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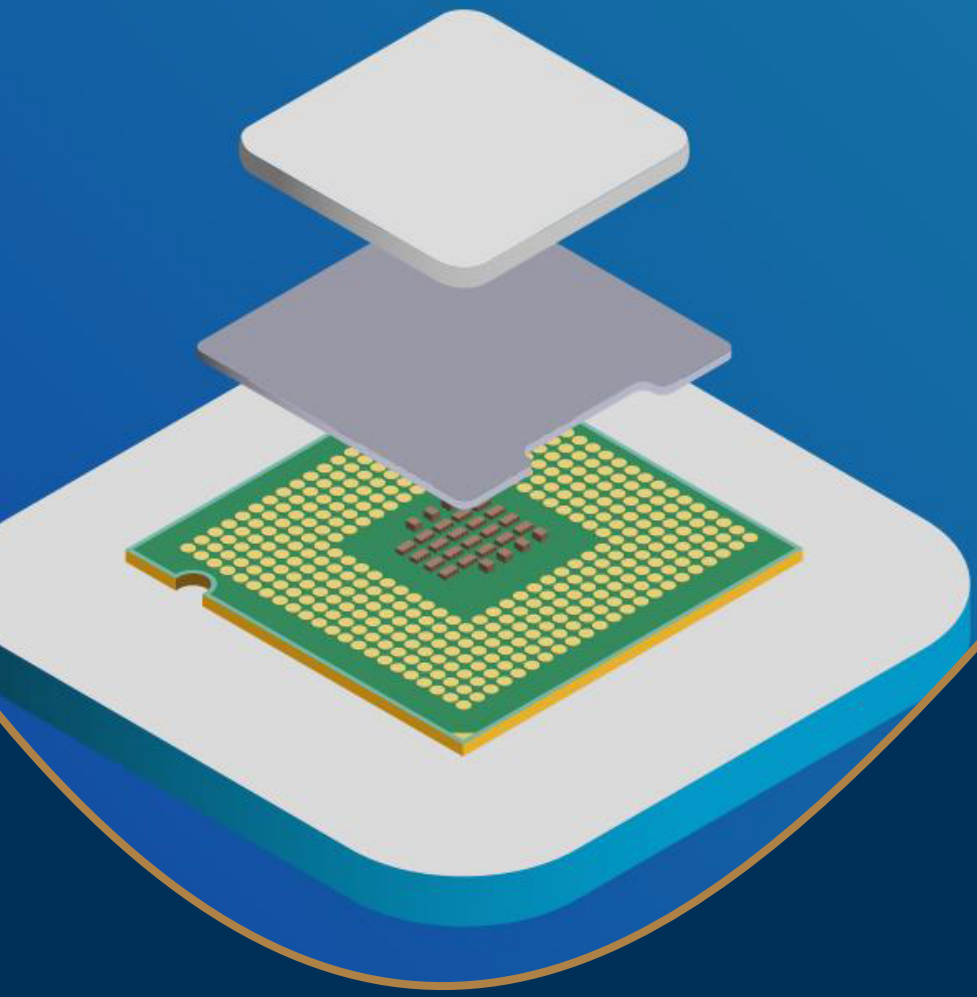

Enhancing the Role of Latin America in the Semiconductor Global Value Chain – Part 1: Market Dynamics

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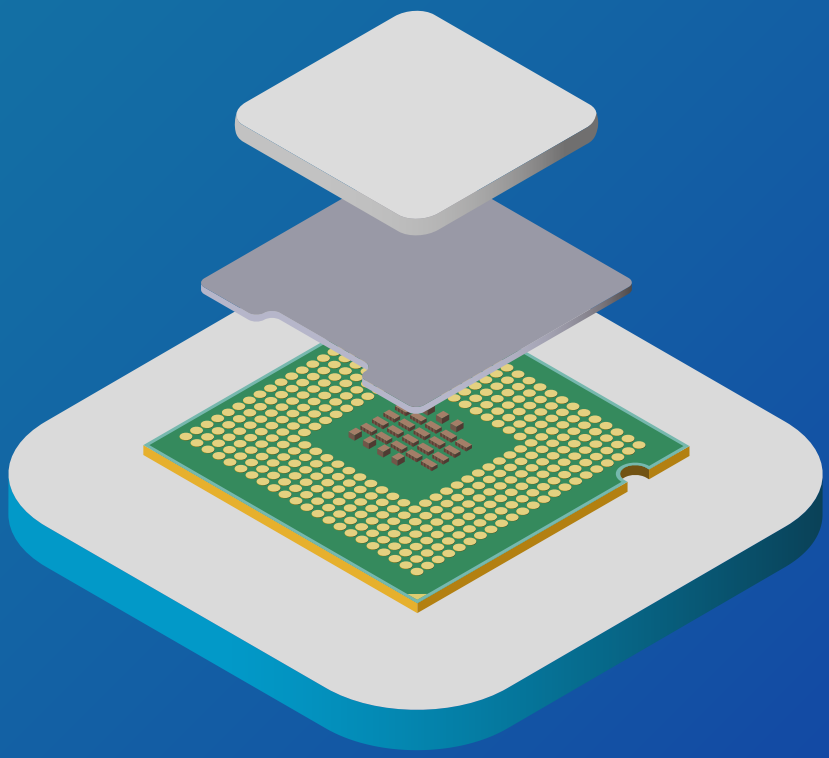
Part 1: Market Dynamics



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Introduction

Semiconductors are an integral part of our modern technology landscape; small chips are found within most of the electronics, appliances, and entertainment systems we use. They are responsible for the computing power in our PCs, the graphics on the latest app of our cellphones, the processing power that backs the latest AI models, and even the guidance of orbiting satellites and military grade missiles.

