

SUPPORTING BRAZIL'S FUTURE READINESS

AN INNOVATION, TECHNOLOGY
AND HUMAN CAPITAL
ROADMAP

WHITE PAPER



PORTULANS
INSTITUTE



Brazilian National Confederation of Industry
THE FUTURE OF INDUSTRY

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About Portulans Institute: Co-founded in 2019 by Soumitra Dutta and Bruno Lanvin, with Carolina Rossini as the founding CEO, the Portulans Institute (PI) is an independent nonprofit, nonpartisan research and educational institute based in Washington DC.

Portulans Institute’s areas of expertise include technology competitiveness, innovation readiness, and people and global talent. Portulans’ mission is:

- To develop cross-community knowledge and dialogue on how people, technology, and innovation contribute to sustainable and inclusive growth.
- To inform policymakers by producing independent, data-based research.
- To collaborate with private sector leaders in driving a business agenda that invests in people, technology and innovation.
- To host and co-organize events and conferences on the above issues affecting human-centric sustainable economic prosperity.

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LIST OF ACRONYMS

ABC	Brazilian Science Academy
ABDI	Brazilian Agency for the Industrial Development
Anpei	National Association for Research and Development of Innovative Companies
BDNES	Brazilian Development Bank
BERD	Business Expenditure on Research and Development
BRICS	Brazil, Russia, India, China, and South Africa
CNI	National Confederation of Industry - Brazil
CNPEM	Brazilian Center for Research in Energy and Materials
CNPq	National Council for Scientific and Technological Development
CONOCER	National Council for the Standardization and Certification of Labor Competencies
CPI	Corruption Perception Index
CRA	Contingent Reserve Arrangement
CTA	Brazilian Aerospace Technical Center Brazilian
DBI	Ease of Doing Business Index
EBD	Singapore Economic Development Board
E-Ciber	Brazilian National Cyber Security Strategy
E-Digital	Brazil's Digital Transformation Plan
EMBRAER	Brazilian Aeronautics Company
EMBRAPA	Brazilian Agricultural Research Corporation
EMBRAPII	Brazilian Company of Industrial Research and Innovation
ENCIT	National Strategy in Science, Technology and Innovation
EPI	Environmental Protection Index
EU	European Union
FAPs	State Foundations for Research Support
FDI	Foreign Direct Investment
FINEP	Brazilian Innovation Agency
FIOCRUZ	Oswaldo Cruz Foundation
FNDTC	National Fund for Scientific and Technological Development
FREA	Future Readiness Evaluation Approach
FRI	Future Readiness Index
FRR	Future Readiness Ranking
FTE	Full-time equivalent
ICT	information and communications technology
IDB	Inter-American Development Bank
IIA	Israel Innovation Authority
IMF	International Monetary Fund
IoT	internet of things
IP	intellectual property
ITA	Brazilian Aeronautic Institute of Technology
ITT	Innovation, Talent and Technology Triangle
ITU	International Telecommunication Union
GERD	Gross expenditure on Research and Development
GDP	Gross Domestic Product
GII	Global Innovation Index
GSMA	Global System for Mobile Communications

GTCI	Global Talent Competitiveness Index
GTI	Global Talent Independent
MAS	Monetary Authority of Singapore
MCTI	Ministry of Science, Technology and Innovation
MEC	Ministry of Education
MEI	Entrepreneurial Mobilization for Innovation
MFN	most-favored nation
NDB	New Development Bank
NIS	National Innovation System
NRI	Network Readiness Index
OECD	Organization for Economic Co-operation and Development
OSTP	USA Office of Science, and Technology Policy
PMB	Greater Brazil Plan
PDP	Productive Development Policy
PITCE	Industrial, Technological and Foreign Trade Policy
PNI	Brazilian National Innovation Policy
PPP	Public-Private Partnerships
RIA	Regulatory Impact Assessment
SBPC	Brazilian Society for the advancement of Science
SENAI	National Service of Industrial Training
SMEs	Small and Medium Enterprises
STEAM	Science, Technology, Engineering, Arts and Mathematics
STIS	Science, Technology and Innovation System
ST&I	Science, Technology and Innovation
TJLP	long term interest rates
UIS	UNESCO Institute for Statistics
WEF	World Economic Forum

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FOREWORD

2020 has demonstrated with newfound urgency the importance of national future readiness. More than ever before, global disparities between countries in terms of digital innovation, and science and technology excellence were apparent. It is clear that innovation, technology and talent are not only the key to enhanced global competitiveness, but also improved lives and livelihoods.

As the main representative of Brazilian industry in the defense and promotion of public policies favoring entrepreneurship and industrial production, the National Confederation of Industry - Brazil (CNI) recognizes that innovation is essential for Brazil to achieve economic development and social wellbeing, particularly in a post-Covid-19 world.

In 2008, CNI created the Entrepreneurial Mobilization for Innovation (MEI), which aims to embody innovation in the strategy of companies operating in Brazil and drive efforts to improve the effectiveness of innovation policies. MEI brings together more than 300 of the country's main business leaders and aims to turn Brazil into an innovative country. MEI's priorities include: regulation, governance, innovation financing, entry into global markets, talent development and support to small and medium enterprises.

In partnership with CNI, and in line with MEI advocacy for innovation-oriented public and corporate policies in Brazil, the Portulans Institute is excited to present this landmark Report of Brazil's future readiness. Portulans is a Washington DC-based think tank developing knowledge, expertise and dialogue at the interaction of tech, talent and innovation.

This Report uses the Future Readiness Evaluation Approach (FREA) model to generate recommendations for improving Brazil's competitiveness in innovation, technology and talent (the 'ITT' triangle). It is based on indicators from three influential global reports: the Network Readiness Index, the Global Talent and Competitiveness Index and the Global Innovation Index.

Despite notable progress in recent years, there is much to be done in building Brazil's future readiness. Policymakers possess a remarkable constitutional mandate to build innovation into the core of Brazil's institutions and infrastructure. It is crucial that innovation is prioritized at the highest levels of the federal, state and municipal governments, feeding into a national vision of innovation.

The Brazilian government must build a fertile ecosystem for innovation, science and technology, and should jump at the opportunity to prioritize data-driven policy-making and initiatives, in addition to necessary public investment in Research and Development and the entrepreneurial sector.

The report's findings demonstrate the power of looking both inwards and outwards for innovation solutions. The meaningful inclusion of Brazil's key players in innovation – from entrepreneurs and researchers to private sector leaders – in the policy decisions underlying Brazil's future readiness is decisive. They are both actors and advocates for progress, and should be closely consulted in policy-making and implementation. Additionally, Brazil should study other countries and their innovation track records to learn about effective policies and assessment tools.

Leveraging Portulans' international outlook, this report draws on global examples to exhibit why and how good policy is based on accurate data and strategic forecasting. This report uses the FREA to analyze Brazil's current state of future readiness, as an assessment tool that enables data-based scenarios to support policy decisions.

This publication is the latest of CNI/MEI and Portulans' contributions to the development of solid innovation ecosystems, representing a collaborative attempt to provide a roadmap for increasing the competitiveness of Brazil's economy and the wellbeing of its citizens.

CNI and the Portulans Institute hope this contribution will spark lively, productive discussions about how to improve Brazil's future readiness. We encourage individuals and organizations from the private sector, academia, civil society and government to read and take advantage of this report's conclusions.

We wish you pleasant reading,



Robson Braga de Andrade
President, CNI



Prof. Soumitra Dutta
President, Portulans Institute

EXECUTIVE SUMMARY

This unprecedented Report presents a series of policy recommendations to improve Brazil's competitiveness via innovation, technology, and talent, the *Future Readiness Triangle* (ITT). It offers an overview of Brazil's current state of Future Readiness by reflecting on its capacity to (i) maximize the potential of its local and regional assets to create new technological and industrial landscapes, (ii) develop and retain skilled talent, and (iii) absorb and benefit from new technology. This Report describes and examines the present state of Brazil's Science, Technology and Innovation System (STIS), as a first step to understand its landscape and to help signal priorities and existing roadblocks to achieving these capacities. In addition, this assessment considers the views and recommendations of international organizations and Brazil's local industry and entrepreneurial sectors regarding STIS governance. This assessment also examines the challenges that the current COVID-19 pandemic has imposed on Brazil's competitiveness and prospects for economic growth.

