

Multidisciplinary Action Project: Puerto Rico 5G Zone



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Executive Summary

The purpose of this report is to identify technological infrastructure that can benefit Puerto Rico. Businesses often face challenges in deciding which technological advancements to pursue. The proposal put forth by the team involves an analysis of existing sectors, their rates of technology adoption, and case studies to evaluate the efficiency of these technologies leading to the 'New Economy' and 'NextG' smart growth. The team was tasked with identifying technologies that PR5G Zone should invest in to support the growth and development of various sectors, ensuring that the country continues to be a hub for innovation and progress.

Looking closely at Puerto Rico, it is a US territory located in the Caribbean with a strategic location that has made it an attractive destination for businesses. With a bilingual workforce, government incentives, and a strong history in manufacturing, Puerto Rico has been able to attract various industries, such as the pharmaceuticals and aerospace sectors. The island offers low corporate tax rates, credits, and incentives for industries such as manufacturing, export services, and research and development. However, Puerto Rico faces various challenges, including an aging infrastructure, a declining population, a shrinking K-12 educational pipeline, and a high poverty rate. Overall, Puerto Rico remains an attractive destination for businesses looking to take advantage of its location and incentives while navigating the challenges it faces.

During the initial stages of the project, the team was tasked with determining the scope to reach a meaningful recommendation. Secondary research was used to gather initial information about 20 overarching sectors and a methodology was devised to determine which sectors would be researched in more detail. The team visited Puerto Rico to get first-hand information from government officials, academic leaders, company leaders, and entrepreneurs. Based on our research, a determination was made on which sectors to exclude and which to focus on, then secondary research was conducted on the high value sectors. The information found through our secondary detailed research was then used to make recommendations.

Some of the sectors researched were Pharmaceutical, Aerospace, Wired/Wireless Communication, Financial Services, Educational Services, which were obvious choices because of existing capabilities, tech infrastructure, presence of research facilities, and university relations on the island. These sectors provide opportunities for immediate investment in recommended technologies so that the island along with several companies in the sector can benefit. Film and Music production, Solar Energy, Warehousing and Storage sectors were also studied because of Puerto Rico's geography, location, and weather conditions, generating several growth opportunities in these sectors on the island. We conducted an analysis of the current infrastructure, government initiatives, available innovations, and technology usage in Puerto Rico and other leading countries in each sector. In addition, we researched and selected a cost benefit methodology that can be used to determine if the application of the selected technology is worthwhile.

After researching the possibilities, our recommendation is for PR5G Zone and its CEO, Gail Nolan, to pursue Artificial Intelligence as the core technology enabler. More specifically, by targeting growing industries with established capabilities on the Island such as the pharmaceutical and aerospace industry. PR5G Zone must establish an artificial intelligence facility focused on data analysis and algorithm development that can act as a hub bringing together resources from industry and academia. Success hinges upon collaboration and targeting of specific projects from industry with measurable outcomes, participation of academia through student projects, resources in the facility such as high-performance computing power, and the appropriate knowledgeable personnel. Additional details and information can be found in the report.



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1. Introduction

PR5G Zone, a non-profit organization, founded in 2000 with a mission to be the most successful, creative, and ground-breaking advocate for critical intelligent infrastructure in Puerto Rico is looking to make strategic investments in digital technology that can enable economic growth in the island of Puerto Rico.

PR5G Zone has sponsored this Multidisciplinary Action Project (MAP), which is an action-based learning program where teams of students apply structured problem-solving techniques to analyze multidisciplinary business problems or opportunities and make recommendations for improvements, to help PR5G Zone and the island of Puerto Rico in identifying key sectors and digital technologies for businesses to invest in Puerto Rico. This project also provides a cost-benefit methodology to help businesses planning to invest in Puerto Rico assess the cost and benefits of adopting a certain technology.

1.1. Project Background

Rapid advancements in 5G, AI, ML, 6G, IoT, Blockchain, Web3, and QA require secure and sophisticated communication infrastructure. Many companies lack the time and expertise to navigate all these technologies. Often this means that companies delay the adoption of these technologies, thereby diminishing competitiveness.

Puerto Rico is uniquely positioned to be a testing and development hub for various technologies. Additionally, Puerto Rico can be a central point of research for both U.S. and multinational companies because of its connections and proximity to major American universities.

Because Puerto Rico lacks a stable political landscape, investments in advancing technology are not consistent. PR5G Zone wants to build Puerto Rico into a technology hub for companies both domestically and internationally, which requires a thorough analysis of opportunities on the island. There are 20 sectors, as identified by NAICS (excluding NAICS 81 and 92), and a plethora of technologies all of which are potential targets for investment.

1.2. Project Goal

With the emerging need for technological advancements in different commercial sectors, this project identified potential sectors to implement digital technologies like 5G, AI/ML, IoT, Blockchain, etc. Tailoring Puerto Rico's needs, this project will provide a model for companies in these sectors, to decide if there is a benefit in implementing these technologies to be competitive. The reason for identifying these technologies is to establish Puerto Rico as an innovation and growth hub. This will be done by analyzing technology adoption in U.S. and Foreign companies and proposing a cost/benefit methodology to recommend how businesses already existing and those that want to invest in Puerto Rico could benefit from their investments.

1.3. Project Scope

Our work includes:

- Research on project background technology usage in multiple advanced countries, and on all sectors, based on NAICS Code except 81 & 92
- Research on technologies such as 5G, 6G, IoT, Blockchain, Web3, AI, and ML
- Cost-benefit analysis to determine appropriate methodologies to implement these technologies in Puerto Rico
- A recommendation for technological implementation bringing the greatest value to support sector advancement in Puerto Rico

1.4. Project Deliverables

Upon careful research with experts in the field and articles we are providing a report on-

- Which sectors are attractive for Puerto Rico based on comparative studies done on different countries as well as capabilities of Puerto Rico
- Technologies used in various commercial sectors in advanced countries such as USA, Singapore, Germany, UK, France, Japan, Hong Kong, and South Korea
- Cost-benefit methodology to help businesses investing in Puerto Rico decide if the tech investment is worth it
- Recommendation on technology to focus in the immediate future and in the distant future.

1.5. Project Research

We conducted both primary and secondary research. Primary research included information gathered through meetings, tours, and presentations provided by existing companies, universities, and research institutions in Puerto Rico. Secondary research included information from data provided by Puerto Rico 5G Zone's previous research, the University of Michigan Kresge library resources, remote discussions from experts in a particular area, and the MAP team's extensive online research.

2. Investment Factors in Puerto Rico

Puerto Rico offers businesses unique advantages, including a strategic location, a highly skilled workforce, and favorable tax incentives. Despite being a U.S. territory and the advantage it brings, Puerto Rico has been struggling with high levels of poverty, low economic growth, and a declining population.

Figure 2.1. SWOT of Puerto Rico

Strengths	Weaknesses
<ul style="list-style-type: none"> • Tax incentives • US Territory- 'Made in USA' • Location & Climate • Culture • Bi-lingual skilled workforce 	<ul style="list-style-type: none"> • Dependance on imports • Under utilized resources • Unemployment • Underground economy • Media coverage
Opportunities	Threats
<ul style="list-style-type: none"> • Renewable energy • Emerging Industries- Biotech, aerospace, IT • Transshipment hubs • Controlled environment agriculture • Remote work- retain/bring back workforce 	<ul style="list-style-type: none"> • Brain drain • Vulnerable power, communication infrastructure • Political instability • Debt burden/financial crisis • Natural Disaster

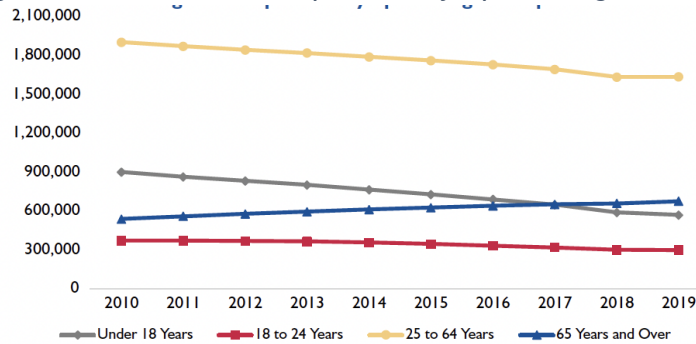
Puerto Rico is strategically located making it an important hub for trade and transportation between North America, South America, Europe, and Africa. The island is also a natural hub for transshipment and telecommunications with a number of undersea fiber optic cables landing on its shores. The island's status as a U.S. territory has made it an attractive destination for businesses looking to access the U.S. market, providing industries the opportunity to develop and invest in products involving intellectual property. The availability of bilingual language and skilled workforce especially in pharmaceuticals, and aerospace industries in Puerto Rico is a significant advantage for businesses looking to invest in the region.

In addition, Puerto Rico being in U.S. jurisdiction provides investors with the legal and financial stability of the U.S. Furthermore, the Puerto Rican government has implemented various tax incentives to encourage investment in the island. These incentives include lower corporate tax rates and tax credits for businesses that create jobs in Puerto Rico.

Puerto Rico has been facing significant challenges in meeting its energy demands due to the gap in demand and supply. Puerto Rico consumes almost 70 times more energy than it produces and relies heavily on imported fossil fuels to meet its energy demands (US Energy information administration 2023). The island has been facing long-standing problems with its aging electrical grid, leading to frequent power outages and blackouts. Natural disasters and underinvestment are important reasons for the current state of the electrical infrastructure. Industries are resorting to cogeneration techniques to manage the shortcomings and be more efficient. Developing a more reliable and resilient power generation is essential for the island's economic growth.

In recent years, the population in Puerto Rico has decreased from 3.7 million to under 3.2 million in 2019 (Labandera, Santiago, and Laurel 2021, 6). The younger and traditional working-age population has decreased while the population that is 65 years and over has increased (see Figure 2.2). This disrupts the education services sectors including schools, colleges, and universities, and the availability of a skilled workforce on the island.

Figure 2.2. Puerto Rico Population by Specific Age Groups

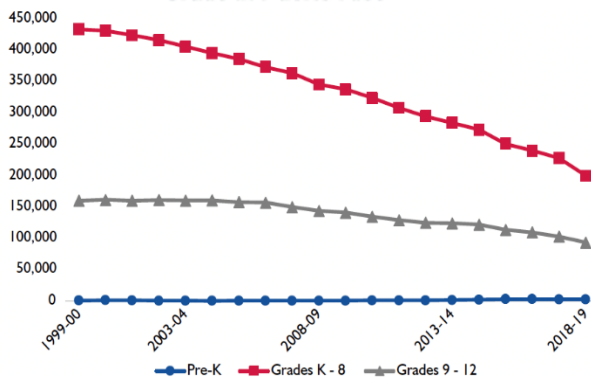


Source: Labandera, Santiago, and Laurel 2021, 7

In terms of education, Puerto Rico has a strong university system that has produced many talented graduates in engineering and other sectors. However, there has been a brain drain in recent years, with many graduates leaving the island to seek employment opportunities in the mainland U.S.

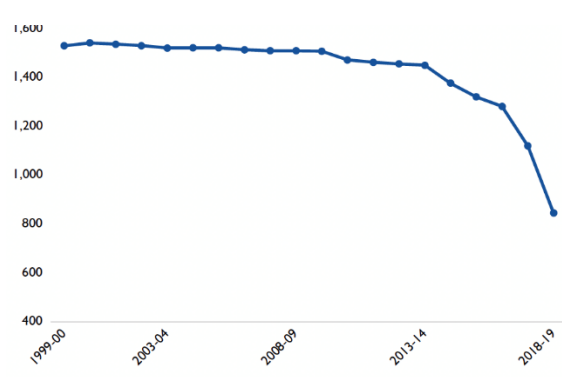
High unemployment rates and low starting salaries compared to the mainland are some contributing factors to the brain drain. The K-12 educational pipeline is declining as well with a reduction in the number of students, teachers, and schools (see figures 2.3 & 2.4). The government needs to address the entire ecosystem by investing in and improving public schools, research and development, and technology, and providing job opportunities that are attractive for students to reside on the island.

Figure 2.3. Number of Students in Pre-K Through 12th Grade in Puerto Rico



Source: Labandera, Santiago, and Laurel 2021, 11

Figure 2.4. Total Number of Public K-12 Schools in Puerto Rico

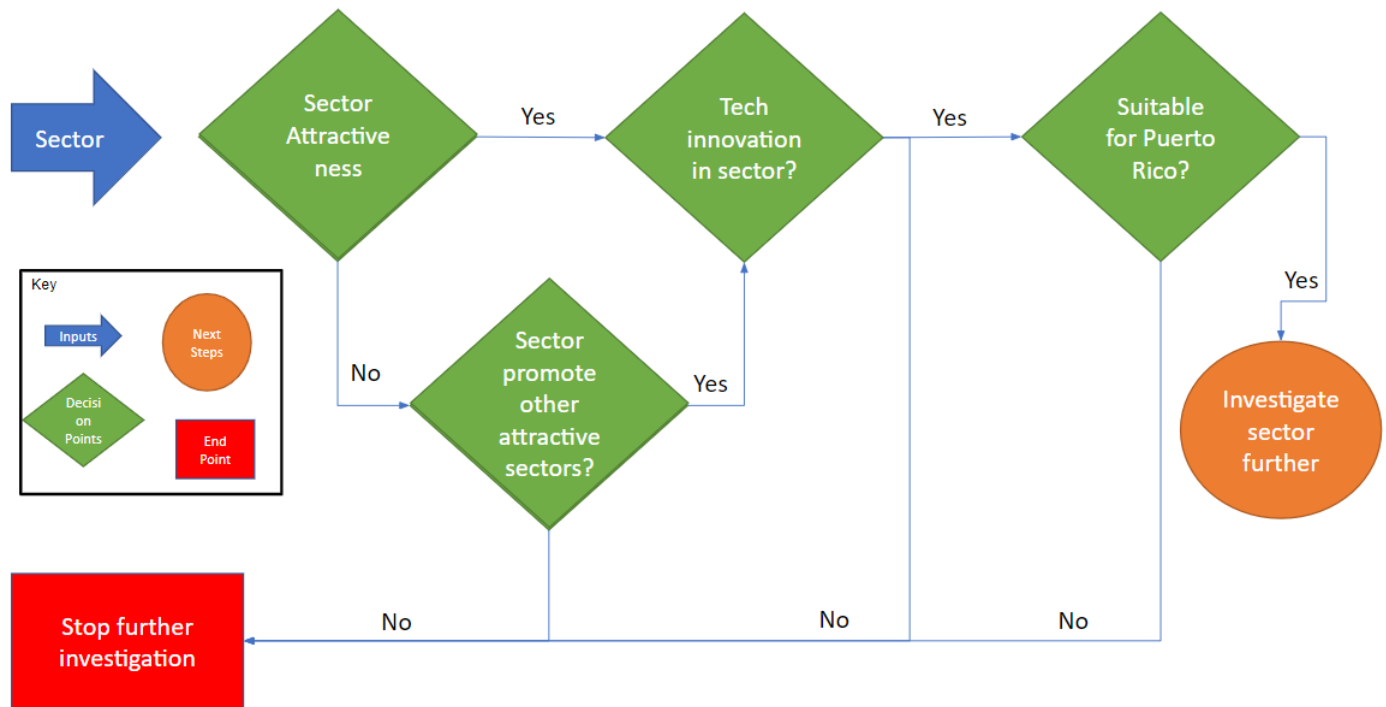


In conclusion, Puerto Rico has a number of strengths and weaknesses that businesses should take into account. The island's strategic location, bilingual language, and skilled workforce make it an attractive destination for companies across a range of industries. Furthermore, the availability of tax incentives and other government support can help mitigate the challenges posed by the island's economic and social issues. However, businesses must also be aware of

the challenges posed by the island's energy infrastructure, political background, and education system. Despite these challenges, Puerto Rico remains an attractive destination for businesses looking to invest in the Caribbean region, and with the right investments and support, it has the potential to become an even stronger economic powerhouse.

