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Assessing the Dominican Republic's Readiness to Play a Greater Role in Global Semiconductor and PCB Value Chains

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The Dominican Republic is one of the world's fastest-growing economies, offers perhaps the most attractive business environment in Latin America, and is a leading candidate for nearshored investments in advanced manufacturing activity—particularly for electronics such as printed circuit boards (PCBs) and the assembly, test, and packaging (ATP) of semiconductors.

KEY TAKEAWAYS

- Geopolitical tensions, supply chain disruptions, and rising Asian production costs are driving a reorganization of global value chains in high-technology industries, with the Dominican Republic well positioned to attract such nearshored investment.
- The Dominican Republic has grown at an almost 5 percent annual rate over the past half century, transforming it into Latin America's seventh-largest economy and positioning it to graduate from middle-income to advanced-economy status by 2060.
- The Dominican Republic's 87 free zones (FZs), which exempt exporters from paying 100 percent of income tax (and a range of other taxes), make the country a regional powerhouse in the production and export of electronics and medical devices.
- The 25 leading electronics manufacturers operating in the Dominican Republic's FZs provide a well-developed advanced electronics manufacturing base to serve as a springboard for the country getting into semiconductor ATP and PCB manufacturing.
- The Dominican Republic's "Bureaucracy Zero" program, which seeks to enhance public administration efficiency through clear and appropriate regulatory frameworks, has recently streamlined 315 procedures operated by 63 government institutions.
- The Dominican Republic's flagship workforce training program, the National Institute of Professional Technical Training, or "INFOTEP," equips the country with the mechanism needed to train a larger workforce to support advanced electronics manufacturing.

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EXECUTIVE SUMMARY

The global economy is currently undergoing a dramatic reordering, driven by a multitude of factors including COVID-19 pandemic-induced supply chain disruptions; the emergence of breakthrough digital technologies such as artificial intelligence (AI); and geopolitical tensions, not least between the United States and China. In a quest to enhance the stability, resilience, and cost-competitiveness of their supply chains, advanced electronics manufacturers are considering alternative production locations worldwide, presenting nations with a unique opportunity to present their distinctive value propositions to attract globally mobile investment in an international economy that's reorganizing in real time.

In few sectors is this opportunity greater than in semiconductors, an industry that's expected to grow 40 percent globally to a $1 trillion by 2030, and where the U.S. government is stimulating its growth across North America through the CHIPS and Science Act, which committed $52 billion in federal investment and has already attracted $220 billion in announced investments across some 70 projects. The Dominican Republic is a prime candidate to capture increased North American investment in printed circuit board (PCB) manufacturing and offers considerable attractiveness as a destination for near-shored semiconductor assembly, test, and packaging (ATP) activity, in which semiconductors are tested and assembled into sophisticated packages.

Indeed, the Dominican Republic presents one of the most attractive foreign direct investment (FDI) environments the Americas have to offer. The country's political economy is marked by a business friendly environment that features political stability, a liberalized trade regime, and regulatory continuity that affords a stable and predictable operating environment for multinational corporations. These factors have contributed to the Dominican Republic becoming the seventh-largest Latin American economy and growing at a nearly 5 percent (4.9 percent) growth rate from 1972 to 2022, making it one of the world's fastest-growing economies over the past half century. As the International Finance Corporation (IFC) has written, the Dominican Republic's, "remarkable performance can be attributed to several factors, including implementation of sound policies, particularly by the central bank, improvements in policy framework, a more diversified export base, and the economy's structural flexibility to changing global condition." The IFC predicts the Dominican Republic's over 5 percent annual growth rate will persist into the foreseeable future, with the country graduating from middle-income to advanced economy status potentially as soon as 2060.

The Dominican Republic presents one of the most attractive FDI environments the Americas have to offer.

A key driver of the Dominican Republic's economic growth has been FDI in the country's 87 free zones (FZs) that underpin advanced manufactured goods production—notably of electronics products and medical devices/instruments—for export to regional (though principally North American) markets. In the decade from 2013 to 2022, the Dominican Republic attracted a total of $27.7 billion in inbound FDI, with annual investment levels more than doubling from $1.9 billion in 2013 to $4.01 billion in 2022. Just under 20 percent of the inbound investment goes toward industry/manufacturing (tourism and energy being the Dominican Republic's other leading FDI sectors).

The Dominican Republic's FZs are situated across 28 of the country's 32 provinces, supporting 820 companies in operations that employ over 197,600 direct jobs, produce over $8.1 billion in exports annually, and have made cumulative investments of over $7.16 billion in the country. The flourishing of the Dominican Republic's FZs has been made possible by Law 8-90, which exempts beneficiaries from paying 100 percent of income taxes; export or-reexport taxes; import taxes and customs duties on machinery, raw materials, equipment, and construction materials; taxes on the transfer of industrialized goods and services; taxes on patents, estates, or assets; and municipal taxes. Thus, the FZs present a very attractive environment for near-shored manufacturing, particularly of goods intended for export to North American markets.

Medical devices/instruments constitute the country's leading export sector, accounting for $2.25 billon in annual exports, with 5 of the world's top 10 medical device manufacturers operating in the Dominican Republic, and the sector enjoying an annual growth rate of 17.7 percent in 2022. But just behind medical devices comes electronics, the second-largest exporter from the country's FZs and which accounted for $1.2 billion of exports in 2022, with this representing 15 percent of total FZ exports and a 3.8 percent growth rate from the prior year.

Twenty-five leading electronics companies are active in the Dominican Republic's FZs, led by enterprises such as Eaton, Rockwell Automation, Jabil, Fenix Manufacturing Solutions, and Cutler Hammer Industries; 16 of these 25 electronics companies are headquartered in North America, with 22 of the 25 the subsidiary of a foreign parent. Collectively, electronics companies operating in Dominican Republic FZs generate 11,120 jobs, 6 percent of all employment in Dominican Republic FZs. Dominican Republic electronics exports from FZs flow overwhelmingly to North America, with 98.8 percent going to the United States. By product exports to the United States, circuit breakers lead with 62.5 percent of such exports, followed by cellular phones and wireless network equipment at 9.1 percent, and other devices, such as junction boxes, with a 5.3 percent share.

The Dominican Republic offers a cost-competitive manufacturing environment.

Two of the most notable electronics manufacturers in the Dominican Republic are Eaton Corporation and Rockwell Automation. Eaton operates three manufacturing plants in the PIISA FZ in Haina, which together cover 460,000 square feet and employ over 5,000 individuals manufacturing a variety of electrical products, though most notably molded-case circuit breakers, electronics/commercial smart breakers, and miniature and residential circuit breakers. Eaton's Dominican Republic team also won a global competition to site a Santo Domingo R&D and Design Center that will attract some $3 billion in research and development (R&D) investment through 2030. For its part, Rockwell Automation, a global developer of industrial automation and digital transformation technologies, employs over 300 individuals who produce 12 million electronic units (again, largely circuit breakers, PCB assemblies, cabling, etc.) and $53 million in total cost of goods sold annually.

The Dominican Republic offers a cost-competitive manufacturing environment. In fact, the World Bank found that the hourly manufacturing labor cost in the Dominican Republic is $2.50, 6 percent the rate in the United States, approximately half that of Costa Rica or Mexico, and even less than in China.

But another key reason why the Dominican Republic attracts multinationals is that its liberalized trade regime permits exporters duty-free access to more than 900 million consumers across 49 countries. Most importantly, the Dominican Republic-Central America-United States Free Trade Agreement (CAFTA-DR) liberalizes trade in goods and services between the United States and six Central American countries: Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, and Nicaragua. The country entered into an Economic Association Agreement with the European Union (EU) in 2008, since when its trade with the EU has increased 231 percent. As the EU has written, "The Dominican Republic has stood out for its punctual implementation of the assumed commitments in the EPA, including the tariff reduction schedule." Critically for electronics manufacturers, the Dominican Republic is also a member of he seminal World Trade Organization (WTO) Information Technology Agreement (ITA), through which 82 nations have collaborated to eliminate tariffs on trade in hundreds of information and communications technology (ICT) products. Lastly, the Dominican Republic collaborates with its partners in Costa Rica, Ecuador, and Panama as part of the Alliance for Development in Democracy (ADD), an initiative to promote democratic strengthening and economic growth through the tightening of the three countries' commercial, demographic, and cultural ties.

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Exporters are also attracted to the Dominican Republic's enviable geographical position in the Caribbean and its world-class logistical infrastructure. The country has the third-best maritime connectivity in the region and the seventh-largest multimodal maritime port in Latin America, meaning products can reach the U.S. East Coast in three to four days. The Dominican Republic ranks second in Latin America regarding international connectivity by air transport, with flights servicing U.S. semiconductor-producing locations across the Northeast, Midwest, and South. The country also enjoys the strongest Internet connectivity in the Caribbean, in part due to being home to NAP del Caribe, one of the most significant network access points (NAPs) in Latin America and one of the 220 NAPs located in 26 countries globally. It is one of only three carrier-neutral NAPs in all Latin America. While the country has traditionally been dependent on imported fossil fuels for energy, clean energy generation now accounts for 18.1 percent of the country's energy supply, with renewable energy expected to account for 25 percent of the country's energy production by 2025. Moreover, in interviews, manufacturers operating in FZs emphasized they receive power from dual sources and indicated that power outages were uncommon.

Countries have moved from being "price makers" to "price takers" in the quest to attract globally mobile advanced-technology industry investment. In fact, leading semiconductor manufacturers may consider as many as 500 discrete factors—ranging from countries' and states' talent, tax, trade, and technology policies to labor rates and laws and customs policies—as they evaluate where to situate multi-billion-dollar fab, or ATP, investments. In other words, the ease and certainty of doing business in a country matters greatly.

Here, the Dominican Republic has worked to make strides, particularly through its "Burocracia Cero" ("Bureaucracy Zero") Program, established through Decree No. 640-20, which seeks to enhance public administration efficiency through clear and appropriate regulatory frameworks. To

date, 315 procedures from 63 government institutions have been streamlined or reformed. For instance, Law No. 167-21 seeks to promote innovation through the application of regulatory policy tools that help inform the policymaking process with evidence-based analysis, with a goal of raising the quality of policies and legislation. From 2019 to 2002, the Dominican Republic's score on the World Bank's "Government Effectiveness" indicator increased from the 38.1 to 50 percent.

The Dominican Republic has also worked assiduously to improve the quality of its customs environment. A flagship initiative has been the 24-Hour Clearance Program, also called Dispatch 24h (or D24H), which seeks to clear containers within 24 hours. To date, the program has cleared over 50,000 containers in 24 hours or less, benefitting more than 6,700 importers. Another critical program for exporters from the Dominican Republic is Exporta Más (or Export +), through which participating companies can export without a physical inspection process and in A fully digital format, eliminating the need for paper documents, thus decreasing the time and costs associated with exporting. Over 250 companies are enrolled in the Exporta Más program, with participating companies making over 177,000 export declarations and the program now covering 58 percent of total exports from the country.

Despite these strengths, if the Dominican Republic is to migrate up the value chain in advanced electronics manufacturing, it will have to be able to educate and field a skilled workforce with the requisite skills to compete in advanced electronics manufacturing. Here, a crucial player will be the National Institute of Professional Technical Training, or "INFOTEP," whose charter is to organize and govern the Dominican Republic's national system of professional and technical training. INFOTEP has 245 operational centers nationwide, through which it offers a total of 920 technical courses, including 86 in electricity and electronics; 36 in ICT; and 104 in the manufacturing, installation, and maintenance of machinery and equipment. Companies fund INFOTEP by contributing 1 percent of their monthly payrolls to the program. INFOTEP is active across virtually all the country's FZs, and manufacturers reported working extensively with INFOTEP to develop customized technical education courses, such as in microelectronics, precision welding, and use of robotics and other "Industry 4.0" automation technologies. Since its inception, INFOTEP has trained 770,914 workers in different competencies and fields via over 40,000 courses and close to 800,000 training hours.

Other important players in the Dominican Republic's technical education ecosystem include the Technological Institute of the Americas (ITLA), a technical institution of higher education founded in 2000. ITLA specializes in training Dominican youth in fields such as software development, information networks, multimedia, mechatronics, automated manufacturing, and computer security. The Technological Institute of Santo Domingo (INTEC) is considered the leading technical institute in the country, and it offers extensive courses in fields such as electrical and mechanical engineering. In short, the Dominican Republic possesses a robust technical education training infrastructure.

In summary, the Dominican Republic has demonstrated the ability to support a high-tech electronics manufacturing industry and possesses the requisite ecosystem assets—digital and physical infrastructure, technical education institutions to support a microelectronics-skilled workforce, regulatory environment, etc.—needed to support its aspirations to compete in semiconductor ATP and PCB manufacturing. The Dominican Republic should be considered a

prime candidate for nearshored, greenfield investment in these sectors. The country should also be considered a leading candidate to be designated a recipient of funding from the U.S. Department of State's International Technology Security and Innovation (ITSI) Fund, which seeks to enhance and ensure semiconductor supply chain security and diversification and promote the development and adoption of secure, trustworthy telecommunications networks.

The report makes the following policy recommendations:

- The Dominican Republic should be considered a leading candidate to be designated a recipient of funding from the U.S. Department of State's ITSI Fund.
- The government of the Dominican Republic should develop an explicit national semiconductor value proposition and broader competitiveness strategy.
- The Dominican Republic should launch an awareness campaign reaching out to global investors in advanced electronics industries highlighting the country's favorable FZs and tax policies.
- The Dominican Republic can help address this gap by expanding the availability of degree programs in electrical engineering, computer science, and related courses.
- The Dominican Republic needs to increase the number of individuals holding IPC 610 certifications.
- The Dominican Republic should consider expanded use of investment incentives to attract semiconductor industry manufacturing activity.
- The Dominican Republic should set up a "one-stop-shop" to facilitate the regulatory clearance of all permits and approvals, such as environmental review permits, that would be required to launch a semiconductor ATP or PCB facility in the country.
- The Dominican Republic should join the expanded ITA (ITA-2) and join discussions toward promulgating an ITA-3.
- The Dominican Republic should champion robust digital trade regulations, and one way it could do so would be by joining the WTO's Joint Initiative on E-commerce.
- The Dominican Republic should explore the possibility of entering into such a protocol with the United States, with the intent of further strengthening the trade and investment environment between the two nations.

INTRODUCTION

The global economy is currently undergoing a dramatic reordering, driven by a multitude of factors including COVID-19 pandemic-induced supply chain disruptions; the emergence of breakthrough digital technologies such as AI; and geopolitical tensions, not least between the United States and China. In a quest to enhance the stability, resilience, and cost-competitiveness of their supply chains, advanced electronics manufacturers are considering alternative production locations worldwide. This reshuffling of global value chains affords nations with a unique opportunity to present their distinctive value propositions to attract globally mobile investment in an international economy that's reorganizing in real time.[1]

In few sectors is this opportunity greater than in semiconductors, an industry that's expected to grow 40 percent globally to a $1 trillion by 2030.[2] One study finds that global demand for semiconductor manufacturing capacity will increase by 56 percent in the 2020s decade.[3] Another study estimates that over 70 new semiconductor fabs are expected to be constructed worldwide by 2030 to satisfy the growing global demand for semiconductors.[4] The U.S. government has committed to stimulating the semiconductor industry's growth in North America through the CHIPS and Science Act, which committed $52 billion in federal investment, including $39 billion in incentives and $11 billion for R&D and workforce training activities, and which has already attracted $230 billion in announced investments across some 70 proposed projects in the United States.[5]

The reshuffling of global value chains affords nations with a unique opportunity to present their distinctive value propositions to attract globally mobile investment in an international economy that's reorganizing in real time.

The Dominican Republic represents a prime candidate to capture increased North American investment in PCB manufacturing and offers considerable attractiveness as a destination for near-shored semiconductor ATP activity (the step in which semiconductors are tested and assembled into sophisticated packages). That's in large part because the Dominican Republic represents one of Latin America's most-attractive destinations for inbound FDI, thanks to its stable, predictable, and business-friendly regulatory, tax, and trade policy environment. This fits well with the Biden administration's ambition to decrease technological production dependence on Asia while strategically relocating semiconductor manufacturing closer to home.[6]

The Dominican Republic's 86 FZs anchor the country's manufacturing economy, supporting over 800 companies that collectively employ nearly 200,000 workers, produce over $7.77 billion in exports annually, and have made cumulative investments of over $7.16 billion into the country. Twenty-five electronics companies, anchored by leaders such as Eaton and Rockwell Automation, manufacture in the Dominican Republic, supporting over 11,200 jobs and producing $1.2 billion of exports in 2022. The country's extant electronics manufacturing base equips the Dominican Republic with the business expertise and skilled technical workforce requisite to support its aspirations to migrate up the advanced electronics value chain to compete in semiconductor ATP and PCB manufacturing activity, especially at a time when the global reorganization of production chains in these industries is driving a push toward reshored or nearshored manufacturing in the Americas. Indeed, the country has a rich track record of

successfully attracting and supporting high-tech companies across a range of advanced technology sectors from medical devices to ICT/electronics.

Moreover, it's time for both policymakers in Washington and corporate leaders worldwide to more seriously consider regional partners in the Americas as candidates for greater levers of advanced electronics manufacturing activity. As *Chip Wars* author Chris Miller wrote with David Talbot, "The Western hemisphere deserves more focus as Washington seeks to better secure the broader electronics supply chain."[7] As they continued, "Building regional capacity offers a way to limit Asia-focused supply risks and, in the event of a major China-U.S. conflict, an interhemispheric supply chain would be much less susceptible to interference."[8] That's indeed so. Enrolling Western hemispheric partners in semiconductor supply chains can prove beneficial to the United States, regional partners, and global semiconductor enterprises alike, and the Dominican Republic is poised to join other Latin American countries such as Costa Rica and Mexico as leaders in this regard.

The first half of this report examines the Dominican Republic's economic, business, and policy environment. It starts by providing an overview of the country's economy and key industrial sectors, before turning to examine its policy environment, considering issues such as the country's regulatory, trade, customs, taxation, and innovation policies. The business environment section examines the country's infrastructure, education, and workforce training programs. The remainder of the report explores the Dominican Republic's potential capacity to compete in semiconductor ATP and PCB manufacturing activity specifically. But before turning to these topics, the report explores why the Dominican Republic should want to get into the competition to attract semiconductor sector investment in the first place.

WHY SHOULD THE DOMINICAN REPUBLIC SEEK TO ESTABLISH A PRESENCE IN SEMICONDUCTOR VALUE CHAINS?

As this report explores, semiconductors represent one of the world's most important industries. Semiconductors represent the heartbeat of the modern global digital economy, an industry that's expected to reach $1 trillion in value by 2030 and which stimulates another $7 trillion in global economic activity annually.[9] Semiconductors power (both literally, through power management, and figuratively, through computational capacity) virtually every modern device—from computers and smartphones to electrical vehicles and toaster ovens—and underpins a range of downstream applications from AI to big data analytics. Put simply, semiconductors are foundational to the ability of enterprises and nations alike to compete in the global economy; they truly represent the "commanding heights" of the modern global digital economy.