The second analytical layer offers a deeper look into Brazil's current state of Future Readiness - 44th in 47 economies in the Future Readiness Index (FRI) - by exploring various components that shape its ITT, in addition to those of a fourth underlying dimension that measures the strength of local Institutions and Infrastructure. This analytical approach, based on the new *Future Readiness Evaluation Approach* (FREA), merges components of the Network Readiness Index (NRI), the Global Talent Competitiveness Index (GTCI) and the Global Innovation Index (GII) into a single analytical tool.

This analysis also includes a review of policies and strategies in other countries that have led to successful outcomes in identified priority areas. Reviewing these policies and strategies as benchmarks provides a series of alternative perspectives, and offers experience that enriches the recommendations issued. These insights also provide another context to the simulated scenarios explored, by displaying a list of reviewed economies and their best practices identified in topic areas.

Some of the Report's **key findings** include:

1. Investment in innovation, technology, and talent go hand-in-hand with competitive levels of innovation.

In economies like Israel and the Republic of Korea, gross expenditure on research and development (GERD) is nearly 5% of their GDP. Other economies, like Japan and Denmark, display levels that are above 3%. All of these economies are in the FRI's top 10 rankings for Innovation. ***Brazil, located in the last five positions of the FRI, displays a GERD as a percentage of Gross Domestic Product (GDP) that is only near 1.3%. While this percentage is above the average of economies from Latin America and the Caribbean featured in this Report (0.4%), it is far from that displayed by its fellow BRICS economy China (2.2%).*** Consequently, Brazil ranks 29th (out of 47 economies) in this specific investment indicator and 37th in Innovation. In comparison, China ranks 13th and 15th, respectively.

2. Governments play an active role in financing Science, Technology, and Innovation in some developing economies.

Although the percentage of GERD financed by Brazil's government amounts to nearly 50%, ***this figure represents only about 0.63% of Brazil's GDP, which is almost half in comparison to other countries part of the FRI.*** Economies like the Republic of Korea, Sweden, and Germany – all in the FRI top 15 rankings for the ITT Innovation pillar – show that the proportion of GERD financed by the government

nears 1% of their GDP, all the while showing a total GERD with respect to GDP above 3%.

3. Balanced and stable markets attract foreign capital investment.

While Brazil's ratio of market value of listed domestic companies to GDP nears 46% (three-year average) and the volume of the financial resources provided to the private sector by financial corporations (to GDP) is 61.8%, ***the local financial system appears far from the levels of sophistication seen in economies at higher stages of development.*** This is corroborated by its gross capital formation, measured by a ratio of total investment to GDP of only 15.7%. This disparity may partially influence Brazil's low venture capital investment in 2019, reporting a mere 67 venture capital deals that year, ranking 36th among the included economies.

4. Brazil records higher competitiveness in the ITT Innovation pillar than in Technology, Institutions and Infrastructure, but lacks an overarching policy framework.

Data suggest that Brazil performs better in the ITT Innovation pillar compared to its underperformance in the ITT Technology pillar. In addition to its underperformance in the underlying core enabler dimension of Institutions and Infrastructure. ***The ITT Technology pillar and the ITT dimensions of Institutions and Infrastructure are the areas that require the most immediate attention for improving Brazil's competitiveness, as also proven by the impact scenarios.*** Currently, science, technology and innovation (ST&I) policies and initiatives lack the institutional and social linkage to be high-impact. A national vision of innovation is also not yet apparent. To achieve higher levels of competitiveness, Brazil needs to revert to a more inclusive and objective ST&I policy design system to build comprehensive, overarching frameworks that can guide these policies holistically. Collective actions to bring back multi-sector orchestrated efforts that can help Brazil get back on track in these areas are of paramount importance.

5. There are serious – yet not insurmountable – hurdles to financing innovation in Brazil.

Financing innovation in Brazil faces several serious hurdles. Critical funding gaps remain despite recent policy action. Further, the great diversity of investment opportunities in innovative individuals, ideas and companies across different stages of the innovation lifecycle are not sufficiently supported by infrastructure, institutions or security for investors.

6. Offline barriers hinder Brazil's digital development, but opportunities persist.

Offline insufficiencies and inefficiencies, such as bureaucratic hurdles, hinder digital development frontiers. These offline barriers stifle homegrown innovation on the one hand, and disincentivize international investors on the other hand. However, policies and programs like *E-Digital* show promising progress. Fixing Brazil's offline challenges may generate new opportunities for investment and growth. ***Both international organizations and corporations note that Brazil's chronic underinvestment in the information and communications technology (ICT) sector, combined with its projected explosion of growth over the next few years, represents a pathway for investment for international and local investors – and the improved wellbeing of Brazilian citizens.***

7. Global talent landscapes are rapidly changing, and people-first innovation is a strategic imperative.

Global talent landscapes are rapidly changing and evolving, as is the standard for global competitiveness. Several world-leading innovators, like Israel and the US, are *not the stars we think they are* when it comes to talent. Even well-rounded innovating economies under-perform on the expectations observers would have for countries in their income group, especially the speed of new skills absorption. ***This stresses the need for a holistic approach to the ITT triangle, melding technical excellence with good governance and a people-first innovation strategy, focused on the constant development of talent.*** As the successful examples of economies such as Australia, Chile and Germany demonstrate, a country's innovation strategy benefits from a strong innovation ecosystem that looks both outwards to foreign investment and inwards to homegrown ideas and talent. ***This global trend – countries easily falling behind on talent performance – is a cautionary tale for Brazil. Data projections show Brazil lagging further behind if it does not invest in talent training and competitiveness.***

8. Concluding key finding: Improvements in key areas can drastically improve Brazil's future readiness.

The FREA model suggests that higher performance in key areas (i.e. an increase in GERD of at least 16%; talent development via an expansion of 35% in the number of researchers; better infrastructure for innovation through 4G coverage improvement of no less than 11%; enhanced environmental protection measured by a 10% higher Environmental Protection Index score; etc.) would have a positive effect on Brazil's output. When the recommended changes are applied in tandem, the FREA suggests an overall FRI ranking improvement of three positions, moving Brazil from 44th to 41st in the index (refer to Brazil's Country Profile in Appendix 2 for details and data).

Given the characteristics of the FRI – a compact, elite group of high-performing economies assessed at nearly full data coverage – a rise by three positions is a remarkable improvement. In other words, a variation of this magnitude achieved within such a highly competitive group of economies is highly significant. These results capture the importance of defining and applying policies in the areas outlined in the Report's recommendations; inaction, or the weakening of policies already in place, would curtail these areas of growth and potential, resulting in economic stagnation and the loss of decisive development opportunities.

Overall, these findings indicate that efforts to boost Brazil's innovation-driven competitiveness in the context of Future Readiness would benefit more from the development, application, and monitoring of more holistic and sector-encompassing policies considering all of the elements of the ITT rather than from other aimed at any of these areas individually or at different implementation cycles. Furthermore, these findings reinforce the importance of having full data when it comes to producing more valid and precise performance assessments, regardless of initial adjustment shocks.

In addition to offering a snapshot of *Future Readiness* within various contexts, a feature of the FRI model built from the FREA methodology is scenario analysis. Using algorithm-based forecasting and relying on the economic concept of *ceteris paribus*, this mechanism helps simulate the outcome of four hypothetical scenarios for Brazil: one for each of the ITT components. Over ten scenarios are proposed, and each scenario consists of a series of tests in which forecast values for Brazil are introduced. The outcome of each scenario

produces a simulated (or “what if?”) FRI outcome for Brazil, thus further sustaining the Report’s recommendations.