The semiconductor industry has shown significant expansion in recent years and it encompasses a wide variety of businesses that are in the industry of manufacturing chips, circuits, and other components for use in a wide range of electronic devices. Major players in the industry include TSMC, Intel, Qualcomm, Samsung, Broadcom, NVIDIA, and Micron Technology.[1]

The industry has a favorable view for the future. McKinsey research estimates that it is geared to become a US$1 trillion industry by the end of the decade[2], with potential growth coming from rising demand for semiconductor components in industries that deal with artificial intelligence (AI), the Internet of Things (IoT), and machine learning (ML). During the COVID-19 pandemic the demand for semiconductors rose globally when compared to pre-pandemic levels, growing by 6.8% in 2020 compared to 2019.[3]

The increasing need for chips that are smaller, quicker, and more power-efficient, the advent of new technologies such as artificial intelligence and 5G, and the expanding demand for semiconductor components in the automotive and healthcare industries are key trends and advancements in the industry.

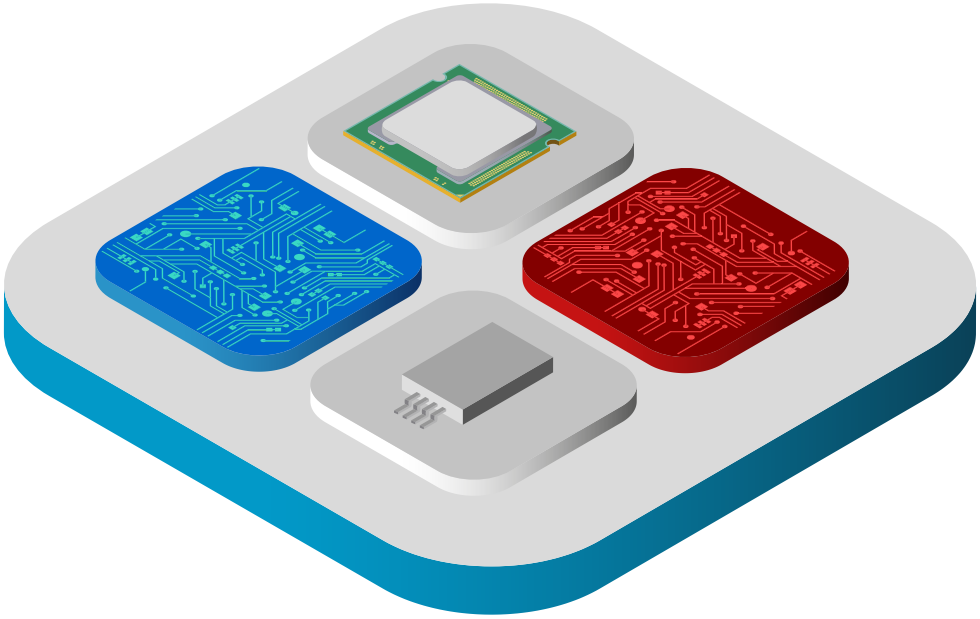
Research and development, design, manufacturing, testing, assembly, and packaging are some of the stages that make up the semiconductor value chain.

The value chain also involves important activities including Electronic Design Automation (EDA) and IP design which allow to rapidly develop product designs and enable faster time-to-market.[4]

The industry is built on the foundry model, which consists of integrated circuit design activities and semiconductor production factories (foundries), each of which is owned by a different company or subsidiary. Only TSMC of Taiwan, Samsung of South Korea, and Intel of the United States are presently able to produce the most cutting-edge semiconductors.[5]

The Creating Helpful Incentives to Produce Semiconductors and Science Act of 2022 (CHIPS Act) provides US$280 billion in spending over the next ten years to boost investments in the United States' domestic semiconductor manufacturing capacity. It also seeks to jump-start R&D and commercialization of leading-edge technologies, such as quantum computing, AI, clean energy, and nanotechnology, as well as create new regional high-tech hubs and a bigger, more inclusive STEM workforce. These investments are expected to drive chip production in the United States, create tens of thousands of new jobs in construction and manufacturing, and bring the United States market share of memory chip production up to 10 percent.[6]

It is in this context in which we will explore **how Panama can provide value** to the global semiconductor value chain, leveraging Panama's world class logistics infrastructure, connectivity, human capabilities and investment regimes to **strengthen the global semiconductor supply chain.**



Why are semiconductors important?

A semiconductor is a material with certain electrical properties that allow it to conduct electricity under certain conditions, making them ideal for use in electronic devices. In electrical engineering, materials are classified based on their ability to conduct electricity. Those that can facilitate the flow of electricity are known as conductors, while those that cannot are referred to as insulators. Semiconductors possess properties that lie between those of conductors and insulators.