Moreover, manufacturing semiconductors represents one of the most complex engineering activities humanity undertakes. The most cutting-edge semiconductor fabs, those producing 3 nanometer (nm) chips, can cost $20 billion to build.[10] Semiconductor ATP facilities generally constitute $2 billion to $3 billion investments; for instance, in November 2023 Amkor announced it would launch a new Arizona ATP facility at a cost of $2 billion, while TSMC announced it will spend $2.87 billion to build its next advanced packaging facility in Taiwan by 2027.[11] In fact, the design and operation of semiconductor fabs is so nuanced and sophisticated that it takes into account details as minute and granular as the gravitational effects of the moon on factory lines.

And so, in a like manner, if countries (and states or regions therein) wish to compete successfully for semiconductor-sector investment, then the policy and business environments they foster must be equally finely tuned, well-crafted, and deeply sophisticated as that semiconductor facility itself, a fact that applies equally to the United States as to China, Germany, Korea, Japan, or India—or the Dominican Republic. But global competition for semiconductor investment is fierce, as nations—and the states, regions, and cities therein—have become price takers, not price makers, in the intense quest to attract globally mobile investment in high-value-added, high-tech industries, such as semiconductors.[12] In fact, leading semiconductor manufacturers may consider as many as 500 discrete factors—ranging from countries' and states' talent, tax, trade, and technology policies to labor rates and laws and customs policies—as they evaluate where to situate multi-billion-dollar fab investments. To win semiconductor investment, locales not only need to get hundreds of factors "right," but the strength of their "checkmarks" on those hundreds of variables needs to be stronger than those of the other countries that are courting the same investment.

But why, amidst other sectors it could target or initiatives it could pursue, should the Dominican Republic prioritize trying to compete in the semiconductor industry? There are several compelling reasons.

First, bolstering manufacturing activity in high-tech sectors such as semiconductors not only provides a significant source of high-value-added, high-paying employment opportunities, but can produce significant employment, and economic, multiplier effects. This is certainly true in the United States, where the semiconductor industry's jobs multiplier is 6.7, meaning that for each U.S. worker directly employed by the semiconductor industry, an additional 5.7 jobs are supported across the wider U.S. economy.[13] (In total, the U.S. semiconductor industry supports 277,000 jobs directly and 1.6 million more jobs indirectly.) Those jobs are highly productive, and thus remunerative, with the average U.S. semiconductor job paying $177,000, compared with the average U.S. wage of $61,900.[14] Semiconductors also produce significant economic multipliers. As one report finds, "Every dollar added to U.S. GDP by the electronics manufacturing sector creates $1.32 elsewhere in the economy. Additionally, every dollar in electronics manufacturing output generates $1.05 of output elsewhere in the economy."[15] Just as U.S. semiconductor jobs produce and pay more, and deliver significant economic and employment multipliers, so too would such jobs in the Dominican Republic's economy.

Second, semiconductor manufacturing can produce tremendous spillover and "learning by doing" effects across the rest of the Dominican Republic's high-tech economy. As Carnegie India's Konark Bhandari observed, "A robust manufacturing base ensures that the knowledge gained from 'learning by doing' is transferred to domestic firms as well."[16] Or, as Rajat Kathuria, former director and CEO of the Indian Institute for International Economic Relations (ICRIER), explained, "Economic growth is influenced by levels of 'sophistication' in a country's production. The nature of production matters for economic growth. Countries that specialize in the production of goods with higher productivity are better placed to achieve higher growth."[17]

Kathuria noted how the economists Ricardo Hausmann and Bailey Klinger developed the notion of "product space" to illustrate how a country's initial pattern of specialization impacts its ability to expand competitiveness in adjacent industries. As Hausmann and Klinger wrote, "The location in the product space is a crucial determinant of a country's potential to develop comparative

advantage in certain products. Countries progress by exploiting the relatedness of products requiring similar inputs including skills and technology."[18] Thus, countries' economic development, "is not merely advancement in general attributes such as education, health, rule of law and infrastructure but also the development of ancillary support systems and activities that are specific to an industry."[19] For the Dominican Republic, its extant capabilities in electronics manufacturing can serve as a platform to enter the manufacturing-oriented elements of semiconductor or PCB production. In turn, if the Dominican Republic can enter the semiconductor manufacturing "product space," this could power its future ability to compete in other high-tech manufacturing sectors, such as robotics. In other words, getting a foot in the door with PCB or semiconductor ATP manufacturing may open up other opportunities for the Dominican Republic to compete in other sectors of the semiconductor value chain that would have been heretofore unobtainable.

Third, there are significant "learning by doing" effects in the policymaking strategies needed to attract investment in high-tech industries such as semiconductors. Indeed, the knowledge spillovers for Dominican Republic policymakers of what it takes to attract semiconductor manufacturing—to the extent it informs how the Dominican Republic competes for other high-tech sectors (such as translating its strengths in the medical device industry into a novel biopharmaceuticals sector) and how it manages its broader economic policy and business environment—are likely to be far more powerful than even the technical "learning by doing" that occurs on the factory floor.

Fourth, the reality is that this is the Dominican Republic's, and Latin America's, moment. As a recent *Financial Times* article observes, the current interest in the reorientation of global supply chains, push for nearshoring, and opportunity to tap into new pools of skilled labor and natural resources "gives Latin America its best chance in a generation to lift its economies out of stagnation, make its people wealthier, and assume a bigger global role" in "helping to meet some of the 21st century's biggest challenges" from generating clean energy to extracting critical minerals.[20] This is a unique moment as multinational companies reassess their global value chains in real time, and so the opportunity is now if countries such as the Dominican Republic wish to break into and attract international investment in advanced technology industries such as semiconductors.

Lastly, just as the opportunity to enter the semiconductor industry would herald the Dominican Republic's ability to move up the economic (i.e., advanced electronics manufacturing) value chain, so too would it represent the opportunity to move up the geopolitical value chain. In other words, it could demonstrate the country's capacity to become a strategic, trusted partner in critical supply chains for the production of advanced technology goods for the United States, Europe, and beyond.

THE ECONOMY OF THE DOMINICAN REPUBLIC

The Dominican Republic is a Spanish-speaking Caribbean nation of 11.3 million citizens whose territory covers 18,700 square miles, about two-thirds of the island of Hispaniola, which it shares with Haiti. The Dominican Republic, whose gross domestic product (GDP) reached $89 billion in 2023 (at official exchange rates), boasts the Caribbean's largest economy, and the seventh-largest in Latin America overall, in both nominal and purchasing power parity terms. The sixth-largest economy in Latin America, Peru, has three times the population of the Dominican

Republic. Since 2010, the Dominican Republic has been the fastest-growing economy in Latin America and the Caribbean. Like Singapore, while small in size, the Dominican Republic's economy and contribution to hemispheric trade punches well above its weight. In fact, as the IFC noted, "Despite being one of Latin America's poorest countries in the mid-1960s, the Dominican Republic has made remarkable progress in terms of income convergence [with the United States]."[21]

Moreover, the Dominican Republic has been one of the world's fastest-growing economies over the past half century. From 1972 to 2022, the Dominican Republic's real GDP growth averaged 4.9 percent, well outpacing its closest Latin American peers—Panama at 4.5 percent, Paraguay at 4.2 percent, and Costa Rica at 4.1 percent—and well exceeding the Latin American average growth rate of 3.2 percent.[22] As the World Bank has explained, the Dominican Republic's "remarkable growth" has been underpinned by macroeconomic stability and an array of market-oriented economic reforms that began in the 1990s, including "tax incentives, the liberalization of foreign exchange transactions and trade agreements, and elimination of price controls and of restrictions on foreign direct investment in almost every sector."[23]

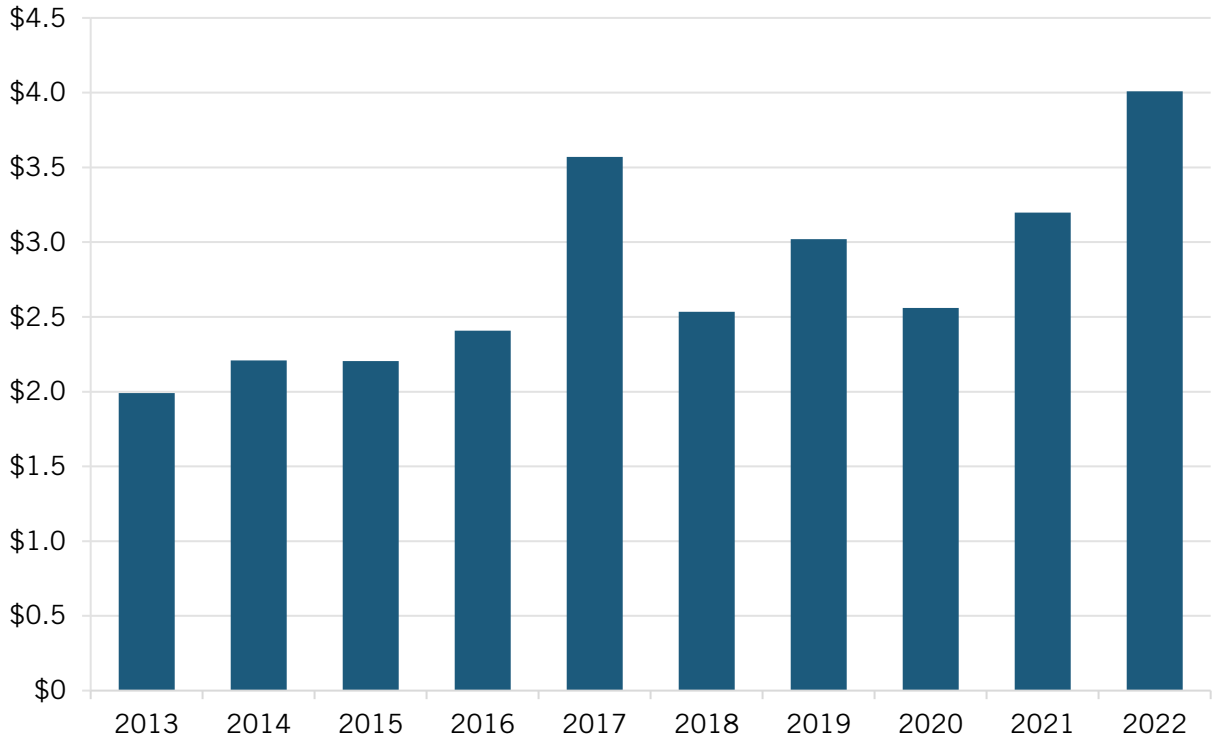
The Dominican Republic's economic growth has actually accelerated in this century, with the country recording real average GDP growth of 5.8 percent from 2005 to 2019.[24] The Dominican Republic's per capita GDP is now the sixth highest in Latin America, right after Argentina in fifth and Mexico at seventh. According to the International Monetary Fund (IMF), the Dominican Republic's per capita GDP (at current prices) reached $27,230 in 2023.[25] The Dominican Republic's continuing high rates of economic growth have meant its economy has demonstrated the fastest income convergence (toward the U.S. level) of any Latin American country over the past half century, with this "convergence velocity" increasing from an average of 3 percentage points per decade over the last 50 years to almost 8 percentage points per decade more recently.[26] As the IFC observed, "This remarkable performance can be attributed to several factors, including implementation of sound policies, particularly by the central bank, improvements in policy framework, a more diversified export base, and the economy's structural flexibility to changing global condition."[27] The IFC expects the Dominican Republic's economy to grow at about a 5 percent annual clip into the foreseeable future, in which case the organization expects the country to graduate from middle-income to advanced economy status potentially as soon as 2060.[28]

Like Singapore, while small in size, the Dominican Republic's economy and contribution to hemispheric trade punches well above its weight.

Attracting robust FDI—the vast majority of it into the country's critically important FZs, as subsequently elaborated upon—has been a critical component of the Dominican Republic's economic growth story. In the decade from 2013 to 2022, the Dominican Republic attracted a total of $27.7 billion in inbound FDI, with annual investment levels more than doubling from $1.9 billion in 2013 to $4.01 billion in 2022. (See figure 1.) For 2023, inbound FDI reached $2.15 billion through June, putting the country on pace to exceed its 2022 levels. By sector, 26 percent of this FDI has gone toward the Dominican Republic's energy sector, 25 percent to tourism, and 18 percent to industry/commerce.[29] Spain has long been the Dominican Republic's leading source of overall FDI investment (including sectors from tourism to manufacturing),

accounting over the past decade for 33.6 percent of inbound FDI, followed by the United States with 24.5 percent.[30] However, the United States is by far the largest foreign direct investor into manufacturing industries in the Dominican Republic, and from 2017 to 2019, it was the main originator of Dominican Republic FDI, accounting for 23 percent of total investment over those years. The Dominican Republic's National Development Strategy as well as its National Competitiveness Agenda "has specifically targeted nearshoring from the United States to facilitate increased sophistication and industrial diversification."[31] The "2023 Greenfield FDI Performance Index" from fDi Intelligence, which ranks the world's best FDI performers relative to the size of their economies, ranked the Dominican Republic 5th out of 10 Latin American countries, but noted the country had the fifth-greatest increase in ranking compared to its score the previous year.[32]

Figure 1: Dominican Republic inbound FDI, 2013–2022 (billions)[33]



Exports from the Dominican Republic have increased steadily over the past 10 years, totaling $107 billion for the decade, and increasing from $9.4 billion in 2013 to $13.8 billion in 2022, with $6.7 billion more through the first six months of 2023. (See figure 2.) Fifty-nine percent of the Dominican Republic's exports originate from FZs. With regard to advanced-technology products, manufacturing, medical, and surgical equipment account for 30 percent of the Dominican Republic's exports, electrical products for 15 percent, and pharmaceuticals 1 percent. (See figure 3.) In 2023, exports from Dominican Republic FZs reached a new record of $8.06 billion. Moreover, from 2020 to 2023, FZ exports grew by 38.4 percent.

Figure 2: Dominican Republic exports, 2013–2022 (billions)[34]

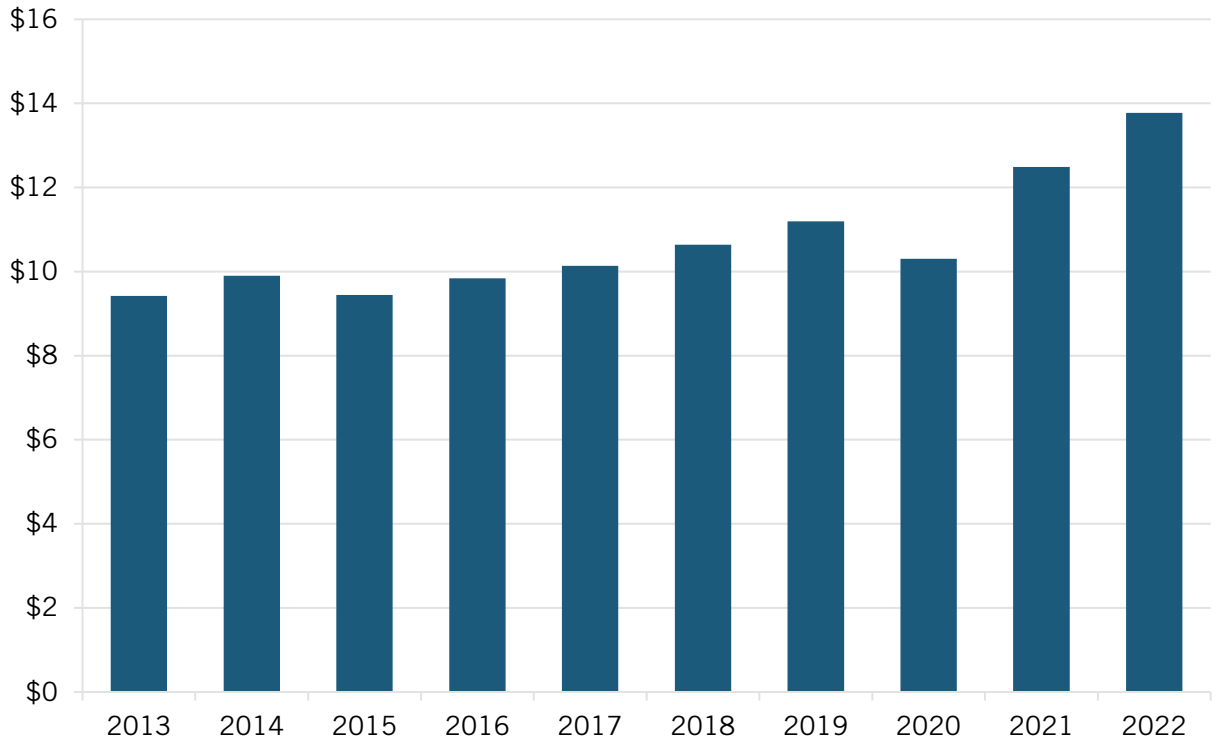
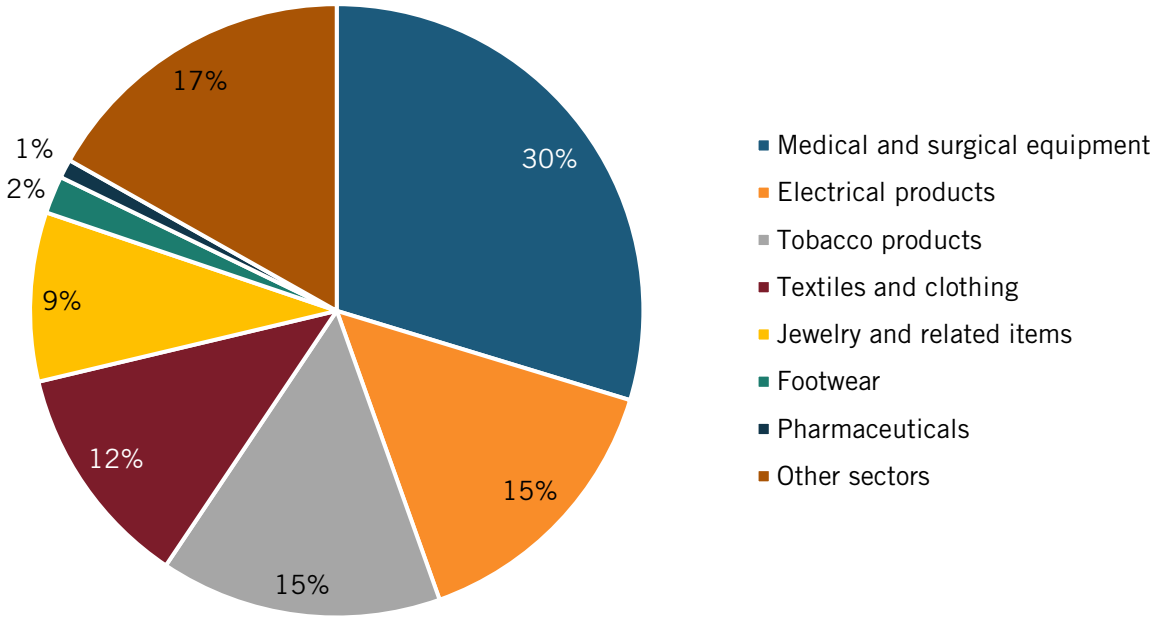


Figure 3: Dominican Republic exports to free trade zones by sector, June 2023 YTD[35]



As noted, electronics and electrical appliances constitute one of the Dominican Republic's most-important export sectors. The electronics industry is the third-largest among the Dominican Republic's FZs, accounting for $1.2 billion in exports in 2022, with the sector's exports growing at an annual rate of 3.8 percent.[36] Twenty-five electronics companies are active in the Dominican Republic's FZs, led by enterprises such as Eaton, Rockwell Automation, Fenix Manufacturing Solutions, and Cutler Hammer Industries; 16 of these 25 electronics companies are headquartered in North America.[37] Collectively, electronics companies operating in Dominican Republic's FZs generate 11,120 direct jobs, 6 percent of all employment in Dominican Republic FZs. Additionally, information and communications industries employ around 45,400 individuals, which represents about 1 percent of the country's nonfarm labor force.[38]

Exports from the Dominican Republic, 59 percent of which originate from FZs, have increased steadily over the past 10 years, totaling $107 billion for the decade.