As discussed in the Report, a Future Readiness Evaluation Approach captures a snapshot of Brazil’s relatively structured ST&I policy framework. Yet a comprehensive, overarching long-term national strategy to guide these policies in a more holistic manner – in a way that does not drastically change with new governments – still remains absent.

This is a surprising finding given the relevance of ST&I in the Brazilian Constitution, which frames public incentives in ST&I as the core enabler of economic development and the principal tool to tackle issue-specific social challenges. Although existing policies display sufficient institutional and societal linkage, these have not yet become impactful enough to induce the sought transformations.

The following general recommendations are drawn from Report results and encompass a wider vision of innovation targeting some of its broader objectives. These recommendations also offer insightful perspectives to assist policymakers in making informed innovation policy decisions.

Generally, the Report suggests that Brazil should:

1. ***Establish solid bridges between public and productive sectors.*** Building the necessary connections between these sectors is fundamental to achieving these objectives, in addition to higher levels of productivity.
2. ***Focus and outline mission-oriented policies.*** Shared perspectives from the private sector highlight the importance of partnering in multi-stakeholder groups for the design of mission-oriented policies and strategies, to leverage both efforts and investment mechanisms in order to advance innovation locally.
3. ***Devise intersectional rather than single domain policies.*** Rather than aiming at ITT components individually or pursuing different implementation cycles for each component, policies should concurrently consider all of the elements of the ITT and be applied jointly.
4. ***Identify and periodically collect data to better support the design of mission-oriented policies.*** Complete and more precise information would help induce the kind of mission-oriented investments that lead to the creation of new technological opportunities and market landscapes in Brazil.

Regarding the need to improve innovation for competitiveness, the Report comments on building stronger public private partnerships, efficient and cost-effective intellectual property protection systems, innovative entrepreneurship actions, and more sophisticated investments frameworks are among the proposed actions aimed at promoting innovation. The next recommendations are specific examples targeting this area:

5. ***Increase gross domestic expenditure on R&D.*** The Report’s findings highlight the need to expand rather than just preserve the current levels of GERD – especially coming from the government. In doing so, this recommendation highlights the fundamental role that the public sector plays in ensuring the stability of and timely access to these resources. It also emphasizes the importance of having a deeper understanding of GERD and its key role for local innovation, especially for projects with multiple rounds of funding.

6. Foster an innovation investment culture via venture and risk capital markets.

Similarly, research also demonstrates that a country's innovation strategy dilutes when investors are not supported by a strong innovation ecosystem that looks both outwards to foreign investment and inwards to homegrown ideas and talent. Thus, the country should foster an innovation investment culture based on venture and risk capital markets through various actions, including: adequate taxation and tax incentives; better regulation for entrepreneurial capital; a reduction of the timelines for opening and closing as well as for organizational changes for companies; and through the design of better investors guidelines for responsibility of debts incurred by start-ups. Improving investment exit mechanisms, like the development of secondary markets, and those that help share risks, such as expanding public-private co-investment in venture capital funds, are additional steps that can assist in the pursuit of this objective.

7. Promote the private sector's engagement in innovation and entrepreneurship.

Based on a series of identified barriers, the Report suggests simplifying and clarifying Brazil's legal and regulatory environments, and developing mechanisms that ensure and improve investor confidence in higher-risk ventures is essential for the expansion of local entrepreneurship and innovation.

8. Foster an IP Culture based on international guidelines for intangible creations.

While the Report finds that Brazil's IP displays decent levels of internationalization, there are signals of untapped potential for Brazil, especially considering creative goods exports. Engaging in additional efforts to not only further expand the internationalization of its high- and medium high-tech industry, but also to expand that of softer innovation-based products and services – including those derived from culture and tradition – can further tap Brazil's potential to develop a lively and fully active IP culture.

Regarding the need to improve talent, the Report draws recommendations on issues including the capacity of professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems; increased productivity and efficiency, lower transaction costs, better access to markets, and sustainable growth. The Report suggests:

9. Tailor a talent-first innovation strategy. While standards of global competitiveness collectively demand the ability to adapt and leverage technological change in favor of local market development and expansion, global talent landscapes are rapidly evolving into pools of versatile and technologically-savvy workers. To improve Brazil's talent improvement trajectory, public-private efforts should develop programs to attract and retain individuals with expertise in strategic management and higher-level skills in emerging technologies and STEM-related occupations. Additional programs can be designed to target workers in areas linked to soft innovation and in sectors projected to experience low displacement, like healthcare and creative and arts management. In addition to technical excellence, the design of such programs should consider workforce transition and new skill development timelines, in addition to factors such as the quality of pension systems, gender wage gaps, urban density, and the scope and reach of local environmental protection.

10. Adapt to the rapidly changing global talent landscape. Both data and literature agree on the existence of a knowledge-technology gap in Brazil. Findings also point at the disjunction between the high demand for high-tech products and services, and the availability of the local high-skilled workforce required. To counter this shortcoming, university and industry partnerships can be promoted to help design a curriculum that focuses on the specific requirements of the ICT industry. Harnessing the vast higher education institutional network operating in Brazil, short-term

certification and technical diploma-issuing programs can be offered both in vivo and online to help fill identified gaps in technical and other high-tech related service provision.

Regarding the need to improve access, use and ability to benefit from technological advances, the Report's recommendations are focused on improving the technology supporting the local innovation ecosystem and its actors, the country's digital transformation and the absorption of Fourth Industrial Revolution technologies:

- 11. Lead innovation and technological change by example.** Findings point at a disconnection between the pace at which new technologies are promoted and adopted, specially by the public sector, hindering the pace at which local technological change advances. Government at all levels should more actively harness new technologies and serve as an example by providing 'a vote of confidence' in front of the local user population.
- 12. Expand local digital development frontiers as a core enabler of public and private competitiveness:** Data and literature points to an infrastructure gap, most evident in ICTs. Regardless, Brazil displays the potential for improvement, reflected by its positive ICT regulatory environment, by strong company willingness to adopt emerging technologies, and its expansion and promotion of cybersecurity technology and efforts. Thus, to foster an expansion of digital development frontiers, Brazilian authorities should lift any barriers to the implementation of new technologies and facilitate the execution of innovation projects through the promotion of initiatives that further facilitate their deployment. In conjunction with these initiatives, the government should implement projects that uphold environmental protection and public safety, plus initiatives underlining the importance and timely adoption of such technologies.
- 13. Ramp up the design of technological regulatory framework** by promoting the swift enactment of regulation to help promote new technologies and create an innovation funding environment (that appears not to be yet fully developed in Brazil), which is essential.

Last, but far from least, the country needs to improve institutions and its infrastructure to support its future readiness in a sustainable manner. The Report clarifies that fostering the frameworks that attract business and promote growth through good governance, appropriate protection and incentives, as well as proper communication, transport, and energy infrastructures are among core elements to pay attention to. Core institutions and infrastructure are also necessary to ease the production and exchange of ideas, services, and goods in Brazil. The need to reduce perceived bureaucratic burdens and corruption are also present in this final set of ITT-drawn recommendations.

- 14. Reduce red-tape and corruption at all levels.** To reduce red-tape and curb corruption, this Report recommends formulating realistic targets and timelines for administrative simplification strategies at all levels of government; revamping multi-level coordination and extortion reporting mechanisms; increasing stakeholders' involvement; and accelerating the adoption of online government services. Additionally, to restore possibly eroded confidence in authorities, it is key to design plans to suppress the potential for political corruption and promote the integrity of political systems.
- 15. Promote regional linkage and cluster development.** To encourage the formation of localized innovation and entrepreneurship ecosystems in Brazil, authorities should develop mechanisms to boost collaboration among government agencies, academic institutions, industry, and civil society organizations. Examples of these are linking agencies and secondary financial markets. Regional linkage, on the other hand, can

be enhanced via the design of policies and programs to improve regional investment and collaboration, like tax incentives, reduced tariffs, and eased restrictions for high-skilled worker cross-border movement.

