capital expenditures of $200 million–$250 million for its new facility in Vietnam.[34] However, as the same report notes, companies looking to understand TCO require information on utilities, labor, and regulatory compliance costs, among others, in addition to construction and real estate.

Workforce presents another major industry challenge. Mexico, despite having a skilled labor pool, still trails many of its top competitors in the race for back-end manufacturing investment in key talent indicators, including the percentage of the labor force with intermediate education and the extent of staff training.[35] Global semiconductor firms (e.g., Intel) often require English proficiency, adding another requirement to the labor pool. More specifically, the industry requires a highly specialized workforce across its many occupational categories, a challenge frequently resolved through the development of close partnerships with economic development organizations (EDOs), community and technical colleges, and other stakeholders to build a talent pipeline.

The Mexican government is making significant headway toward establishing such an arrangement in partnership with Arizona State University (ASU).[36] The ASU president, Michael Crow, and Esteban Moctezuma Barragan, ambassador of Mexico to the US, signed a memorandum of understanding in December 2022 to create an alliance of US and Mexican universities and microelectronics manufacturers focused on worker training. The program, based on ASU's successful partnership with Vietnam, still requires external funding to scale to meet the need.

Infrastructure and rule-of-law challenges also loom large. Reliable energy and clean water are prerequisites for semiconductor facilities. Plan Sonora includes major investments to improve logistics infrastructure and the production and transmission of clean energy, access to which is a top priority for major industry players looking to reduce their carbon footprint. The industry has nevertheless voiced serious concerns about the Mexican government's controversial energy policy, which is the subject of an intense ongoing dispute between the US and Mexican governments. The Interoceanic Corridor is intended to generate growth and prosperity in Mexico's poorer and less developed southern states by creating a logistics and manufacturing corridor between the Pacific and Atlantic coastal states of Veracruz and Oaxaca. The plan, envisioned as an overland alternative to the Panama Canal, is unlikely to appeal to semiconductor firms despite its tax incentives due to disadvantages including its long development timeline and distance from more productive industrial regions in Mexico and the US that are home to upstream and downstream manufacturers.[37]

Transportation infrastructure paints a similarly mixed picture. In July 2022, the US and Mexico pledged a combined US$5 billion to modernize land ports of entry on both sides of the border—critical investments that will enhance Mexico's attractiveness as an investment destination by reducing lengthy wait times. However, the escalation of Mexico's security crisis is creating severe problems that, in addition to the tragic humanitarian toll, is behind a skyrocketing number of highway and railroad robberies that undermine its position as a stable alternative supply chain partner.[38] The reorganization of Mexico's customs agency under military authority, a move intended to combat pervasive corruption, has created a host of new problems, including administrative processing delays and a decline in transparency.[39]

The Milken Institute Global Opportunity Index enables a side-by-side comparison of Mexico's and its top competitors' attractiveness to international investors, which helps underscore the scale of these broader investment climate challenges.[40] Overall, Mexico's performance ranks squarely in the middle of the emerging middle-income G20 countries, scoring slightly better than average on International Standards and Policy and Economic Fundamentals but below average on others, including Financial Services. However, current leaders in ATP (China, South Korea, Taiwan) and emerging destinations (Malaysia, Thailand) outperform Mexico in nearly every category (see Table 3). Mexico is also outperformed by Costa Rica, which is already home to an Intel ATP facility, prefiguring the competitive challenges that may emerge closer to home.

TABLE 3: ASSESSING MEXICO'S INVESTMENT CLIMATE

Country	GOI Rank 2023	Business Perception	Economic Fundamentals	Financial Services	Institutional Framework	International Standards & Policy
Korea, Rep.	22	21	44	2	21	31
Malaysia	27	27	30	24	22	48
Thailand	33	19	23	32	45	58
Costa Rica	45	73	15	59	40	55
China	40	31	52	28	38	69
Mexico	56	51	48	69	57	53
Vietnam	68	72	42	63	92	72

Source: *Milken Institute (2023)*

POLICY RECOMMENDATIONS

The semiconductor industry is foundational in the modern global economy, producing the core technology that drives the digital world. The CHIPS Act opened a once-in-a-generation opportunity to build regionally integrated North American supply chains that can simultaneously boost US competitiveness, catalyze Mexican growth and prosperity, and strengthen the binational relationship at a crucial moment. Firms are actively exploring opportunities to locate back-end-of-line manufacturing and establish contracts with suppliers and assembly companies in Mexico.