3. Sector Selection

Figure 3.1. Sector Selection Decision Flow Chart



To quickly narrow the focus for this project, a strategy was created to determine sectors that were growing and most suitable for Puerto Rico. Each sector went through the same decision points based on the flowchart in Figure 3.1 that we developed and if the sector failed to meet the criteria, it would not be researched in detail, but if a sector met the criteria the sub-sectors within the general sector were researched further. The first decision point looks at how attractive a sector is to invest in.

To best define what an attractive sector looks like, we used the Three Horizons Model from

Figure 3.2. Three Horizons Model

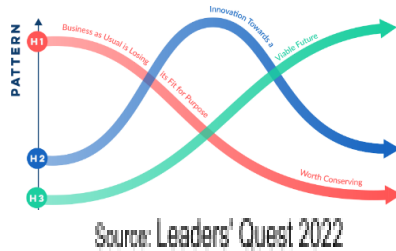


Figure 3.2. The sectors of interest had to be considered a Horizon 2 or Horizon 3 industry which could be seen by the global Compound Annual Growth Rate (CAGR), high profits, low competition, bottlenecks in the value chain, and overall size of the industry. If a sector was deemed attractive based on cursory research, it would be passed to the next decision point, but if it was not seen as attractive, it fell to a sub-decision point.

The sub-decision point was if the sector was in a commensalism relationship with an attractive sector. If an unattractive sector was directly helping an attractive sector then it was moved on to the next decision point, otherwise, it would stop being studied.

Figure 3.3. Final Subsectors

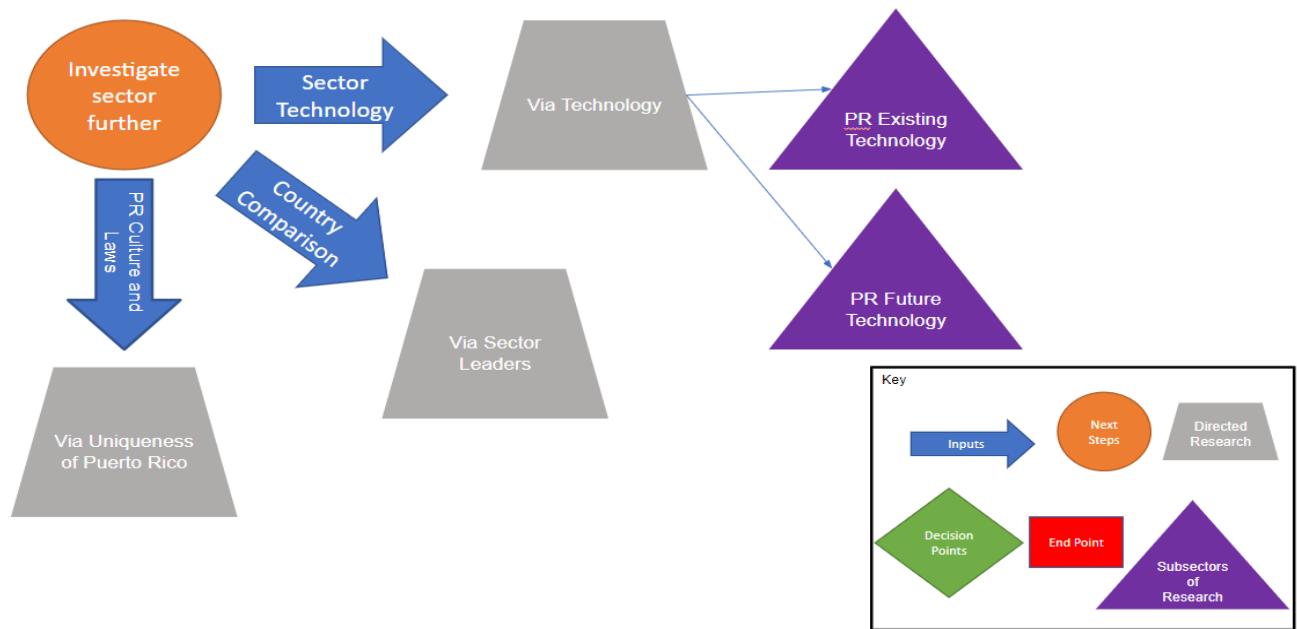


Since this project is focused on technology recommendations, it is crucial to look at innovation within an industry to understand if it is within our scope of work. Some key metrics that were used to determine if there was technology innovation were the number of Unicorns, future technology needs, and adoption of technology.

If the sectors have passed the previous decision points, then it was put through one final test - is the sector suitable for Puerto Rico? Puerto Rico is a unique archipelago where many sectors could flourish, but there are aspects that do not make it the best place for certain industries. While judging suitability, the team looked at the comparative and competitive advantages that Puerto Rico offered, especially compared to the leading countries in the sector. The results of each of the 20 sectors being put through the test can be found in

the Appendix 1 with a summary seen in Figure 3.3 that we developed.

Figure 3.4. Detailed Research Paths



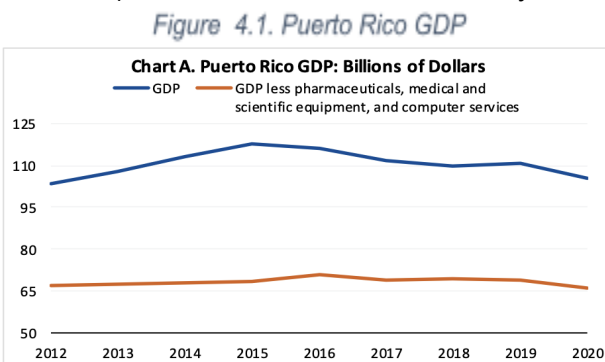
If a sector passed all of these decision points, then detailed research was completed about Puerto Rico's comparative and competitive advantages, leading country comparisons, and finally, the emerging technological advances in the sector as seen in Figure 3.4 that we developed. The three main areas of detailed research within the 10 final subsectors are what you will find in this report. All 20 sectors being put through the decision matrix can be found in Appendix 1.

4. Sector Analysis

Upon narrowing down a list of 20 sectors to 9 sectors and subsectors, we performed a detailed analysis of each narrowed-down sector and subsector, starting with those matured enough to make tech investments right away to those that can potentially reap benefits if they were to be nurtured. The sector analysis includes a comparison between Puerto Rico's existing and potential capabilities to that of other leading countries in the sector. The analysis takes into account several factors but not limited to location, geography, existing infrastructure, skilled labor availability, government incentives, available innovations in the sector, and demand. As a result, the team provided a technology recommendation at the end of each analysis.

4.1. Pharmaceutical Manufacturing

Manufacturing is the largest sector in Puerto Rico's economy, particularly in the pharmaceutical and medical device industries and so top on the list. The GDP in the manufacturing pharmaceuticals sector is around 17.8%, and exports of pharmaceuticals and organic chemicals make up 79.2% of Puerto Rico's exports of goods or 67% of its goods and services. Figure 4.1 highlights the significance of Pharmaceuticals, medical and scientific equipment, and computer services. (U.S. Bureau of Economic Analysis 2022).



Source: U.S. Census Bureau of Economic Analysis

Puerto Rico's pharma exports were \$13.2 billion in 2018 which made it the United States' top exporting region ahead of Indiana and California. The assumed reasons for Puerto Rico's success are due to tax incentives issued in 1976 under section 936 of the Revenue Act of 1921 which provided federal tax incentives to pharmaceutical manufacturers locating their facilities in the territory. The law has since been removed but Puerto Rico has remained a strong pharmaceutical exporter.

The pharmaceutical manufacturing industry in Puerto Rico relies on continuous manufacturing, data analytics, quality control, automation, 3D printing, and bioprocessing as its main technology drivers. These technologies focus mainly on the manufacturing side of the value chain where Puerto Rico is strongest.

4.1.1. Leading Countries

Ireland, which is a leading country shown in Figure 4.2, is very similar to Puerto Rico in terms of exports where 62% of them are related to the biopharmaceutical manufacturing sector. Another similarity is Ireland's favorable tax environment which is a 12.5% corporate tax rate compared to 19% in the United Kingdom or 29.5% in Belgium, in addition, Ireland provides a 25% tax credit. Ireland's location near the EU is instrumental in supporting its large exports as the island is able to leverage its neighbor's large economy to its benefit.

Ireland has been able to develop a strong workforce of educated professionals contributing to its Biopharmaceutical patents number, generating 7.8 patents per million of the population which is only behind Switzerland worldwide. (PwC 2020)

Ireland is focused on Advanced Therapeutic Medicinal Products (ATMPs) which were identified

Figure 4.2. Pharmaceutical Key Stats

Key Statistics

23% investments Ireland attracts from abroad



3.75% corporate tax with innovation deductions



46.4 billion Euros recorded in 2019 in the largest pharmaceutical market in Europe



Source: PwC 2020, KPMG 2020, Germany Trade and Travel 2020

as a high-growth area over the next 6 years. ATMPs include innovative gene, cell, tissue-engineering, and somatic-cell therapy medicines. Ireland is developing skills in areas such as artificial intelligence, machine learning, CGT, digital therapeutics, genomics, and data science. Trends that are being viewed in Ireland also look at the delivery of healthcare, personalized medicine, custom healthcare experiences, and preventative medicines which can possibly be supported with high computational power and artificial intelligence.

Investment in R&D is a major enabler which is why 15% of the industry's net sales are reinvested. In Europe, 35 Billion Euros were invested in R&D in 2017. Investments do have

risks as only a few drugs out of ten thousand investments make it to market successfully but investments still continue and Ireland attracts high investments from abroad, at 23% which is the highest in Europe.

4IR is another venture that Ireland is targeting by working with new technologies, industry, and government to establish facilities as "lighthouses". 4IR, which is also called the Fourth Industrial Revolution is the digitization of the manufacturing sector using technology such as machine learning and artificial intelligence. Lighthouses are considered to be the world's most advanced factories using 4IR technology, J&J was able to achieve recognition in Ireland by reducing carbon emission per kg of the product by 56% while also expanding the plant by 34% through real-time release, adaptive process control, and other sustainability efforts. The lighthouse initiative was launched by the World Economic Forum in collaboration with McKinsey. (World Economic Forum 2022)

Figure 4.3. Pharmaceutical Insights

Insights

AI is the leading technology enabler across different countries



R&D is over 10% for Belgium, Germany and Ireland, increased investment is necessary

Tax breaks and subsidies are the main drivers to attract additional investment



Belgium offers various incentives mainly in the form of tax incentives and subsidies, the incentives are targeted toward research and development. Incentives are a common insight among all countries, others are shown in Figure 4.3. The Innovation Income Deduction allows companies to deduct up to 85% of their net innovation income from their taxable base resulting in a corporate tax as low as 3.75%. Companies can obtain a partial exemption from payment of withholding tax on wages paid to researchers that they employ generating a cash subsidy. In addition, companies can deduct business costs for research and

development immediately or record it as an intangible fixed asset that can be depreciated over 3 years. (KPMG 2022)

Belgium’s manufacturing regions are focused on implementing new technologies to move towards Industry 4.0. In Wallonia, a Digital Innovation Hub was established to focus on High Compute Clusters, Artificial Intelligence, Cyber Security, the Internet of Things, and simulation technology. The hub provides access to various companies that address each of the previously mentioned topics. To enable the digital hub with various technologies, the Agency for Enterprise and Innovation and its subsidiary, the digital agency, invested 500 million euros in a period of 4 years from 2015-2019. (Walhub 2023)

In the Flanders region, a similar initiative to Wallonia’s has been launched, called Flanders Make, a strategic research center for the manufacturing industry that supports innovation through research and provides extensive testing and validation infrastructure to the industry in the region. Flanders focuses on making decisions using algorithms through AI, in addition to using AI to improve driving systems and moving parts in machines for manufacturing. (Flanders Make 2021)

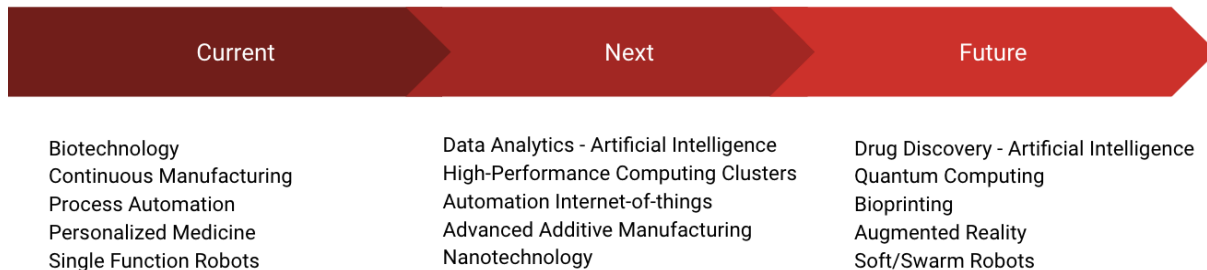
Approximately 65 billion Euros are contributed by the pharmaceutical industry to Germany’s GDP which makes up 2.2% of the country’s GDP. Biopharmaceuticals are the fastest growing area in Germany with an average growth rate of over 10% since 2015. Germany is the largest pharmaceutical by revenue in Europe with 46.4 billion euros recorded in 2019 and an annual growth rate of 5.1%. As with other countries, Germany invests heavily in R&D with 7.4 billion Euros invested in 2018 more than any other European country. Ranking fifth worldwide in the number of clinical trials financed by research-based pharmaceutical companies Germany strives to maintain an innovative culture. (Germany Trade & Invest 2022)

Germany benefits from technology clusters such as Medical Valley, Health Capital, BioM Biotech, Medical Mountains, and Life Science Nord in different regions throughout the country, these innovation hubs help develop new companies and work through partnerships with existing companies in different areas of technology.

4.1.2. Technology Recommendation

The image in Figure 4.4 below shows the current technology used, what is being developed and used next along with what will be developed for the future in the industry. Currently, there is a lot of focus on continuous manufacturing and process automation which is common among manufacturing companies. Advanced facilities are heading toward the fourth industrial revolution through further automation through the Internet of Things and by building on additive manufacturing.

Figure 4.4. Pharmaceutical Technology Projection



The main enabler and recommendation for Puerto Rico is to focus on Artificial Intelligence targeting data analytics with process optimization, supply chain optimization, and quality assurance. In the next phase of technological development, AI can be used to work toward drug discovery by analyzing a large amount of data such as chemical structures.

4.2. Aerospace Sector

Based on our research, the Aerospace sector is the second on our list that has great potential for growth and development in Puerto Rico. Geography plays a vital role in the Aerospace industry and is one of the main reasons the sector is growing in Puerto Rico with Lufthansa Technik's MRO, Honeywell Aerospace's R&D, and Aerospace suppliers investing in the region. The growth is fueled by customers from North America, where the United States leads the production of aircraft and Latin America which is a rapidly growing market. American citizens are required to produce technologies related to military and federal defense as specified by the International Traffic in Arms Regulation (ITAR) providing Puerto Rico with another benefit compared to its nearby rivals. The workforce in Puerto Rico is enabled by universities in the region that have aerospace engineering degrees or concentrations such as The University of Puerto Rico at Mayaguez, The Polytechnic University of Puerto Rico, and The Inter-American University of Puerto Rico. Supplementing traditional education is the Aeronautical and Aerospace Institute of Puerto Rico (AAIPR) an entity established by the University of Puerto Rico to handle academic projects that help grow the aerospace cluster on the Island.