In general terms, semiconductors are specialized components used to process, store, and transmit data in electronic devices. They are typically integrated circuits, or "chips", which are made up of miniaturized electronic circuits consisting of active and passive devices and interconnections between them. These chips are made by layering these circuits on a thin wafer of semiconductor material, usually silicon. Modern chips are incredibly small, packing billions of electronic components into a few square millimeters.

Manufacturers process silicon and other materials to create semiconductors for a variety of electronics that rely on using electricity for processing power. The Fourth Industrial Revolution (4IR), which is currently changing manufacturing, production, and worldwide business in general, is defined by smart computers and connected devices, and these semiconductors, or chips, are in higher demand than ever before.

Furthermore, development of future technology is reliant upon the utilization of semiconductors. The modern world is undergoing transformation due to various trends such as the proliferation of remote work, the expansion of artificial intelligence, and the rise in demand for electric vehicles. Consequently, it is anticipated that there will be a substantial expansion in the semiconductor industry over the course of the upcoming decade.

According to McKinsey's projections, the industry's revenues are expected to reach US$1 trillion by the year 2030. The surge in growth will be primarily propelled by three key industries, namely **automotive, computation and data storage, and wireless**, which collectively account for nearly 70% of the projected increase.[7]

The widespread presence of semiconductors in daily life

Semiconductors have become ubiquitous in modern society, permeating nearly every aspect of daily life. These tiny electronic components are found in everything from smartphones and laptops to cars and home appliances. It can be difficult to fully comprehend the significance of semiconductors in today's environment, especially given how tiny the actual devices are.

A recent report by the Semiconductor Industry Association (SIA)[8], highlights the breakdown of different applications of semiconductor devices by market size in 2022: communications (smartphones) 30%, personal computing 26%, automotive 14%, industrial electronics 14%, consumer electronics 14%, and government 2%.

For example, modern smartphones use semiconductors with several smaller integrated circuits for a variety of tasks. These contemporary processors, for instance, may contain the CPU, GPU, processing, and image processing cores of the phone.

And chips are even essential for vehicles, as the recent pressure on the automotive industry's production capacity showed. Up to 1,400 semiconductor devices are used in cars to control everything from airbags to the engine, and even more are used in electric vehicles.

What are the main categories of semiconductors?

Industry taxonomies often list over 30 different product groups. However, according to a recent report by Boston Consulting Group[9], there are, in essence, three broad categories: Logic, Memory, and DAO (Discrete, Analog, and Other).

Logic semiconductors are used as the building blocks of computing. They operate on binary codes and include microprocessors, graphics processing units, application processors, field programmable gate arrays, microcontrollers, and connectivity products.

Microprocessors cover the breadth of logic products such as central processing units (CPU), graphics processing units (GPU), and application processors (AP) all of which execute complex computing operations. Graphic Processing Units are capable of rendering graphics for display on an electronic device. GPUs can do multiple calculations simulatenously, making them useful for cryptocurrency mining and training artificial intelligence and deep learning models.[10]

Commodity integrated circuits (IC) or general-purpose logic products are another subcategory of logic chips. Commodity integrated circuits are simple chips used for performing repetitive processing routines. If an IC is made for a specific purpose, it is called an ASIC or application-specific integrated chip.

One of the newest types of logic chips, and one that is favorable to new producers is the SoC (system on a chip). The SoC is a single chip that contains every electronic part a system might possibly need. It has a wider range of capabilities than a microcontroller chip, which typically combines the CPU with RAM, ROM, and input/output (I/O).

Memory semiconductors are used to store information necessary for computation. A memory chip is an integrated circuit made up of millions of capacitors and transistors that can be used to process code or store data.

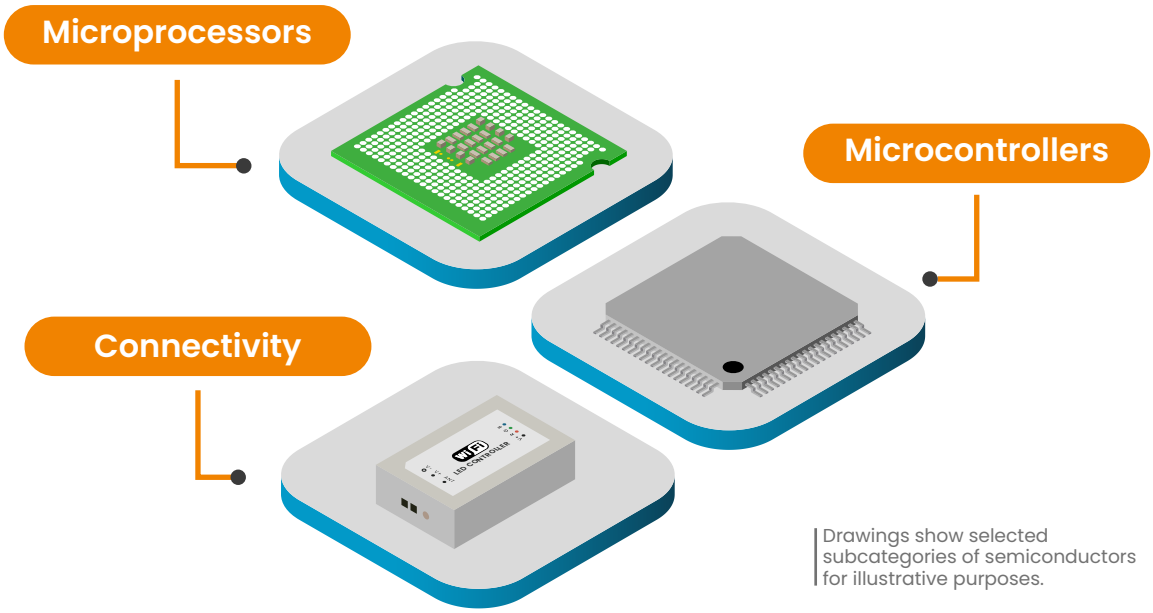
Memory chips can store information either temporarily through random-access memory (RAM) or permanently through read-only memory (ROM).