Two of the most-significant electronics equipment manufacturers in the Dominican Republic are Eaton Corporation and Rockwell Automation.

Eaton Corporation is an intelligent power management company with global operations. Eaton Corporation established its operations in the Dominican Republic in 1985, with its core presence centered at the PIISA Industrial Park in Haina, an industrial suburb west of Santo Domingo. Eaton's three manufacturing plants in Haina cover 460,000 square feet and employ over 5,000 individuals, manufacturing a variety of electrical products, most notably molded case circuit breakers, electronics/commercial smart breakers, and miniature and residential circuit breakers. The COVID-19 pandemic caused disruptions and backlogs to manufacturing globally, including at Eaton's manufacturing operations in Haina, but these were the fastest in Eaton's global network to eliminate the production backlog and return to normal production schedules. Eaton also operates a manufacturing aerospace plant in Santiago, Dominican Republic. In 2019, Eaton was recognized by the Dominican Republic government as one of the companies with the highest contribution to the growth of exports and the generation of foreign exchange in the country, as well as for innovations in the transformation of the productive processes of the FZ sector.[39]

In the early 2020s, Eaton launched a competition among its global manufacturing subsidiaries in developing countries to create proposals for a new R&D and design center for innovative electronic products. Eaton's team in the Dominican Republic won this contest, and on June 23, 2022, Eaton opened the Santo Domingo Design Center, with the facility adjacent to the Technological Institute of Santo Domingo (INTEC) and near the company's manufacturing facilities, forging a strategic hub featuring an advanced lab for design and development.[40] The facility will strengthen Eaton's engineering capabilities in the country by supporting new product development for key product lines, including residential circuit breakers, molded case circuit breakers, and industrial control equipment.[41] The investment is part of the country's commitment to invest $3 billion in R&D to accelerate the development of sustainable solutions by 2030.[42] The investment will also support Eaton's commitment to industry education in the region through ongoing partnerships and internship programs with INTEC University as well as other local vocational training schools such as Instituto Politécnico de Haina (IPHA) and Instituto Politécnico Loyola.

Rockwell Automation, a global developer of industrial automation and digital transformation technologies, employs nearly 400 individuals in the Dominican Republic, who manufacture a variety of electrical switches, including safety switches, limit switches, proximity switches, and photo sensors. Rockwell's Dominican Republic operation produced 12.1 million units in fiscal year 2022, generating $52.8 million in cost of goods sold. Rockwell's Dominican Republic plant delivers world-class manufacturing standards, achieving 96 percent on-time delivery of products to customers. Over the past four years, Rockwell has invested nearly $5 million into its Dominican Republic operations, with 47 percent of those investments going toward capacity increases, 38 percent to business continuity, 12 percent to asset replacement, and 3 percent to product upgrades and acquisitions.

Dominican Republic electronics exports from FZs flow overwhelmingly to North America, with 98.8 percent going to the United States. By product exports to the United States, circuit breakers lead with 62.5 percent of such exports, followed by cellular phones and wireless network equipment at 9.1 percent, and other devices, such as junction boxes, with a 5.3 percent share.[43]

Table 1 summarizes some of the key electronic product manufacturers operating in the Dominican Republic and the extent of their exports for the first 11 months of 2023.

Table 1: Leading electronics manufacturers/exporters in the Dominican Republic[44]

Electronic Products Manufacturer	Description
Airlink Distribution DR	Exports of parts for cellular devices, watches, laptops, tablets, and iPads
Amlat PCS Wireless DR	Manufactures and reconditions smart electronic devices for resale, such as security cameras, tablets, watches
Back & Forth Logistics	Exports electronic products such as Sony brand video game consoles, speakers, batteries, chargers, etc.
Cutler Hammer Industries Ltd.	Manufactures and exports electronic switches to multinational clients such as Eaton Corporation
E-Cycling International SRL	Exporters of printers, circuit boards, hard drives, power cables, and other electronic parts
Fenix Manufacturing Solutions GMBH	Exporters of switches, computer parts, and wiring for assembly of electrical and electronic products
Johanson Dominicana SA	Manufactures and exports electrical capacitors to customers worldwide
K&L Microwave DR	Manufactures and exports radio frequency filters to U.S.-based customers
NAPCO DR SAS	Exporters of security equipment such as electronic locks, sensors, and alarms

Electronic Products Manufacturer	Description
PC Precision Engineering Inc.	Precision-engineered electronics, such as PCBs, for U.S. defense contractors, industrial, and Original Equipment Manufacturer (OEM) customers
Prime Technology Inc.	Exporters of panel meters and circuit boards to U.S.-headquartered parent company
RK Power Generator Corp.	Manufactures power plants, automatic transfer systems, and parts for generator maintenance
Rockwell Automation Technologies	Manufactures electrical switches, circuit cards, conductive cables, and sensors
Souriau Dominican Republic Ltd.	Manufactures and exports electrical connectors for Eaton Corporation in the United States
Vishay Hirel Systems International LLC	Manufactures and exports inductors and electrical circuits for brand labels in Asia, Europe, and U.S.

Most of the electronics manufacturers in the Dominican Republic are concentrated on the country's southeastern coast around the provinces of San Cristóbal, Santo Domingo, and San Pedro de Macoris, although there is another important cluster in the northeastern part of the country centered around the Santiago province. (See figure 4.)

Figure 4: Location of leading electronics manufacturers in the Dominican Republic[45]

REGULATORY ENVIRONMENT

As the Dominican Republic seeks to migrate up the advanced manufacturing value chain in electronics to potentially capture semiconductor-sector investment, the country recognizes it needs to foster a regulatory environment that provides stability, certainty, predictability, and transparency to investors. This section examines the country's regulatory policy environment, policies to attract international investment, customs procedures, and trade and innovation policies.

Regulatory Policy

The Dominican Republic has taken strides to fortify its institutions and regulatory policy environment. Decree No. 640-20 established the "Burocracia Cero (BO)" (or "Bureaucracy Zero") program aimed at enhancing public administration efficiency through clear and appropriate regulatory frameworks that simplify procedures and services while improving the quality of regulations. The coordination of this program has been entrusted to the Ministry of Public Administration, the Ministry of the Presidency, the National Competitiveness Council, and the General Office of Information Technology. To date, 315 procedures from 63 institutions have been reformed, prioritized for the 2020–2024 period.

The specific objectives of the Bureaucracy Zero program are to:

- enhance the effectiveness, transparency, and fairness of public administration by streamlining processes;
- encourage the utilization of ICT to automate and digitalize public services;
- implement tools of the better regulation practices to enhance the quality of regulations, foster increased citizen participation, and instill confidence in the country's regulatory processes; and
- monitor and evaluate the functionality of public services.

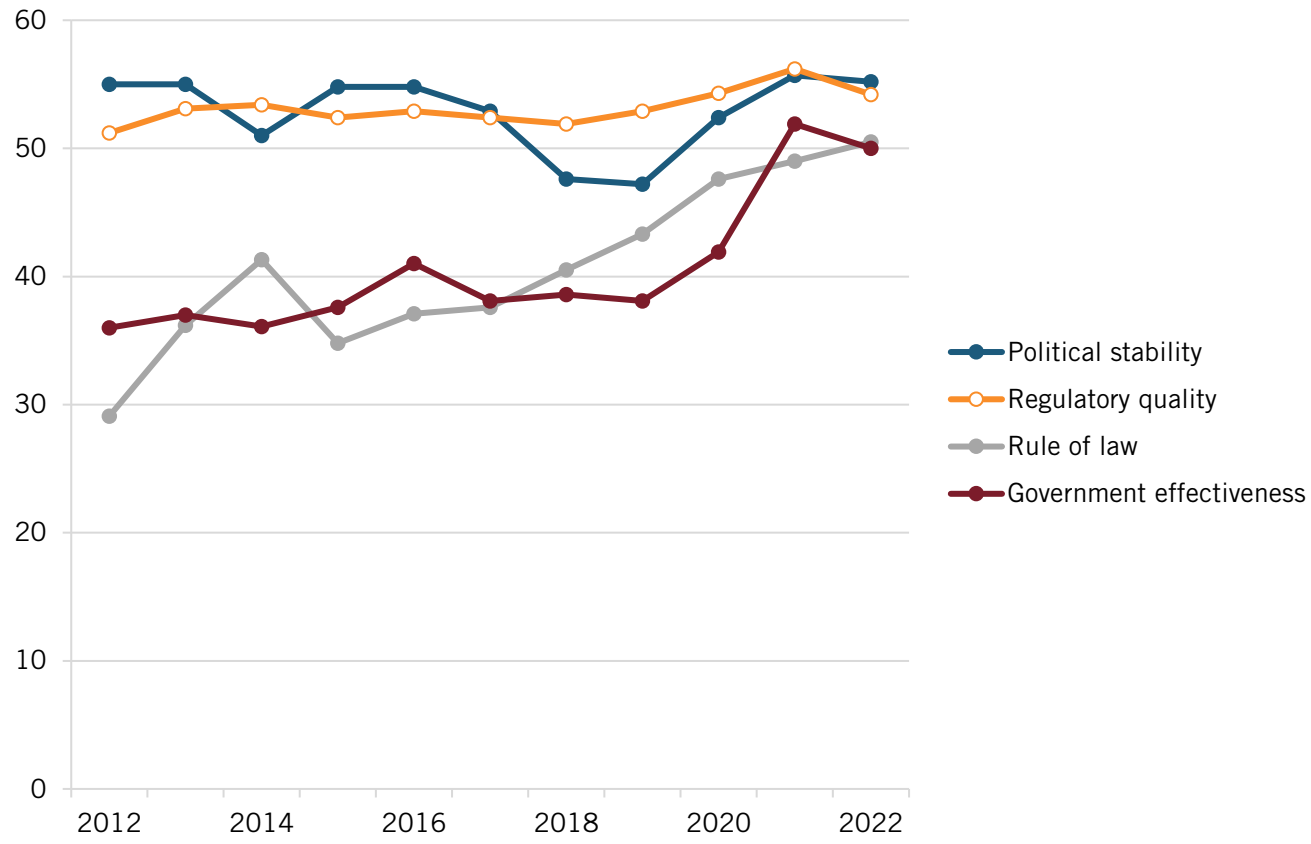
Specifically, the program includes the following components:

- Better Regulatory Practices and Innovation. This involves regulatory policy tools that help inform the policymaking process with evidence-based analysis, with a goal of raising the quality of policies and legislation. This is Law No. 167-21.
- Simplification of Public Service Processes. This includes any action or initiative by public agencies focused on streamlining administrative procedures, making them more accessible and convenient for both the development of procedures and serving the public. This initiative aims to ensure transparency and efficiency in service delivery.
- Digital Transformation. This involves the digitization, automation of procedures and services, or both. Leveraging ICT, citizens and companies can access requested services through various digital platforms.
- Omnicanality. This refers to the availability of public services through multiple channels (e.g., virtual windows, telephone assistance, PuntosGob, and chatbots) all integrated into a single portal (www.gob.do). This integration ensures consistency in the design and delivery of public services, allowing citizens to initiate and complete any request through their preferred channel.

- Interoperability. This involves the integration of public procedures and services utilizing the country's interoperability platform (X-ROAD). It facilitates the interconnection of data and processes, enabling the sharing of information and knowledge among public institutions. This integration adheres to principles of data protection, ethics, and cybersecurity.
- Monitoring and Evaluation. This is facilitated through a dashboard, which offers a visual representation of data, consolidating various metrics, key performance indicators, and other crucial information within a single interface or display. The dashboard comprises charts, graphs, tables, and other visual elements, aiding users in swiftly grasping complex data trends, patterns, and insights.

Thanks to these types of efforts, the Dominican Republic has made strides in improving the quality of its ease of doing business environment over the past decade. Such progress is clearly apparent when looking at data from the World Bank's World Governance Indicators dataset.[46] For instance, from 2019 to 2022, the Dominican Republic's score on the "Government Effectiveness" indicator increased from 38.1 to 50 percent. Likewise, its score on "Rule of Law" increased from 48.3 to 50.5 over this period, while its score for "Political Stability" increased from 47.2 to 55.2. The country has performed consistently well on regulatory quality over the past decade, with scores ranging from 51.2 in 2012 to 54.2 by 2022. In total, the below scores (see figure 5) paint a picture of a country working to steadily improve its ease of doing business environment.

Figure 5: Dominican Republic scores on select World Bank Worldwide Governance Indicators[47]



Free Zones

FZs constitute an integral component of the Dominican Republic's economy. In total, the Dominican Republic hosts 87 FZ industrial parks, situated across 28 of the country's 32 provinces, which support 820 companies in operation. Enterprises located in the Dominican Republic's FZs support over 197,600 direct jobs, produce over $8.1 billion in exports annually (constituting the main export sector of the economy), and have made cumulative investments of over $7.16 billion in the country. The United States remains the principal economic partner in the FZs, accounting for around 40 percent of total FDI. About 77 percent of the Dominican Republic FZs exports go to the United States.[48]

Medical devices constitute the country's leading export sector, accounting for $2.25 billion in annual exports, with 5 of the world's top 10 medical device manufacturers operating in the Dominican Republic, and the sector enjoying an annual growth rate of 17.7 percent in 2022. The Dominican Republic is the world's third-largest exporter of medical devices, the leading exporter of ostomy applications to the United States, the third-largest global exporter of ostomy applications, and the third-largest Latin American exporter of medical and surgical instruments and apparatus to the United States. As noted, electronics exports represent the second-largest sector in the Dominican Republic's FZs, accounting for $1.2 billion in exports in 2022. Other significant sectors operating out of the Dominican Republic's FZs include business process outsourcing, IT support, and call centers, supporting 33,200 jobs with 97 companies in operation. Over 20 companies, supporting close to 1,000 jobs, offer logistics services such as warehousing, packaging and labeling, and distribution services.

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The Dominican Republic originally introduced FZs in the 1960s to foster job creation and local industrial development. The flourishing of the Dominican Republic's FZs has been made possible by Law 8-90, which exempts beneficiaries from paying 100 percent of:

- income taxes;
- export or re-export taxes;
- value-added taxes;
- taxes on the transfer of industrialized goods and services;
- import taxes and customs duties on machinery, raw materials, equipment, and construction materials;
- taxes on patents, assets, or estates; and
- municipal, consular, local, or other taxes.

In short, the Dominican Republic offers 100 percent exemptions for virtually all national and local taxes, ranging from income taxes to duties and construction taxes to taxes on assets or intellectual property such as patents. The Dominican Republic has offered these tax incentives consistently for nearly half a century.

The Dominican Republic's Law 8-90 establishes that the FZs are approved by the National Council of Export Free Zones (CNZFE) of the Dominican Republic, which grants permission to operate for a period of 20 years in the frontier and 15 years in the rest of the country. This period may be subsequently extended by the approval of the CNZFE. The government of the Dominican Republic sets a sectorized minimum wage across the FZs and offers companies operating in the FZs simplified customs processes, with an exclusive customs office dedicated to each FZ operation. INFOTEP operates a facility within many of the largest industrial parks, offering customized training courses suited to meet the needs of the workforces of the firms in the respective FZs. The Dominican Republic's FZ operators compete with one another to attract companies, offering services and business solutions that facilitate companies' operations, with many offering value-added services such as hiring, energy provision, food service, security, back office accounting/bookkeeping, etc.

Two of the leading FZs in the Dominican Republic are the PIISA Industrial Park and the Las Americas Industrial Park. The PIISA Industrial Park spans 170 acres in Haina (west of Santo Domingo), with core tenants including electronics firms such as Eaton, Johanson, and Signal Transformer and a host of medical product/components/instruments companies including Accumed, Arjo, Baxter, Biomerics, Convatec, Edwards Lifesciences, Fenwal, Fresenius Kabi, LG, and Jabil. For instance, Fresenius Kabi has satellite R&D support teams in the Dominican Republic to assist the corporation's main R&D facilities in Italy, Germany, and the United States.[49] The Las Americas Industrial Park covers 2.5 million square feet of space to the east of Santo Domingo, near the city's international airport and the Caucedo container port, supporting 35 multinational companies in operations that employ over 21,000 workers.[50] Companies operating in the park include B. Braun, Cardinal Health, Remington Medical, Rockwell Automation, and Oscor. Other large nearby FZs also host world-renowned companies. For instance, Medtronic has carried out major expansions of its manufacturing operations in San Isidro Industrial Park. Meanwhile, the Santo Domingo Cyber Park hosts DRE Global (an electronics repairer and remanufacturer) and PC Precision Engineering (focused on machinery automation) in close proximity to NAP del Caribe, the country's national access point, and Las Americas Technological Institute. Looking forward, a growing industrial park in Punta Cana promises to leverage the destination city's privately-owned international airport—the country's largest by air traffic—as a major air cargo hub.

Other Foreign Direct Investment Policies

The Dominican Republic's Law No. 16-95 addresses legal and tax matters pertinent to FDI into the country. The law establishes a territorial tax regime and affirms most-favored nation treatment for investors, meaning that all investors are granted equal treatment of their investments regarding establishment, acquisition, expansion, or operations. It stipulates that foreign payments are subject to a withholding tax of 25 percent and that for payments of loans contracted with foreign credit institutions, the withholding rate is 10 percent.

Customs

The Dominican Republic has made tremendous strides to improve the quality of its customs regime in recent years as part of its effort to make the country the leading regional logistics hub in the Americas. In particular, on August 14, 2021, a new Customs Law (Law No. 168-21) came into effect, strengthening the autonomy of the General Directorate of Customs, establishing more efficient procedures and clearer timelines, and trying to promote an export culture among small

and medium-sized enterprises (SMEs) by simplifying and transparently streamlining the processes of export and goods clearance.