Nevertheless, a range of challenges must be overcome to maximize prospects. Mexico's fitful approach, often lacking sufficient transparency and federal-state collaboration, threatens its recruitment prospects by failing to provide the stability and certainty companies seek before making billion-dollar investments. The window is rapidly closing and may be shut before the next HLED and NALS meetings this fall. The industry is now making countercyclical capital investments that will determine the sector's trajectory for the next decade. Mexico, the US, industry, and academia should focus on four key areas to realize this latent potential.

First, Mexico should develop and disseminate a narrow and highly targeted strategy to recruit back-end-of-line manufacturing and build regional clusters that facilitate synergies with its leading industries. Subsuming the semiconductor strategy within the broader Plan Sonora and Interoceanic Corridor projects risks diluting the strategy. Similarly, by focusing on too many supply chain segments, particularly high value-added segments most likely to land in the US, Mexico risks undermining its investment pitch and diverting valuable resources from efforts with a higher probability of success. An updated strategy could focus on working with newly expanded US fabs, as well as US and Mexican end users and banks, to recruit OSAT companies, which must then be connected to local suppliers that can meet their sourcing requirements for PCBs, substrates, and other back-end materials.

The supply chain mapping exercise announced at the 2023 North American Leaders Summit (NALS) meeting should be promptly completed and expanded to incorporate workforce talent as recommended during the North American Semiconductor Conference. It is a necessary but nevertheless insufficient piece of this plan. Another essential step will be to secure public or private financing for TCO studies, which would help ease industry concerns by providing additional insight into full life cycle costs. Industry and academia also have clear roles to play in this space. Associations such as the SIA are best positioned to take the lead on a TCO study and, in partnership with academia, could do more to articulate clearly what else is required to unlock investment. The North America Semiconductor Conference represented a pivotal step in the right direction and should be repeated at regular intervals alongside convenings of the new North American Ministerial Committee on Economic Competitiveness. US fabs and end users on both sides of the border could also heighten pressure on their suppliers to look more closely at Mexico as they explore avenues to reduce the high costs of domestic manufacturing.[41]

Second, Mexican federal and state governments should take immediate actions to bend the cost curve. Many states, including Jalisco and Nuevo León, are already offering incentives to lure semiconductor investment. At the federal level, an incentives package should be tailored to recruit the specific back-end-of-line segments highlighted in the new plan—a prioritization tactic that, combined with the lower capital intensity of ATP/OSAT, would reduce its overall cost. Incentives, in addition to improving cost competitiveness, also serve as an indicator of commitment and a pivotal coordination mechanism to help firms from multiple segments and industries "jump together."

Beyond incentives, Mexican officials should act quickly to sponsor and, if necessary, subsidize workforce development efforts. The ASU-led program provides a strong starting point and should be an excellent candidate to receive funding from the State Department-led CHIPS International Technology and Security Innovation Fund. Industry input, particularly workforce and education data to support skills training, will be critical for success. Finally, the Mexican federal government should establish a one-stop shop for semiconductor investors that shares data and provides ombudsman services to help them navigate the investment landscape.

Third, Mexico and the US should jointly announce a package of medium-term commitments to improve the North American investment climate that are geared toward semiconductor supply chains. The relaunch of the HLED marks a crucial step down this path and provides a proven platform for delivering bilateral progress on shared economic priorities. The creation of the new trilateral North American Ministerial on Economic Competitiveness can also play an essential role in delivering key reforms. Beyond the Plan Sonora and Interoceanic Corridor, Mexico should focus on infrastructure investments that spur dynamism in its more competitive regions to maximize the potential gains from its generational nearshoring opportunity.

The US must also "walk the walk" to achieve its supply chain resilience objectives. The joint commitment to invest US$5 billion in border infrastructure and modernization projects is a great example of positive progress, but nevertheless falls short of required spending levels to meet the demand that will be generated by further growth in bilateral trade. Furthermore, too many of the HLED and NALS deliverables to date involve establishing working groups or organizing convenings. Industry would welcome progress on the energy sector dispute and implementation of USMCA customs modernization commitments as well as enhanced cooperation on regulatory and standards alignment and intellectual property protection.

In addition, deeper cooperation to address the root causes of the security crisis is essential for regional stability and Mexico's long-term economic prospects.