PR stands between three continents granting it superior geographical positioning to support the industry on the Island. The global commercial aerospace market is expected to increase with a compound annual growth rate (CAGR) of 4.6% by 2020

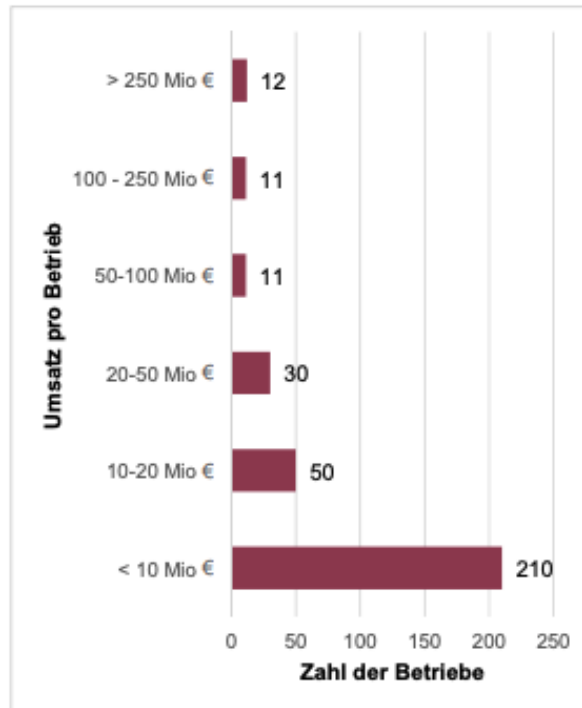
4.2.1. Leading Countries

The United Kingdom is one of the leading countries in Europe in the Aerospace industry and MRO. In the UK, technologies such as advanced materials, cabin technology, Non-destructive evaluation, and cabin technology are used to differentiate its MRO industry. The UK has over 39,000 people employed, more than 1,300 companies, and close to 12 billion pounds of revenue in the MRO industry (Derber 2016), the government launched "Made Smarter" which is a national program targeting technological advancement in the manufacturing sector. ("About the programme - Made Smarter", 2023.).

Similar to the UK, Germany has an industry association named BDLI with 250 members who share the common goal of advancement in the aerospace industry through technology. As of 2021, the German Aerospace industry employs 100,000 people, has 31.4 billion Euros in sales, and invests 2.5 billion Euros in research. Looking at the MRO industry, which is part of civil aviation, employs more than 69,000 people with exports nearly 72% of the industry as a whole. (BLDI 2021). The German aerospace industry has taken a step back after the pandemic and is looking to regain some of its lost sales.

Airbus ties into the German MRO industry and its various suppliers tightly due to it being a conglomeration formed with German, French, and Spanish companies. The next step for Germany is to develop new manufacturing techniques using technology such as Artificial intelligence to strengthen digitalization and Industry 4.0. Currently, it seems behind the curve versus its European counterparts relying on its excellence in the supply chain. The image below shows the number of companies per revenue in Germany.

Figure 4.5. Number of Companies per Revenue in Germany



Source: Federal Ministry for Economic Affairs and Energy, 2017

Singapore has a leading position in the Asia-Pacific market with an annual growth rate of 8.6% and an annual output of more than \$8.0 billion capturing over 10% of the global MRO market. (Ng 2020). Singapore has dominated in the MRO sector due to a number of factors, one of the main ones being technology such as robotic automation and 3D printing of aircraft engine components such as turbine blades. Companies in Singapore are now focused on further automation, advanced inspection, and enhanced connectivity to create a connected factor, with Pratt & Whitney announcing a new technology accelerator facility to develop these new technologies (Pozzi 2022). The Government of Singapore views the country as an aerospace nation and invests heavily in it with numerous grants through A*STAR which is the Agency for Science, Technology, and Research. A*STAR is focused on technological advancements in additive manufacturing, the Internet of Things, and data analytics for predictive maintenance and optimization through artificial intelligence.

4.2.2. Technology Recommendation

As seen in figure 4.6, the industry is currently relying on 3D printing and automation to help increase efficiency, to advance to the next level the recommended technology would be artificial intelligence used to develop models/algorithms to organize and understand data that is obtained in a quicker more useful manner.

The benefits gained from the use of AI in data analytics would be to further improve the speed of the MRO process by identifying areas that need improvement quicker and determining the

most efficient techniques to improve them based on previous information, available materials, and skillset.

Figure 4.6. Aerospace Technology Projection



For other next-generation technologies, Blockchain can be used to maintain accurate accessible records, drone inspection can be used to view areas of the plane that are difficult or time-consuming to view by a human within a quick timeframe, advanced additive manufacturing can help develop new materials which are lighter weight or more resistible to breaking and automation using internet of things can help make the working facility more efficient.

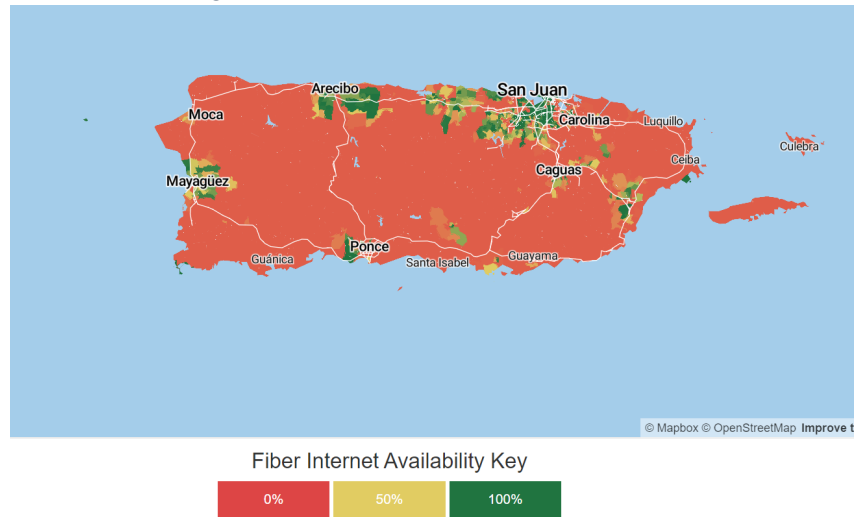
For further future technologies, the MRO industry is experimenting with robots that can do more than one activity, augmented reality that can help keep operators safe by using robots instead of humans in difficult situations, and quantum computing which will further enable technologies such as artificial intelligence through faster computation.

4.3. Wire/Wireless Communication and Software Publishers

Following the Pharmaceutical manufacturing and Aerospace sectors, wired/wireless communication is crucial for enhancing the communication infrastructure and enabling businesses on the island. This section outlines the wireless and wired communication and software publishing sub-sectors within the Information industry. 5.9% of Puerto Rico’s GDP is composed of software services, wired communications, and wireless communication on the island.

Puerto Rico currently hosts companies such as Microsoft and Oracle within the R&D sector. Three key factors that have been a benefit to Puerto Rico are the tax incentives of Act 60, which allows for a 50% tax credit in R&D spend, Puerto Rico’s bilingual workforce, which allows itself to be a bridge to connect between the U.S. and Latin America, and their strong coverage of wireless service, which accounts for 98.3% of Puerto Rico’s land area (Figure 4.7).

Figure 4.7. Fiber Internet Available in Puerto Rico



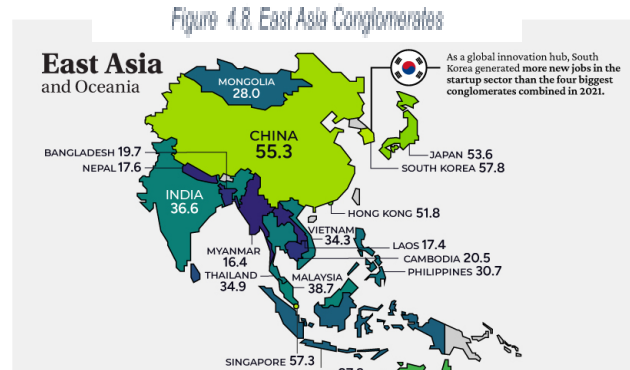
Source: Best Neighborhood Fiber TV and Internet, 2022

4.3.1. Leading Countries

South Korea, Japan, and Singapore have been used as comparable countries to the island of Puerto Rico as they are all leaders in the information sector and have a very similar size, access to resources, and geographical terrain.

South Korea has earned its reputation of being a leader in communication and information technology with hosting leading electronics companies such as Samsung, LG Electronics, and SK Electronics. The country emerged from the Korean War in the 1950s as one of the poorest economies in the world. In the 1960s, Korea established the Ministry of Science and Technology. This ministry helped Korea become a world leader by focusing a large portion of their GDP on the research and development of several electronic devices and technological infrastructure.

South Korea is widely considered to have the fastest and most advanced broadband network in the world. The country has managed to become the world leader in fiber connections in total fixed broadband and fixed broadband penetration. A major factor in Korea being a leader in broadband has been its close relationships with its large conglomerates that helped grow South Korea's infrastructure. This does create some conflicts in their society, such as an unequal distribution of wealth and power among the conglomerates vs others. South Korea has been able to mitigate this through the Monopoly Regulation and Fair Trade Act. The policy established rules that barred unfair practices and prohibited unreasonable rates for access to fiber lines and a country-wide focus on venture investments, where South Korea has also poured into startups and has grown 78% year-on-year in 2021 (Yoon 2021). This resulted in more new jobs in the startup sector than their four biggest conglomerates combined (Figure 4.8).



Source: Global Innovation Index, Amoros 2022

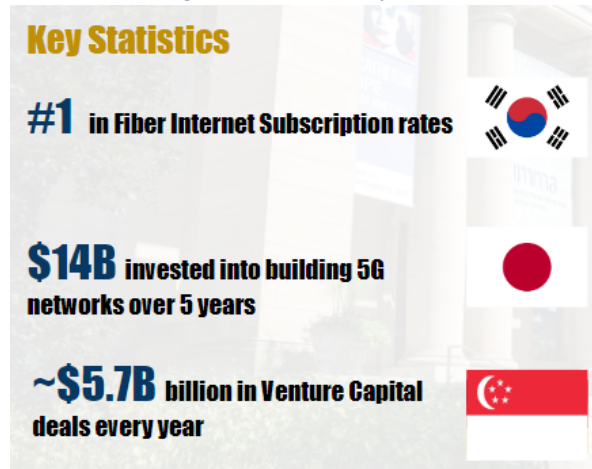
Japan has a similar background to South Korea but is more similar to Puerto Rico’s terrain as it is also an island nation. The country currently has the largest app market in the world, and similar to Korea, it’s working with four conglomerates to invest \$14.4B USD into building 5G networks over the next five years. Japan is very aware of the large benefits of investing in their infrastructure to move from 4G to 5G such as lower costs to transmit data, increasing speed and capacity, which results in the country remaining in the telecom technology forefront, and creating new revenue streams for operators such as an opportunity to lead in the IoT and AI (Holman 2021).

Beyond building networks, the four companies that are investing in this infrastructure are forming partnerships to explore opportunities in high-tech fields for future revenue streams. The country currently has two major tech hubs (Osaka and Tokyo) that are connected by bullet train which enhances communication and ease of livability within the area and retains their top tech talent. All resources and investments that Japan has focused on continuing to make them a market leader in the information sector.

Singapore is currently ranked as one of the top four countries in the world in terms of technological infrastructure. Its size and population is fairly similar to Puerto Rico and they are recognized as a key connecting country between the West and Asia. The country has 5,400 entities registered in Singapore and is also home to many global technology firms including Google, IBM, Meta, Amazon Web Services, and others (International Trade Administration 2022). The Singapore government has various funding schemes and grants for SMEs in the software services industry. These include the Startup SG Founder Grant, the Productivity Solutions Grant, and the Enterprise Development Grant, which provide funding for technology adoption, capability development, and market access.

Singapore has invested heavily in research and development in the software services industry, with programs such as the National Research Foundation’s Research and Innovation and Enterprise (RIE) plan. This has created opportunities for SMEs to collaborate with research institutions and access resources for developing innovative software solutions. Singapore has a highly skilled workforce and the government has implemented various initiatives to attract and retain talent in the software services industry. These include the TechSkills Accelerator (TeSA) program, which provides training and job opportunities in the technology sector, and the Global Talent Scheme, which allows companies to bring in foreign talent to address skills shortages.

Figure 4.9. Internet Key Stats

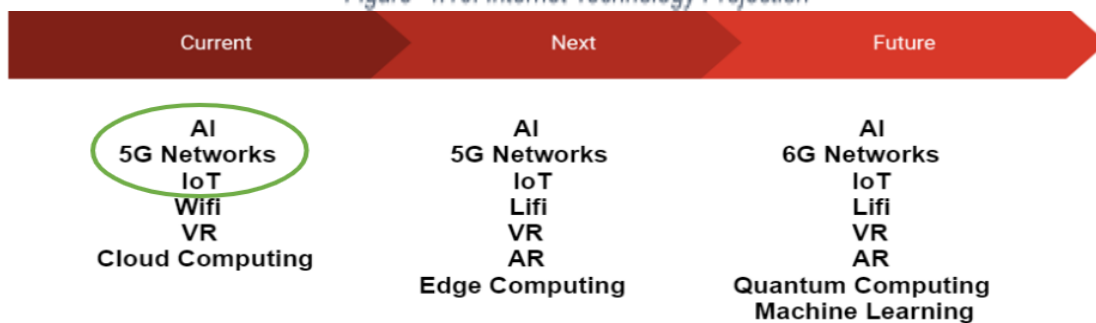


Overall, Singapore's success in bringing SMEs into software services can be attributed to its focus on creating a conducive environment for entrepreneurship and innovation, and its efforts to support the growth and development of SMEs in the technology sector.

4.3.2. Technology Recommendation

Through the analysis of these three nations within the information sector, we were able to generalize common themes that were critical to the success of a small nation with minimal capital. From the exploration of the wired and wireless communication of several countries, the general consensus has been a strong focus on having several key providers for the entire country. This supported their country in terms of greater investments in this technology and cheaper consumer pricing. Most of these countries were able to grow within these areas with strong relationships with conglomerates. Both parties benefit from large investments and help the country succeed in the long term. The high investment into wired and wireless communication also supports these countries to have the ability to succeed in R&D, which was consistently seen as a major contributor to the success of each country. This gives them the opportunity to focus on future cutting-edge technologies such as AI, IoT, and 5G.

Figure 4.10. Internet Technology Projection



After researching several leading countries' future technological investments and seeing how Puerto Rico can compare, we saw that it will require AI, IoT, and 5G in order to be a leader in the information sector. 5G is seen to be a barrier to entry in order for the country to succeed in AI and IoT. Technology companies continue to spend high R&D in all three areas which can support the countries that are seen to be leaders in those areas. AI, 5G, and IoT are all expected to remain of importance within the next five years. Over the next ten years, 5G is

expected to improve to 6G while AI and IoT will be as critical as ever. With a large investment into all three technologies, Puerto Rico would have a great opportunity to become a leading country for all corporations to invest in.

4.4. Financial Sector

Fintech will be one of the most important businesses in the digital world and the second largest contributor to Puerto Rico's GDP. Fintech, a portmanteau of "Financial Technology", refers to firms using modern technologies to compete with traditional financial methods in the delivery of financial services. Fintech applications are Payment & Fund Transfer, Loan, Insurance & Personal Finance, and Wealth management.

Artificial Intelligence, Blockchain, Cloud computing, and Big Data are regarded as the "ABCD" of fintech. Other widely used technologies are Application Programming Interface (API), Robotic Process Automation (RPA), Distributed Computing, Internet of Things (IoT), and Data Analytics.

The finance and insurance sector is an important segment of the economy made up of firms that provide financial services to commercial and retail customers. A strong financial and insurance sector is a sign of a healthy economy. The sector comprises a broad range of industries including banks, investment, insurance, and real estate firms.

The finance and insurance services industries make up 7.7% of the total U.S. GDP (Appendix 8.3). Global FinTech is growing at a CAGR of 20.5%, and the market is to hit USD 699.50 Billion by 2030 ("Top Companies, Growth Rate, Recent Trends, Business Opportunities, and Forecasts Analysis - Adroit Market Research" 2022).