The definition and implementation of coordinated, future-oriented plans and policies to address noted challenges and limitations will help Brazil achieve the economic recovery it requires in the post-pandemic global ecosystem. Indeed, the proposed actions offer the opportunity, if properly maneuvered, for Brazil to distinguish itself in terms of future readiness on the global economic stage. As proposed by the OECD Economic Outlook in December 2020, Brazil's economic activity will still fall short of pre-pandemic levels by late 2022, although GDP growth is projected to reach 2.6% in 2021 and 2.2% in 2022. However, the outlook praised Brazil's "strong fiscal and monetary response", which "managed to prevent a sharper economic contraction". To mitigate against the negative long-term economic impacts of the crisis, the outlook notes that Brazil should undergo structural reforms to improve the investment climate and improve competition, and support opportunities for professional training and reskilling for Brazilian workers.¹

Faced with these uncertainties about prospects for recovery, building *future readiness* with the 'ITT' triangle front-and-center of new policy is a strategic imperative, and will enable Brazil to thrive and grow in a post-pandemic global economy.

¹ OECD, 'Brazil', in *OECD Economic Outlook*, vol. Volume 2020 Issue 2 (Paris: OECD Publishing, 2020), https://read.oecd-ilibrary.org/view/?ref=616_616558-75duvvejy&title=Country-profile-Brazil-OECD-Economic-Outlook-Volume-2020-2.

1. INTRODUCTION

This Report presents research and a series of policy recommendations crafted to improve Brazil's level of *future readiness*, by building competitiveness in innovation, talent and technology – referred to as the 'ITT' triangle. Accordingly, it offers an overview of Brazil's current future readiness status by using data-driven insights to reflect on the country's capacity to (i) maximize the potential of its local and regional assets to create new technological and industrial landscapes, (ii) develop and retain skilled talent and (iii) absorb and benefit from new technology.

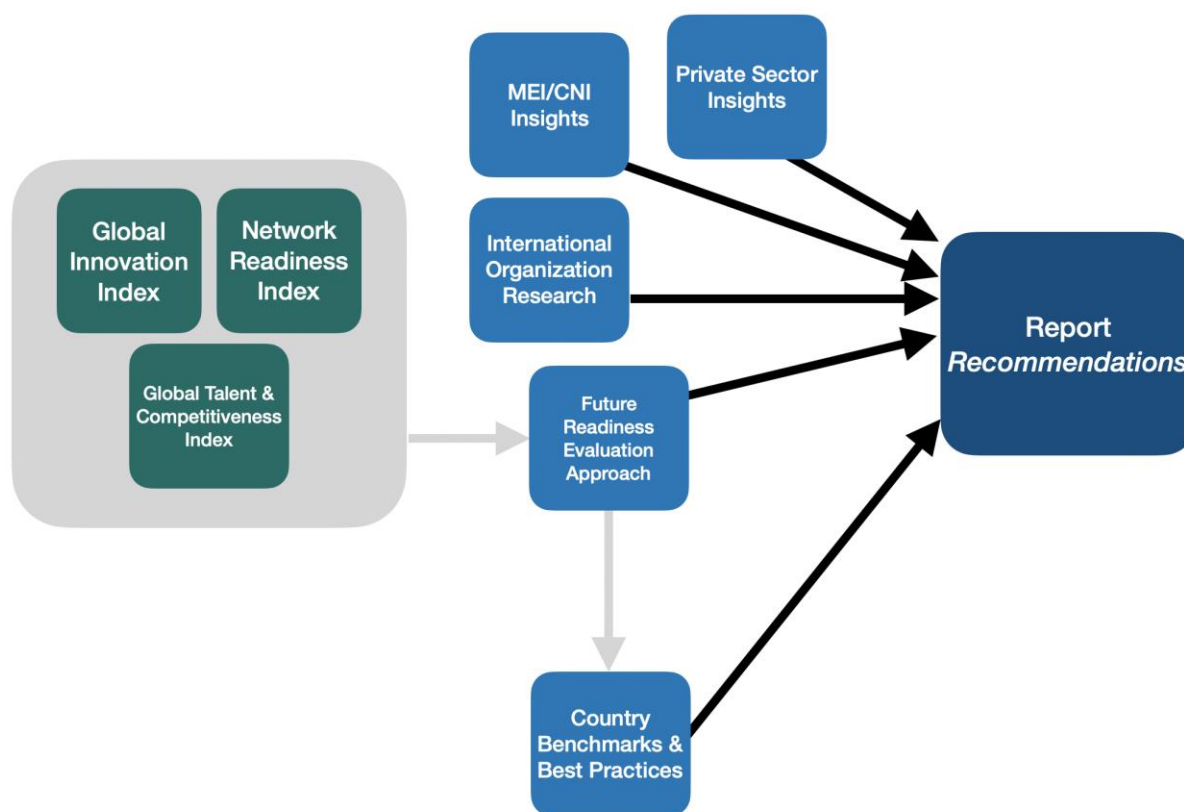
To this end, and as a first step, this Report carefully examines the present condition of Brazil's science, technology and innovation system (STIS), in order to understand and map out the country's future readiness landscape. This process helps identify key priorities and focus areas, and finds existing roadblocks to the achievement of improved capacities in STIS. Additionally, this assessment considers insights and recommendations offered by international organizations and Brazil's local industry and entrepreneurial sectors (most importantly, the policy research and commentaries offered by CNI and MEI) regarding the current governance and efficiency of Brazil's STIS. This Report also examines the current challenges facing Brazil's global competitiveness and prospects for economic growth in light of the COVID-19 pandemic crisis.

The second analytical layer offers a deeper look into Brazil's current state of future readiness based on data-driven exploration of the various components shaping the country's ITT triangle, in addition to those of a fourth underlying dimension, pertaining to the strength of institutions and infrastructure. This analysis is based on a Future Readiness Evaluation Approach (FREA), which merges components of the Global Innovation Index (GII), the Global Talent Competitiveness Index (GTCI), and the Network Readiness Index (NRI) into a single analytical tool, defined as the '**Future Readiness Index**' (FRI). FREA not only helps identify Brazil's competitive advantages, but also areas of opportunity and improvement, supporting the development of various recommendations for the country. Additionally, this approach identifies a range of economies (in the OECD Plus, BRICS and Latin American and Caribbean regional groups) excelling in areas where Brazil is underperforming; this report provides a commentary of international benchmarks and good practices as valuable references for Brazil.

The third and final analytical layer explores Brazil's performance in the FRI under different scenarios, drawn from previous findings. Section 8 offers insights into the FREA in action in four different thematic areas: strengthened innovation, improved talent, better technology and solid institutions and infrastructure.

Finally, the Report, by merging data-driven insights from the FREA with research insights drawn from international organizations and the private sector, generate a list of recommendations, both general and decurrent. Section 9 is by no means an exhaustive list of both general and specific to ITT domain recommendations. Readers are encouraged to draw on sector-specific guidelines from the lessons and data gathered.

FIGURE 1. RESEARCH METHODOLOGY



KEY FINDINGS

Based on the Report's Research Methodology, the key findings are: Some of the Report's **key findings** include:

1. Investment in innovation, technology, and talent go hand-in-hand with competitive levels of innovation.

In economies like Israel and the Republic of Korea, gross expenditure on research and development (GERD) is nearly 5% of their GDP. Other economies, like Japan and Denmark, display levels that are above 3%. All of these economies are in the FRI's top 10 rankings for Innovation. **Brazil, located in the last five positions of the FRI, displays a GERD as a percentage of Gross Domestic Product (GDP) that is only near 1.3%. While this percentage is above the average of economies from Latin America and the Caribbean featured in this Report (0.4%), it is far from that displayed by its fellow BRICS economy China (2.2%).** Consequently, Brazil ranks 29th (out of 47 economies) in this specific investment indicator and 37th in Innovation. In comparison, China ranks 13th and 15th, respectively.