The Dominican Republic continues to make concerted attempts to improve its logistics environment, with the effort spearheaded through a new Logistics Cabinet, coordinated at the presidential level, and led by the Ministry of Industry, Commerce, and SMEs (MICM) in coordination with the General Directorate of Customs (DGA). The effort seeks to work hand-in-hand with the private sector to identify customs bottlenecks or impediments and streamline customs procedures to facilitate increased levels of imports and exports.

A flagship initiative has been the 24-Hour Clearance Program, also called Dispatch 24h (or D24H), which seeks to clear containers within 24 hours. To date, the program has cleared over 50,000 containers in 24 hours or less, benefitting more than 6,700 importers. Moreover, over 65,000 import manifests have been submitted in advance, resulting in savings of almost $20 million for taxpayers.

The Dominican Republic's accelerated customs clearance procedures have been made possible by technical, operational, and procedural improvements. For instance, the DGA has implemented a new, comprehensive Risk Management System that seeks to direct customs agents' attention to cargo of the most-pressing concern. Using tools including AI, DGA has developed 158 new dynamic indicators, which have allowed an almost 60 percent reduction in physical inspections of containers, decreasing from 49.6 percent of containers being inspected in 2020 to 20.1 percent in 2023. Moreover, the DGA has accelerated use of nonintrusive technologies, such as X-ray machines, which can inspect up to 1,000 containers daily. The use of such nonintrusive technologies has significantly advanced the security and control of imports, with 96 percent of imported containers having undergone inspections using this technology. The streamlining of customs procedures has been further abetted by the implementation of over 160 technological enhancements in the DGA's IT systems, including the launch of a new DGA web interface that offers 85 services, 25 of which are fully automated.

The Dominican Republic's 24-Hour Clearance Program, also called Dispatch 24h (or D24H), seeks to clear containers within 24 hours.

A critical program for exporters from the Dominican Republic is Exporta Más (or Export +), through which participating companies can export without a physical inspection process and in a fully digital format, eliminating the need for paper documents and thus decreasing the time and costs associated with exporting. Over 250 companies are enrolled in the Exporta Más program, with participating companies making over 177,000 export declarations and the program now covering 58 percent of total exports from the country.

The World Customs Organization (WCO) has introduced the Authorized Economic Operator (AEO) program, which seeks to enhance international supply chain security and facilitate legitimate trade.[51] The AEO constitutes an international accreditation created under the regulatory guidelines of the WCO SAFE framework in 2005. Nearly 600 (596) companies operating in the Dominican Republic have received AEO certification, with 374 AEO Standard and 212 AEO Simplified certifications. In total, AEO companies account for 31.7 percent of imports coming into the Dominican Republic.

Furthermore, the Dominican Republic is one of the 168 signatory companies to the WTO's Trade Facilitation Agreement (TFA), through which member nations commit to efforts toward process simplification, transparency, and cooperation. The Dominican Republic was 8th among the Latin America and the Caribbean's 33 signatories to achieve 100 percent compliance with TFA guidelines, and the 80th country in the world to do so.[52]

It should also be noted that the Dominican Republic works closely with the United States on the flows of goods and individuals. For instance, the DGA has signed an agreement with the U.S. Department of Homeland Security to optimize risk detection, through which information is exchanged to detect potentially risky cargo and to detect and track cargo that might pose risks to national security or consist of counterfeited goods. The Dominican Republic also was the 15th country (and 6th in Latin America) to be admitted to the U.S. Global Entry program, enabling expedited entry for travelers to the United States.

Trade Policy

The Dominican Republic-Central America-United States Free Trade Agreement (CAFTA-DR) liberalizes the Dominican Republic's trade in goods and services with the United States and five Central American countries: Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua. CAFTA-DR also contains other disciplines and standards pertinent to customs administration and trade facilitation, technical barriers to trade, government procurement, investment, telecommunications, electronic commerce, intellectual property (IP) rights, transparency, and labor and environmental protection.[53]

The Dominican Republic is also the main trading partner and the main recipient of European investment in the Caribbean region. Since entering the European Union-CARIFORUM Economic Partnership Agreement (EPA) of 2008, bilateral trade in goods between these entities has grown by 231 percent, reaching an all-time high of $4.65 billion in 2022.[54] As the European Union has written, "The Dominican Republic has stood out for its punctual implementation of the assumed commitments in the EPA, including the tariff reduction schedule."[55]

In 2022, two-way trade between the Dominican Republic and the United States totaled $30.5 billion, including U.S. exports of $17 billion and imports of $13.5 billion.[56] The total stock of U.S. FDI in the Dominican Republic reached $2.5 billion in 2022, a 3.7 percent increase over the previous year.

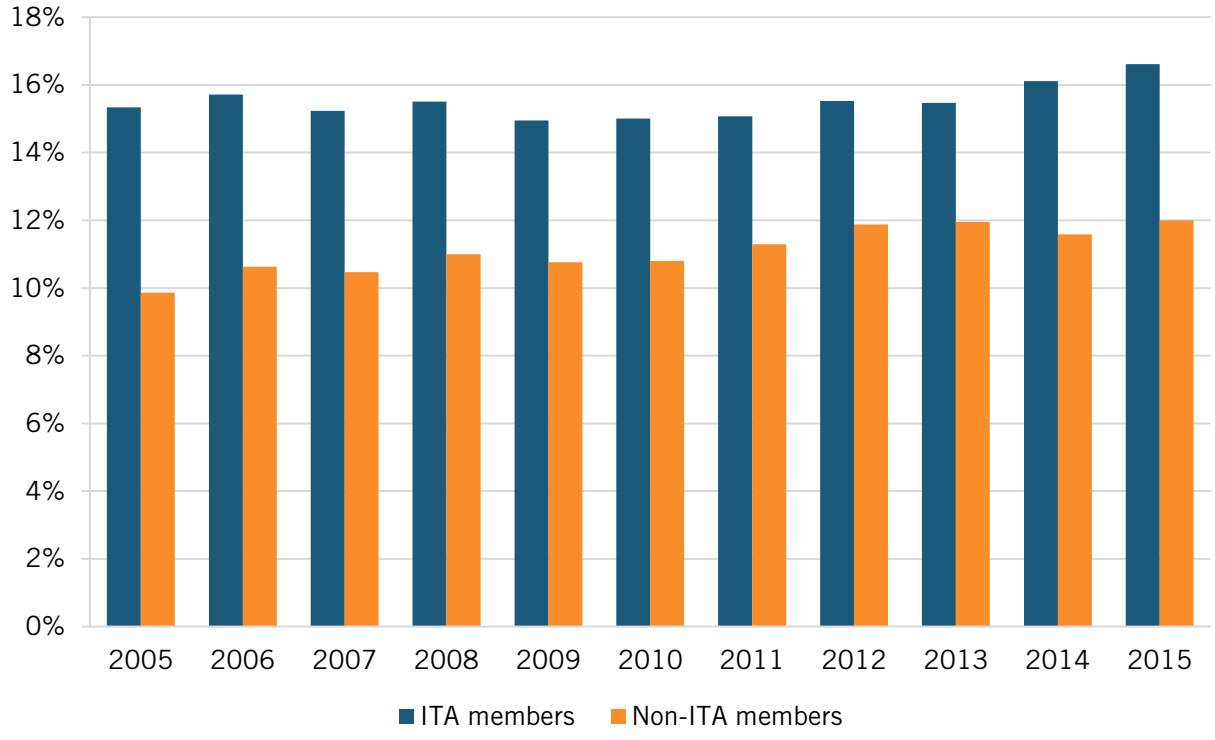
In total, the Dominican Republic has several favorable trade agreements with strategic partners, ranging from smaller economies, such as the Caribbean Community (CARICOM), Central America, and Panama, to major economies, such as the United States, European Union, and United Kingdom. These partnerships have allowed exporters duty-free access to more than 900 million consumers in 49 countries, reduced trade barriers, and increased export potential for both local and foreign companies.[57]

The Dominican Republic initiated a partnership with Costa Rica, Ecuador, and Panama known as the ADD to promote democratic strengthening and economic growth through the tightening of the countries' commercial, demographic, and cultural ties. The ADD is predicated on the belief that democracy and development are mutually reinforcing, wherein democracy creates favorable conditions for investment and growth.[58] On July 25, 2022, the ADD signed a Memorandum of Understanding (MOU) with the U.S. Department of State to advance a consultative dialogue on

supply chains and economic growth, and it is also working with the U.S. Chamber of Commerce to identify opportunities, challenges, and areas of collaboration for supply chain resilience. The ADD thus seeks to position its partners as prime destinations for U.S. nearshoring.[59] To these ends, the Dominican Republic chairs the ADD Business Council, based in Washington, D.C.

Countries that offer "zero-in/zero-out" tariff environments for the parts, inputs, and components that flow through semiconductor value chains position themselves well for competition in the global ICT industry. The WTO ITA—implemented in 1996 and to which the Dominican Republic is an original signatory—has played a catalytic role in this regard, eliminating tariffs on trade in hundreds of ICT products.[60] Nonsignatories of the ITA saw their participation in global ICT value chains decline by more than 60 percent from 1995 (two years before the ITA went into effect) to 2009.[61] And from 2005 to 2015, ITA-member nations enjoyed nearly one-third greater participation in ICT global value chains than did non-ITA-member nations.[62] (See figure 6.) However, it's not just that ITA membership makes nations more attractive for ICT manufacturing by lowering costs of inputs and components used in ICT manufacturing, it's that by reducing the cost of these productivity- and innovation-enhancing capital goods (by not imposing tariffs on them), countries can also boost their stock of ICTs in use by individuals and businesses, which further drives countries' economic growth.[63]

Figure 6: Participation rates in global ICT value chains, indexed as a share of gross ICT output[64]



National Innovation Policy

As the Information Technology and Innovation Foundation (ITIF) has extensively documented, at least six dozen nations throughout the world have articulated national innovation strategies that explicitly link science, technology, and innovation with economic and employment growth, effectively creating a game plan to compete and win in innovation-based economic activity.[65]

Such policies matter because, as Finland's National Innovation Strategy framed it, "piecemeal policy measures will not suffice in ensuring a nation's pioneering position in innovation activity, and thus growth in national productivity and competitive ability."[66]

In this regard, the Dominican Republic is to be commended for promulgating its National Innovation Policy 2030 (PNI 2030) which aims to establish a general framework for the promotion and coordination of innovation, creativity, and scientific and technological research from a shared vision of an ecosystem that integrates human talent, institutional capabilities, and the sectors involved in order to enhance the creation of useful knowledge, competitiveness, and sustainable productive transformation and inclusion, contributing to sustainable development and improvements in quality of life.

PNI 2030 is based on five foundational pillars: human talent, effective governance, investment in innovation, a mentality and culture of innovation, and sustainability, transition, and energy efficiency. Through the PNI 2030, the Dominican Republic seeks to promote innovation-oriented mindsets and capabilities, the more sustainable management of natural resources, and the promotion of the transition to clean and efficient energies. Another objective of the PNI 2030 is to bolster the country's R&D intensity, which matters, as one report found Dominican Republic investment in R&D of just 0.01 percent of GDP in 2015, below even the already-low average level of Latin America and the Caribbean at 0.7 percent.[67]

In addition to formulating a national innovation strategy, the Dominican Republic has articulated a National Artificial Intelligence Strategy (ENIA), which addresses the transformation of the country's institutional infrastructure and productive work models that can position the country as a regional leader in leveraging AI. The strategy comprehensively lays out how the Dominican Republic can leverage AI across key sectors of the economy, including the following:

- Public sector: Use of AI to improve the efficiency and effectiveness of government services, such as health care, education, and transportation
- Private sector: Use of AI to boost productivity and innovation in businesses of all sizes
- Education: Use of AI to improve the quality of education and make it more accessible
- Society: Use of AI to address social challenges, such as poverty, inequality, and climate change[68]

BUSINESS ENVIRONMENT

This section examines the workforce training environment in the Dominican Republic, key infrastructure supporting industry in the Dominican Republic, and factors impacting the cost environment in the Dominican Republic.

Workforce Training and Education

Ensuring that the Dominican Republic can supply a sufficiently skilled workforce will be absolutely vital to supporting the country's aspirations in the PCB/semiconductor ATP sectors. Here, a crucial player will be the National Institute of Professional Technical Training, or "INFOTEP." INFOTEP's charter is to organize and govern the Dominican Republic's national system of professional and technical training, focusing on the full development of human

resources, increasing the productivity of companies across all sectors of economic activity, and advancing social equity by enhancing workforce skills.[69]

Companies fund INFOTEP by contributing 1 percent of their monthly payrolls to the program. This amounts to the contribution of 0.5 percent of the annual profit bonuses that workers receive. Organizationally, INFOTEP has three national centers: a Teaching Development Center, a Virtual Training Center, and an Innovation and Business Development Center. These national assets are supported by six regional directorates, which house 16 community technology centers and 56 mobile workshop programs. In total, INFOTEP has 245 operational centers across its system nationwide. Critically, most of the leading FZs in the country have an INFOTEP office on-site, which works hands-on with employees of the companies operating in the FZ to build tailored skill sets. INFOTEP works hand-in-hand with companies to understand the specific skillsets that companies need and then builds technical training programs accordingly. For instance, for Convatec, a medical products manufacturer that operates out of the PIISA FZ employing 1,500 workers and shipping 185 million units annually, INFOTEP developed custom courses on ultrasonic welding and the application of radio frequency technologies.[70]

INFOTEP works hand-in-hand with companies to understand the specific skillsets that companies need and then builds technical training programs accordingly.

INFOTEP offers a total of 920 technical courses, including 86 in electricity and electronics, 36 in ICT, and 104 in the manufacturing, installation, and maintenance of machinery and equipment. Since its inception, INFOTEP has trained 770,914 workers in different competencies and fields via over 40,000 courses and close to 800,000 training hours.

INFOTEP offers a number of courses directly relevant to the country's goals of competing in PCB/ATP. Consider, for instance, the core subjects studied by students taking the 290-hour course "Basic Electronics Product Assembler":

- Assembly with passive and active electronic devices (teaches PCB principles) (80 hours)
- Assembly with linear integrated circuits (85 hours)
- Assembly with digital integrated circuits (85 hours)
- Integrative project (20 hours)
- Human training (20 hours)

Similarly, the 685-hour industrial electronics technician course consists of the following subjects:

- Installation of passive and active electronic devices (80 hours)
- Installation of operational amplifiers (90 hours)
- Printed circuits and soldering processes (90 hours)
- Construction of cards with logic, sequential circuits, and memories (70 hours)
- Installation of power electronic devices (70 hours)
- Installation of industrial electronic devices and pneumatic valves (95 hours)

- Repair of electrical and electronic controls of industrial machines (95 hours)
- Programmable logic control (PLC) programming and installation (95 hours).[71]

In the industrial electronics training course, basic knowledge of the design of electronic cards (PCBs) is taught, simulated, and then built in a classroom project. From 2021 to 2023, 7,817 individuals took electronics training/coursework from INFOTEP. In short, INFOTEP provides a vital and effective mechanism to upskill the workforce of the Dominican Republic to compete in PCB/semiconductor ATP manufacturing.

Las Americas Institute of Technology (ITLA)

The Dominican Republic government established the Las Americas Institute of Technology (ITLA) as a technical institution of higher education in 2000.[72] Its mission is to educate professionals in high technology, promoting specialized education based on innovation and entrepreneurship, contributing to the development of the nation's productive sectors. ITLA's main areas of specialization are mechatronics, automated manufacturing, medical device manufacturing, industrial design, software development, information networks, multimedia, computer security, and data science, but in total it offers training across 15 technology areas. ITLA's mission is to prepare students to become technology professionals in two years, enrolling about 4,500 students per quarter. The education takes a practical, active learning approach, with hands-on laboratories and workshops at the core of the pedagogical approach, which is delivered by nearly 330 professors in total. Over 400 companies operating in the Dominican Republic employ ITLA graduates, and 92 percent of ITLA graduates receive employment offers upon graduation. Since its inception in 2002, over 50,000 students have received an education from ITLA. The Institute also recently launched an Innovation Solution Factory focused on the digital transformation of government and private sector entities to take a qualitative leap toward Industry 4.0 practices.

INTEC

The Technological Institute of Santo Domingo (INTEC) is considered the leading technical institute in the country, and it offers extensive courses in fields such as electrical and mechanical engineering.[73] INTEC offers a very robust set of engineering courses, including degrees in Data Science, Biomedical Engineering, Engineering in Logistics and Transport, Civil Engineering, Software Engineering, Mechatronics Engineering, Industrial Engineering, Systems Engineering, Industrial Design, Electronic and Communications Engineering, Electric Engineering, Mechanical Engineering, and Cybersecurity Engineering.[74] INTEC also operates partnerships with Penn State University, Southwest Minnesota State University, Texas A&M University, the City College of New York, and Western Michigan University to afford engineering students opportunities for international study.[75] Over each of the past two years, INTEC has been named the Dominican Republic's leading university in the QS World University Rankings report.[76]

MESCYT

The Dominican Republic's Ministry of Higher Education, Science, and Technology (MESCyT) plays an important role as the government institution that regulates higher education in the country and which also disburses research grants and contributes to technology development and diffusion. MESCyT has focused on developing research for the improvement of manufacturing and industry in the different institutions that make up the national science and technology system, allowing the generation of new knowledge that can be transferred and applied to

industry. MESCyT has been heavily involved in promoting the development and adoption of "Industry 4.0" technologies in the Dominican Republic, including funding of research and training into areas such as AI, automation, robotics, additive manufacturing/3D printing, big data and analysis, advanced materials, and augmented/virtual reality. In its funding of Dominican Republic higher education institutions and research centers, MESCyT supports 1) training of students and workers; 2) collaborative research; 3) technology transfer; 4) establishment of joint R&D centers; and 5) disbursement of scholarships and grant programs to companies.

Many research programs are funded by the Dominican Republic's National Fund for Innovation and Scientific and Technological Development (FONDOCYT), including research initiatives pertinent to microelectronics. For instance, Dr. Fabrice Piazza of the of the Pontificia Universidad Católica Madre y Maestra (PUCMM) completed pioneering work on nanocrystalline diamond thin films, diamond crystals, and carbon nanotubes targeting emerging technologies in electronics, bio-nanoprobes, and innovative coatings. They were the first to successfully report on the low-temperature synthesis of diamond nanocrystals on polymers for electronics and thin film coating applications.[77] Mr. Luis José Quiñones Rodríguez of Universidad APEC (UNAPEC) has received several patents for innovative microchip design. Dr. Melvin Arias and his team at INTEC received a patent for technology for the manufacture of rechargeable lithium-ion batteries that improved their efficiency by nearly 95 percent while making their manufacturing process more sustainable.[78]

In the fall of 2023, a delegation from the Dominican Republic—including representatives from government, academia, private industry, and the investor community—participated in the MIT Regional Entrepreneurship Accelerator Program (REAP). REAP is a support program organized by MIT experts to advance entrepreneurship and innovation in emerging economies through sessions, methodologies, and practical cases. In the case of the Dominican Republic, participation in the program was based on the need to design investment schemes that strengthen public-private efforts in innovation processes that promote continuous improvement in the country's main industries, strengthening quality of products and services and promoting greater access to global value chains and the competitive positioning of Dominican Republic products and services in the region and the world.