Dynamic random-access memory (DRAM), a type of RAM memory, is used to store data or program code needed by a computer processor, while NAND memory, a type of storage technology that doesn't require power to retain data, is used for permanent storage in devices like solid-state drives (SSD), SD cards and portable devices.

Discrete, Analog, and Other (DAO) semiconductors deal with continuous parameters such as temperature and voltage. Discrete products include diodes and transistors, which are used in electronic devices to control electric current, while analog products include voltage regulators and data converters. Other DAO products include power management integrated circuits, radio frequency semiconductors, optoelectronics, and a variety of non-optical sensors and actuators.

Main types of semiconductors

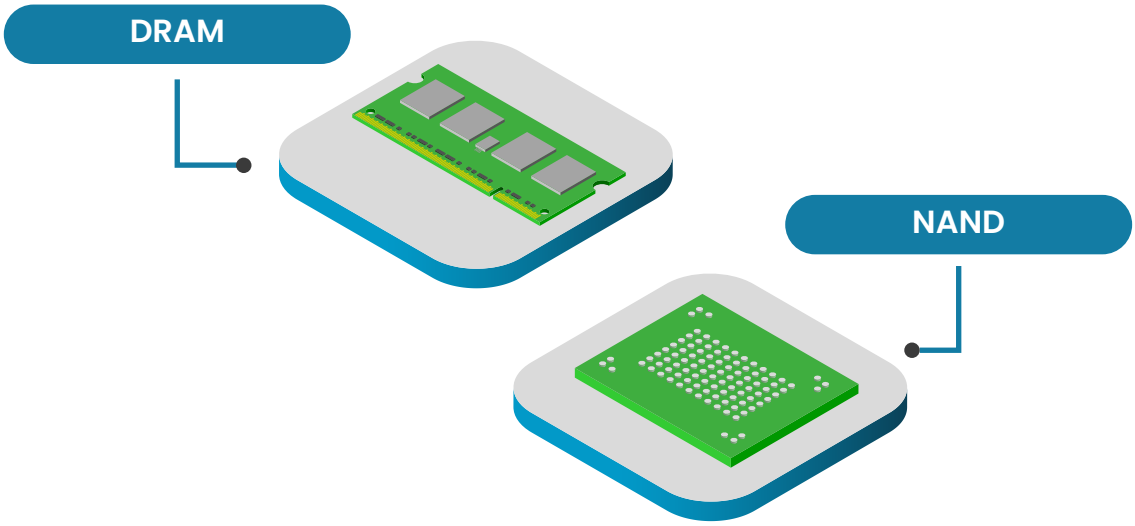
Logic | Used for data processing and to control the operation of electronic devices.



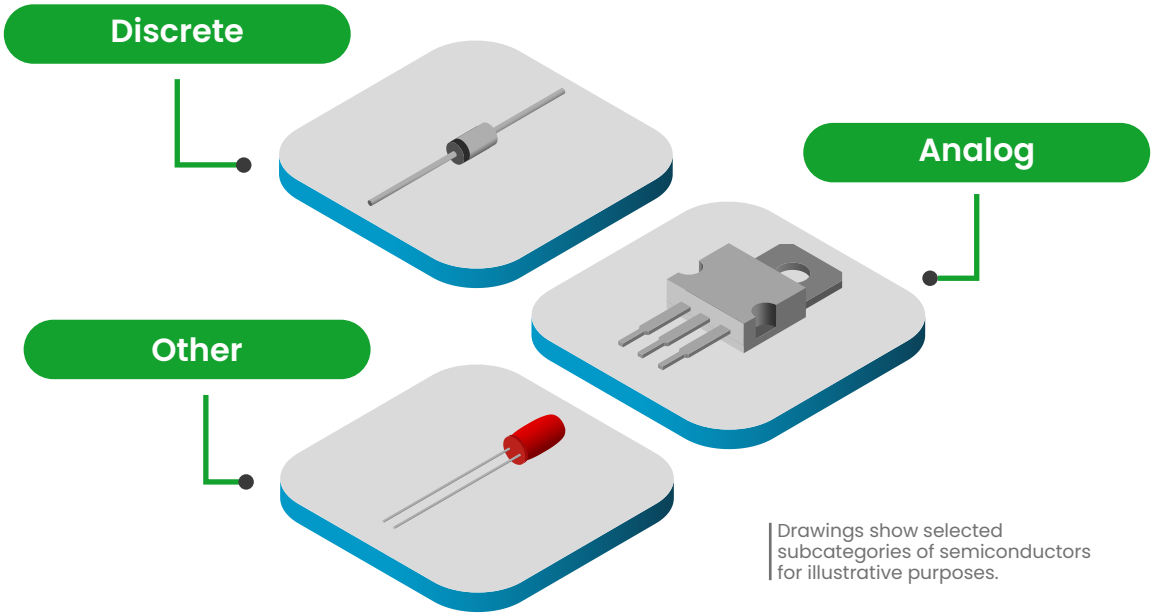
Drawings show selected subcategories of semiconductors for illustrative purposes.