Puerto Rico ranked 18 among Latin America and the Caribbean (Appendix 8.4). Financial services are the second largest sector in Puerto Rico (Appendix 8.3). Puerto Rico had the largest insurance premiums as a share of gross domestic product (GDP) in Latin America. Puerto Rico has STEM talents and attractive tax incentives are an added advantage. Puerto Rico has the advantage to offer international financial and banking entities (IFEs and IBEs). Puerto Rico has advanced technology and infrastructure to support skills like mobile banking, blockchain, and payment & fund transfer.

4.4.1. Leading Countries

Israel, Singapore, and Switzerland have been picked based on the global top 20 fintech rankings (Appendix 8.5) and used as comparable countries to Puerto Rico, as they have similar population size, land area, tax incentives, and support system for startups (Appendix 8.6).

Israel is growing at a CAGR of 16.1% ("An Overview of the Israeli FinTech Ecosystem Law" 2023) in the fintech sector. The competition among domestic banks fostered innovation in the fintech by constant launch of new products, hackathons and incubation. Their strategy is to focus on the challenges in Europe, Asia, or in the U.S. and design a solution to earn foreign currencies. The government is providing soft loans and funding to encourage startups.

Singapore is growing at a CAGR of 16% ("Singapore Fintech Market Size & Share Analysis - Industry Research Report - Growth Trends" 2023) in the fintech sector. Singapore is a large fintech hub in Asia. It's one of the frontrunners gaining smart city status through the Smart Nation program.

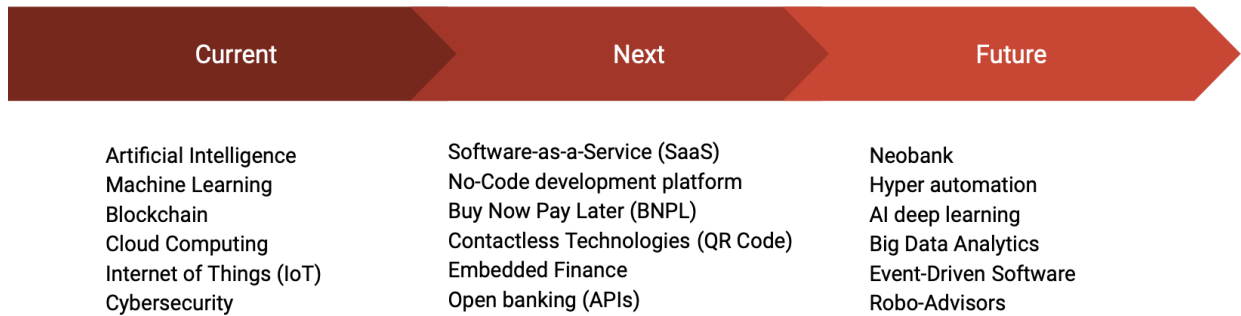
Switzerland is growing at a CAGR of 13.2% (Deep Knowledge Analytics 2021) in the fintech sector. Home to leading banks and insurance companies, as well as world-class research institutes and universities. A well-developed financial sector, an educated workforce, and a supportive regulatory environment are all important factors in attracting FinTech businesses in Switzerland. The below technologies and financial services are adopted widely in the leading countries,

- **No-Code or Low-Code Development Platform** is projected to grow at a CAGR of 28.1% by 2025. It is a visual development tool for enterprise-grade applications with minimal coding to accelerate the development process by relieving technical skills (“Low-Code Development Platform Market Size | Trends, Statistics, Forecast” 2019)
- **Buy Now Pay Later (BNPL)** is one of the fastest-growing trends in fintech. The global BNPL market is expected to grow at a CAGR of 33.3% during 2021-2026. Affirm Inc is the leading player in the BNPL Market (“The Buy Now Pay Later Market in 2021-2026: A Complete Overview” 2022)
- **QR Code Payment** adoption is predicted to surpass U.S.\$ 55.6 billion by 2033, exhibiting a CAGR of 16.9% between 2023 and 2033 (Accesswire 2023). QR Code makes it convenient to pay without withdrawing money and also saves time.
- **Embedded Finance** Market growing at a CAGR of 28.1% by 2029 in Latin America (“Growth Opportunities in the Embedded Finance Market in Latin America: CAGR of 28% Forecast During 2022-2029” 2022). Embedded finance is the placing of a financial product in a nonfinancial customer experience. Basically, the banks are behind the firms to finance their customers.
- **Banking as a Service (BaaS)** is an integrated financial service solution for third-party service providers through APIs. BaaS is a component of Open Banking and Embedded Finance.
- **Neobank** is an online bank that does not have a physical representation. All communications and customer services will be managed through smartphones or PCs. The advantages of new banks are low upfront costs, quick response time, and competitive pricing. The popular Neobanks in the world today are Revolut, Monzo, Statrys, and N26.

4.4.2. Technology Recommendation

Innovation in Fintech is endless as its constantly evolving emerging technologies. In Puerto Rico, the Fintech sector has great potential to attract small/medium foreign investors to leverage its technological skills and its tax incentives. Access to talent, proximity to business opportunities, and network effects are the keys to fintech innovation. Here are some recommendations based on the current, next, and future technologies in Fintech (Figure 4.11).

Figure 4.11. Financial Technology Projection



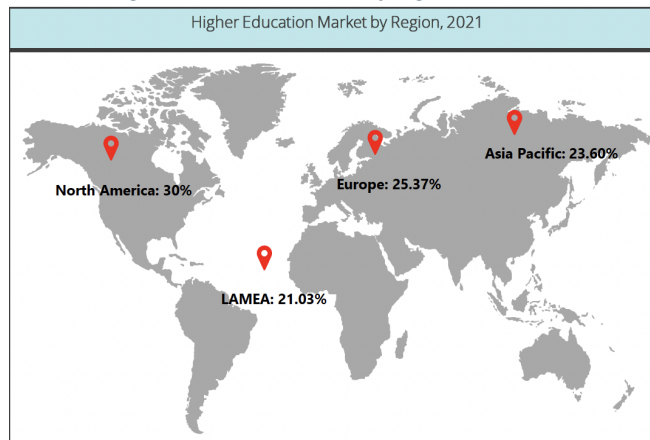
- Build Puerto Rico to become the first territory in the U.S. to **go cashless** by promoting mobile payments and online banking. This is possible only if all the mom & pop shops have card readers or QR Payments.
- Puerto Rico’s success in fintech will be based on the strong prospective demand, robust investment, **high-tech talent availability**, and regulatory environment.
- The future of Fintech depends on **Data Analytics**. It will strengthen the foundation of a firm's knowledge about its customer behavior, needs, and expectations.
- Blockchain, IoT, and hyper-automation that involves **Artificial Intelligence** and Machine Learning to automate business processes will increase efficiency and customer satisfaction.
- Develop Application Programming Interface **API** knowledge to integrate digital payment and banking methods for seamless online payment solutions to implement Banking as a Service.

4.5. Educational Services

Education services are fifth on our list as this sector is important for the development of human capital, improving workforce skills, and thereby attracting businesses to the island. This sector encompasses institutions providing training and instruction in various fields. These establishments can be schools, colleges, universities, or training centers that are privately or publicly owned and operated for profit or not-for-profit. These services can be provided through online and offline modes.

The global educational services market will be a \$10 trillion industry in 2030 growing at a CAGR of 4.5% (“\$10 Trillion Global Education Market in 2030” 2018). The sector revenue in the U.S. reached \$2.2 trillion in 2023 and will increase at a CAGR of 1.0% to \$2.3 trillion through 2028 (IBISWorld 2023). Figure 4.12 shows the share in each region.

Figure 4.12. Market Share of Higher Education



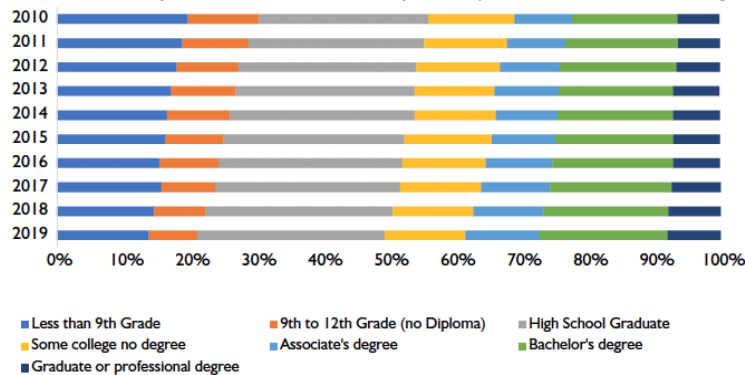
Source: Makreo Research & Consulting 2022, 10

The global higher education market was valued at \$85.24 billion with an expected CAGR of 11% through 2027 (Makreo Research & Consulting 2022, 10). North America has the highest market share followed by Europe, Asia Pacific, Latin America Middle East and Africa (LAMEA).

Educational services contributed to 0.5% of Puerto Rico’s GDP based on the Puerto Rico economic analysis report 2019-2020 (PR Bureau of Labor Statistics 2020, 7). Educational services is one of the important sectors for Puerto Rico as it provides significant social and economic benefits, including the development of skilled human capital and enabling other sectors to thrive. Puerto Rico has over 80 colleges and universities mostly offering 4-year degree programs. The average tuition fee for an undergraduate degree in Puerto Rico is \$4,304 (collegetuitioncompare 2023).

In recent years, education attainment has grown and there has been a 40% increase in total certificates and degrees awarded (Labandera, Santiago, and Laurel 2021, 8). Figure 4.13 shows the share of education attainment of the population in Puerto Rico (25 years and older). Factors positively favoring Puerto Rico as a higher education destination are its location, climate, two official languages, and affordability. The biggest threat Puerto Rico faces is declining population, especially the younger and traditional working-age population.

Figure 4.13. Share of Education Attainment of the Population in Puerto Rico Aged 25+

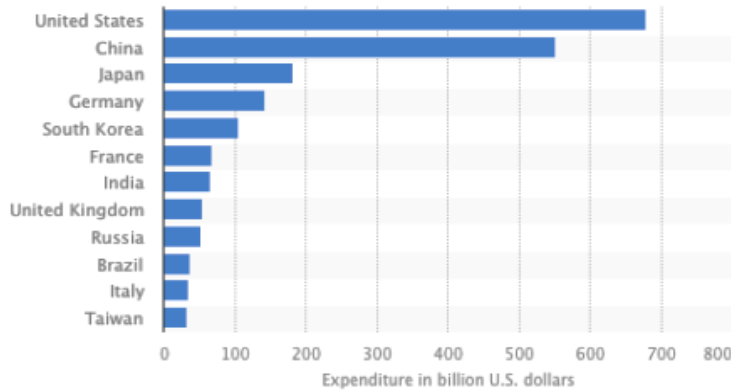


Source: Labandera, Santiago, and Laurel 2021, 8

4.5.1. Leading Countries

The USA, Germany, and Japan are performing well in this sector and are strong in their own ways. In terms of gross domestic spending in research and development, the United States is at the top, followed by Japan and Germany as shown in figure 4.14. Interestingly, all these countries have spent around 3% of their GDP on R&D. Puerto Rico’s spend on R&D in 2019 totaled 0.63% of its GDP (nces 2022).

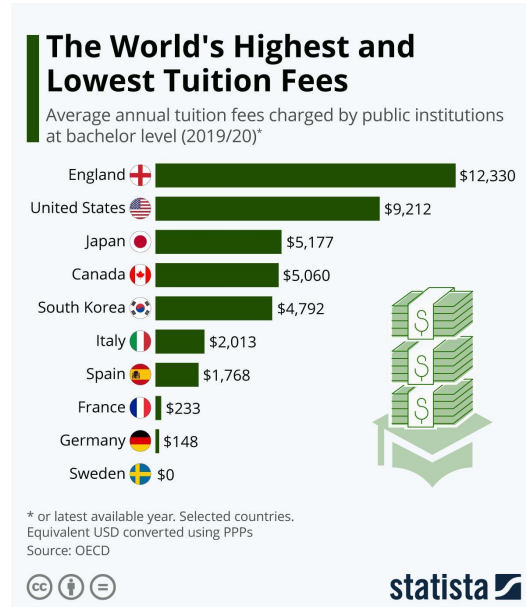
Figure 4.14. Leading Countries by Gross Research and Development Expenditure Worldwide in 2022 (in Billions of USD)



Source: Top countries by R&D expenditure 2022” 2022

In terms of affordability, Germany has the lowest average annual tuition fees charged by public institutions at the bachelor level followed by Japan and the United States (Armstrong 2021). Germany offers tuition-free education to both domestic and international students. This is an important factor in making education accessible to all students regardless of financial background.

Figure 4.15. The World's Highest and Lowest Tuition Fees



Source: Armstrong, 2021

Employability after graduation is an important factor for students in deciding what to study and where to study. Puerto Rico has high unemployment rates and the average salary post-graduation is very low compared to the mainland. Students graduating from universities in Puerto Rico find attractive opportunities in the U.S. mainland leading to a brain drain.

In terms of internationalization, Puerto Rico stands ahead as it has two official languages (English and Spanish). Though Universities in Germany and Japan offer English language courses, students may need to learn the local language to communicate outside the classroom. USA is the top host destination for international students in 2020 with 1,075,496 international students (5.5% of the total higher education population), Germany in the 7th spot with 302,157 students (5.5% of total higher education population), and Japan in the 8th spot with 228,403 students(6.2%) (Institute of International Education 2021).

The key insights from the leading countries are a strong focus on R&D; a culture of discipline and rigor for education- Japan is a top-performing OECD country in reading literacy, math, and sciences having 95% education attainment (OECD, n.d.); and accessibility for all (Germany). Key enablers for success in this sector are adequate funding to support research and infrastructure, access to technology, and collaboration with industry.

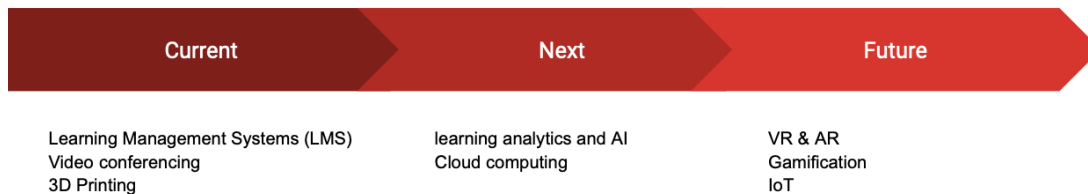
Figure 4.16. Puerto Rico in Comparison to Leading Countries - Education

Item	PR	USA	Germany	Japan
R&D	Base	+++	+	++
Affordability	Base	-	+++	+
Employment	Base	+	+	+
Internationalization	Base	-	--	--
Recognition	Base	+++	++	+

4.5.2. Technology Recommendation

Technology has been transforming the education sector in numerous ways, leading to an increased focus on student-centered learning, personalized instruction, efficient use of resources, and providing education to everyone, especially students who need to work during the day and others who cannot commute to school every day.

Figure 4.17. Education Technology Projection



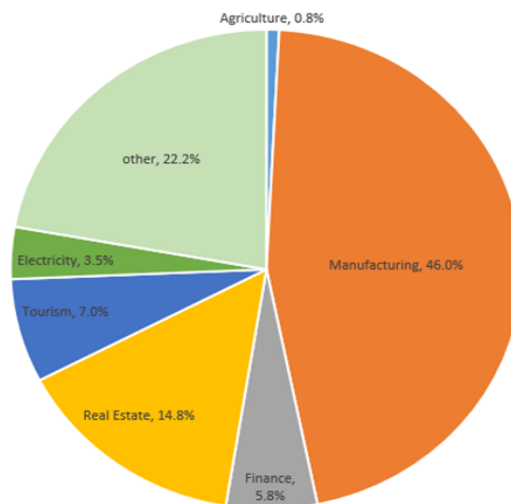
Learning Management Systems (LMS) platforms like Blackboard and Canvas have been widely adopted by universities to manage and deliver course content online. Video conferencing tools like Zoom and Microsoft Teams have become essential for remote learning and online meetings. In the next generation of technology implementation shown in Figure 4.17, Puerto Rico can utilize learning analytics and AI to analyze student performance, engagement, and behavior to improve and personalize learning experiences. AI can also help universities to study retention

rates based on student performance, and behavior to take actions needed to increase retention rates. Universities can utilize cloud computing to enable collaboration between students and teachers, as well as run applications and software. Immersive technologies such as VR & AR provide an interactive learning experience that simulates real-world scenarios and improves student engagement. Gamification mechanics can be incorporated into learning experiences to increase student motivation and engagement.