Finally, the US and Mexico should find creative ways to enhance binational cooperation at the federal and state levels. The State Department should commit at least 25 percent of the CHIPS International Technology Security and Innovation Fund to projects in Mexico, focusing in the first year on workforce development and a TCO report. Taking inspiration from planning for the FIFA 2026 World Cup™, SelectUSA and US EDOs could work with the Mexican federal and state governments to organize joint roadshows to attract investment across supply chain segments. Once established, the National Advanced Packaging Manufacturing Program could explore technical assistance opportunities to help Mexico build expertise in packaging. The US Export-Import Bank, Development Finance Corporation, and Trade and Development Agency could similarly explore relevant export and project financing and infrastructure project preparation opportunities. Subnational diplomacy and multistakeholder initiatives such as the North America Semiconductor Conference serve an essential role in both supplementing and informing federal initiatives.

Looking ahead, the US and Mexico could explore forming a binational lab for semiconductor R&D to help Mexico achieve its vision of moving up the value chain. One of the most compelling recommendations that emerged from the North American Semiconductor Conference was to explore opportunities for trilateral research through the US National Semiconductor Technology Center. Successful nearshoring, at the end of the day, will require a long-term vision and clear demonstration of political will from both the US and, especially, the Mexican government.

CONCLUSION

In a bilateral relationship too often defined by its frictions, strengthening US–Mexico semiconductor supply chains offers an essential opportunity to advance shared interests by increasing commercial opportunities and the quality of life on both sides of the border. If successful, developing a regional semiconductor ecosystem will create jobs, enhance supply chain resilience, and improve the competitiveness of downstream industries with North American operations. Achieving this vision, however, will not be as easy as recruiting investment in other sectors. Mexican officials must act quickly to prioritize back-end manufacturing segments, capitalize on cross-sectoral synergies, and address the principal barriers to investment. The US government must simultaneously step up efforts to support its Mexican federal and state counterparts, including by directing funding and providing technical assistance to harness the benefits of coproduction for new and existing US fabs.

The stakes are high. Progress will bolster regional cooperation and improve North American security in a changing world, whereas failure would threaten to undercut the US CHIPS Act and Mexican economic development goals.

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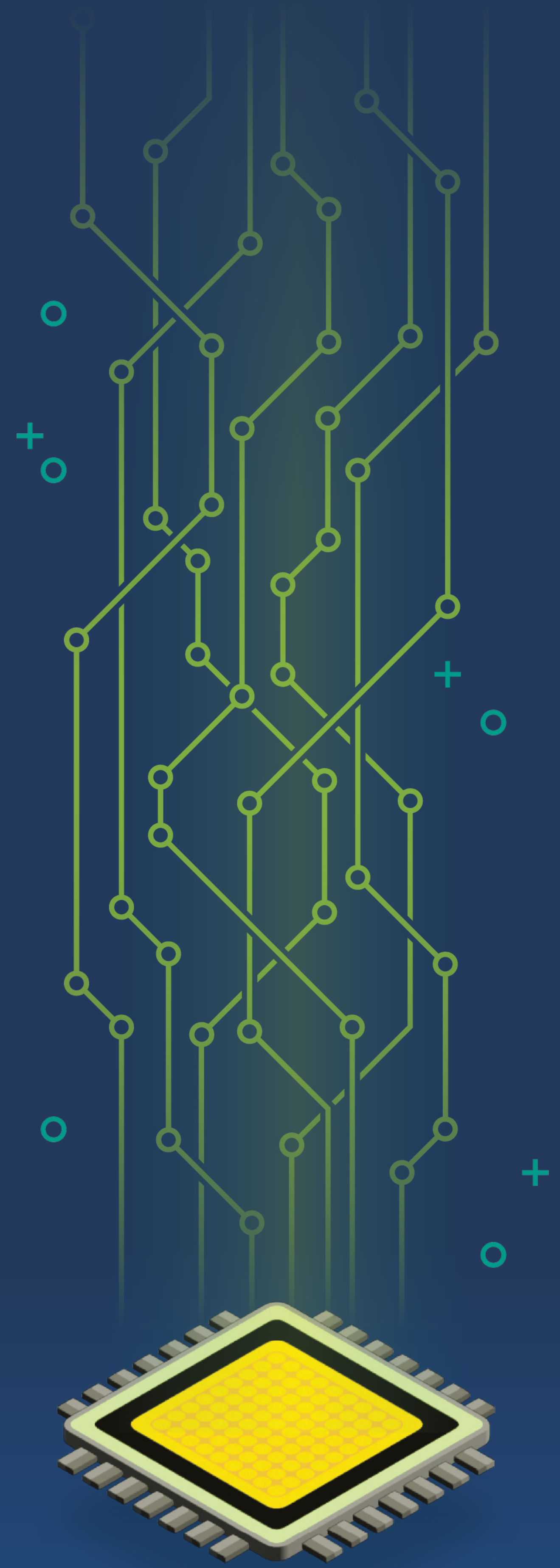

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