2. Governments play an active role in financing Science, Technology, and Innovation in some developing economies.

Although the percentage of GERD financed by Brazil's government amounts to nearly 50%, **this figure represents only about 0.63% of Brazil's GDP, which is almost half in comparison to other countries part of the FRI.** Economies like the Republic of Korea, Sweden, and Germany – all in the FRI top 15 rankings for the ITT

Innovation pillar – show that the proportion of GERD financed by the government nears 1% of their GDP, all the while showing a total GERD with respect to GDP above 3%.

3. Balanced and stable markets attract foreign capital investment.

While Brazil's ratio of market value of listed domestic companies to GDP nears 46% (three-year average) and the volume of the financial resources provided to the private sector by financial corporations (to GDP) is 61.8%, ***the local financial system appears far from the levels of sophistication seen in economies at higher stages of development.*** This is corroborated by its gross capital formation, measured by a ratio of total investment to GDP of only 15.7%. This disparity may partially influence Brazil's low venture capital investment in 2019, reporting a mere 67 venture capital deals that year, ranking 36th among the included economies.

4. Brazil records higher competitiveness in the ITT Innovation pillar than in Technology, Institutions and Infrastructure, but lacks an overarching policy framework.

Data suggest that Brazil performs better in the ITT Innovation pillar compared to its underperformance in the ITT Technology pillar. In addition to its underperformance in the underlying core enabler dimension of Institutions and Infrastructure. ***The ITT Technology pillar and the ITT dimensions of Institutions and Infrastructure are the areas that require the most immediate attention for improving Brazil's competitiveness, as also proven by the impact scenarios.*** Currently, science, technology and innovation (ST&I) policies and initiatives lack the institutional and social linkage to be high-impact. A national vision of innovation is also not yet apparent. To achieve higher levels of competitiveness, Brazil needs to revert to a more inclusive and objective ST&I policy design system to build comprehensive, overarching frameworks that can guide these policies holistically. Collective actions to bring back multi-sector orchestrated efforts that can help Brazil get back on track in these areas are of paramount importance.

5. There are serious – yet not insurmountable – hurdles to financing innovation in Brazil.

Financing innovation in Brazil faces several serious hurdles. Critical funding gaps remain despite recent policy action. Further, the great diversity of investment opportunities in innovative individuals, ideas and companies across different stages of the innovation lifecycle are not sufficiently supported by infrastructure, institutions or security for investors.

6. Offline barriers hinder Brazil's digital development, but opportunities persist.

Offline insufficiencies and inefficiencies, such as bureaucratic hurdles, hinder digital development frontiers. These offline barriers stifle homegrown innovation on the one hand, and disincentivize international investors on the other hand. However, policies and programs like *E-Digital* show promising progress. Fixing Brazil's offline challenges may generate new opportunities for investment and growth. ***Both international organizations and corporations note that Brazil's chronic underinvestment in the information and communications technology (ICT) sector, combined with its projected explosion of growth over the next few years, represents a pathway for investment for international and local investors – and the improved wellbeing of Brazilian citizens.***

7. Global talent landscapes are rapidly changing, and people-first innovation is a strategic imperative.

Global talent landscapes are rapidly changing and evolving, as is the standard for global competitiveness. Several world-leading innovators, like Israel and the US, are *not the stars we think they are* when it comes to talent. Even well-rounded innovating economies under-perform on the expectations observers would have for countries in their income group, especially the speed of new skills absorption. ***This stresses the need for a holistic approach to the ITT triangle, melding technical excellence with good governance and a people-first innovation strategy, focused on the constant development of talent.*** As the successful examples of economies such as Australia, Chile and Germany demonstrate, a country's innovation strategy benefits from a strong innovation ecosystem that looks both outwards to foreign investment and inwards to homegrown ideas and talent. ***This global trend – countries easily falling behind on talent performance – is a cautionary tale for Brazil. Data projections show Brazil lagging further behind if it does not invest in talent training and competitiveness.***

8. Concluding key finding: Improvements in key areas can drastically improve Brazil's future readiness.

The FREA model suggests that higher performance in key areas (i.e. an increase in GERD of at least 16%; talent development via an expansion of 35% in the number of researchers; better infrastructure for innovation through 4G coverage improvement of no less than 11%; enhanced environmental protection measured by a 10% higher Environmental Protection Index score; etc.) would have a positive effect on Brazil's output. When the recommended changes are applied in tandem, the FREA suggests an overall FRI ranking improvement of three positions, moving Brazil from 44th to 41st in the index (refer to Brazil's Country Profile in Appendix 2 for details and data).

Given the characteristics of the FRI – a compact, elite group of high-performing economies assessed at nearly full data coverage – a rise by three positions is a remarkable improvement. In other words, a variation of this magnitude achieved within such a highly competitive group of economies is highly significant. These results capture the importance of defining and applying policies in the areas outlined in the Report's recommendations; inaction, or the weakening of policies already in place, would curtail these areas of growth and potential, resulting in economic stagnation and the loss of decisive development opportunities.

Overall, these findings indicate that efforts to boost Brazil's innovation-driven competitiveness in the context of Future Readiness would benefit more from the development, application, and monitoring of more holistic and sector-encompassing policies considering all of the elements of the ITT rather than from other aimed at any of these areas individually or at different implementation cycles. Furthermore, these reinforce the importance of having full data when it comes to producing more valid and precise performance assessments, regardless of initial adjustment shocks.

In addition to offering a snapshot of *Future Readiness* within various contexts, a feature of the FRI model built from the FREA methodology is scenario analysis. Using algorithm-based forecasting and relying on the economic concept of *ceteris paribus*, this mechanism helps simulate the outcome of four hypothetical scenarios for Brazil: one for each of the ITT components. Over ten scenarios are proposed, and each scenario consists of a series of tests in which forecast values for Brazil are introduced. The outcome of each scenario produces a simulated (or "what if?") FRI outcome for Brazil, thus further sustaining the Report's recommendations.

As discussed in the Report, a Future Readiness Evaluation Approach captures a snapshot of Brazil's relatively structured ST&I policy framework. Yet a comprehensive, overarching long-term national strategy to guide these policies in a more holistic manner – in a way that does not drastically change with new governments – still remains absent.

2. NATIONAL INNOVATION SYSTEM: DEFINITION AND IMPORTANCE

A core part of the ITT is a country's National Innovation System (NIS). According to Metcalfe's research, a NIS is defined as:

that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies.²

More recently, Lundvall et al define a NIS in the following terms:

an open, evolving and complex system that encompasses relationships within and between organizations, institutions and socioeconomic structures which determine the rate and direction of innovation and competence-building emanating from processes of science-based and experience-based learning.³

Although there is no commonly accepted definition of a NIS, it is essential to note that a NIS “rests on the premise that understanding the linkages among the actors involved in innovation is key to improving technology performance,”⁴ a notion captured by both Metcalfe's and Lundvall's definitions.⁵

In this sense, a NIS is the result of a complex interactive web, in which different actors and institutions produce, distribute and apply knowledge. The interactions between different institutions and actors, as well as the structure of knowledge flows – in a simultaneous and complementary way – vary from country to country. These interactions and structures depend on a broad framework of policies related to regulation, taxes, financing, intellectual property, competition, among others.⁶

In this context, understanding a country's NIS is crucial. Technological innovation occurs within a specific industrial structure and national context. A better understanding of the system as a whole enables more effective government technology and innovation policy-making. Understanding a country's NIS helps identify leverage points for improving innovation performance and, consequently, the country's level of competitiveness. Similarly, a comprehensive understanding of a country's NIS facilitates the analysis of incompatibilities, within and among institutions and government policies, that may hamper technology development and innovation.⁷ Moreover, as demonstrated by Chaminade et al, a strong understanding of a NIS is important for countries to achieve inclusive and environmentally sustainable development.⁸

² John S. Metcalfe, 'The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives', in *Handbook of the Economics of Innovation and Technological Change*, ed. Paul Stoneman (Oxford, UK and Cambridge, MA: Blackwell, 1995), 409–512.

³ Bengt-Åke Lundvall et al., 'Innovation System Research and Developing Countries', in *Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting* (Cheltenham, UK and Northampton, MA, US: Edward Elgar, 2009), 1–32, 7.