Infrastructure

The following addresses key attributes of the Dominican Republic's physical and digital infrastructure across areas including logistics, energy/electricity, and digital infrastructure.

Energy

Privately owned generation accounts for 73 percent (3,822 megawatts (MW)) of the country's total installed electricity capacity, with the remainder delivered by fully public companies or through public-private partnerships (PPPs).[79] Historically, imported fossil fuels accounted for the majority, over 80 percent, of the Dominican Republic's primary energy supply (making the country susceptible to international fuel price shocks), but an ever-increasing share of the country's energy supply now comes from renewable sources. By December 2022, clean generation accounted for 18.1 percent of the country's energy supply, of which nonconventional renewables (e.g., solar energy, bioenergy, wind energy, and tidal energy) represented 10.6 percent.[80] Analysts rate the country's potential generation of renewable energy sources at 6 gigawatts (GW) by 2030, and the country has committed to working with other Caribbean nations

to meet the goal established at the United Nations COP26 climate conference of raising the regional share of renewables in power generation to 70 percent by 2030.[81] The addition of 400 MW of solar and wind power generation from 2015 to 2018 represents an important step toward greater reliance on renewables, and in 2023 a number of projects added 800 MW of renewable energy to the Dominican Republic's electricity mix. In total, the country expects to generate 25 percent of its electricity from renewables by 2025.[82]

The country has experienced challenges with power disruptions in the past. One study finds that Dominican firms lose 5 percent of their sales due to power outages annually and that "removing distortions in the energy sector could potentially unlock 0.09 percentage points in GDP by reducing blackouts that disrupt manufacturing activity."[83] However, observers have stressed that this challenge rarely afflicts industrial parks, which generally have redundant, dual-sourced power supply. Companies operating in FZs interviewed for this report indicated they had not experienced significant difficulties or challenges with power supply disruptions.

Digital Connectivity

The Dominican Republic also enjoys the strongest Internet connectivity in the Caribbean, in part due to being home to NAP del Caribe, one of the most-significant NAPs in Latin America and one of the 220 NAPs located across 26 countries globally. It is one of only three carrier-neutral NAPs in all Latin America. NAP del Caribe represents the most advanced technological complex in the Dominican Republic, offering data center, disaster recovery, and business continuity solutions using state-of-the-art infrastructure, providing 24/7 assistance and monitoring.[84] It integrates leading-edge fiber optic and satellite data systems.[85] Since its launch in 2008, NAP del Caribe has delivered 100 percent uptime and has not experienced a service outage.

Logistical Infrastructure

The quality of countries' logistical environments matters tremendously to capturing greenfield investment. As one report explains, "Companies identify logistics as the most important factor when deciding where to source materials from and make direct investments, reflecting the impact of shipping costs and lead time for deliveries."[86]

As noted, the Dominican Republic possesses one of the most-enviable geographic positions in the Americas, which has enabled the country to become a regional logistical powerhouse. According to the 2019 Global Competitiveness Index, the Dominican Republic possesses the top transportation infrastructure in Latin America. In fact, the participation of the logistics sector in the country's trade has increased by over 3,000 percent over the past seven years.[87]

The Dominican Republic hosts the second-highest container throughput in the Caribbean, and the eighth-highest in Latin America and the Caribbean region overall. The country ranks second in Latin America regarding international connectivity by air transport and third in terms of maritime services and maritime connectivity. In 2019, the Dominican Republic ranked first in Latin America in the Delivery Mean Time Postal Index.

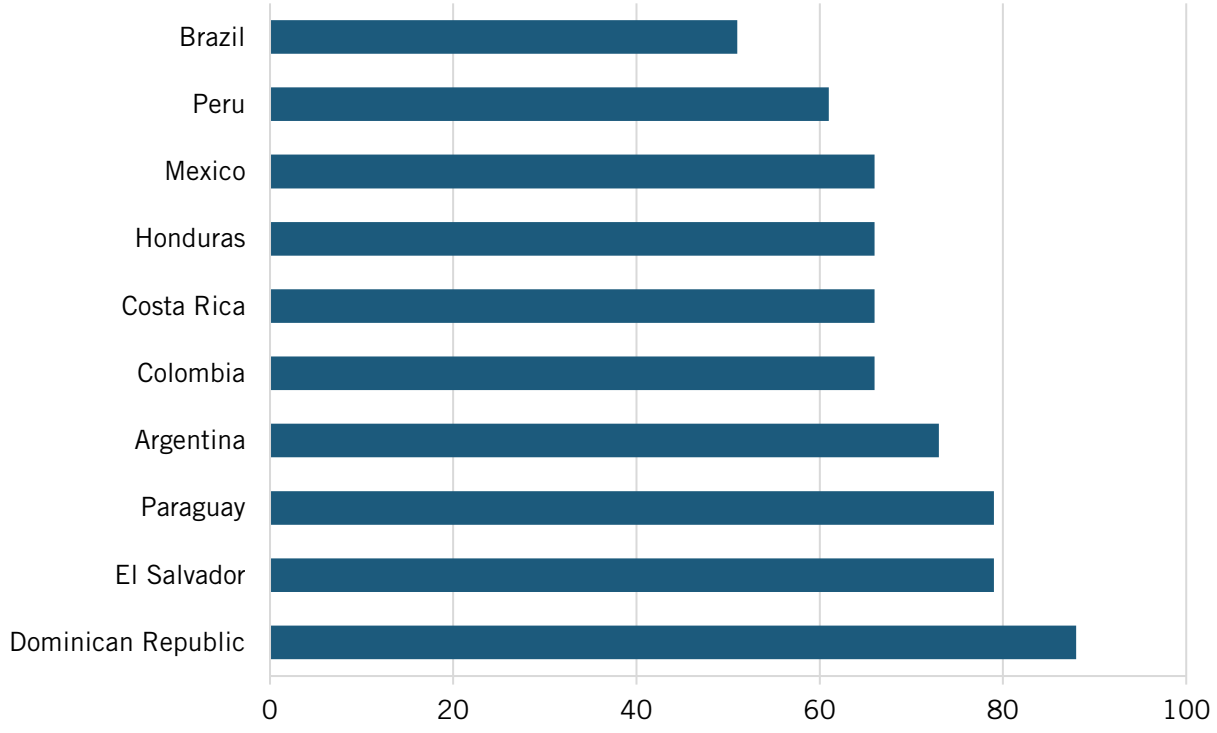
The Dominican Republic's two leading ports are the Western Haina and Caucedo ports. The Haina Port, located west of Santo Domingo, is a multipurpose port that handles 38 percent of the containers and 60 percent of the total load inside and outside the country. It represents the main general port for cargo, containers, and petroleum products in the Dominican Republic.[88] The Caucedo Sea Port, built by private sector actors in 2003 and located 25 kilometers from

Santo Domingo, represents the Dominican Republic's newest and most modern port. Currently managed by DP World, Caucedo Port handles 30 percent of the maritime cargo movement in the Dominican Republic and serves as an important transshipment center.[89] Goods shipped from Dominican Republic ports can generally reach U.S. East Coast port destinations in three to four days.

The Dominican Republic has multiple international airports with strong air connectivity to the U.S. East Coast and Midwest and also to Europe. Punta Cana International Airport, one of the world's largest privately owned commercial airports, is the second-busiest in the Caribbean, operating more than 500 weekly flights (during the high season) and receiving 67 percent of passengers and flights entering the country.[90] The airport has set a goal "to become the most important air cargo hub in the region" and has become a key conduit for the transshipment of goods from South America to Europe and North America.[91] Santo Domingo's airport, Las Américas International Airport, offers service by 27 airlines to 57 destinations and also constitutes the busiest cargo hub in the Caribbean and Central America, with 355 million pounds of cargo transported in 2019. In 2022, 118.2 million kg of air cargo were mobilized, of which 38.7 million were in imports and 79.6 million in exports, with a total FOB (freight on board) value of $6.5 billion.[92] The Dominican Republic's strong air transport infrastructure matters greatly, as semiconductor wafers are often flown to their destinations where ATP activities occur.

Overall, the Dominican Republic does have a very strong logistics environment; however, the country ranked just 10th among Latin American peers in the 2023 Logistics Performance Index report. (See figure 7.) Improving the country's performance in this ranking represents a core focus of the aforementioned efforts to improve its customs and regulatory policy environment.

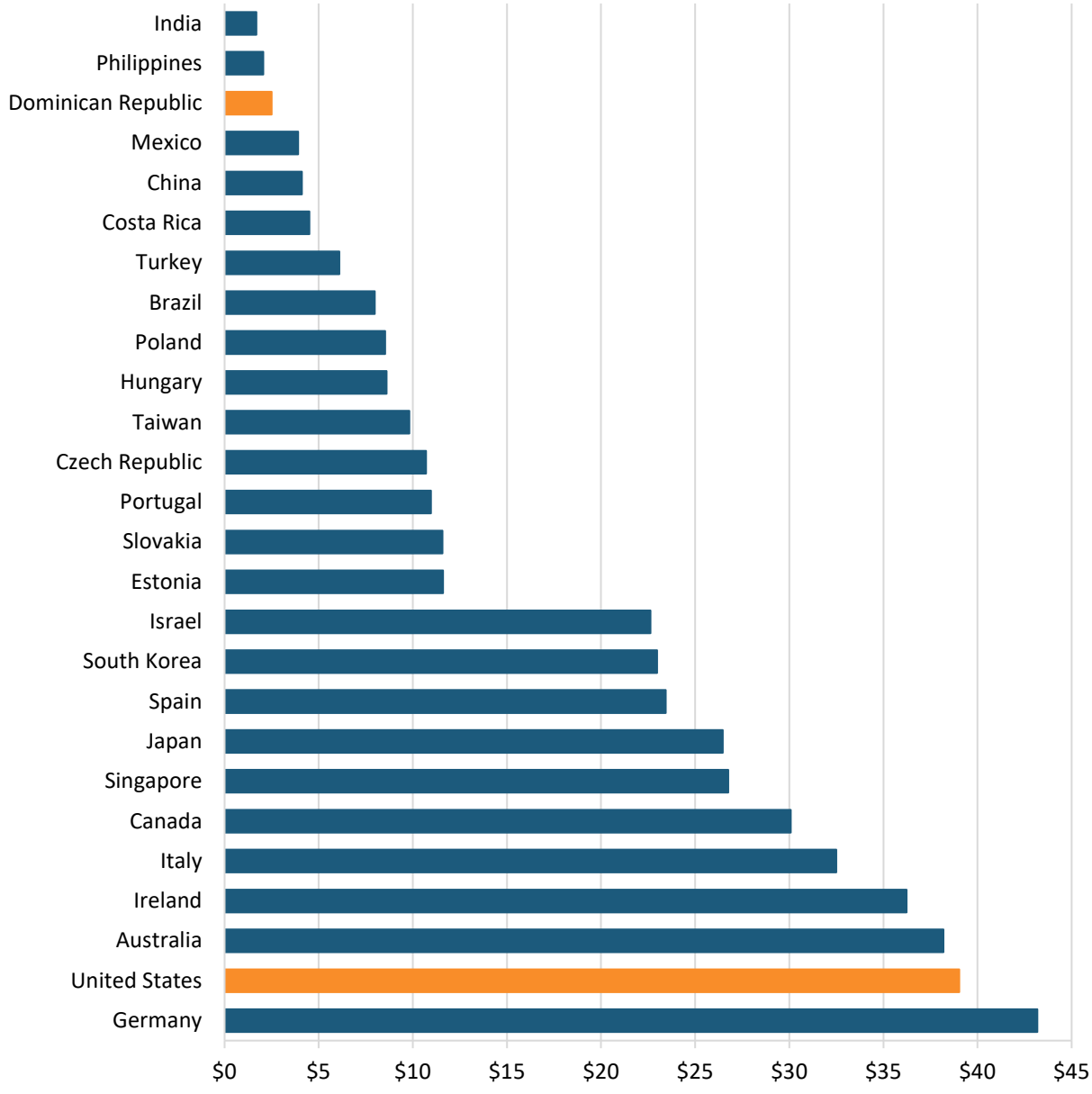
Figure 7: Latin American country performance on 2023 Logistics Performance Index[93]



Labor Cost Environment

The Dominican Republic offers a highly competitive manufacturing environment in terms of labor costs. In fact, the World Bank found that the hourly manufacturing labour cost in the Dominican Republic is $2.50, 6 percent the rate in the United States, approximately half that of Costa Rica or Mexico, and even less than in China.[94] (See figure 8.) This matters considerably in an environment of rapidly increasing labor costs elsewhere. In fact, from 2018 through 2022, labor costs adjusted for productivity rose by 24 percent in China, 22 percent in Mexico, 21 percent in the United States, and 18 percent in India.[95]

Figure 8: Hourly labor cost in manufacturing in the Dominican Republic and selected countries, 2018 or last available year (U.S. dollars)[96]



THE REORGANIZATION OF GLOBAL ADVANCED-INDUSTRY VALUE CHAINS

The aftershocks from the COVID-19 pandemic; increasing efforts globally to rebalance supply chains; rising labor and broader production costs in China; increasing U.S. tariffs on China's exports; transformative, emerging technologies such as AI; demographic shifts; and a host of other factors have led multinational enterprises to reassess the structure of their global value chains in a quest for enhanced diversification, resilience, sustainability, and cost competitiveness. As multinational businesses react to these trends and look to make their supply chains more diverse and resilient, governments have an opportunity to present their countries' value proposition for how they can compete in high-tech industries to a global economy that's reorganizing in real time.[97]

Indeed, multinational companies are reassessing their global value chains in real time in response to multiple factors, including the COVID-19 pandemic; natural disasters or challenges including earthquakes, floods, freezes, droughts, and climate change; geopolitical risk and instability; and emerging threats such as cybertheft and terrorism. As a recent McKinsey Global Institute (MGI) study concludes, enterprises have learned over the past several years that the risk, severity, and expense from supply chain disruptions have all increased.[98] MGI's report estimates that companies should expect supply chain disruptions of 1 to 2 weeks occurring at least once every 2 years; 2 to 4 weeks occurring once every 2.8 years; 1 to 2 months every 3.7 years; and 2 months or more every 4.9 years.[99]

U.S. imports from Asia consist of 4 percent U.S. value added, whereas U.S. imports from Latin America on average contain 40 percent U.S. value added.

In recent years, growing geopolitical tensions have resulted in multinational companies turning to a "China-plus-one" (or "China-plus-two") strategy in order to bolster their supply chain resilience. For instance, consulting firm Kearney's "2022 Reshoring Index" report finds that "80 percent of companies across almost all industries are now on a path to reshore."[100] And in a survey released by the American Chamber of Commerce in Shanghai in September 2023, some 40 percent of companies responded that they "are moving investments elsewhere [from China]."[101] A study conducted by the UBS Evidence Lab finds that 71 percent of U.S. companies with manufacturing in China are either in the process of or planning to shift operations to other countries.[102] And another survey finds 87 percent of U.S. firms expressing pessimism regarding the outlook for the relationship between the world's two largest economies.[103] Meanwhile, China accounted for just 13.3 percent of U.S. goods imports during the first six months of 2023—the lowest level since 2003, and far below the annual peak of 21.6 percent in 2027.[104] U.S. imports of semiconductors and materials from China fell by 29 percent from 2018 to 2022.[105]

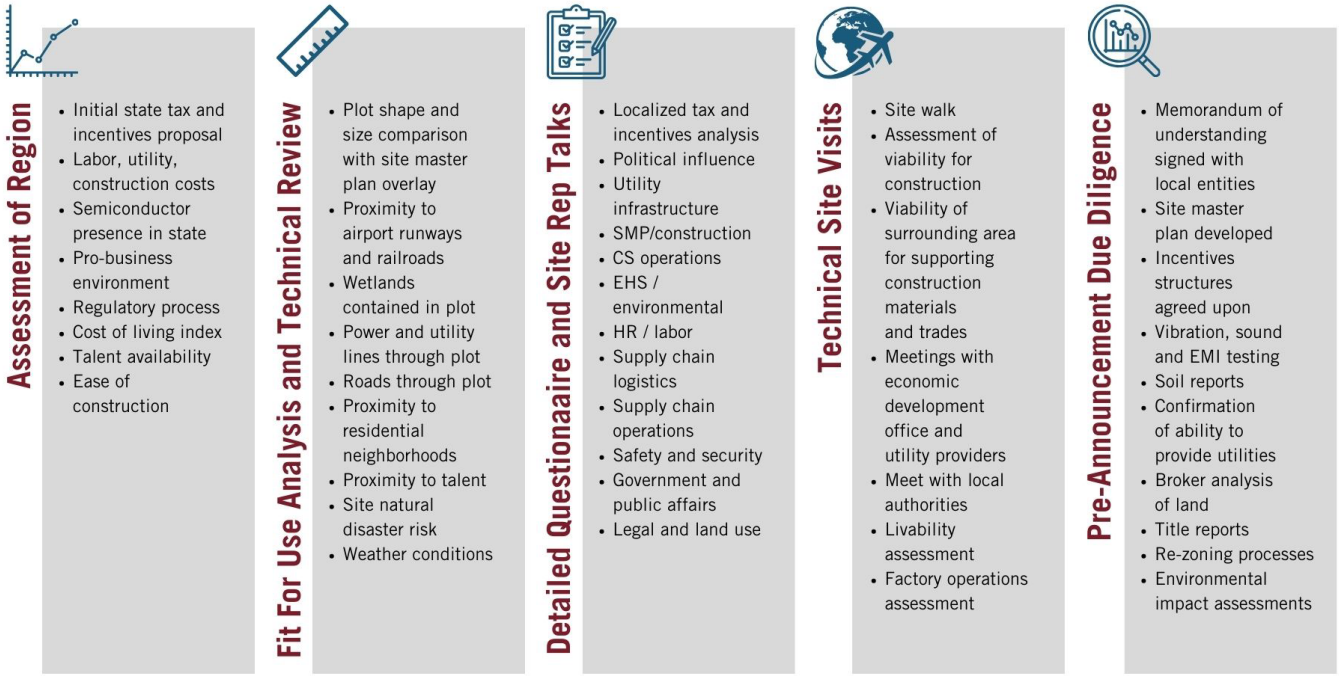
A 2023 report by the U.S. Chamber of Commerce International Affairs team finds that 28 percent of businesses (in a survey of 105 decision-makers at multinational manufacturing companies) that manufacture in Asia are planning to leave their current location in the next five years. Of those responding that their business has plans to relocate manufacturing operations, 15 percent indicated they would move to other locations in Asia, 14 percent to Mexico, 11 percent to South America, 8 percent to Europe, 6 percent to Central America and the Caribbean, 4 percent to Africa, and 3 percent to Oceania.[106]

It is important to recognize that it really is manufacturing that is driving global supply chain reordering. For instance, one study finds that, when it comes to offshoring, manufacturing accounts for 72 percent of global capital investments, and knowledge-intensive activities increased to 8 percent of global capital investment by 2019.[107]

Nearshoring between the United States, Canada, and Latin America and the Caribbean has been on the rise. From 2016 to 2019, intra-regional offshoring accounted for 18 percent of total FDI and as much as 10 percent of capital investment, up from 15 percent and 8 percent from 2003 to 2006, respectively.