4.6. Utilities – Solar Energy

Followed by education services, the Solar Energy sub-sector presents an opportunity to generate reliable energy and reduce energy dependence on fossil fuels. This sector is focused on the Utilities that are further narrowed down to the solar energy sub-sector primarily due to several opportunities offered by Puerto Rico’s geography and economy. Electricity contributes 3.5% of the total Puerto Rico GDP (National Renewable Energy Laboratory (NREL) 2020). 80% of Puerto Rico’s electricity is generated by fossil fuels and the rest is attributed to Hydro, Wind, and Solar. Compared to top solar energy generating countries like the USA at 123GW, Germany at 58GW, and Japan at 74GW (Statista 2022), Puerto Rico's solar energy generation capacity is at just 147.1MW (National Renewable Energy Laboratory (NREL) 2020) while the demand for a reliable source of electricity is very high. With the high demand and need for less dependence on fossil fuels, which are getting expensive every day, investments in solar energy are one of the biggest opportunities for Puerto Rico’s economic development. With an increased push for the development of the solar energy sector comes a high need for digital technologies. Digitalizing is important as it allows for more efficient, reliable, and cost-effective operation of solar energy systems.

Figure 4.18. Puerto Rico GDP Contribution
GDP contribution



4.6.1. Leading Countries

The Solar Energy Market is expected to reach 1015.4 GW by the end of this year and is projected to register a CAGR of 12.7% during the forecast period (Mordor Intelligence™ Industry Reports 2023). Shown below is the CAGR for leading solar energy-generating countries.

- USA Solar Energy CAGR 17.32% (Mordor Intelligence™ Industry Reports 2023)
- Japan Solar energy CAGR 9.2% (Mordor Intelligence™ Industry Reports 2023)
- Germany Solar energy CAGR 7% (Mordor Intelligence™ Industry Reports 2023)

The United States is one of the leading nations in the development and adoption of solar energy, and digital technologies. The country has made significant progress in developing and deploying solar energy, which is driven by a combination of government incentives, declining costs, and growing demand for clean energy. The U.S. generates 123 GW of energy, enough to power 20 million homes in the country and this market has grown at an average rate of 24% each year in the U.S. alone. Solar accounted for 50% of all new electricity-generating capacity added to the U.S. grid in 2022, the fourth consecutive year that solar was the top technology for new additions. In terms of job generation, the Solar industry employed more than 255K employees. Most importantly, 161 million metric tons of carbon emissions were reduced, which is equivalent to not using 18 billion gallons of gas (Solar Energy Industries Association 2023). With falling prices, increased government regulations, and incentives, investing in this sector is a great opportunity for a sustainable future.

Japan is another leading county in generating solar energy. With high dependence on fossil fuels and increasing prices of fossil fuels, Japan is actively promoting the development and use of solar energy. By 2021, Japan had installed a solar capacity of 74GW, according to a report from Mordor Intelligence. Solar energy accounted for 8% of Japan’s total electricity generation in 2020 and created about 200K jobs according to the Ministry of Economy, Trade and Industry (METI). Japan’s government is encouraging solar energy through subsidies, FITs, and also regulations like mandatory solar for all residential constructions after 2025.

Despite being among the countries with the least sunshine hours, Germany is one of the largest solar power producers in the world. With an installed capacity of nearly 60 gigawatts (GW) in 2021, the country ranked 4th globally (International Renewable Energy Agency 2023) after leading the field for several years. With the share of solar systems in net public electricity generation at 12% and 2.5 million systems installed, Germany was able to save 41.7 million tons of greenhouse gas emissions in CO2 equivalents. Not to mention the economic impact of solar energy which added about 12 million Euro revenue and 55K jobs. (BSW Solar 2023)

Puerto Rico, being in an advantageous location with ample sunlight and consistent average weather conditions, is a great place to invest in solar energy. With 80% of electricity generated using fossil fuels, Puerto Rico can take advantage of solar energy and reduce its dependence on fossil fuels. This strategy can save money, as the price of fossil fuels has been increasing. The problem of unreliable electricity both for residential and commercial purposes can also be overcome using investments in solar energy. Puerto Rico is one of the 3 U.S. states to set a goal to use 100% renewable energy by 2050 (National Renewable Energy Laboratory (NREL) 2020) and is providing several rebates, incentives, and funding to develop solar energy infrastructure.

Figure 4.19. Puerto Rico in Comparison to Leading Countries - Solar

Item	PR	USA	Japan	Germany
Government support	Base	++	++	++
Digital technology usage	Base	+++	+++	+++
LCOE of solar energy	Base	+++	+	++
Demand	Base	++	++++	+++
Location and weather	Base	++	++	++
Jobs	Base	+++	++	+

The adoption of several digital technologies like data analysis, AI/ML and IoT can optimize the generation and distribution of solar energy in Puerto Rico. For example, although Germany has less sunny days, it is using technologies like AI/ML, data analytics, IoT, digital twins, and blockchain to increase the efficiency of solar farms. Similarly, even with less land availability, Japan is one of the top countries in solar energy generation. This would not be possible without the use of advanced technologies along with digital technologies like data analytics, ML/AI, etc.

Figure 4.19 shows the comparative advantages of each country relative to each other and with respect to Puerto Rico. The table also lists any areas of opportunities for Puerto Rico compared to other countries.

4.6.2. Technology Recommendation

Figure 4.20. Solar Technology Projection

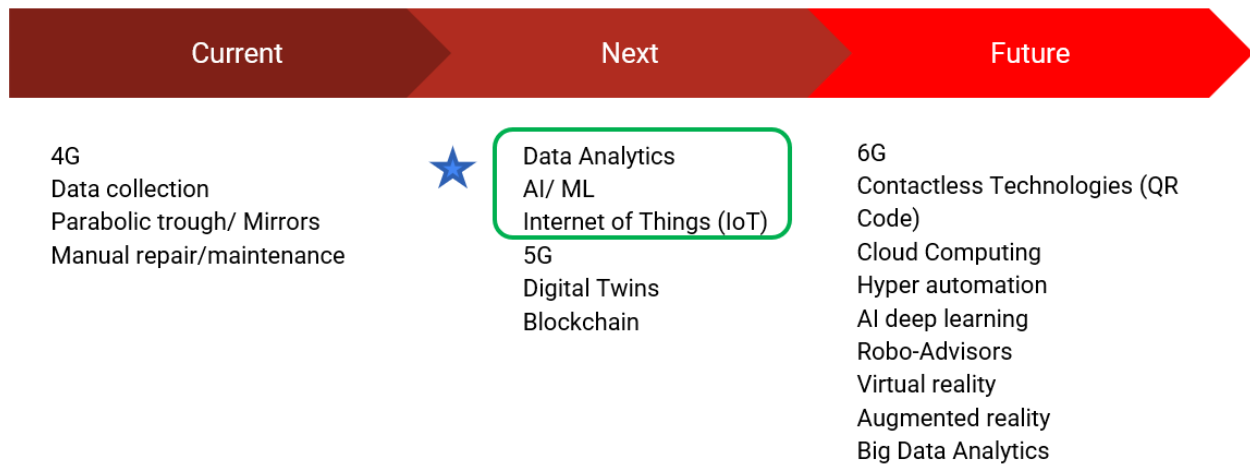


Figure 4.20. illustrates the current status of technology usage on the island followed by our tech recommendations (highlighted), which are then followed by potential tech upgrades in the future.

Data analytics plays a crucial role in the solar industry. Based on the historic data, the potential of a given area for setting up a solar farm can be assessed. Data analysis also includes analyzing historical weather data, satellite imagery, and other sources to determine the amount of solar energy that can be generated in a particular location. This technology can help develop models to support power needs for customers, both residential and commercial. Data and its analysis are also needed to support other digital technologies like AI/ML, automation, etc.

Secondly, **AI/ML** is rapidly transforming the solar energy industry in other advanced countries. These technologies will help Puerto Rico improve efficiency on existing and future solar infrastructure. For example- AI/ML can help optimize the design and placement of solar panels for maximum energy production, predict maintenance requirements for solar panels and other components in a solar energy system, optimize energy management in solar systems, including energy storage and grid integration, optimize the design and operation of solar panels, such as adjusting and orienting solar panels based on changing weather conditions and other factors to maximize energy production and to optimize the integration of solar energy into the electric grid by predicting energy demand and adjusting solar energy production to meet that demand.

Finally, using **IoT**, the solar industry can benefit from real-time monitoring, control, and optimization of solar systems to enhance the consumer experience. Some examples of IoT usage can be found in monitoring solar energy systems in real-time to track energy production, detect issues, and optimize performance. IoT devices can be used to control solar systems that help adjust the tilt and orientation of solar panels based on the Sun's movement. The use of IoT sensors can also be extended to detecting issues, enabling companies to perform proactive maintenance and avoid downtime, and monitoring the solar systems remotely from any place.

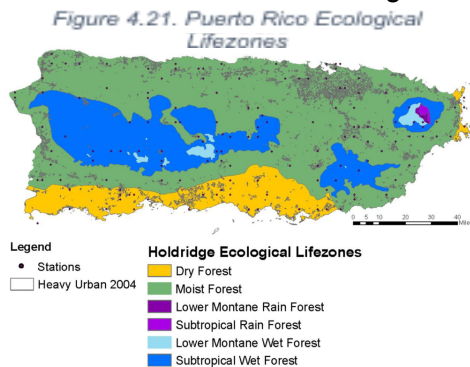
In the future, the solar energy sector has the potential to adopt several other technologies like Blockchain, Digital Twins, Big Data Analytics, and Cloud Computing to further optimize solar systems and their operations.

Puerto Rico should start utilizing data analytics during the positioning and construction of solar installations by using existing data to strategically locate solar plants and power requirements. After installing solar, AI/ML and IoT should be immediately implemented to effectively operate and maintain the solar infrastructure.

4.7. Film Production

The beautiful and diverse landscape makes Film production an attractive sector for Puerto Rico. This sector includes all the technology and production needed to make films for companies, studios, and festivals. As an archipelago, Puerto Rico is situated between North America and Latin America and has unique sceneries that can replicate a variety of world landscapes which gives it an opportunity to thrive in this slowly growing industry.

Though the United States, through Hollywood, is the leading box office market and is anticipated to remain that way for the foreseeable future, Puerto Rico can capitalize on many of its competitive and comparative advantages. Puerto Rico only has 3,425 square miles of land, but it has diverse climates throughout the island as seen in Figure 4.21. These vastly different climates in such a small area give film producers the opportunity to have many scenery choices



Source: Torres-Valcárcel et al.

without having to travel the world. This is especially helpful for small and medium production companies without the economic resources that established production studios have. In addition, Puerto Rico has another comparative advantage for the film industry and that is the labor market is cheaper than many traditional film production locations such as the United States or Western Europe.

As for the competitive advantages, Puerto Rico offers both comprehensive corporate and individual tax breaks that can offset much of the filmmaking costs. Act 60 allows for 40% of production expenses to be counted towards tax credits for Puerto Rico residents and 20% for non-residents up to \$4 million annually. Massive tax credits implore both local production studios to stay on the island as well as outsiders to seek Puerto Rico for producing films.

4.7.1. Leading Countries

In terms of revenue by country, there is a clear first and second ahead of the rest of the pack. Figure 4.22 shows the large gap that the United States and China have amongst the rest of the world. The United States, China, and Japan have various reasons why they are the top countries in the world when it comes to the film industry. Since the U.S. has some of the most established production studios in the world and a large population with disposable income, it becomes a target audience.

As for China, due to strict government regulations, the Chinese government must approve all content before being shown to its population, so films have to be specially crafted for that market. For foreign production studios to enter

the Chinese market, they must also either agree to a reduced revenue-sharing method, a reduced-flat fee sale, or co-producing with a Chinese company. These all enable Chinese film producers to have the upper hand in the Chinese market as well as learn the tricks of the trade from some of the leading international production companies.

Japan is a distant third in terms of revenue by country, but the reason it beats most of the world is the uniqueness of the population. There is a growing trend in Japan to not have kids which are leading to both freer time and disposable income. In addition, the Japanese population utilizes social media efficiently to find the latest movie clips and thus become excited to see the latest films.

When comparing Puerto Rico to the top three countries in the world from a film industry

Figure 4.24. Puerto Rico in Comparison to Leading Countries - Film

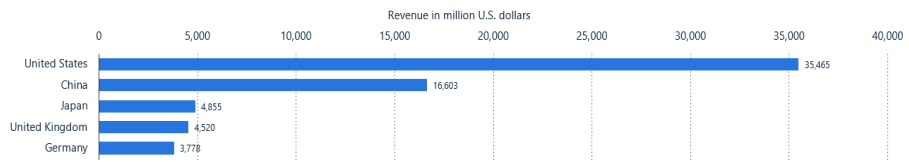
Item	PR	US	China	Japan
Tax Incentives	Base	-	-	-
Established	Base	+	0	+
Government Power	Base	0	+	0
Population	Base	+	+	+
Backdrop	Base	-	-	-
Social Media	Base	+	-	+

production studios that have been successful for the past few decades. Population refers to the number of people with disposable income and a propensity to spend on films. Backdrop refers to the closeness of distinct sceneries or climates that can be utilized for a wide range of movies.

Overall, we can see that Puerto Rico has advantages in tax incentives as well as its natural backdrop. That being stated, the lack of a large population with disposable income sets it behind, but Figure 4.23 shows some takeaways from the leading countries that Puerto Rico could adopt which was created by the team.