Main types of semiconductors

Memory | Store retrievable information necessary for computation (short-term and long-term).



Discrete, Analog and Other (DAO) | Deal with continuous parameters such as temperature and voltage. Include diodes, transistors, voltage regulators and data converters.



Drawings show selected subcategories of semiconductors for illustrative purposes.

The rapid expansion of the semiconductor market

According to a recent report published by the Semiconductor Industry Association, the global sales of semiconductors attained a record high of **$573.5** billion in the year 2022, indicating a **3.3%** increase from the previous year. Worldwide semiconductor industry sales are forecasted to decrease to $556 billion in 2023 and increase to $602 billion in 2024.[8]

The two most significant categories of semiconductors in terms of sales were **Logic**, which generated $176 billion in sales, and **Memory**, which generated $130 billion in sales. The total revenue generated from the sales of automotive integrated circuits (ICs) reached a record high of $34.1 billion, reflecting a significant year-over-year increase of 29.2%. According to this same report, the **Analog** category exhibited a remarkable annual growth rate of 7.5%, culminating in sales worth $89 billion.[11]

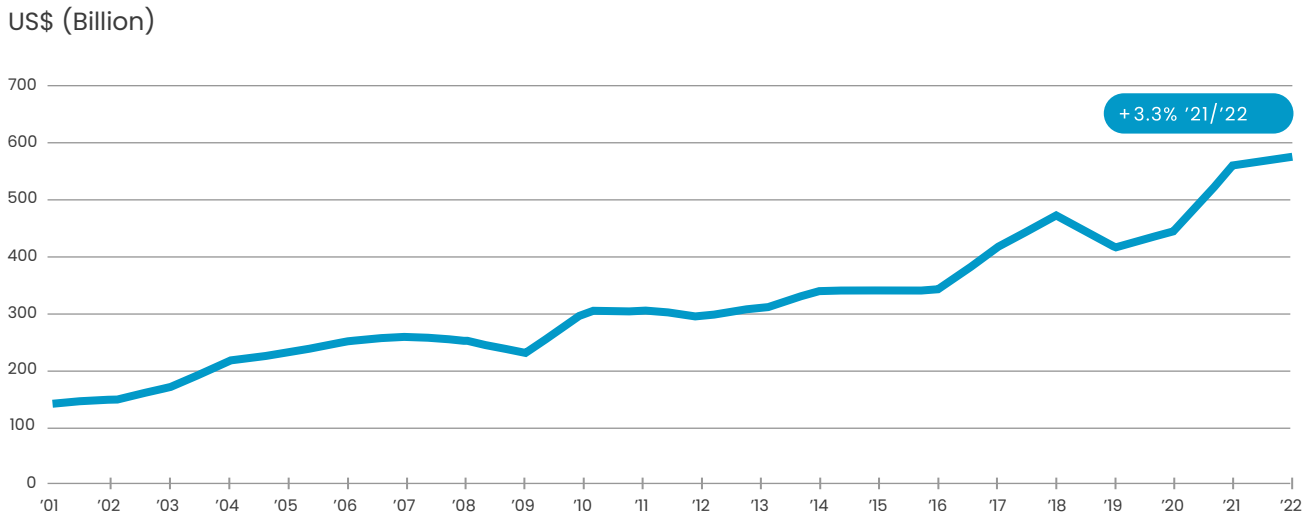


Figure 1: Growth in the Semiconductor Industry. Source: World Semiconductor Trade Statistics (WSTS) and SIA estimates