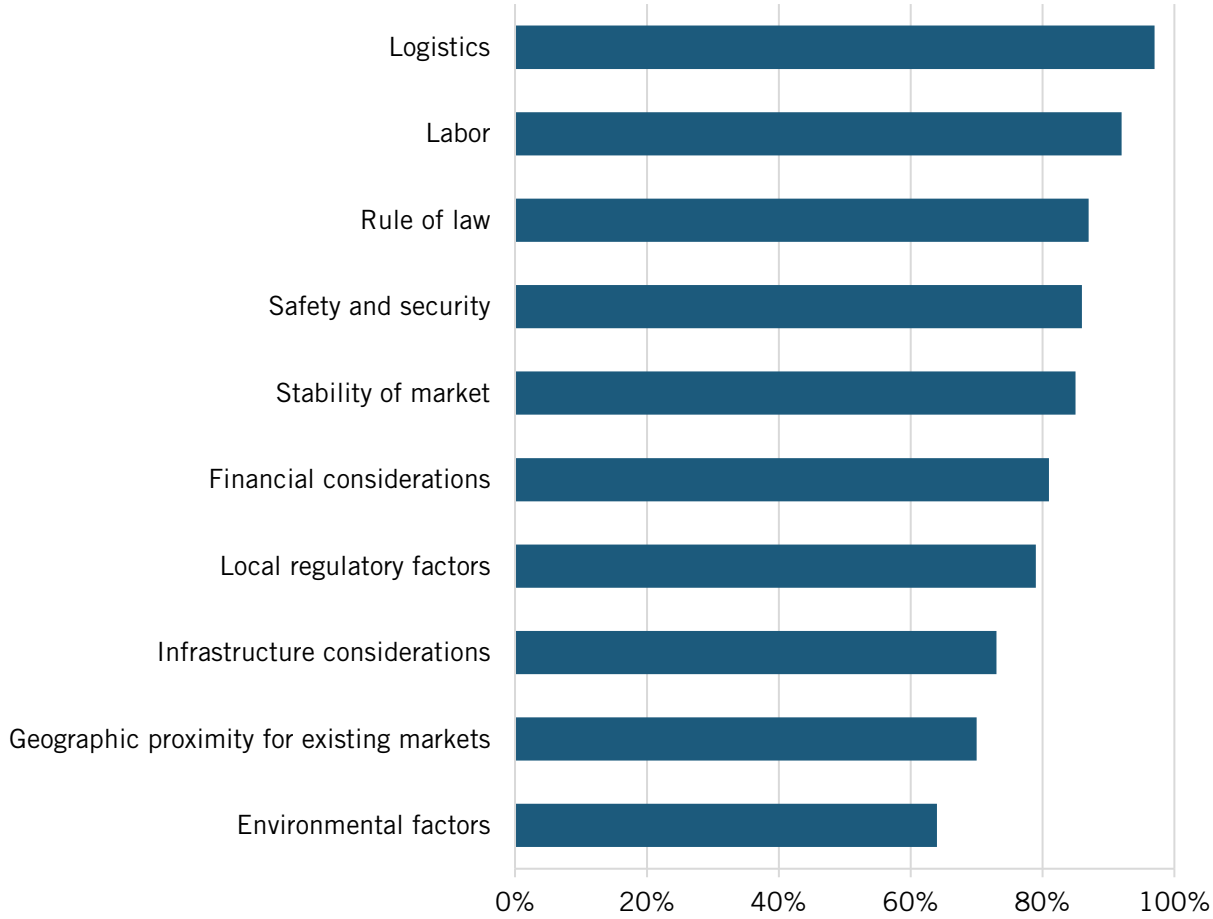
The global competition for advanced-technology industry investment is fierce, as nations—and the states, regions, and cities therein—have become price takers, not price makers, in the intense quest to attract globally mobile investment in high-value-added, high-tech industries, such as semiconductors.[108] In fact, leading semiconductor manufacturers may consider as many as 500 discrete factors—ranging from countries' and states' talent, tax, trade, and technology policies to labor rates and laws and customs policies—as they evaluate where to situate multi-billion-dollar fab or ATP facility investments. See figure 9 for a stylized set of some factors one leading semiconductor manufacturer considers as part of its site selection process. Thus, to win semiconductor sector investment, locales not only need to get some 500 factors right, but the strength of their "checkmarks" on those 500 factors needs to be stronger than that of other countries that are courting the same investment. That's why it's so important that the Dominican Republic (and others soliciting semiconductor-industry investment) get right all the policy, regulatory, and business environment considerations explored at the beginning of this report.

Figure 9: Factors considered by a semiconductor manufacturer during site selection process[109]



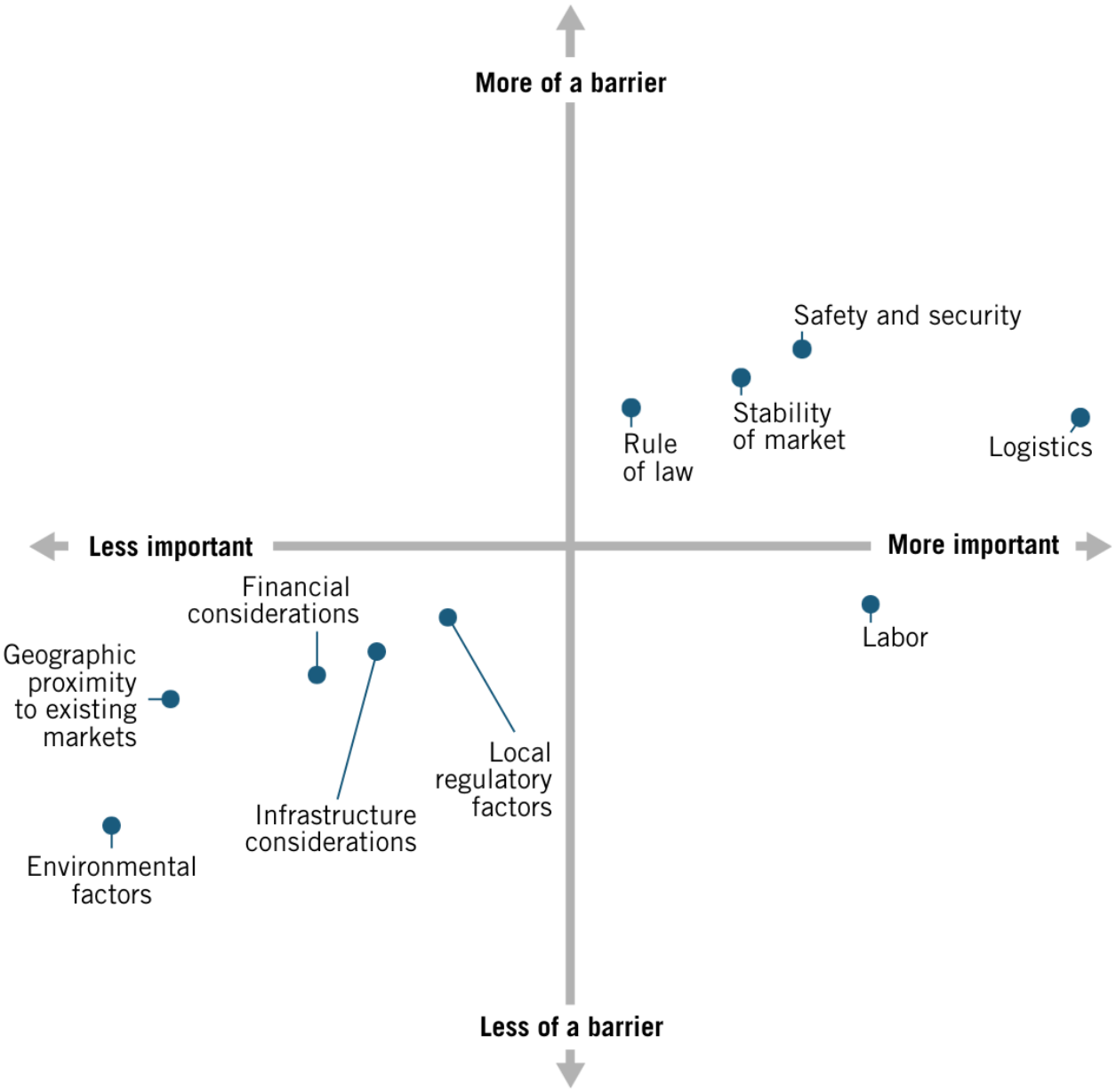
For instance, in the aforementioned U.S. Chamber of Commerce report, for the surveyed manufacturers who confirmed they would be relocating manufacturing activities from Asia, 97 percent reported that logistics was a key consideration, followed by labor at 92 percent, the rule of law at 87 percent, safety and security at 86 percent, and stability of market at 85 percent. (See figure 10.)

Figure 10: Most important factors in manufacturers' relocation from Asia decisions[110]



The Chamber of Commerce survey interviewed manufacturers on their respective considerations when it comes to the opportunity to move manufacturing operations to Central American or Caribbean countries specifically. In such cases, manufacturers viewed logistics, safety and security, and stability of market as their top three considerations when investing in the region, citing infrastructure as a very important concern as well. (See figure 11.)

Figure 11: Manufacturers' most-significant considerations in relocating to Central America and the Caribbean[111]



However, while the U.S. Chamber of Commerce found that just about one in four manufacturers were looking to relocate outside of Asia, other studies have found far more robust estimates. For instance, a September 2023 report by the Boston Consulting Group (BCG), "Harnessing the Tectonic Shifts in Global Manufacturing," finds that "90 percent of North American manufacturing executives" report "they have moved some of their production and sourcing to different countries over the past five years—and will continue to do so during the next five years."[112] Of those companies that have relocated production, over half reported that they had shifted more than 20 percent of their supply chain spending and manufacturing activity elsewhere.[113] The report notes that, from 2018 through 2022, U.S. goods imports declined by

10 percent from China in inflation-adjusted terms, but rose by 18 percent from Mexico and by 44 percent from India. The report clearly shows that global manufacturing activity is on the move, concluding, "The bottom line is that manufacturers in a broad range of industries can achieve substantial—and in some cases game-changing—cost reductions, along with improved resilience and sustainability, by boldly transforming their global manufacturing and sourcing footprints."[114]

It's also important to recognize that when this manufacturing activity moves to some locale in the Americas, even if not always to the United States, the United States still benefits considerably. That's because U.S. imports from Asia consist of just 4 percent U.S. value added, whereas U.S. imports from Latin America on average contain 40 percent U.S. value added.[115] In short, more global manufacturing activity coming to the Americas represents a win for the United States.

THE GLOBAL SEMICONDUCTOR INDUSTRY

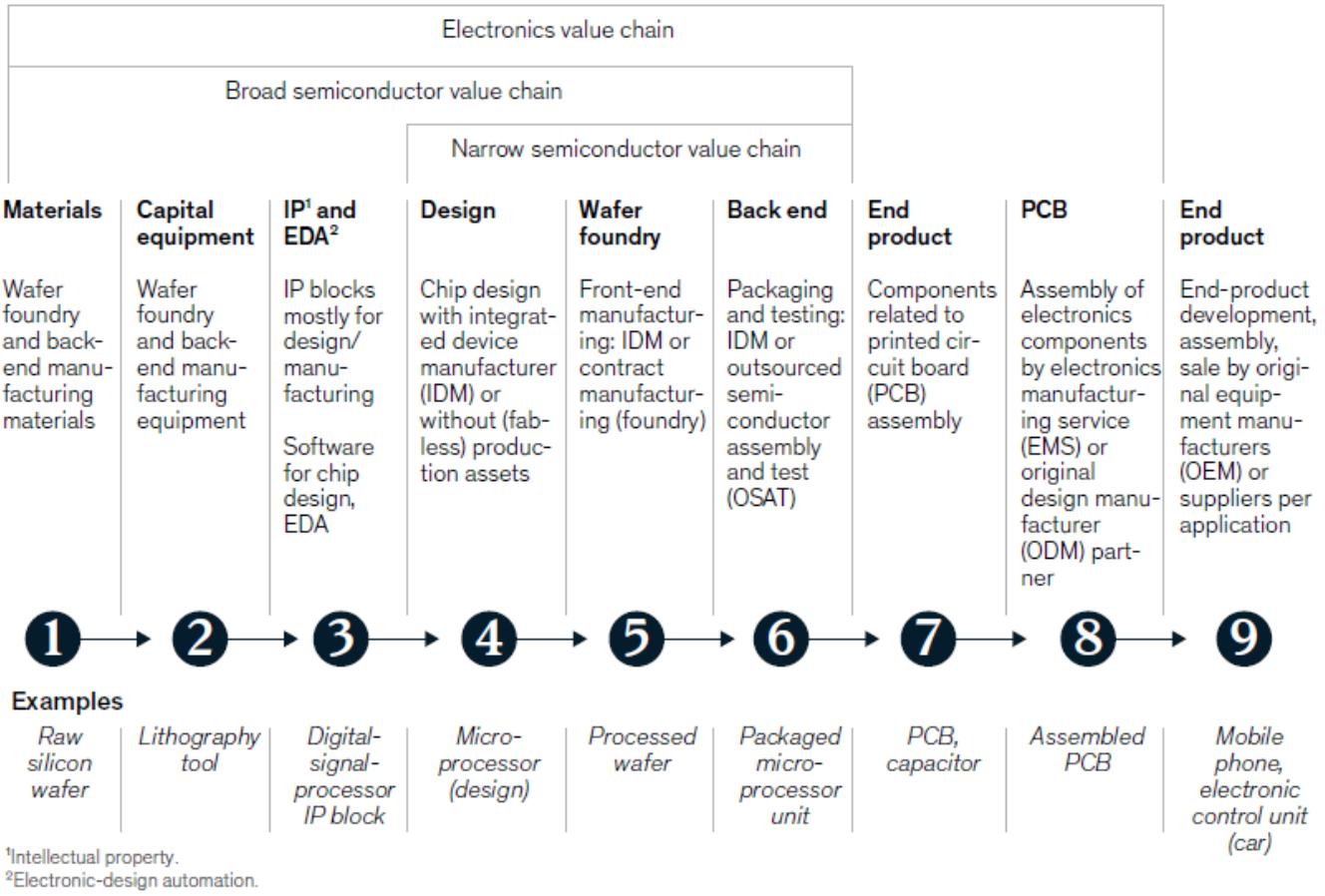
This section provides an overview of semiconductor value chains and then considers the ATP segment specifically.

Semiconductor Value Chains

Semiconductors represent the heartbeat of the modern global digital economy, an industry that's expected to reach $588 billion in 2024 (and grow to $1 trillion by 2030),stimulates another $7 trillion in global economic activity annually, and underpins a range of downstream applications such as AI and big data.[116] Moreover, semiconductors—the world's fourth-most-traded product—have perhaps the most complex and geographically dispersed value chain of any industry in the world.[117] When all production phases are considered, the entire semiconductor production process extends from material procurement to end-product manufacturing.[118] (See figure 12.)

However, in general, the three highest-level facets of the semiconductor production process are semiconductor R&D and chip design, semiconductor fabrication, and semiconductor ATP. It's also important to note that, in electronic products, semiconductors are situated onto a PCB, which is a rigid structure that contains electrical circuitry comprising embedded metal surfaces called "traces" and larger areas of metal called "planes."[119]

Figure 12: Key facets of the semiconductor production chain[120]

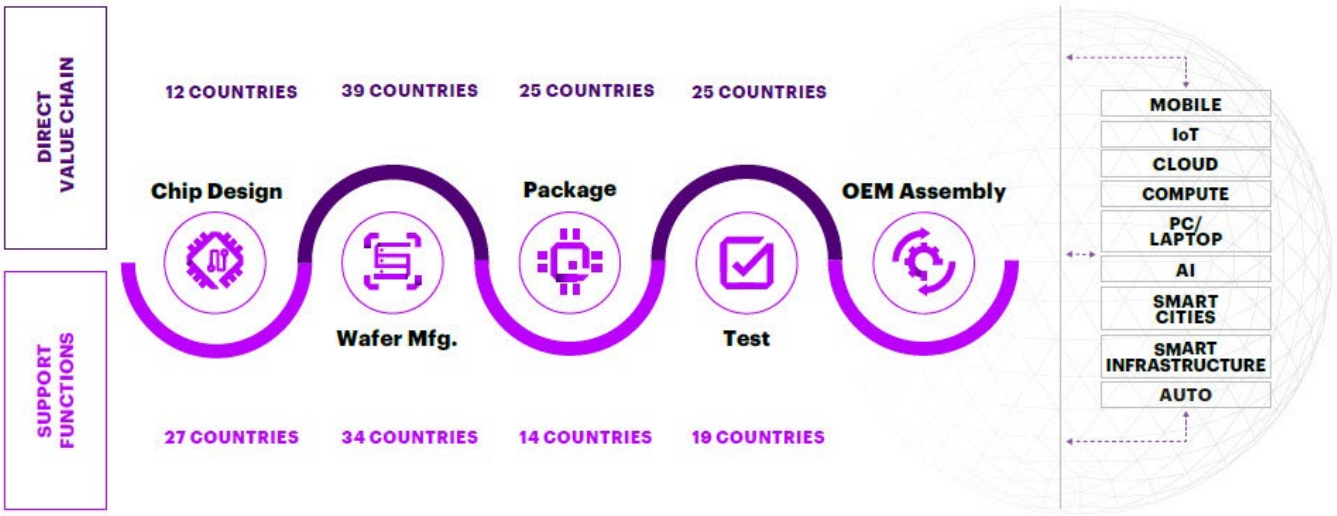


As the Interamerican Development Bank (IADB) explained:

> The intricate global semiconductor supply network has evolved over the past three decades: there are more than 30 types of semiconductor product categories, with different sizes and levels of complexity; semiconductor manufacturing typically requires up to 300 different inputs, as well as more than 50 types of highly engineered precision equipment and tools supplied by highly specialized companies that are also located in different parts of the world.[121]

Indeed, dozens of countries throughout the world field enterprises competing across multiple facets of semiconductor production. In fact, each segment of the semiconductor value chain has, on average, 25 countries involved in the direct supply chain and 23 countries involved in support functions. Over 12 countries have enterprises directly engaged in semiconductor chip design, 39 countries have at least 1 semiconductor fabrication facility, while over 25 countries have enterprises engaging in ATP activities.[122] (See figure 13.) As the IADB has elaborated, "Cost competitiveness, a business-friendly investment climate, improvements in infrastructure in terms of water supply, electricity, transportation, and logistics are some of the factors" that influence how attractive the Latin American region can be for semiconductor-sector investment.[123] But, in short, countries of all sizes throughout the world have demonstrated they can effectively compete for semiconductor sector investment, and the same certainly goes for the Dominican Republic.