Figure 4.22. Projected Global Film Revenue by Country

Estimated filmed entertainment revenue in selected countries worldwide in 2025 (in million U.S. dollars)
Forecast filmed entertainment revenue in selected countries worldwide 2025



Source: Filmed Entertainment Revenue Worldwide by Country 2023

perspective, there are clear comparative and competitive advantages for each country which can be seen in Figure 4.24 which was developed by the team. Using Puerto Rico as the baseline, a negative sign (-) means that the country is worse off than Puerto Rico, a positive sign (+) means that the country is better off than Puerto Rico, and a null (0) means that the country is relatively similar to Puerto Rico. The established line item refers to

Figure 4.23. Film Industry Key Takeaways

Promote Local Talent

Insights

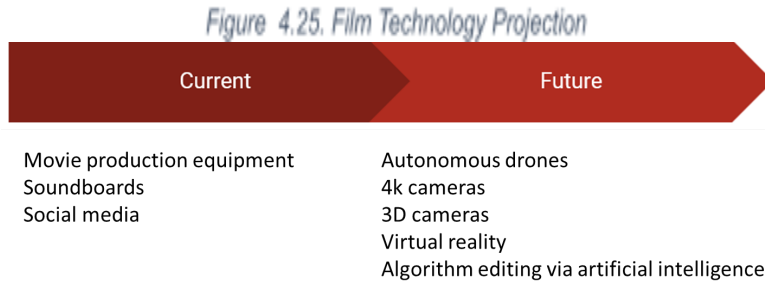
- AI** is one of the leading emerging technologies that will be pushed in the industry
- Scenery** is still vital in the film industry, despite the new technology
- Population** that has a growing amount of disposable income is important for films to cater towards that group

Enablers

- Tax incentives and Unique Scenery
- Promoting local talent to create an incubator

4.7.2. Technology Recommendation

Artificial intelligence in the film industry is being used to edit scenes throughout the movie. Figure 4.25 shows the projected technologies in the sector as a summary that was developed by the team. The artificial intelligence technology being employed in the film industry significantly cuts down the time needed to make edits as the algorithm can superimpose faces

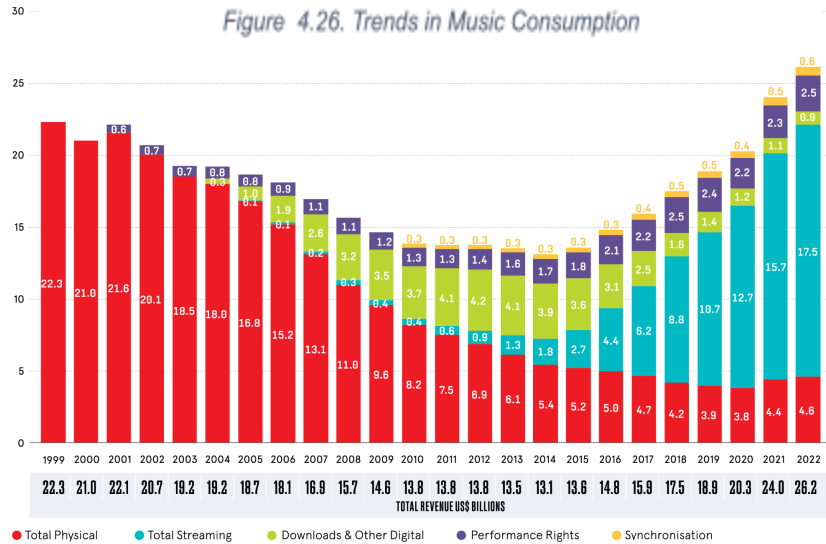


or features on certain parts. In addition, the algorithm can be taught to pick the best cuts, scenes, and angles to give the best results without a human having to watch hours of film and make tedious edits. Leading countries also have creative or film industry hubs that allow for sharing of ideas and

equipment. Up-and-coming film producers could thrive in an environment that is collaborative and allows for rental equipment as well as marketing connections to assist in the advertisement so that the up-and-coming film producers will be known and relevant beyond the archipelago. The rental equipment should include at a minimum, drones, 4k cameras, and editing equipment that can access artificial intelligence and machine learning algorithms.

4.8. Music Production

The bilingual and vibrant culture makes music production very attractive in Puerto Rico. This sector encompasses the creation, production, and distribution of music. Due to a smaller population, situated between North America and Latin America, Puerto Rican musical artists have found success in making songs that are enjoyed by both Americas. Since 2014, the global music industry has grown year over year due to the emergence of streamable content. Looking at Figure 4.26, streaming makes up over 67% of the entire global revenue within the industry while physical sales and revenue have steadily decreased since 1999.

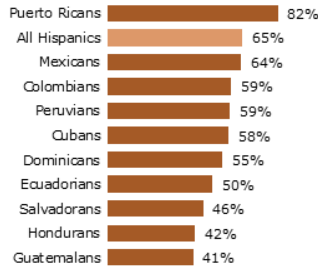


Puerto Rico has distinct comparative and competitive advantages that allow it to compete with leading countries in the music sector. This is not to say that the archipelago will be able to be a leading country and topple the giants in the United States; but there are unique elements to Puerto Rico that can be leveraged to improve the sector and GDP.

Due to Puerto Rico's dual language system, it is the leading country/territory in English

Figure 4.27. Hispanic English Speakers

Share of U.S. Hispanic Population Ages 5 and Older Proficient in English, by Origin, 2010



Notes: "Proficient in English" includes those who speak only English at home or speak English very well. Total U.S. share is 91%.

Source: Pew Hispanic Center tabulations of the 2010 ACS (1% IPUMS)

PEW RESEARCH CENTER

Source: Motel, Seth, and Eileen Patten. 2012

proficiency amongst the Hispanic population within the U.S. as seen in Figure 4.27. This is a massive advantage as the laborers can speak the world's language. In addition, local artists can create music for the largest music consumer - The United States - as well as the fastest-growing region - Latin America. Since Puerto Rico does not have a large population, it must export its music to generate revenue and with it located between the U.S. and Latin America, it can create music for multiple regions easily. The ability to know the target audience is crucial in becoming famous and well-known in the music industry.

Similar to other entertainment industries, Puerto Rico offers both comprehensive corporate and individual tax breaks that can offset much of the music production costs. Act 60 allows for 40% of production expenses to be counted towards tax credits for Puerto Rico residents and 20% for non-residents up to \$4 million annually. Massive tax credits implore local production studios to stay on the island and cultivate Puerto Rican talent.

4.8.1. Leading Countries

The top countries in terms of the music market are the U.S., Japan, and the United Kingdom (UK). In addition to these countries, the Latin America region is experiencing massive growth that is partly due to unlocking the streamable music market within the countries.

The United States is a leading country due to the amount of established music production studios that exist within the borders which can be seen by Figure 4.28. In addition to these established production studios, the U.S. has one of the globe's target audiences which allows the domestic producers to know the culture and music that will be best accepted. The emergence of streaming and social media has accelerated new artists within the country and showcased international artists without having a label attached to them.

In the UK, the population has a large amount of disposable income and a willingness to spend on both music and concerts. Since the United Kingdom speaks English, much of the music that is made for the United States can be repurposed for the UK population. Japan, on the other hand, is a leader in the music market due to its high number of people with disposable income as well as its ability to consume media through short bites from social media. There is an emerging music and entertainment hub in Southeast Asia that also keeps Japan at the forefront of this sector. When comparing Puerto Rico to the top three countries in the world from a music industry

Figure 4.28. Leading Countries in Music



Source: IFPI 2022

Figure 4.29. Puerto Rico in Comparison to Leading Countries - Music

Item	PR	US	Japan	UK
Tax Incentives	Base	-	-	-
Established	Base	+	0	0
Cultural Influence	Base	+	0	-
Population	Base	+	+	+
Social Media	Base	+	+	0

perspective, there are clear comparative and competitive advantages for each country as seen in Figure 4.29 based on a summary of all of our research that we created. Using Puerto Rico as the baseline, a negative sign (-) means that the country is worse off than Puerto Rico, a positive sign (+) means that the country is better off than Puerto Rico, and a null (0) means that the country is relatively similar to Puerto Rico. The established line item

refers to production studios that have been successful for the past few decades. Population refers to the number of people with disposable income and a propensity to spend on music and concerts. Cultural influence is based on music’s origins and how various genres became popular. For example, though Salsa originated in Cuba, it became a musical phenomenon due to the Puerto Rico-Americans that immigrated to the U.S..

4.8.2. Technology Recommendation

The leading production studios and countries leverage emerging technology such as augmented reality, virtual instruments, and artificial intelligence. Though music is most consumed via streaming services, there is still a push to give an authentic experience when listening to music whether at concerts, festivals, or in-home. This can be done via holograms or virtual DJs that utilize artificial intelligence.

Figure 4.30. Music Technology Projection

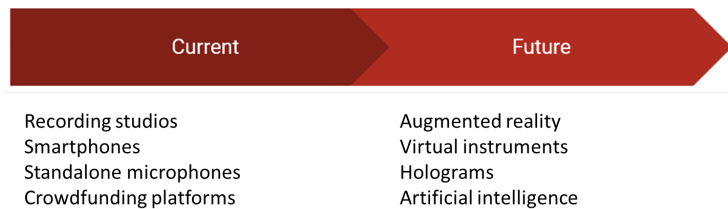


Figure 4.30 displays the projected technology growth within the sector based on a summary of all of our research that we created.

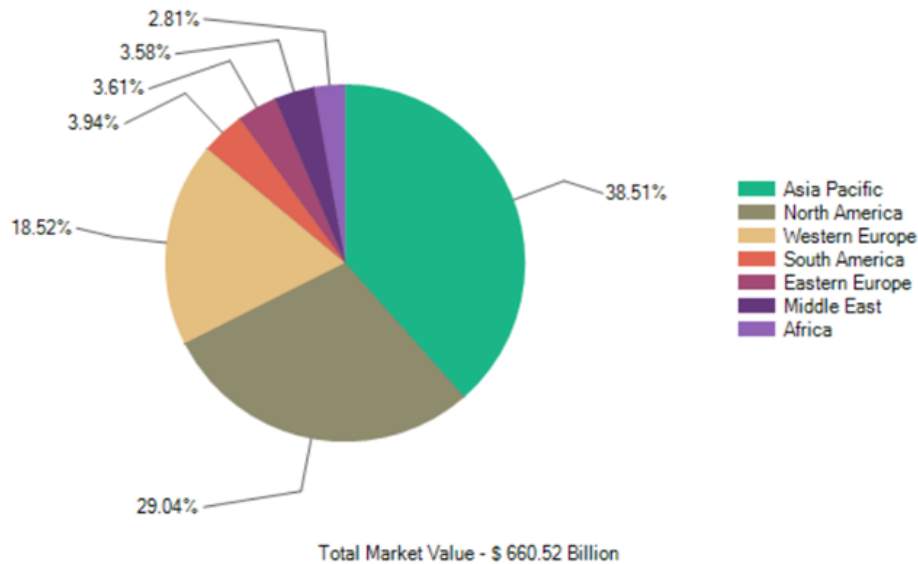
Artificial intelligence is a technology that has not been fully analyzed in the industry, but given the need for better streamable content and a more inclusive concert experience, this is something that will continue to evolve. In addition to these new technologies, it is also required to have a stable internet connection to share up-and-coming musical artists so that people outside of Puerto Rico can experience the culture. Many local musical artists could benefit from an entertainment hub where current and emerging technologies could be leveraged. This could look like having virtual instruments available for rent or avenues where social media and marketing firms partner with talent.

4.9. Storage and Warehousing

Finally, storage and warehousing are essential for handling Puerto Rico logistics and supply chain management. This sector is focused on the sales of warehousing and storage services by entities (organizations, sole traders, and partnerships) that operate warehousing and storage facilities for general merchandise, refrigerated goods, and other warehouse products that service manufacturing, wholesale, and retail sectors. These establishments generally handle goods in containers, such as boxes, barrels, and/or drums, using equipment, such as forklifts, pallets, and racks.

Based on a report from a business research company, the global warehousing, and storage (W&S) market is expected to grow from \$660.52 billion in 2022 to \$950.84 billion in 2027 (The Business Research Company 2023) at a CAGR of 7.4%.

Figure 4.31. Global Storage and Warehousing - Split by Region in 2022



Source: The Business Research Company, 2022

With the rise in e-commerce and country-provided opportunities like free trade zones (FTZ), Puerto Rico can make use of its strategic location to store and distribute goods. Also with the existing manufacturing sector in Puerto Rico, the W & S sector has a great opportunity to expand. Compared to other countries such as the UK, which has a CAGR of >5% (Mordor Intelligence™ Industry Reports 2023) and location of several FTZs, Germany, with an industry valued at €25 Bn along with being ranked #1 in Europe (IBISWorld 2023), and HongKong, which is also a strategic location in Asia and smaller country with efficient W&S services, Puerto Rico has immense opportunity to learn and adopt the technology practices from these countries and make use of its location and other factors to benefit from.

4.9.1. Leading Countries

Germany, with a land area of 138,065 sq. miles, is located in the heart of Europe, making it an ideal location for warehousing and distribution. The country is home to 10 major ports (Mohit and Marine Insight 2021), which are key gateways for goods entering and exiting Europe. Germany also has a well-developed transportation system, including highways, railways, and air cargo facilities. This allows the efficient movement of goods throughout the country and into countries within the European Union, which means that goods can move freely between member countries without customs duties. Germany is a leader in technology and innovation, and this extends to the warehousing and logistics industry. Many warehouses in Germany are equipped with the latest technologies, including automated systems and other warehouse management equipment like robots, IoT sensors, devices, etc. Germany also has strict regulations governing the storage and handling of goods, which ensures that warehouse facilities are safe and secure.

Hong Kong, with a land area of 430 sq. miles that is about 8 times smaller than Puerto Rico, is a strategic location for the movement of goods within Asian countries. As one of the regional hubs for Asia, Hong Kong has good connections with most Asian countries, and about half of the world's population is within 5 hours of flight time. Prior to the pandemic, around 120 airlines linked the Hong Kong International Airport (HKIA) to about 220 destinations worldwide (Hong

Kong International Airport 2022), including about 50 destinations in mainland China. Hong Kong is also equipped with a well-developed seaport with 9 container terminals and an airport with five first-tier cargo handling facilities, and transportation infrastructure to transfer goods to other countries. Hong Kong, being a free trade zone port provides business-friendly imports and exports along with minimal restrictions on international trade. Hong Kong is using digital technologies that are poised to create efficiencies in the W&S industry by introducing applications that allow customers better track and manage their shipments in real-time. With the 5G network, Hong Kongers enjoy faster internet access and have access to next-generation Internet of Things (IoT) applications and solutions (International Trade Administration 2023). Hong Kong is investing in AI/ML heavily to create efficient warehouse management systems.

The United Kingdom (UK), with a land area of 94,058 sq miles is also a great location for the W & S sector because of its close proximity to Europe. The country's sea ports, airports, and extensive road and rail networks provide easy access to other parts of the world, most importantly to the European region. The UK has a well-developed infrastructure that includes advanced telecommunications, transportation, and energy systems. This makes it easier for businesses to manage their operations and respond to customer needs. UK's warehouses are used by e-commerce businesses to store their inventory and fulfill orders when needed. They are often highly automated and use advanced technologies such as robotics and artificial intelligence to optimize their operations. The UK also offers several free trade zones, also known as freeports, which are designated areas within the country that offer special customs and tax incentives to businesses operating within them. The UK government has established eight freeports in England (Maan and Morris 2021), which attract investment, create jobs, and boost economic growth.

Like Germany, Hong Kong, and the UK, Puerto Rico can benefit from its strategic location with easy access to the U.S. mainland, Latin America, and the Caribbean. Free trade zone 61 lets Puerto Rico offer numerous tax incentives and other benefits to businesses that operate on the island. These incentives include tax exemptions (Act 159) on corporate income, property, and excise taxes, as well as special deductions for research and development expenses. In addition to tax incentives, Puerto Rico's FTZ also offers a skilled workforce, modern infrastructure, and a strategic location that makes it an attractive location for businesses looking to expand into Latin America and the Caribbean. Locations of various seaports can be found in Figure 4.32. below.

Figure 4.32. Location of Various Seaports in Puerto Rico



Source: Seabury Maritime, 2019

Although Puerto Rico has several advantages, it faces challenges like high cost of real estate, limited land, natural disasters, and unreliable power especially for refrigerated storage. These challenges can be turned into opportunities by using digital technologies like 5G, data analytics, IoT, AI/ML, automation, etc.

Figure 4.33. shows comparative advantages of each country relative to each other and with respect to Puerto Rico. The table also lists any areas of opportunities for Puerto Rico compared to other countries.