⁴ OECD, *National Innovation Systems* (Paris: OECD Publishing, 1997), <https://www.oecd.org/science/inno/2101733.pdf>, 9.

⁵ For other definitions, see: Richard R. Nelson, ed., *National Innovation Systems: A Comparative Analysis* (Oxford, UK and New York, NY, US: Oxford University Press, 1993); Parimal Patel and Keith Pavitt, 'The Nature and Economic Importance of National Innovation Systems', STI Review (Paris: OECD, 1994). Also, as characterized by Chaminade et al, while an innovation system includes all the actors and institutions involved, a national innovation system “gives special attention to those institutions and organizations which are located in or rooted in a nation state”; on the other hand, being the National System of Innovation open, it is able to absorb and use knowledge developed abroad. See: Cristina Chaminade, Shagufta Haneef, and Bengt-Åke Lundvall, *Advanced Introduction to National Innovation Systems* (Cheltenham, UK and Northampton, MA, US: Edward Elgar, 2018), <https://cristinachaminade.files.wordpress.com/2018/07/advanced-intro-nis-for-distribution.pdf>, 2.

⁶ OECD, *National Innovation Systems*, 13.

⁷ Ibid.

⁸ Chaminade, Haneef, and Lundvall, *Advanced Introduction to National Innovation Systems*, 80-107.

Increasingly aware of the importance of a NIS, global economic leaders have defined a broad range of strong strategies for technological advancement, encompassing measures such as the qualification of local talent, reform agendas aimed at improving the business environment, improvement of research infrastructure, stimulation of partnerships between S&T companies, among other strategies. These strategies can be observed in Germany (“Industrie 4.0: Smart-Smart Manufacturing for the Future”), the United States (“National Network for Manufacturing Innovation, Manufacturing USA”) and China (“Made in China 2025”).⁹

The newfound importance granted to NIS is not only observed in rich countries. Innovation system approaches have been officially adopted in a range of developing countries, to facilitate the formulation of ST&I strategies. Countries such as Ghana, Honduras, Mauritania and Nicaragua have implemented initiatives in this direction.¹⁰

In general, as observed by Chaminade and Padilla-Pérez, instead of focusing on specific technologies or segments of the innovation economy, developing countries should adopt strategies that involve broad spectrums of action, contemplating the innovation system as a whole. German and US NIS strategies do so successfully. A holistic approach to innovation involves not only science and technology, “but all public actions influencing competence building and learning, like education and training, social policies underpinning social capital and labor market dynamics”.¹¹

⁹ Confederação Nacional da Indústria, ‘Agenda Da Mobilização Empresarial Pela Inovação: 2019-2020’ (Confederação Nacional da Indústria, 2018), <http://www.portaldaindustria.com.br/publicacoes/2018/12/agenda-da-mei-2019-2020/>, 23-24.

¹⁰ Cristina Chaminade and Ramon Padilla-Pérez, ‘The Challenge of Alignment and Barriers for the Design and Implementation of Science, Technology and Innovation Policies for Innovation Systems in Developing Countries’, in *Research Handbook on Innovation Governance for Emerging Economies: Towards Better Models*, ed. S Kuhlman and Ordóñez-Matamoros (Cheltenham, UK: Edward Elgar, 2017), 181–204, https://cristinachaminade.files.wordpress.com/2016/11/chaminadeperez_2017_sti-policies.pdf, 1.

¹¹ Ibid.

BOX 1. DISRUPTIVE TECHNOLOGIES AND THE FOURTH INDUSTRIAL REVOLUTION¹²

The Fourth Industrial Revolution is evolving at an exponential pace, and is disrupting almost every industry on a global scale. Like the Third Industrial Revolution, the Fourth demands unprecedented innovations. However, unlike the Third, hinged upon the digitization of processes, the Fourth requires firms and governments that are digital at heart and function with a combination of innovative and evolving technologies. Most, if not all, of the Fourth Industrial Revolution's most powerful technologies are disruptive innovations by nature. The following list defines the top disruptive technologies in the 2020s:

- Artificial Intelligence
- Internet of Things
- Blockchain Technologies
- Cloud Storage and Computing
- 5G Network
- Big Data
- Digital Security

While the Fourth Industrial Revolution will bring unprecedented opportunities, it will also be the harbinger of disruptive changes. As the Founder and Executive Chairman of the World Economic Forum argues, the Fourth Industrial Revolution, in its most pessimistic conception, threatens to wreak disruptive havoc on the global economy as we know it. But with the right vision, strategy and tools, it has the potential to bring overwhelmingly positive change to the lives and livelihoods of billions.

Harnessing the Fourth Industrial Revolution's technologies and integrating them into a national innovation system (NIS) is a strategic imperative for countries in their efforts to build *Future Readiness*.

¹² Klaus Schwab, 'The Fourth Industrial Revolution: What It Means, How to Respond', World Economic Forum, 14 January 2016, <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/>; Erik Brynjolfsson and Andrew McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (London: W.W. Norton and Company, 2016).. The First Industrial Revolution mechanized production; the Second Industrial Revolution created mass production; the Third Industrial Revolution utilized electronic and information technology to automate production.

3. BRAZIL'S SCIENCE, TECHNOLOGY AND INNOVATION SYSTEM

Over the past two decades, Brazil has undertaken several measures to strengthen the capacity of its Science, Technology and Innovation (ST&I) system. Although these measures – in addition to some pre-existing initiatives – have allowed for the design of a relatively broad framework of innovation policies, especially those concerning the diversity of instruments,¹³ Brazil still faces challenges in achieving more significant results in terms of innovation and competitiveness.

3.1. GOVERNANCE: NORMS AND POLICIES (INNOVATION LAW AND ASSOCIATED POLICIES)

The National Fund for Scientific and Technological Development (FNDTC) is the largest financial source for ST&I in Brazil.¹⁴ Created years before more recent innovation policies, the FNDCT aimed to provide financial support to priority programs for scientific and technological development.¹⁵ In the late 1990s, in order to guarantee the FNDCT's funding, the Brazilian government created the Science and Technology Sector Funds. These Sector Funds are linked to strategic sectors including oil, health, biotechnology, mining and aeronautics, among others.¹⁶ Within this framework, the Brazilian Innovation Agency (FINEP) performs the function of Executive Secretariat of FNDTC and is responsible for all administrative, budgetary, financial and accounting activities.¹⁷

More recent measures to strengthen the Brazilian innovation system were implemented under the Industrial, Technological and Foreign Trade Policy (PITCE).¹⁸ The first, the Innovation Law (Law no. 10,973/2004) provided for the possibility of the State to subsidize investments in research and development (R&D) in private companies. The Innovation Law has encouraged the participation of researchers from public entities in private sector projects, in addition to the commercialization of intellectual property derived from these kinds of partnerships, which has encouraged the public and private sectors to share personnel, resources, and facilities.¹⁹

The second law implemented under PITCE was the Good Law (Law no. 11,196/2005), which aimed to reduce the risks associated with private investment in R&D through the use of tax incentives for companies investing in R&D.²⁰ Unlike previous mechanisms, the law automatically allows the use of tax incentives by companies that carry out technological R&D, without the need to present a prior project.²¹

The Constitutional Amendment (no. 85/2015) updated the treatment of ST&I activities by the Brazilian Federal Constitution, verifying the revision of relevant legal devices. The New ST&I

¹³ Fernanda de Negri, André T. Rauen, and Flávia D. H. S. Squeff, 'Ciência, Inovação e Produtividade: Por Uma Nova Geração de Políticas Públicas', in *Desafios Da Nação: Artigos de Apoio, Volume 1*, ed. João Alberto de Negri, Bruno César Araújo, and Baclette (Brasília, Brazil: Instituto de Pesquisa Econômica Aplicada, 2018), 533–60, https://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=32982.

¹⁴ Fernanda de Negri, 'Por Uma Nova Geração de Políticas de Inovação No Brasil', in *Políticas de Apoio à Inovação Tecnológica No Brasil: Avanços Recentes, Limitações e Propostas de Ações*, ed. Lenita M. Turchi and José M. de Moraes (Brasília, Brazil: Instituto de Pesquisa Econômica Aplicada, 2017), 25–46, https://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=30774.