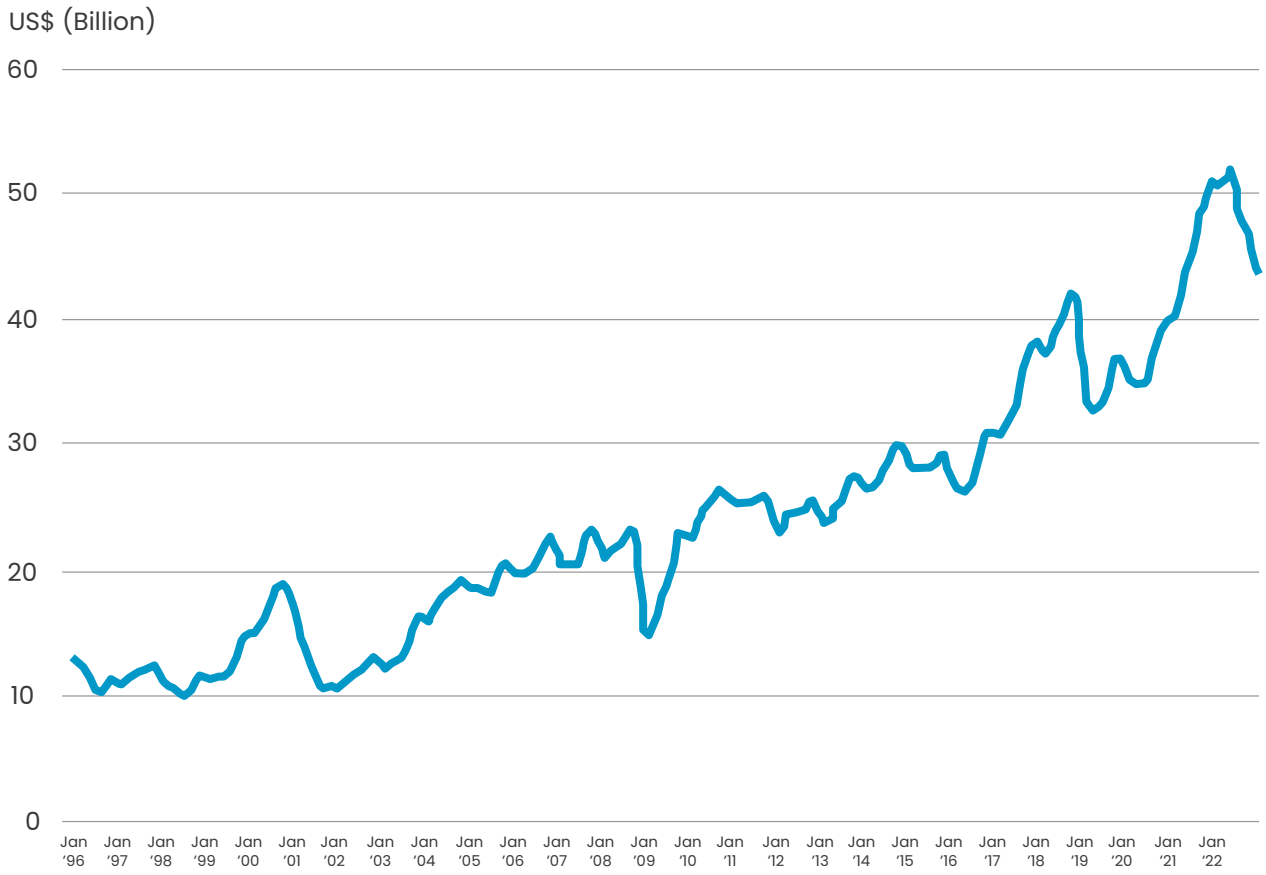


Figure 2: Worldwide Monthly Semiconductor Revenues. Source: World Semiconductor Trade Statistics Organization (WSTS)

It is important to highlight that the semiconductor market exhibits cyclical behavior. Despite experiencing short-term sales changes because of macroeconomic conditions, the long-term picture appears positive because chips are playing an increasingly important role in many facets of the global economy. Figure 2 illustrates this cyclicality with a 4.3% drop in global sales in December 2022 compared to November 2022, but it is clear that growth has been trending upward since the early 2000s.

Market growth perspectives

The semiconductor industry is projected to increase at a compound annual growth rate (CAGR) of 13.4% up to $1,380 billion in 2029. The worldwide COVID-19 pandemic effects were felt in every industry. In the case of the semiconductor industry demand increased globally relative to levels before the outbreak. According to a report by Fortune BI, the worldwide semiconductor industry increased 6.8% in 2020 compared to 2019.[12]

The same report states that this rapid expansion is, nevertheless, accompanied by uncertainty. The sector is still recovering from the US-China trade war and the global economic slowdown of 2019, which reduced global trade and decreased demand for goods and services. The COVID-19 pandemic, according to UNCTAD, decreased exports from China to the European Union by more than 2%, particularly from the Chinese province of Wuhan, which has the factories for General Motors, Honda, Nissan, Peugeot Group (PSA), Renault, and Toyota.

Furthermore, there has been a decrease in demand for segments reliant on semiconductors, such as desktop computers, towards the conclusion of 2022. According to Gartner's research, there was a significant decline in global PC shipments during the fourth quarter of 2022, with a decrease of 28.5% compared to the same period in 2021.[13]

However, industry insiders estimate that the rise of work-from-home employment, which has significantly improved networking and communication, the rising global demand for consumer electronic products, as well as the development of **artificial intelligence (AI)**, the **Internet of Things (IoT)**, and **machine learning (ML)** technologies, will pave the way for the semiconductor industry's continued and rapid growth. These technologies utilize memory chips to process enormous volumes of data in a shorter amount of time. In addition, it is estimated that the growing need for faster and more powerful memory chips in industrial applications will propel market expansion.

The geography of semiconductor diplomacy

Emerging markets

The United States imposed extensive limits on China's semiconductor manufacturing industry, creating possibilities for other nations to strengthen their supply chain positions. This is advantageous not just for their economies, but also for those utilizing semiconductors in their own digital transformation and energy transition initiatives.