Figure 4.33. Puerto Rico in Comparison to Leading Countries - Storage/Warehousing

Item	Puerto Rico	UK	Germany	Hong Kong
Location advantage	Base	+	++	+++
Advanced technologies	Base	++	+++	+++
Free trade zones	Base	++	+++	++
Demand	Base	++	+++	++++
Reliable energy	Base	+	+++	+++

4.9.2. Technology Recommendation

Figure 4.34. Storage and Warehousing Technology Projection

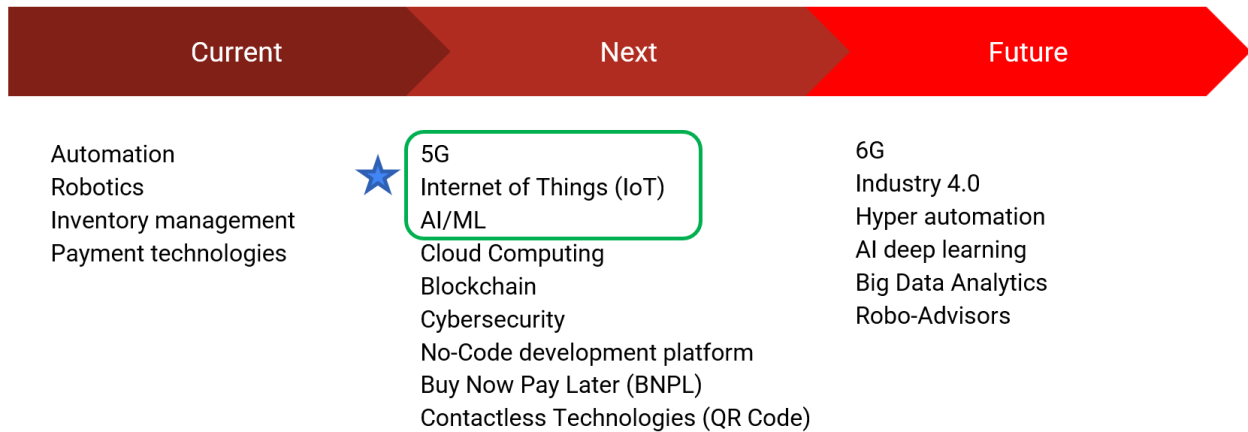


Figure 4.34. illustrates the current status of technology usage on the island followed by our tech recommendations (highlighted), which are then followed by potential tech upgrades in the future. With strategic investments in digital technologies like 5G, IoT, and ML/AI, Puerto Rico can benefit immediately, with the help of existing warehouses and associated equipment, data centers, HPCs, and skilled labor.

5G Technology has the potential to revolutionize the W&S industry by enabling faster and more reliable communication between devices and systems. It can enable real-time tracking of inventory using IoT, enhance autonomous vehicle communication, improve worker productivity by enabling faster and more reliable communication between warehouse workers and management systems, and support remote monitoring of warehouse operations. Overall, 5G technology has the potential to improve efficiency, accuracy, and safety in storage and warehousing operations, enabling businesses to operate more effectively and cost-efficiently.

The Internet of Things (IoT) along with other digital technologies will improve the efficiency, productivity, and safety of warehouse and storage operations. For example - IoT sensors can be used to monitor inventory levels and locations in real-time. They can be used to track the location of vehicles and other equipment. IoT sensors can monitor the condition of goods and equipment, by using temperature or humidity sensors, to ensure that they are stored under the appropriate conditions. They can be used to monitor equipment performance and predict when maintenance is needed, helping to prevent equipment failure and reduce downtime. Finally, IoT can be an important tool to monitor worker safety and energy usage in the warehouse.

Artificial intelligence and Machine learning (AI/ML) is another set of technologies that enable a smart warehouse. As warehouse operations trend towards being automated, AI/ML will help optimize the movements of autonomous vehicles and other robots by improving the accuracy and speed of material handling operations. AI/ML algorithms can analyze historical data and predict future demand. It can also predict quality issues and proactively predict failure or maintenance of equipment. Lastly, AI/ML can analyze sensor data to detect safety risks and alert managers to take corrective action.

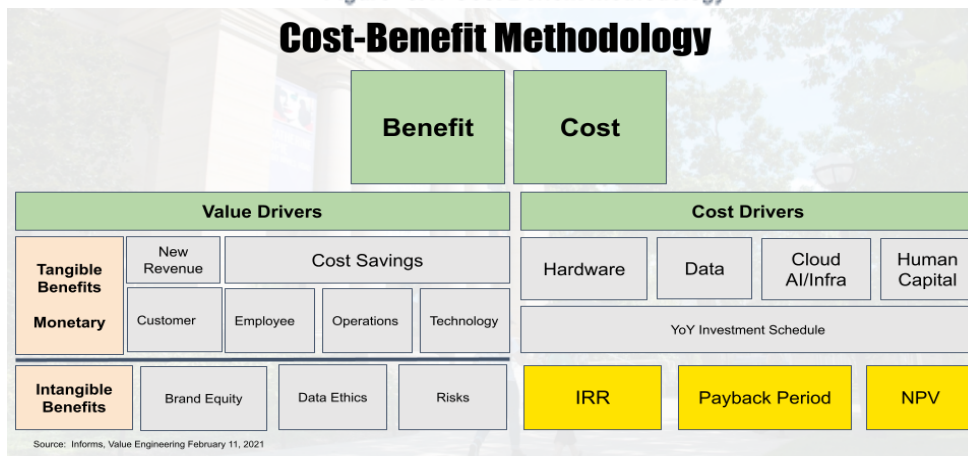
Several other advanced technologies can be implemented in later stages as the sector gets matured. Some of them include but are not limited to, Cloud Computing, Blockchain, 6G, Hyper Automation, AI Deep Learning, Big Data Analytics, etc

5. Cost-Benefit Methodology

The cost and benefit of implementation of a technology can help determine the success of it in any sector. Through research of different cost-benefit methodologies to be used across businesses looking to measure the benefits, it was determined that the cost methodology shown in Figure 5.1 and Published by Informs (Nath 2021) is the most useful. This concept can be used to deduct the true value and cost drivers of a potential technology solution and give all stakeholders an opportunity to see the amount of capital needed to fund each project.

The first step within this cost-based approach is to identify the current technological gaps a company is facing and how it would be able to close these gaps after implementation. Some questions that could be asked prior to using this methodology are asking what are the current state of the company's activities, what the overall goals of the organization are and what are the key value drivers within the company.

Figure 5.1. Cost Benefit Methodology



Source: Informs Value Engineering, 2021

5.1. Value Drivers

When using the value drivers, a company looking to invest is to identify the possible tangible and intangible benefits. Looking into the value drivers, a company would be able to review the potential new revenue and cost reduction opportunities. For cost reduction, it is helpful for a company to calculate the possible reduction of employees, operational efficiency improvement, and reduction in alternative technology use with the implementation of AI. For new revenue, a company could work to determine the number of new customers they would acquire due to the reduction in costs that could lead to a lower sale price or an increase in capabilities. Increasing operational efficiency, capabilities, and potentially price can also support the brand of the company and install trust from its customers. These are a few of the intangible benefits that could be used to help support business cases to implement potential technology.

5.2. Cost Drivers

Cost drivers are as critical as the value drivers in order to fully determine the worth of a potential investment. The standard investments needed for any technology would be the hardware, data storage, cloud infrastructure, and skilled technical support to keep the technology to function smoothly. All the tangible benefits and main cost drivers mentioned above can be added to a YoY investment schedule. From this schedule, the company would be able to calculate the Net Present Value, Internal Rate of Return, and Payback period to make the decision on whether to invest in technology.

5.3. Lufthansa MRO Example

Lufthansa can be used as an example for this methodology as they are one of the large companies operating in Puerto Rico. Let's say that Lufthansa MRO is considering implementing AI in its aircraft maintenance processes. The project can be expected to cost \$1 million upfront for the overall software and hardware with a useful life of 20 years, as well as \$40,000 per year for data storage, \$150,000 per year for technical support, \$10,000 per year in cloud infrastructure, and \$50,000 per year for the servers.

We can say this could generate a cost savings of \$500,000 per year over the next 5 years. This cost savings would mostly come from a \$150,000 reduction in workforce, a \$100,000 reduction in alternative technology services, and a \$250,000 reduction in waste and lost time with increased operational efficiency. We can also estimate a \$150,000 salvage value if we were to sell this over

To calculate the NPV, IRR, and payback period, we need to discount the cash flows to their present value. Let's assume a discount rate of 10%.

Figure 5.2. Total NPV Example

	0	1	2	3	4	5	6
Revenues		\$500,000.00	\$500,000.00	\$500,000.00	\$500,000.00	\$500,000.00	\$500,000.00
- Operating expenses		(\$250,000.00)	(\$250,000.00)	(\$250,000.00)	(\$250,000.00)	(\$250,000.00)	(\$250,000.00)
- Depreciation		(\$50,000.00)	(\$50,000.00)	(\$50,000.00)	(\$50,000.00)	(\$50,000.00)	(\$50,000.00)
= Taxable Income		\$200,000.00	\$200,000.00	\$200,000.00	\$200,000.00	\$200,000.00	\$200,000.00
- Tax (18.5%)		(\$37,000.00)	(\$37,000.00)	(\$37,000.00)	(\$37,000.00)	(\$37,000.00)	(\$37,000.00)
= NOPAT	\$0.00	\$163,000.00	\$163,000.00	\$163,000.00	\$163,000.00	\$163,000.00	\$163,000.00
+ Depreciation		\$50,000.00	\$50,000.00	\$50,000.00	\$50,000.00	\$50,000.00	\$50,000.00
- Gain (Equipment)							\$150,000.00
= Operating Cash Flows	\$0.00	\$213,000.00	\$213,000.00	\$213,000.00	\$213,000.00	\$213,000.00	\$363,000.00
- Investment in fixed assets	(\$1,000,000.00)						
=Free Cash Flow	(\$1,000,000.00)	\$213,000.00	\$213,000.00	\$213,000.00	\$213,000.00	\$213,000.00	\$363,000.00

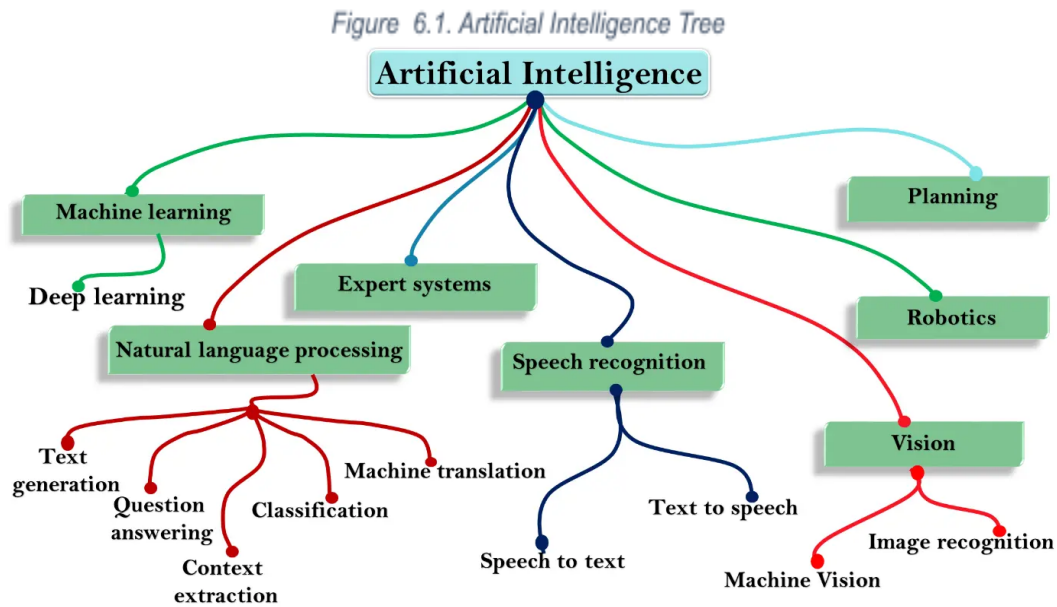
NPV \$12,341.62
IRR 10.39%

To calculate the **payback period**, we divide the initial investment by the annual net cash flow:
 $\$1,000,000 / \$250,000 = 4$ years

Based on this analysis, the investment in AI for Lufthansa MRO appears to be a profitable venture, with a positive NPV, IRR above the discount rate, and a relatively short payback period.

6. Technology Building Blocks

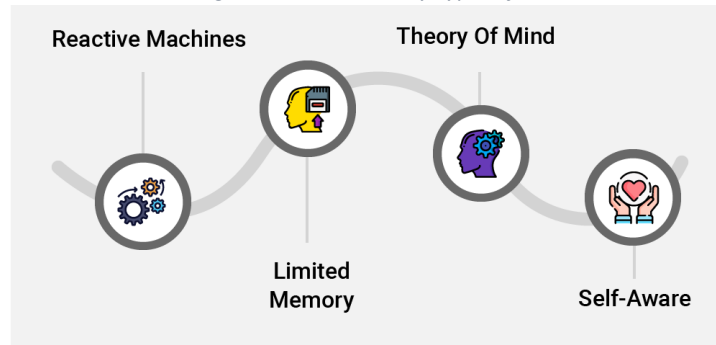
Artificial Intelligence (AI) is the current disruptive technology for any large-scale business and research organization. AI has widely adapted our Day-to-Day life applications like Maps/Navigation, Face recognition, Speech recognition, Text Editors/Auto-correct, Search and recommendation algorithms, Chatbots, etc. (Figure 6.1).



Source: The role of artificial intelligence in future technology, 2020

The model development either happens Cloud or On-Premises. Both cloud and on-premises software comes with their own pros and cons. The cloud is cheaper compared to on-premises, as the hardware and replacement cost are higher. Cloud is charged based on subscription fees. On-premises would be the best choice if the firm requires a high level of control, security, and reliability. Cloud solution does not require a high initial investment or expenditures.

Figure 6.2. Four Primary Types of AI



Source: Hdatasystems, 2021

Reactive Machines are task-specific Ex. Netflix recommendations. **Limited Memory** is an algorithm that imitates the way our brain's neurons work Ex. Deep Learning. **The theory of Mind** is to understand human intentions and predict behavior as if to simulate human relationships. **Self-Aware** is the evolution of AI to design systems that have a sense of self, a conscious understanding of their existence (Figure 6.2).

The building blocks (Figure 6.3) involve hardware, storage, network resources, software applications, and tons of data,

- ❖ Structured data - Generally stored in a database.
- ❖ Unstructured data - Large set of files in text, video, audio, and images.
- ❖ Data Preprocessing - A technique to clean and organize the raw data suitable for training the models.
- ❖ Reliable/uninterrupted Network with High bandwidth Internet.
- ❖ Security - Helps detect anomalies, vulnerabilities, and malicious activity.
- ❖ Need basic knowledge of statistics, probability, linear algebra, calculus, and specialization in programming languages like Python and R.
- ❖ Powerful Graphic Processing Unit (GPU) - Used in deep learning multiple large datasets and neural network algorithms.
- ❖ Cloud Computing (IaaS, PaaS, SaaS) with Scalable Data Storage for Data Analytics and AI provides machine learning capabilities with a computing environment that is cloud ready. For example, Vertex AI in Google Cloud Platform (GCP)

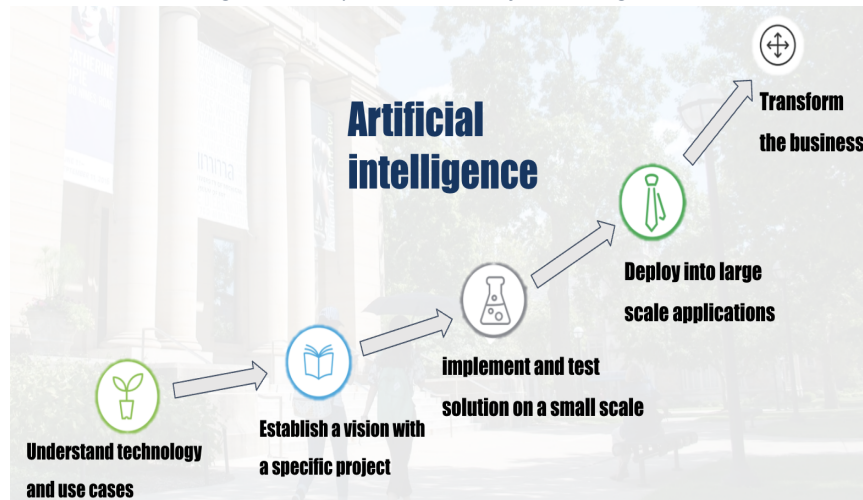
Figure 6.3. Building Blocks of Various Technologies

	AI/ML	Blockchain/Crypto	IoT	RPA	5G
Reliable Network	Required	Required	Required	Required	Required
Security	Required	Required	Required	Required	Required
Special Software/Skills	Required	Required	Required	Required	NA
Powerful GPU/Memory	Required	Good to Have	NA	NA	NA
Cloud Computing	Required	Good to Have	Good to Have	Good to Have	NA
Scalable Data Storage	Required	Good to Have	NA	NA	NA
IaaS	Required	Required	NA	NA	NA
PaaS	Required	Required	NA	NA	NA
SaaS	Based on Use Case	Based on Use Case	Required	Required	NA
Sensors & Controllers	Based on Use Case	Based on Use Case	Required	Based on Use Case	NA
UI (Apps/Portal)	Based on Use Case	Based on Use Case	Good to Have	Based on Use Case	NA

7. Operationalization

It is apparent throughout our analysis that artificial intelligence was present in every sector as a technology that will enhance productivity, output, and ultimately revenue. Puerto Rico has the opportunity to advance multiple sectors through artificial intelligence due to its intersection in various fields by focusing on only one area. The research has demonstrated that leading countries in sectors such as pharmaceutical manufacturing are using artificial intelligence and continuing to grow it. Recent developments have seen large investments in artificial intelligence across technology companies in Silicon Valley and Seattle, this interest and commitment from industry giants further strengthen our analysis. It is worth noting that the majority of the research and development in artificial intelligence was conducted before the year 2023 making it apparent that this path was clear and now industry leaders are determined to utilize unlocked capabilities in artificial intelligence.