¹⁵ Implemented in 1969 under the Basic Plan for Scientific and Technological Development (PBDCT). Before the creation of FNDTC, research funding in Brazil was provided at the individual level (researcher), a mechanism that was considered insufficient given the desired expansion sought at the time for the scientific and technological agenda.

¹⁶ Naercio M. Filho et al., 'Políticas de Inovação No Brasil', Insper Policy Papers (Insper, August 2014), <https://www.insper.edu.br/wp-content/uploads/2018/09/Políticas-Inovacao-Brasil-CPP.pdf>.

¹⁷ As determined by Decree No. 68,748/1971, and ratified by Law No. 11,540/2007.

¹⁸ Launched in 2004 as the first industrial policy from the Luiz Inácio Lula da Silva government. At the time, the government stated that PITCE represented a change in the government's conception of innovative activities, bringing innovation to the center of competitiveness policy. See: Filho et al., 'Políticas de Inovação no Brasil'.

¹⁹ De Negri et al., 'Por uma Nova Geração de Políticas de Inovação no Brasil'.

²⁰ The Informatics Law (Law no. 8,248/1991) is another important tax incentive mechanism for R&D. Created in 1991, this Law determines a reduction in the Industrial Production Tax (IPI) for companies that invest in R&D and that comply with content local requirements.

²¹ Filho et al., 'Políticas de Inovação no Brasil'.

Law (Law no. 13,243/2016) altered the Innovation Law, and others related to ST&I in Brazil, and sought to advance the reduction of legal uncertainties and the promotion of a safer, stimulating regulatory environment for innovation.²² Decree no. 9,238/2018 regulated this law.

After the launch of the PITCE, Brazil had two new editions of industrial policy: the Productive Development Policy (PDP), in 2008, and the Greater Brazil Plan (PMB), in 2010, in the wake of the global financial crisis.²³ The PBM was proposed as an initiative to continue and improve Brazil's industrial policies and the competitiveness of PDP and PITCE. Compared to prior policies, the PBM increased the scope of ICT company actions and enabled greater sector coverage and the regulation of contracts with technological risk clauses.²⁴

In addition to the PBM, Brazil's Ministry of Science, Technology and Innovation (MCTI)²⁵ instituted the National Strategy in Science, Technology and Innovation for 2012-2015 (ENCTI 2012-2015).²⁶ The ENCTI 2012-2015 concerns the promotion of innovation in the business sector, and aimed to: expand business participation in technological efforts in Brazil; reinforce research and infrastructure for ST&I; increase qualified human capital to meet demands for research, development and innovation in strategic areas.²⁷

The Inova Empresa Plan, launched in 2013 through a partnership between Finep, the Brazilian Development Bank (BNDES) and other government agencies, connects the PBM with the ENCTI, allocating resources in strategic sectors, accelerating technological diffusion. The Inova Empresa Plan integrates different instruments: credit, economic subsidy and non-refundable resources for projects in partnership with ICTs and companies, and investment in companies directly or through funds. Some observers claim that it is the largest business innovation support plan ever carried out in Brazil.²⁸

TABLE 1. EMBRAPII AND SENAI INVESTMENT TRENDS

EMBRAPII	SENAI
1026 R&D and innovation project supported 697 companies involved in projects Around USD\$300 million invested in companies and R&D projects 53 research institutions accredited as EMBRAPII universities	76 million workers trained 19,700 companies received technical and technology consultancy 27 innovation institutes founded in Brazil

Source: EMBRAPII/SENAI

Within the ENCTI 2012-2015 framework, the Brazilian Company of Industrial Research and Innovation (EMBRAPII) was created to support technological services for industrial companies.²⁹ Despite its small budget, EMBRAPII is a good example of diversification in

²² André T. Rauen and Lenita M. Turchi, 'Apoio à Inovação Por Institutos Públicos de Pesquisa: Limites e Possibilidades Legais Da Interação ICT-Empresa', in *Políticas de Apoio à Inovação Tecnológica No Brasil: Avanços Recentes, Limitações e Propostas de Ações*, ed. Lenita M. Turchi and José M. de Moraes (Brasília, Brazil: Instituto de Pesquisa Econômica Aplicada, 2017), 113–64, https://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=30774.

²³ De Negri et al., 'Ciência, Inovação e Produtividade'.

²⁴ Filho et al., 'Políticas de Inovação no Brasil'.

²⁵ Ibid.

²⁶ Ministério da Ciência, Tecnologia e Inovação, 'Estratégia Nacional de Ciência, Tecnologia e Inovação 2012–2015' (Brasília, Brazil: Secretaria Executiva do Ministério da Ciência, Tecnologia e Inovação, 2012), <https://livroaberto.ibict.br/218981.pdf>.

²⁷ Ibid.

²⁸ Confederação Nacional da Indústria, 'Agenda Da Mobilização Empresarial Pela Inovação: 2019-2020' (Confederação Nacional da Indústria, 2018), <http://www.portaldaindustria.com.br/publicacoes/2018/12/agenda-da-mei-2019-2020/>, 35-38.

²⁹ EMBRAPII was inspired by the Fraunhofer-Gesellschaft institutes in Germany. De Negri, 'Por uma Nova Geração de Políticas de Inovação no Brasil'.

public agencies responsible for innovation,³⁰ increasing institutional articulation between universities, research centers and companies in innovation development.³¹ The National Service of Industrial Training (SENAI) Innovation Institutes have been involved in EMBRAPII since its launch.

In 2016, ENCTI 2016-2022 was launched, reestablishing the planning behind Brazilian public policies regarding ST&I.³² The ENCTI 2016-2022 has three dimensions that constitute its structuring axis: the expansion, consolidation and integration of ST&I. The first step involves universities, laboratories, researchers, funding, and publications. Next, the consolidation of ST&I depends on its expansion, seeking the continuity of programs and projects. Finally, the integration of actors, resources, and infrastructure is crucial, particularly knowledge and technology transfers. To realize the strategy, actors must cooperate and approach innovation as a kind of productivity improvement, both in R&D and in products and services designed for the market. The ENCTI 2016-2022 highlights the aerospace sector given the strategic importance of the sector as a whole and the significance of Embraer in the Brazilian economic landscape.³³

Decree no. 10,222/2019 created the National Committee of Initiatives to Support Startups, which includes inputs from the Secretariat for Entrepreneurship and Innovation of the MCTI, the Central Bank of Brazil, the BNDES, and the Brazilian Agency for the Industrial Development (ABDI), among other secretaries, agencies and public organs. The Committee's tasks include the articulation of initiatives and programs of the government related to startups and the promotion of good practices. The Committee also provides a digital platform with public initiatives to support startups and collects and evaluates relevant information for startups.

In February 2020, Decree no. 10,222/2020 established the Brazilian National Cyber Security Strategy (E-Ciber),³⁴ which defines basic macro guidelines to ensure the public and private sectors can enjoy resilient, reliable, inclusive and safe cyberspace. The Decree has two parts. Its first aspect presents a diagnosis of international and national cybersecurity, drawing attention to research regarding the kinds of attacks on Brazil's digital structure and the impact of these problems and vulnerabilities on the market. The Decree's second aspect contains further research on specific thematic areas, including the governance of national cybersecurity, its normative dimension, research, development and innovation, and education, among other areas. Based on this analysis, policy measures are proposed to achieve certain strategic objectives, such as strengthening cyber governance, establishing a centralized national governance model and raising the level of protection of critical digital infrastructure.

Recent research published by the Inter-American Development Bank and the Department of Business, Energy and Industrial Strategy (UK Government) may provide helpful strategies for mission-oriented policy evaluation of Brazil's innovation governance.³⁵

³⁰ De Negri et al, 'Ciência, Inovação e Produtividade'.

³¹ Filho et al, 'Políticas de Inovação no Brasil'.