Figure 13: Number of countries participating in various phases of semiconductor manufacturing activity[124]



The Semiconductor Assembly, Test, and Packaging Market

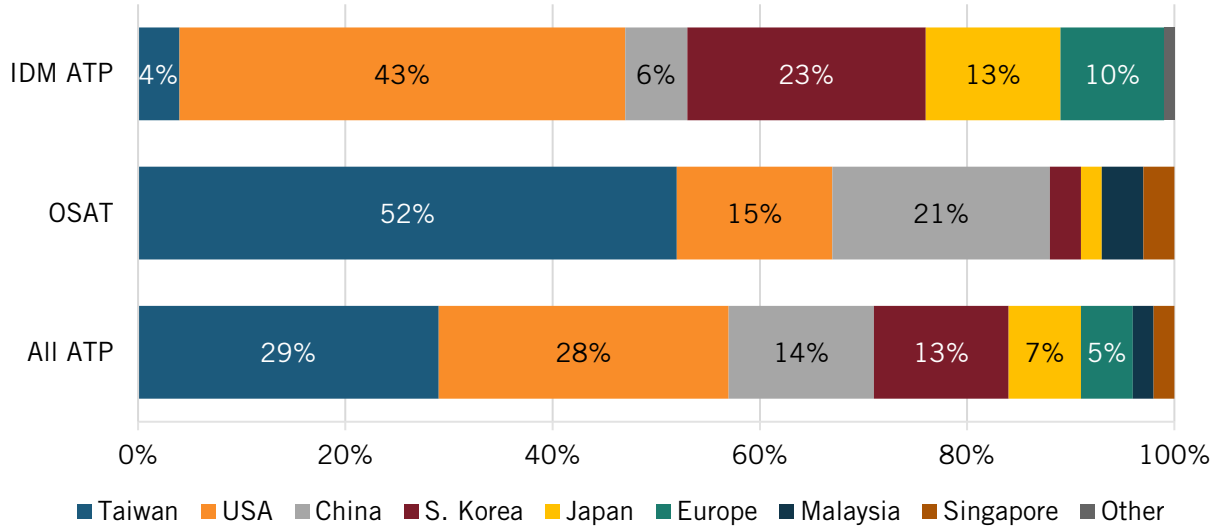
As noted, after front-end fabrication of the chips, wafers are typically sent to other facilities for back-end manufacturing activities such as ATP. At this step, chips are cut from the silicon wafer, tested for performance, and packaged to protect the chip and allow for its integration into finished electronic devices by attaching electrical interconnections.[125]

Countries of all sizes throughout the world have demonstrated they can effectively compete for semiconductor sector investment.

Semiconductor ATP generally occurs through one of two business models: 1) as in-house ATP services performed by integrated device manufacturers (IDMs) and foundries after fabrication, or 2) by outsourced assembly and test (OSAT) firms, which perform ATP activities for third-party customers.[126] ATP is typically labor intensive and lower value added than design and fabrication, explaining why, historically, firms have set up ATP facilities to a larger extent in developing countries.[127]

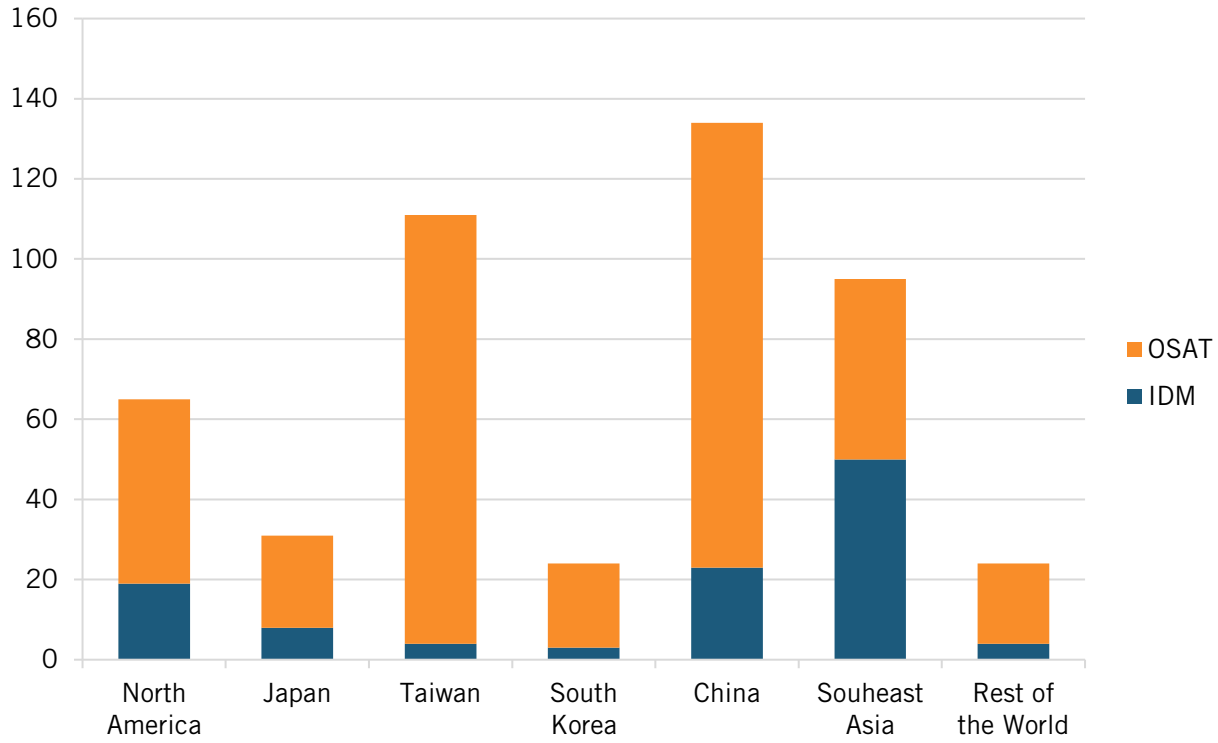
By firm headquarters, Taiwan and the United States lead in terms of the companies instigating the most global ATP activity, accounting for 29 and 28 percent of the market, respectively, in 2019, followed by China (14 percent), South Korea (13 percent), Japan (7 percent), and Malaysia (5 percent). (See figure 14.) In terms of OSAT, Taiwan dominated, with its enterprises accounting for over half the market, followed by China (21 percent) and the United States (15 percent). In turn, the United States led in IDM ATP activity (43 percent), followed by South Korea (23 percent) and Japan (13 percent).

Figure 14: IDM ATP, OSAT, and all ATP country market share, by firm headquarters, 2019[128]



However, in terms of where ATP activity is actually conducted, over 95 percent of ATP facilities exist in Indo-Pacific countries, "with a heavy concentration of OSAT providers in Taiwan, China, and Southeast Asia (particularly in Singapore, Malaysia, Vietnam, and the Philippines)."[129] In fact, of an estimated 484 ATP facilities located worldwide as of 2021, only 65 were found in North America (19 IDM and 46 OSAT), and just 24 across the rest of the world combined.[130] (See figure 15.)

Figure 15: Number of ATP facilities per country/region (2021)[131]

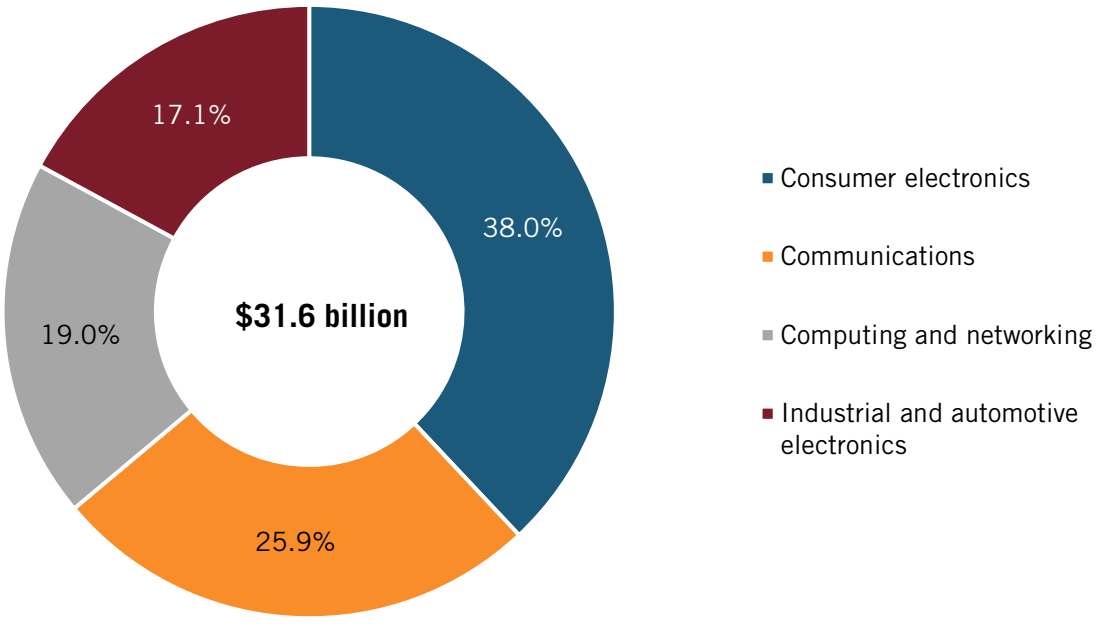


The global ATP market is highly concentrated, with the market share of the top 10 manufacturers at about 80 percent and, as one report notes, "mainly occupied by mainland of China and Taiwan of China manufacturers."[132] As of January 2023, the 10 largest OSAT players globally were JCET, HT-Tech, TF, LCSP, Chippacking, ASE, Powertech, Amkor Technology, UTAC Holdings, and Unisem.[133] The first five of these players are China-headquartered, while ASE and Powertech hail from Taiwan, with Amkor Technology the only U.S. player in the top 10 (UTAC is headquartered in Singapore and Unisem in Malaysia). (In 2017, Taiwan OSAT player ASE acquired Siliconware Precision Industries (SPIL), which at the time was the third-largest OSAT player in the world.)[134]

However, semiconductor ATP certainly represents a significant global growth market. Analysts pegged the global semiconductor assembly and testing services market to have accrued $33.4 billion in revenues in 2023, and expect it to grow at a compound annual growth rate (CAGR) of 5.6 percent over the remainder of this decade, becoming a $48.8 billion global market by 2030.[135]

As of 2022, consumer electronics accounted for the largest share of semiconductor ATP activity, at 38 percent, followed by communications, computing and networking, and industrial and automotive electronics. (See figure 16.) Analysts expect consumer electronics to continue to be the fastest-growing segment of the ATP market over the remainder of the decade, owing to "the growing consumption of smartphones, tablets, and smart television sets, as well as the adoption of 5G technologies and others."[136]

Figure 16: Global semiconductor assembly and testing services market share, by application (2022)[137]



As Chris Miller, renowned author of *Chip Wars*, observed, "If you look at the way that Korea, Taiwan, and Singapore entered the chip industry, they entered with assembly, testing and packaging before moving to fabrication."[138] In commenting upon India's opportunity to get into semiconductor ATP manufacturing, Miller continued, "[T]here's a lot of scope for India to win investments in that sphere, particularly because it's right adjacent to the device assembly, smartphone assembly, and PC assembly, where India is also in the early stages of winning a lot of market share."[139] Certainly the same applies for the Dominican Republic, and as noted, its extant base of extensive electronics manufacturing gives the country a powerful springboard to attract ATP investment.

While ATP is certainly more labor intensive than semiconductor manufacturing, industry executives have commented that labor accounts for only around 5 percent of total ATP production costs.[140] Thus, while certainly countries' labor cost environments are a critical determinant of attracting semiconductor ATP investment, it suggests that other cost drivers, such as the ability to cost-effectively import components and export finished products, to construct and operate facilities efficiently, or to achieve extremely high yield rates (i.e., production efficiency) are core cost drivers.

However, the packaging industry is undergoing an evolution, particularly with regard to advanced chip packaging. As a McKinsey Global Institute (MGI) report explains:

> Compared with the front-end process of designing and fabricating wafers, the back-end process of packaging has been undervalued for two reasons: First, it's still possible to package wafers using old-generation equipment. Second, packaging is mostly done by outsourced semiconductor assembly and test companies (OSATs) that compete largely based on low labor costs, rather than other sources of differentiation.[141]

As the report elaborates, packaging technology has evolved from the wire-bonding practices of the 1950s to the flip-chip approach in the mid-1990s (which connected a chip to the PCB with solder bumps) to wafer-level integration in the 2000s (where chips were packaged as part of the wafer rather than individually sliced) to the 2.5-D stacking approach of the 2010s and now the 3-D stacking approach of the 2020s in which multiple chip layers are stacked rather than laterally connected, and bonded using TSV (through-silicon vias) or other materials such as copper.[142] In short, the technology of advanced packaging is evolving rapidly, and as the MGI report explains, "The advent of advanced packaging has changed the competitive landscape for chip manufacturers."[143] The MGI report elaborates:

> Packaging is no longer a commodity process, and the majors have moved first to make advanced packaging a strategic part of their offerings. Other manufacturers risk being commoditized if they don't find a way to incorporate advanced packaging into their strategies and offerings. The advanced-packaging market offers many disruptive opportunities, as well as challenges that will likely go beyond business as usual.[144]

Indeed, as another report explains, "Technical advancements in packaging innovation can provide enhanced functionalities for chip applications, offering higher value and making reshoring to the United States [or elsewhere] more economically feasible than traditional, low-

value-added packaging operations."[145] The broader point here, thus, is that the evolution of the industry may present nations such as the Dominican Republic with new opportunities to approach semiconductor manufacturers and their packagers with unique value propositions as to how their countries can offer an attractive manufacturing environment to support such new advanced packaging approaches.

Growing Semiconductor Output in North America

The U.S. share of global semiconductor production has fallen substantially in recent decades. In fact, from 1990 to 2021, the U.S. share of global semiconductor production fell from 37 percent to 12 percent, an over 70 percent decline.[146] Moreover, BCG estimated in 2020 that, without effective policy intervention, just 6 percent of new global capacity development would be located within the United States.[147]

This was the impetus for congressional development and ultimate Biden administration passage of the CHIPS Act, which allocated a total of $52.7 billion to stimulate U.S. competitiveness in semiconductor production, composed principally of $39 billion for incentives and $11 billion for R&D and workforce training programs.[148] Importantly, the CHIPS Act also included a 25 percent investment tax credit for capital expenses for manufacturing of semiconductors that analysts valued as much as $24 billion. The legislation also stood up a CHIPS Program Office, located within the National Institute of Technology and Standards (NIST) within the U.S. Department of Commerce.[149]

The legislation notably further included a "CHIPS for America International Technology Security and Innovation Fund" that would provide $500 million ($100 million per year for FY 2023–FY 2027), to the Department of State for the purposes of coordinating with foreign government partners to support international ICT security and semiconductor supply chain activities, including supporting the development and adoption of secure and trusted telecommunications technologies, semiconductors, and other emerging technologies. This subsequently evolved into the ITSI Fund, administered by the U.S. Department of State.[150]

Emboldened by the CHIPS Act, from the spring of 2020 through February 2023, companies in the semiconductor ecosystem announced more than 40 new projects in the United States totaling nearly $200 billion in private investments and supporting an anticipated 40,000 new jobs.[151] By January 2024, companies had announced over $231 billion in commitments in semiconductor and electronics investments in the United States.[152] In total, the U.S. Department of Commerce has received more than 570 statements of interest and more than 170 pre-applications, full applications, and concept plans for CHIPS incentive programs.[153] Some of the most-notable announcements of expanded U.S. semiconductor production include the following.

By January 2024, companies had announced over $231 billion in commitments in semiconductor and electronics investments in the United States.

Intel has committed to invest at least $20 billion in two new Ohio semiconductor fabs. Construction on the facility began in late in 2022, and Intel expects production to come online in 2025, delivering chips using the company's most-advanced transistor technologies. At full buildout, Intel's total investment in the site could grow to as much as $100 billion over the next

decade, which would make it one of the largest semiconductor manufacturing sites in the world.[154]

In May 2020, the Taiwan Semiconductor Manufacturing Corporation (TSMC) announced it would invest $12 billion to build a semiconductor fab in Arizona. However, in December 2022, the company announced it would more than triple its initially anticipated investment in Arizona to $40 billion and build a second, 3 nanometer semiconductor fab.[155] TSMC's first Arizona fab will utilize TSMC's N4 process technology and is expected to enter operation later in 2024, while TSMC's second Arizona fab is slated to enter operations in 2026. Analysts expect TSMC's two Arizona fabs will manufacture over 600,000 wafers per year, with estimated end-product value of more than $40 billion, and create as many as 10,000 jobs.[156]

In October 2022, dynamic random access memory (DRAM) chip manufacturer Micron announced it would build a megafab near Syracuse, New York, that may entail as much as $100 billion in total investment over the next 20 years.[157] The site could eventually include four 600,000 square-foot cleanrooms, for a total size of 2.3 million square feet of cleanroom space (which would be equivalent to the size of 40 U.S. football fields). The megafab will support Micron's strategy to increase American-made leading-edge DRAM production to 40 percent of the company's global output over the ensuing decade, and is expected to support the creation of 9,000 new Micron jobs, and 50,000 jobs in New York state.[158]

The CHIPS Program Office's first investment, in December 2023, went to British-based BAE Systems to help expand a plant in New Hampshire where it makes chips for U.S. fighter jets; this was followed on January 4, 2024, with an announcement that Microchip Technology would receive $162 million in federal incentives to support the onshoring of the company's semiconductor supply chain.[159]

Latin America's Semiconductor Opportunity

In total, these aforementioned investments will amount to a significant increase in U.S production of semiconductors over the remainder of the decade, increasing opportunities for the Dominican Republic and other regional players to expand their semiconductor ATP footprints.