Figure 7.1. Steps to Achieve Artificial Intelligence



To effectively implement artificial intelligence across industries the first step is to understand the current art and technology from other countries and how they have implemented it. Then it is crucial to pick a focused project with deliverables that will lead to measurable key performance indicators that can determine the success of implementation. After this, small-scale projects can be run to determine the viability of the application and its success. When the small-scale application of artificial intelligence is determined the large-scale application of the technology is the next step. Finally, the key performance indicators can be measured to determine the application improvement. The steps are summarized in Figure 7.1.

Establishing an artificial intelligence facility can support the advancement and application of the technology across various industries. From our research, the main drivers to ensure successful application rely on having the appropriate personnel in place by investing in the talent required to lead the facility, the personnel should be well versed in artificial intelligence, machine learning, neural networks, and other subfields with proven success applying solutions to real-world applications. Another important driver is ensuring collaboration with educational institutions and industry, this can be achieved through the selection of projects that benefit a specific company and also providing benefits to an educational program. For example, Honeywell performs MRO activities in Puerto Rico which could benefit from improved inspection

techniques to identify areas that need to be repaired on a component that can be achieved with artificial intelligence, the University of Puerto Rico Mayaguez has an artificial intelligence.

To illustrate steps in using artificial intelligence in the pharmaceutical industry, an example is shown below.

- 1- Establishment of an artificial intelligence hub located in an area near the pharmaceutical industry, also located near academic institutions.
- 2- Enablement of the artificial intelligence hub by funding it with the appropriate equipment such as high-performance computing which PR5G zone already obtains. Other equipment needed such as data centers and networking equipment can be purchased or agreements with facilities like Hub 787, a data center in Puerto Rico, can be obtained. Tools such as electronic components, specialized software, office equipment, data acquisition equipment and will also be needed, some facilities in Puerto Rico contain some of these tools such as electronic equipment which is found in the 5G & NB-IoT Innovation Lab in Bayamon.
- 3- Ensuring that appropriately qualified personnel is hired to manage the artificial intelligence hub, the hiring criteria should include experience in artificial intelligence and machine learning, advanced computer science degrees, and program management experience.
- 3- Working with industry leaders in the pharmaceutical industry in Puerto Rico such as Pfizer, Merck, Abbvie, or others to select a project that could benefit the company. An example for a project could be to monitor various characteristics of all industrial machines on a line to determine when failures will occur on any machine and optimize the use to avoid line downtime or predict maintenance by using an artificial intelligence data analytics algorithm. Another example would be to monitor temperature, humidity, pressure, and other factors for chemicals used to determine optimal conditions. Other areas such as supply chain optimization and quality control could serve valuable purposes.
- 4- Working with Academia to provide graduate students with the opportunity to work on industry issues for a thesis or internship opportunities. This helps grow a local capable workforce, supports industries on the Island, and provides the artificial intelligence hub with additional resources. The University of Puerto Rico Mayaguez has an Artificial Intelligence Education and Research Institute (AIERI) that can potentially become a partner.
- 5- After the selection of a project and alignment between a company such as Pfizer, an academic institution such as AIERI at UPR, and the Artificial Intelligence hub facility, the next step is to develop a timeline and measurable objectives for success. The management of this would be led by the personnel at the artificial intelligence hub facility.
- 6- The technical aspect of the work can be taken on now, focusing on data analytics, algorithm development, small scale deployment and then large scale application.
- 7- The last step is to review if the targets were met, reflect on successes and challenges and carry those forward to the next project. In addition, participation in Artificial intelligence communities to share results and learn from others' experiences.

These steps use available resources to build on a newly established artificial intelligence hub to lead Puerto Rico into the next generation of technological development and ensure continued competitiveness with leading countries in similar sectors.

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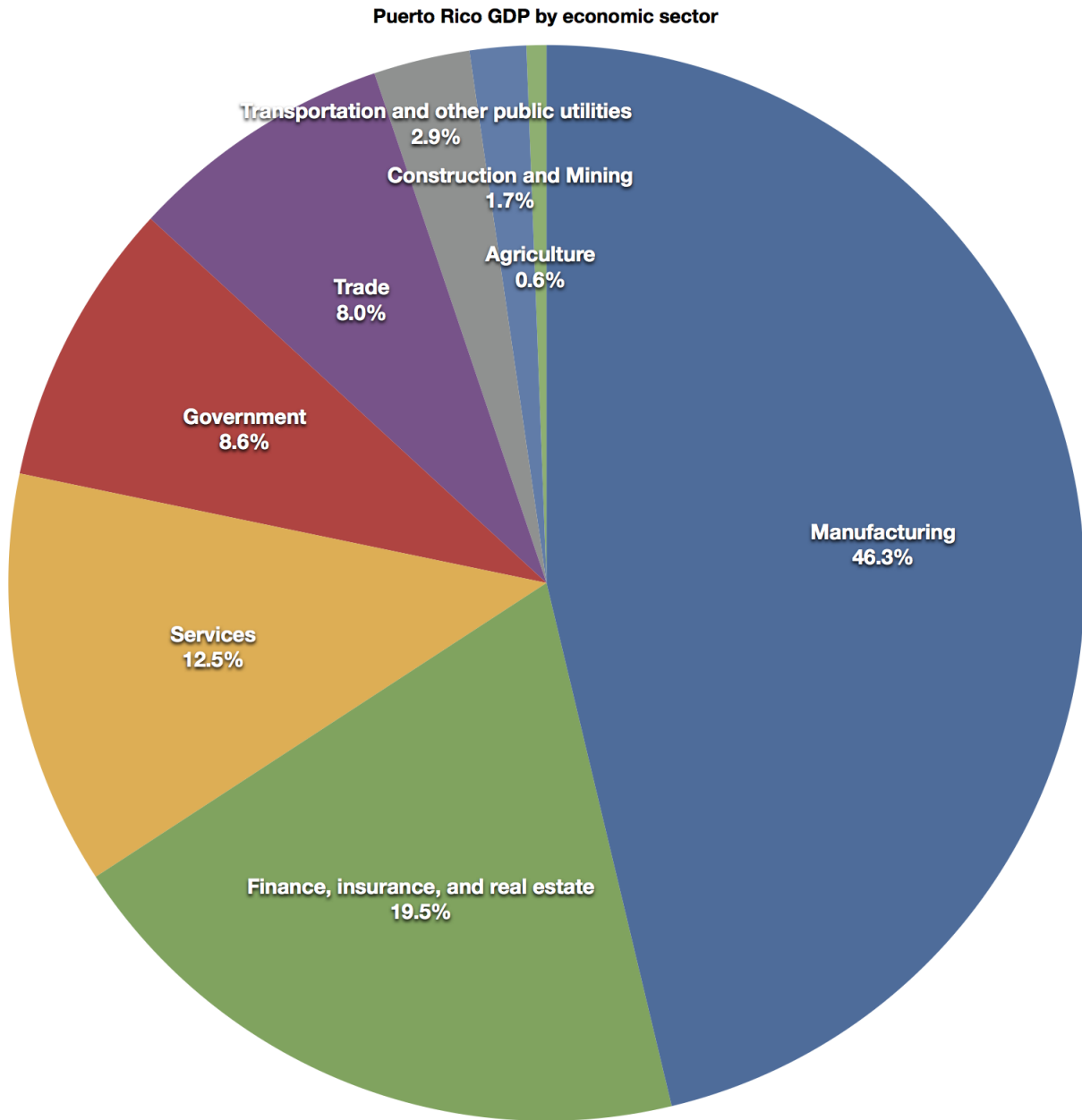
Appendix 1. Sector Selection

Putting all 20 overarching sectors through the decision points in the algorithm we were able to consolidate into 10 subsectors. Below is the table that depicts each decision point and how consolidation happened.

Sector	Decision Points				Comments
	Sector Attractiveness	Promotes Other Attractive Sectors	Technology Innovation	Suitable for Puerto Rico	
11. Agriculture	Fail	Pass	Fail	N/A	Not a growing climate and lacks technology innovation
21. Mining	Fail	Fail	N/A	N/A	Revenue growth is decreasing
22. Utilities	Pass	Pass	Pass	Pass	Use subsector <u>Solar Energy</u>
23. Construction	Fail	Pass	Pass	Fail	Not a growing industry, but support other sectors; however not ideal in Puerto Rico
31-33. Manufacturing	Pass	Pass	Pass	Pass	Use subsectors <u>Pharmaceutical Manufacturing</u> and <u>Aerospace Manufacturing</u>
42. Wholesale Trade	Pass	Pass	Pass	Pass	Use aspects in the transportation & warehousing sector due to the niche aspect of trade that passes
44-45. Retail Trade	Pass	N/A	Pass	Fail	This sector does not seem to have an ability to thrive in Puerto Rico
48-49. Transportation & Warehousing	Pass	Pass	Pass	Pass	Use subsector <u>Warehousing and Storage</u>
51. Information	Pass	Pass	Pass	Pass	Use subsectors <u>Software Services</u> , <u>Film Production</u> , <u>Music Production</u> , and <u>Wireless Communication</u>
52. Finance	Pass	Pass	Pass	Pass	Use subsector <u>Commercial Banking</u>
53. Rental / Leasing	Pass	N/A	Fail	N/A	There is not a tremendous amount technological advances in this sector
54. Professional Services	Pass	Pass	Pass	Pass	Use aspects in the information sector due to the niche aspect of professional services that passes
55. Management of Companies	Pass	N/A	Pass	Fail	The company infrastructure on the island does not bode well for this sector
56. Waste Management	Fail	Pass	Pass	Fail	Not a growing sector, but interesting technology advantages; still not suitable for Puerto Rico
61. Educational Services	Pass	Pass	Pass	Pass	Use subsector <u>Educational Services</u>
62. Healthcare	Pass	Pass	Pass	Pass	Combine with manufacturing sector due to the niche aspect of healthcare that passes
71. Entertainment	Pass	Pass	Pass	Pass	Combine with information sector due to the niche aspect of entertainment that passes
72. Accommodation	Pass	N/A	Fail	N/A	Small portion of Puerto Rico GDP and is a stand alone sector

The decision points that failed are marked in red, the decision points that passed are marked in blue, and the decision points that were not taken are in gray. The comments showcase why a sector failed or if there were further actions taken in terms of research.

Appendix 2. Puerto Rico GDP by Economic Sector

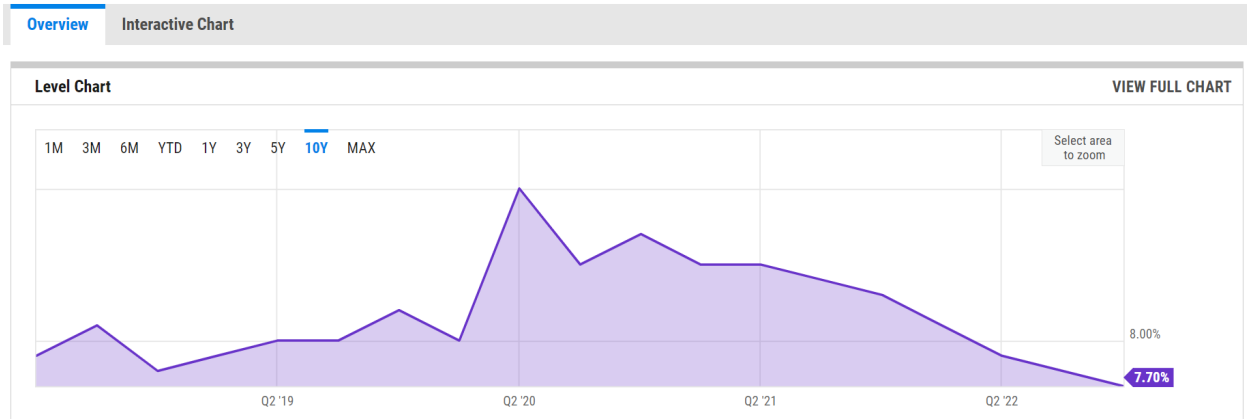


Source: Real estate in Puerto Rico, 2023

Appendix 3. Financial Sector US GDP

US GDP - Contribution of Finance and Insurance Industries (I:USGDPC01)

7.70% of GDP for Q4 2022



Source: YChart, 2022

Appendix 4. Fintech Rankings in Latin America & Caribbean

LATIN AMERICA & CARIBBEAN				
Region Rank	Global Rank	Change from 2020	City	Country
1	4	▲ +1	Sao Paulo	Brazil
2	44	▲ +86	Montevideo	Uruguay
3	48	▼ -27	Mexico City	Mexico
4	74	▼ -34	Bogota	Colombia
5	76	▼ -34	Buenos Aires	Argentina
6	80	▼ -26	Santiago	Chile
7	103	▼ -34	Belo Horizonte	Brazil
8	104	▲ 1	Lima	Peru
9	122	▲ 49	Medellin	Colombia
10	125	▼ -68	Rio de Janeiro	Brazil
11	131	▼ -34	Curitiba	Brazil
12	150	▼ -59	Porto Alegre	Brazil
13	174	▼ -22	Guadalajara	Mexico
14	192	▼ -41	Monterrey	Mexico
15	198	new	Quito	Ecuador
16	207	▼ -88	Florianopolis	Brazil
17	217	new	Brasilia	Brazil
18	221	▼ -4	San Juan	Puerto Rico
19	230	new	Cali	Colombia
20	232	▼ -97	Mendoza	Argentina
21	239	▼ -26	Panama City	Panama
22	244	new	Caracas	Venezuela
23	251	new	San José	Costa Rica
24	255	▼ -22	Belize City	Belize

Source: Global Fintech Rankings Report - BRIDGING THE GAP, 2021

Appendix 5. Global Top 20 Fintech Rankings



Source: Chaudry and Ali, 2021

Appendix 6. Comparative Countries

Country	Rank	Population	Land Area	Fintech Unicorns
Israel	3	8,655,535	21,640 Km ²	3
Singapore	4	5,850,342	700 Km ²	6
Switzerland	5	8,654,622	39,516 Km ²	2
Puerto Rico		2,667,888	8,870 Km ²	

Sources: Population by Country, 2023, Fintech Unicorns of the 21st Century, 2022, and Balakrishnan, 2023