Emerging markets are seeking to leverage the CHIPS Act to grow their semiconductor industries and win market-share from China in the Asia-Pacific region, which accounts for 60% of global sales. Southeast Asian nations, such as Indonesia, Malaysia, the Philippines, Thailand, and Vietnam, have all aggressively sought funding to expand their semiconductor businesses.

The launch of the Indo-Pacific Economic Framework in May 2022 has spurred Indonesia and the Philippines to seek fresh investment from the United States in their respective semiconductor industries. The framework, which aims to promote economic cooperation and integration in the region, has provided a timely opportunity for these nations to attract foreign investment and expand their semiconductor sectors. As such, the two countries are expected to intensify their efforts to attract US investors in the coming months.

Malaysia has established itself as a significant player in the semiconductor industry, boasting seven production plants situated across the nation and a 13% market share in the worldwide assembly and testing of chips. The country is now proactively seeking investment from prominent corporations such as Taiwan's TSMC to construct new fabs within its borders.

Semiconductor leaders develop connections

On the other end of the spectrum, the world's leading semiconductor producers, including China, South Korea, Taiwan, the United States, and

Japan, are actively pursuing semiconductor diplomacy in order to expand their market reach.

North American leaders have committed to assist the development of new hubs in Mexico for Taiwanese semiconductor manufacturers. President Biden and his Mexican counterpart, President Lopez Obrador, have reportedly reached an agreement to establish high-level teams aimed at enhancing collaboration in the chip industry. As per a Bloomberg report[14], the primary objective of this partnership is to extend support for the construction of a new hub in southern Mexico, which will respond to the requirements of Taiwanese semiconductor manufacturers. This move is expected to bolster the chip industry and promote economic growth in the region.

On the Asian continent, China, South Korea, Japan and Taiwan have engaged in their own semiconductor diplomacy. The president of South Korea recently embarked on a visit to the United Arab Emirates with the aim of establishing new technology companies for semiconductors and challenging China's dominance in the Middle East, Samsung announced a $850 million investment to manufacture semiconductor components in Vietnam, while Amkor Technology began construction of a $1.6 billion plant in Vietnam to manufacture, assemble and test semiconductors. Japan and India are also investigating investment potential, with the International Semiconductor Consortium announcing intentions to begin building on India's first fab in February and Tata Group committing $90 billion over the next five years to the semiconductor sector, including fabs for advanced chip manufacturing.[15]

Mexico and Brazil seek to expand their presence in the industry

In Latin America, Mexico is looking to expand its semiconductor manufacturing and build production in the southern states in partnership with the United States. Both countries recently agreed to

increase the competitiveness of their shared semiconductor supply chains during a High-Level Economic Dialogue; Mexico would contribute on assembly, packaging, and with manufacturing of wafers.[16]

The reshoring of semiconductor value chain activities in the United States also poses additional nearshoring opportunities for Mexico, in light of a greater regionalization of the semiconductor value chain in the Americas. According to an article by IBD, Mexico already has a high demand for semiconductors, since its automotive industry depends on them and it also participates in the global value chain's design and back-end segments. In light of these points, Mexico would then aim to look for chances to expand its footprint in the industries in which it currently has a presence and increase its position in the fabrication sector through “fab-lite” manufacturers.[17]

Brazil has had a semiconductor industry going on since the 1980’s, albeit with its up and downs due to various reasons. Of all the companies in this sector in Brazil, five produce chips and use highly advanced encapsulation techniques, mainly in the memory chips sector. Even with multinational chipset makers such as Qualcomm employing 2,500 people in Brazil, the Brazilian semiconductor industry has been unable to meet domestic demand, as a result importing 90% of all semiconductors used in phones, cars, and other electronics.[18]

Recently, Brazil has been engaging in diplomatic talks with South Korean chipmaker Samsung to establish a chip and semiconductor facility in Brazil, looking to diversify its supply chain in light of recent geopolitical tensions between China and the United States. Their plan is for Samsung to build a factory in Brazil that would produce semiconductor parts for the local industry, as well as to be exported to countries in Latin America, Europe and Africa.[19] Brazil has also been open towards engaging in talks with China to attract semiconductor manufacturing and packaging.[20]

Opportunities for Panama and Latin America

The rapid expansion of the global semiconductor market, the recent macroeconomic factors brought on by escalating geopolitical tensions between the United States and China, as well as the chip shortage resulting from the COVID-19 pandemic, are all factors reshaping global semiconductor value chains. In this changing environment, the Latin American region has the potential to make significant advances in this sector.

The global outlook seems to suggest that the major semiconductor producing nations are looking for strategic allies around the globe to strengthen their semiconductor supply chains, potentially creating win-win opportunities for the economies and regions they interact with, while taking advantage of structural complementarities in logistics, manufacturing and engineering capabilities.

In Latin America, Mexico and Brazil are leading the way in the push for enhancing regional manufacturing capabilities. As the global economic and geopolitical landscape evolves, companies are looking to diversify their supply chain footprint, opening the door for other players to establish themselves as viable sites for production, assembly, testing, packaging and distribution in the near future.