And that matters, for as one commentator observed, "As the U.S. and China vie for dominance in the global semiconductor industry, Latin America has become a key battleground for the geopolitical competition."[160] And, as noted, decreasing technological dependence on Asia and strategically relocating semiconductor manufacturing activity closer to the United States represents a key objective of the Biden administration, which it's pursuing through initiatives such as the aforementioned Department of State ITSI fund, as well as the North American Semiconductor Conference (NASC), a trilateral endeavor between the governments, academic, institutions, and private sectors of Mexico, Canada, and the United States.[161]

Indeed, the Latin American region has tremendous potential in assuming a greater role in global semiconductor value chains. For instance, Intel's CEO Patrick Gelsinger has stated that Intel's ultimate goal is for 30 percent of the world's semiconductors to be produced in the Americas by the end of this decade (to be sure, most of that would be in the United States, but Mr. Gelsinger meant production is the Americas broadly).[162] In November 1996, Intel established ATP operations in Costa Rica, and by 1999, the company had invested $390 million in the operations and employed over 2,200 workers.[163] The relationship was highly productive for both

Intel and Costa Rica's economy. A report by the International Labor Organization (ILO) finds that Costa Rica was able to migrate up the electronics value chain and over time add considerably increased domestic value added (DVA) to Intel's operations in the country, making the relationship a very successful endeavor for both parties. As the ILO report wrote:

> The DVA for Intel Costa Rica was 18 per cent, while for 2016, for the new operation in shared services and R&D, the DVA had increased to 44 per cent. In other words, for each dollar that Intel Costa Rica produced and sold outside of the country in 2013, 18 cents stayed in the country in the form of payments for the factors of production and inputs produced by Costa Rican companies. In 2016, for each dollar exported, 44 cents stayed in Costa Rica for these same purchases. In conclusion, during the 19 years in which Intel has operated in Costa Rica, the company has had a significant and positive macroeconomic impact on areas like growth of production, foreign trade, direct foreign investment, employment, salaries, contributions to social security, and by increasing the DVA.[164]

While Intel pulled out of Costa Rica in 2014, in August 2022, it relaunched ATP activities at its facilities in San Antonio de Belén, Costa Rica, and in September 2023, the chip manufacturer announced it intends to invest $1.2 billion in its Costa Rican operations over the next two years.[165]

For its part, Mexico currently operates four semiconductor ATP facilities, several multinational companies have major back-end chip operations in Mexico, and others are growing their chip engineering and design workforce in the country.[166]

While Latin America's potential to more significantly enter the global semiconductor industry is considerable, as one observer noted, "The electronics industry in Latin America is still developing, and it faces several barriers, such as low levels of innovation, limited access to financing, and dependence on imports. The semiconductors subsector is particularly underdeveloped, as there are few local manufacturers and suppliers, and most of the demand is met by foreign companies."[167]

However, Latin America represents a rapidly growing region for the production and consumption of ICT goods and consumer electronics (and the semiconductors that power them). For instance, the Latin American region's total ICT exports reached nearly $73 billion in 2021.[168] And one report finds that the total market demand for semiconductors between Argentina, Brazil, and Mexico alone reached over $8 billion in 2022.[169] Moreover, according to the research firm IDC, Latin American IT spending is expected to outpace GDP growth, with a 12.6 percent increase in 2023 and a forecast rise of over 15 percent by 2026. Analysts expect Latin America's telecommunications spending to grow by close to 5 percent by 2026.[170] The region's rapidly growing middle class has increased the consumption of electronic products such as smartphones, laptops, tablets, and smart TVs, with one report finding that smartphone utilization in Latin America has risen considerably, and that the region's Internet penetration rate has now exceeded that of India and China.[171] Latin America's growing demand for electronic products, and the semiconductors that power them, adds another reason for global semiconductor manufacturers to more seriously consider the region for semiconductor production activities, as market demand for the end products using them dramatically grows throughout the region.

Printed Circuit Boards

The Dominican Republic certainly has the capacity to compete in PCB manufacturing. That reality is demonstrated by the fact that the company Power One manufactured PCBs in the Dominican Republic until 2010, when the company unfortunately shuttered its Dominican Republic facility, transitioning its operations to China in what was viewed as a cost-driven move at the time.[172] Aside from that history, several manufacturers operate surface-mount technology (SMT) operations in the Dominican Republic today. SMT refers to a component assembly technology related to printed-circuit boards wherein the components are attached and connected on the surface of the board using batch solder-reflow processes.[173] Rockwell Automation and PC Precision Engineering Inc. are among the companies that currently operate SMT lines in the Dominican Republic, illustrating that the capabilities, skills, and knowhow to support PCB manufacturing activities are certainly present there. As Joan Henríquez, plant manager for Rockwell Automation's operations in the Dominican Republic, commented, "The mechanical, electrical, and programming capabilities [to support PCB manufacturing] are all available here in the Dominican Republic."[174]

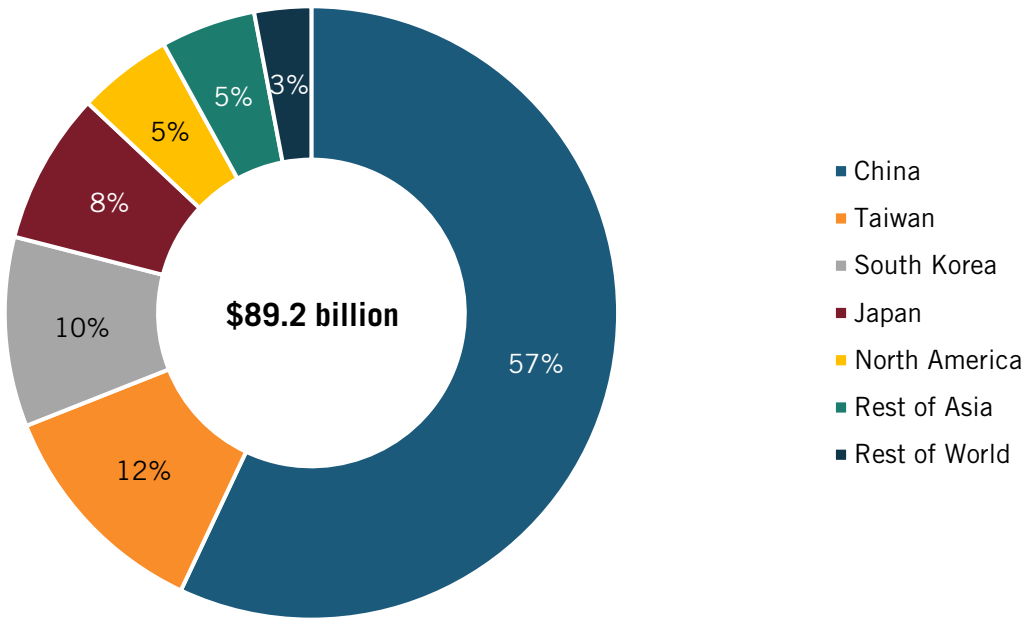
The country does have an incipient, though small, PCB manufacturing and export industry (which exported $55,200 worth of PCBs in 2021), which could serve as a base for future expansion in this sector.[175]

The capabilities, skills, and knowhow to support PCB manufacturing activities are certainly present in the Dominican Republic.

PCBs matter because they represent the foundational building block of most modern electronic devices and are composed of printed pathways that link the board's various components, including integrated circuits, resistors, electrolytic capacitors, PLCs, transistors, and resistors, which also offer mechanical support.[176] Analysts report the global PCB market reached $89.2 billion in 2021 with growth predicted at a 5.6 percent CAGR over the next decade and the industry growing to be a $140 billion market by 2032.[177] Analysts view increased demand for consumer electronics and automotive and industrial applications as the most significant growth drivers for the PCB industry over the coming decade.

China dominates global PCB manufacturing activity, accounting for just under 60 percent (57 percent) of global PCB manufacturing, followed by Taiwan with 12 percent, South Korea with 10 percent, and Japan with 8 percent. (See figure 17.) The U.S. share of global PCB production has cratered from 30 percent 25 years ago to just a mere 4 percent today.[178] China holds the largest market share due to its high-end technology, availability of materials, and cheap, skilled labor force.[179] Taiwan has the second-largest market share, largely because of its position as a global leader in electronics manufacturing and chipmaking. South Korea ranks third, largely due to its advanced infrastructure and large skilled labor force.

Figure 17: Regional shares of global output in the PCB manufacturing industry, 2021[180]



There are generally two types of PCBs: rigid printed circuit boards (RPCBs) and flexible printed circuit boards (FPCBs). Generally, RPCBs are made from a glass epoxy resin (FR4), a hard plastic board with copper wiring printed on the circuit board. FPCBs are made from polyethylene terephthalate or polyimide with copper wires printed onto the circuit board.[181]

The main drivers of PCB production costs result from the materials and manufacturing process, as well as the complexity of the design.

Materials and Manufacturing

The first cost driver is material choice; material specifications vary depending on the end-product application of the PCB. In general, five factors go into material choices: thermal reliability, temperature reliability, heat transfer, signal performance, and mechanical properties. End products involving higher frequencies require a higher grade of material than the standard FR4 and are thus more expensive.[182] PCB manufacturing also requires ISO 7 or 8 cleanrooms to reduce contamination between the line width of the circuit boards. Moreover, most films used in multilayer circuits are hygroscopic, requiring them to be printed at a specific and consistent temperature and humidity level.[183] Cleanrooms and the equipment required for PCB manufacturing in those rooms also contribute to the cost of manufacturing. Aside from the cost of the facilities and materials for PCBs, another cost driver is the labor force required for manufacturing, which requires a skilled labor force with the experience and knowledge to operate the machines and systems involved in manufacturing, as well as the ability to handle the chemicals that are part of the process.[184]

Design

The number of layers, size, and shape of a PCB also influences its cost. With each additional layer of a PCB, more production steps are required in the lamination process, as well as a larger supply of material. The size of the PCB, as well as its shape, also impacts the price, with larger PCBs and PCBs with custom shape requirements costing more because of the extra materials needed or the specialized tools required for meeting the specific design and shape requirements.

In 2021, RPCBs made up more than 85 percent of the global market demand because of their ability to withstand UV radiation, harsh chemicals, and corrosive lubricants. As the global electronics industry continues to evolve, demand for this type of PCB will likely increase.[185] One of the main market drivers for PCBs is the rapid advancement of electronics and digital technologies. Increased demand for digital products and equipment, health care devices and technologies, and high-tech features in the automotive industry and electronic vehicles have all contributed to market growth.

Analysts have observed that integrating the Internet of Things (IoT) and AI into PCB technology transformed this industry in 2023, providing greater efficiency and functionality through increased automation. Researchers have also recently printed system-on-chip microcontrollers, which offer 7,000 times the memory of other flexible PCBs.

Several players in the Dominican Republic, including Rockwell Automation and Precision Engineering, Inc., currently operate surface-mount technology lines, which refers to the tooling whereby electrical components are mounted directly onto the surface of a PCB. In short, the Dominican Republic possesses the extant domain (i.e., subject knowledge and engineering) expertise, workforce training infrastructure, competitive labor cost structure, and broader attractive investment environment to support expanded PCB manufacturing activities in the country.

POLICY RECOMMENDATIONS

The following are policy recommendations for the Dominican Republic and other stakeholders that can help advance the country's ambition to compete in semiconductor ATP and PCB manufacturing value chains.

- **The Dominican Republic should be considered a leading candidate to be designated a recipient of funding from the U.S. Department of State's ITSI Fund,** which seeks to enhance and ensure semiconductor supply chain security and diversification and promote the development and adoption of secure, trustworthy telecommunications networks. ITSI funding provides recipients with capacity-building funds that can be used for local ecosystem and strategy development. The U.S. Department of State has announced partnerships with several countries to explore semiconductor supply chain opportunities, including with Costa Rica (on July 14, 2023), Panama (on July, 20, 2023), Vietnam (on September 11, 2023), Indonesia (on November 13, 2023), and the Philippines (on November 16, 2023).[186] The U.S. Department of State should certainly view the Dominican Republic as a leading candidate for a similar partnership to explore semiconductor supply chain partnership opportunities.
- **The government of the Dominican Republic should develop an explicit national semiconductor value proposition and broader competitiveness strategy** that addresses topics such as plans

for expanding the pool of trained industrial workers, scientists, and engineers in the country capable of supporting advanced electronics manufacturing; how the government can better support applied industrial R&D activity; and how it can further improve regulatory, tax, customs, and incentive programs to attract globally mobile investment in the sector.

- **The Dominican Republic should launch an awareness campaign reaching out to global investors in advanced electronics industries highlighting the country's favorable FZs and tax policies.** Although its primary exports are medical devices and electronics, the Dominican Republic has historically been viewed narrowly by the international business community as largely a tourist destination or a primary-sector exporter. The country should showcase its economic diversification and improve its global outreach to garner greater international recognition as a leading industrial and logistics player in the Latin American region. As such, the country should focus and invest more on sector-focused promotion, marketing, and communications and build an awareness campaign and country strategy for promoting FDI in the country's FZs for emerging technologies. Further, representatives from the country's Ministry of Commerce, business associations, and FZs should attend semiconductor and PCB conferences and road shows, such as Semicon West or the Asian Semicon conferences (such as SEMICON Southeast Asia, SEMICON Korea, or the Conference of Science & Technology for Integrated Circuits (CSTIC) in China).[187]
- There exists a global shortage of talent in the semiconductor industry. In fact, Deloitte found that, by 2030, more than one million additional skilled workers will be needed to meet demand in the semiconductor industry.[188] For its part, the United States faces a significant shortage of technicians, computer scientists, and engineers as well, with a projected shortfall of 67,000 of these workers in the semiconductor industry by 2030.[189] In other words, the semiconductor workforce gap is a regional challenge**. The Dominican Republic can help address this gap by expanding the availability of degree programs in electrical engineering, computer science, and related courses.** The country's universities and vocational training schools should also seek to expand relationships with U.S. universities such as Arizona State University, Purdue, Ohio State, the University of Texas at Austin, and others to build on existing training programs and support the circulation and training of students pursuing degrees in these fields.

  For instance, in May 2023, the union minister of Electronics and IT, Ashwini Vaishnaw, on behalf of the Indian Semiconductor Mission, signed an MOU with Purdue University for capacity building, research, and development and also industry participation.[190] As part of the five-year MOU, Purdue will create cutting-edge online and hybrid academic programs for specialized training in areas including chip design and fabrication, advanced packaging, semiconductor materials, and embedded system design that can be made available to Indian students as ISM-endorsed training programs. The Dominican Republic should seek to forge similar relationships.
- **The Dominican Republic needs to increase the number of individuals holding IPC 610 certifications.** IPC A-610, *Acceptability of Electronics Assemblies*, is the most widely used inspection standard in the electronics industry and has earned an international reputation as the source for end-product acceptance criteria for consumers and high-reliability printed circuit assemblies.[191] (IPC is the leading source for industry standards, and

training in the electronics industry.)[192] Essentially, IPC 610 provides quality criteria for soldering. Stakeholders interviewed in the Dominican Republic for this report indicated the country needs more individuals trained in this certification, and that INFOTEP could launch a "train the trainers" initiative in this regard.

- **The Dominican Republic should consider expanded use of investment incentives to attract semiconductor industry manufacturing activity.** Particularly impactful could be a sector-specific investment tax credit. For instance, as part of the CHIPS Act, the United States offers an investment tax credit of 25 percent for capital expenses for manufacturing of semiconductors and related equipment.[193] Similarly, Taiwan's Chips Act, passed in January 2023, offers investment tax credits of 25 percent on R&D and 5 percent on equipment.[194] Likewise, South Korea's K-Belt semiconductor strategy raised the tax deduction ratio for semiconductor R&D by companies to 40 percent from the current 30 percent.[195]

  As BCG wrote in its September 2023 report "Navigating the Costly Economics of Chip Making," "While the government incentives landscape is still evolving across multiple parts of the world, new, more aggressive financial support programs will be critical to make the economics of these massive capital-intense projects viable."[196] And while the BCG article mostly deals with the economics of building new semiconductor fabrication facilities, certainly the same underlying dynamics apply to semiconductor ATP manufacturing activities as well. While the Dominican Republic does offer an attractive tax-free environment in the free zone, the country may need to consider investment incentives as part of its attraction package for semiconductor manufacturers.

- **The Dominican Republic should set up a "one-stop-shop" to facilitate the regulatory clearance of all permits and approvals, such as environmental review permits, that would be required to launch a semiconductor ATP or PCB facility in the country.** As noted, the Dominican Republic's Bureaucracy Zero program already provides a strong framework for streamlining regulatory processes in the country, but the Dominican Republic should consider establishing a cabinet-level office or team that would expeditiously handle any cross-government (i.e., inter-agency) regulatory permitting or clearance needs.

- **The Dominican Republic should join the expanded ITA (ITA-2) and join discussions toward promulgating an ITA-3.** As noted, the Dominican Republic is a member of the initial ITA, but this was expanded in 2015, when 53 countries agreed to expand the original ITA with an additional 201 ICT products. Countries are now considering a second expansion of the ITA, an "ITA-3," which could bring more than 400 unique ICT products under the ITA's tariff-eliminating framework, which would add more than $750 billion to the global economy over 10 years.[197] The Dominican Republic should formally accede to the ITA-2 and join a group of countries beginning the effort to advocate for an ITA-3.

- The United States signed the CAFTA-DR in August 2004, and while the agreement does have an e-commerce chapter with some basic principles, namely, not enacting duties on digital products or discriminating against digital products, the global framework supporting digital trade flows has evolved significantly since then. Moreover, the movement of data—from semiconductor chip designs to the designs of semiconductor fabs or ATP facilities—is foundational to the global semiconductor industry. As such, **the**

Dominican Republic should champion robust digital trade regulations, and one way it could do so would be by joining the WTO's Joint Initiative on E-commerce, through which over 75 WTO member nations are seeking to develop "global digital trade rules that will facilitate electronic transactions and foster an open and trusted digital economy."[198]

- The United States has recently strengthened trade and investment relations with several Latin American trade partners. For instance, in February 2022 "The U.S. – Brazil Protocol Relating to Trade Rules and Transparency," entered force (after having been signed in October 2020). The protocol modernized the 2011 Agreement on Trade and Economic Cooperation by adding new commitments on trade facilitation, good regulatory practices, and antic-corruption practices based on the relevant chapters of the United States-Mexico-Canada (USMCA) Agreement.[199] Similarly, in August 2021, the United States and Ecuador entered into a similar protocol that addressed issues including trade facilitation and customs administration, good regulatory practices, anti-corruption, and SMEs.[200] **The Dominican Republic should explore the possibility of entering into such a protocol with the United States, with the intent of further strengthening the trade and investment environment between the two nations.**

CONCLUSION

Global production chains in advanced-technology industries are undergoing a dramatic reordering. U.S.-China geopolitical tensions, the search for lower production-cost environments, and a desire to tap into new pools of skilled talent and locate production closer to end users are all factors compelling multinational manufacturers of advanced electronic products to explore new production environments and nearshore part of their operations to the Americas. The Dominican Republic offers a stable political economy and one of the most-attractive environments for FDI in the Western Hemisphere. Leveraging its existing strengths in advanced electronics manufacturing, the country is well positioned to attract a considerable share of nearshored manufacturing investment to the region. In conclusion, the Dominican Republic possesses the requisite capabilities, knowhow, and infrastructure alongside a supportive regulatory and policy environment needed to attract PCB and semiconductor ATP investment to the country. As such, the Dominican Republic is poised to both play an important role in helping diversity and make more sustainable and resilient global supply chains in the semiconductor sector.

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