In particular, integrated clusters already serving global value chains, such as the rapidly growing logistics hub in Panama, have a natural edge for supporting the region's operational capabilities and providing opportunity for future growth. Achieving that integration to the global semiconductor supply chain will require a concerted effort across the region, and a comprehensive assessment of regional challenges and complementarities.

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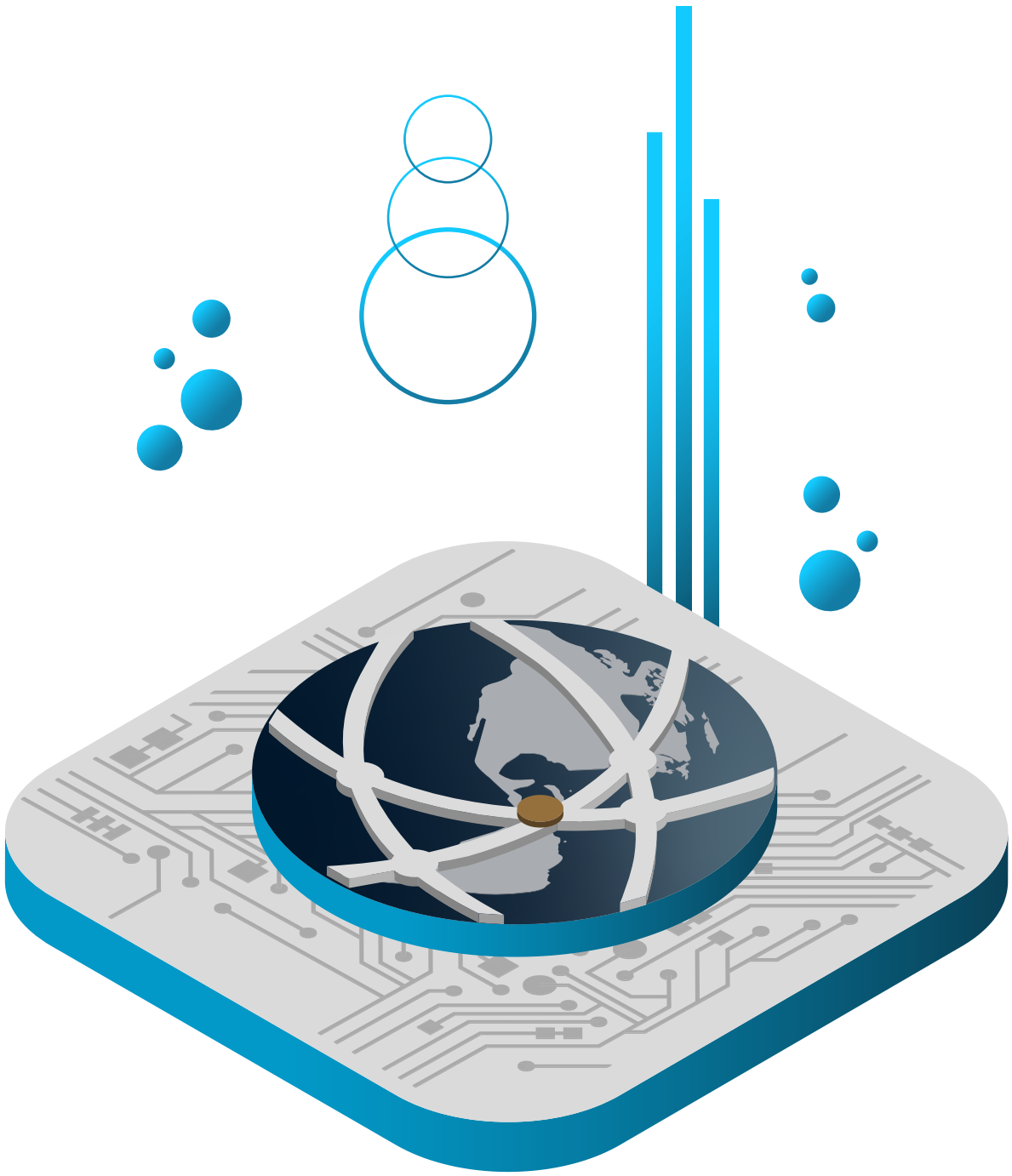

About the Why Panama Program

In the current dynamic global landscape, it is clear that having access to high-quality insights is crucial when determining the optimal location for regional distribution in order to take advantage on the present structure of global value chains.

Georgia Tech Panama Logistics Innovation & Research Center recognizes the importance of key insights in the decision-making process, and works closely with companies seeking to assess their supply chains and how Panama can become a key part of their global logistics network.

The "Why Panama" program utilizes quantitative data and analytics to assess key variables and compare the costs, investments, and service benefits of setting up a distribution center in Panama. By conducting a thorough analysis, the program aims to provide businesses with valuable insights into the advantages of establishing a hub in Panama.

To know more you can contact Jeancarlos Chen at jeancarlos.chen@gatech.pa or Jorge Barnett at jorge.barnett@gatech.pa

About Us

The Georgia Tech Panama Logistics Innovation and Research Center is located in Panama City, Panama. It was launched in 2010 by an agreement between the Georgia Institute of Technology and the Goverment of Panama through the National Secretariat of Science, Technology and Innovation (SENACYT).

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