³² Ministério da Ciência, Tecnologia e Inovação, 'Estratégia Nacional de Ciência, Tecnologia e Inovação 2012-2015' (Brasília, Brazil: Secretaria Executiva do Ministério da Ciência, Tecnologia e Inovação, 2012), <https://livroaberto.ibict.br/218981.pdf>. Initially, the document presented plans until 2019, but it was extended to 2022.

³³ Israel d. O Andrade and Alixandro W. Leite, 'A Indústria de Defesa No Contexto Da Política de Inovação', in *Políticas de Apoio à Inovação Tecnológica No Brasil: Avanços Recentes, Limitações e Propostas de Ações*, ed. Lenita M. Turchi and José M. de Moraes (Brasília, Brazil: Instituto de Pesquisa Econômica Aplicada, 2017), 371-94, https://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=30774.

³⁴ Brasil País Digital, 'Estratégia Brasileira de Inteligência Artificial', Brasil País Digital, 2019, <https://brasilpaisdigital.com.br/estrategia-brasileira-de-inteligencia-artificial/>.

³⁵ Mariana Mazzucato and Rainer Kattel, 'Alternative Policy Evaluation Frameworks and Tools: Exploratory Study' (London: Department for Business, Energy & Industrial Strategy, UK Government, 15 October 2020), <https://www.gov.uk/government/publications/alternative-policy-evaluation-frameworks-and-tools-exploratory-study>; Mariana Mazzucato and Caetano C. R. Penna, 'The Age of Missions: Addressing Societal Challenges Through Mission-Oriented Innovation Policies in Latin America and the Caribbean' (Washington, DC: Inter-American Development Bank, 2020),

3.2. NEW HORIZONS: FUTURE PLANS AND THE FNDTC BILL

In November 2019, the MCTI launched a public consultation to receive contributions around a National Innovation Policy (PNI),³⁶ which would be responsible for structuring the federal government's actions in ST&I for the next ten years. According to the documents opened to the public consultation, the PNI's objective would be to position Brazil among the twenty most innovative countries in the world by 2030 (based on the GII). The MCTI lists a number of challenges to the sector:

- *Relatively low levels of innovation*, reflected in Brazil's limited international patent registrations, meaning that most innovations are related to the import and adaptation of technology from other countries;
- *Lack of coordination between institutions*, especially between the production of knowledge in universities and its application in companies;
- *Limited funding for ST&I*;
- *Low planning capacity of training human resources*;
- *Low capacity to transform innovation inputs into products*;
- *No support from adequate institutional framework* for innovations, thus making it difficult to reduce the uncertainties endemic to the innovative process.

To overcome these challenges, the PNI proposes a series of objectives, such as stimulating knowledge bases for innovation, disseminating a culture of innovation and entrepreneurship, ensuring the promotion of technological development, expanding the talent base for innovation, fostering markets for Brazilian products and services, and improving the regulatory environment. These objectives are within reach if Brazil expands its research infrastructure, simplifies the process of granting patents, encourages open scientific knowledge available on digital platforms, promotes the creation and development of startups, values Brazilian creators and developers, and encourages increased private investment in R&D. The public consultation regarding the PNI has been concluded; so far, the MCTI has no new position.

In January 2020, the MCTI opened another public consultation: this time, to define the National Strategy for Artificial Intelligence, aiming to identify priority areas in the development and use of technologies related to artificial intelligence (AI), considering the areas of greatest potential to solve Brazil's main problems.³⁷ The MCTI's proposal is divided into three transversal axes: legislation, regulation and ethical use of AI, AI governance and international aspects. The MCTI's proposal also has six vertical axes: education, workforce and training, research, development, innovation, and entrepreneurship, application in productive sectors, application in public power, and public security. The public consultation ended in early March.

The result of the consultation process was the enactment of a Decree by the Executive branch of the Brazilian government. This Decree - Federal Decree 10534 on 28 October 2020 - sets the National Innovation Policy for Brazil.³⁸ The decree aims to coordinate and articulate strategies, programs and actions for encouraging innovation, and increase the productivity, competitiveness and innovation of Brazilian companies, institutions and organizations. The Policy also establishes mechanisms for cooperation between the States, Federal District and Municipalities to promote the alignment of policy.³⁹ Most importantly, the Decree creates the Brazilian Innovation Chamber, which is only composed by

<https://publications.iadb.org/publications/english/document/The-Age-of-Missions-Addressing-Societal-Challenges-Through-Mission-Oriented-Innovation-Policies-in-Latin-America-and-the-Caribbean.pdf>.

³⁶ Available from the Ministry of Science, Technology, Innovation and Communications website (<https://ibrazil.mctic.gov.br/>).

³⁷ Find further information online at: <http://participa.br/profile/estrategia-brasileira-de-inteligencia-artificial>.

³⁸ Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2020/decreto/D10534.htm

³⁹ PwC, 'Política Nacional de Inovação - Instituição - Decreto Federal Nº 10.534/2020', PwC Brasil, October 2020, <https://www.pwc.com.br/pt/sinopse-legislativa/outros-assuntos/politica-nacional-de-inovacao-instituicao-decreto-federal-n-10534-2020.html>.

representatives from the public sector. While the Decree foresees the Chamber will be supported by expert groups, it does not directly involve representatives of the private sector in its activities. During the consultation phase, MEI's contributions proposed a Policy rooted in five axes: 1) broad and effective participation of the private sector in the governance, monitoring and evaluation structure, including at strategic level; 2) maintain the budget and increase investments in STI and education; 3) debureaucratization and legal security of the means of fostering innovation; 4) preservation of successful initiatives, such as EMBRAPA and SENAI, and the creation of new programs that promote more interaction between companies and science and technology institutions and; 5) investment in cutting edge technology areas, such as 5G, Artificial Intelligence, Internet of Things, advanced materials and energy efficiency, to promote the development of disruptive technologies.⁴⁰ However, differently from the resulting Decree, CNI/MEI's contributions were centered in the core role of the private sector on leading innovation aligned with the primary role of the public sector in financing science and technology as a core element for innovation and competitiveness of the country.

Recently, the Federal Senate approved Bill 135/2020,⁴¹ which ensures the maintenance of the FNDCT funds are invested in ST&I. To this end, the project prohibits the contingency of resources from the Fund and transforms it into a fund of an accounting and financial nature. Approved in the Federal Senate and in the Chamber of Deputies, the bill was sanctioned by the President of Brazil with two vetoes, which were overturned by the National Congress, maintaining the original text.⁴² CNI warns that only R\$600 million of the R\$5.2 billion raised by the FNDCT in 2020 is available for investment in research, development, and innovation activities conducted by universities, research institutes and companies this year.⁴³

3.3. BRAZIL'S RESEARCH INFRASTRUCTURE

In the 2000s, Brazil recorded broad growth in the volume of investments in research infrastructure, mainly due to resources from the MCTIC, the Ministry of Education (MEC), the State Foundations for Research Support (FAPs), and companies like Petrobras. However, despite the growing volume of investments, these resources were allocated haphazardly, without a sense of building a comprehensive and competitive ST&I arrangement.⁴⁴

A 2016 study collected data from around two thousand laboratories and research institutions in Brazil.⁴⁵ More than half of the laboratories were created in the 2000s and many have made significant investments in the last eight years, suggesting the prevalence of relatively new research infrastructure (however, these findings do not imply up-to-date infrastructure by global standards).⁴⁶ On average, teams of laboratories consist of just four researchers. 52% are laboratories whose value does not exceed R\$500,000. Around 1% of the total laboratories have an estimated value above R\$20 million.

Brazilian laboratories and research institutions are public, with a few exceptions. Most are located within public universities. In this sense, universities assume the responsibilities of

⁴⁰ CNI, 'Public Consultation - National Innovation Survey', CNI, 2020.

⁴¹ Senado Federal, 'Projeto de Lei Complementar N° 135, de 2020', Atividade Legislativa, 2020, <https://www25.senado.leg.br/web/atividade/materias/-/materia/142077>.

⁴² Câmara dos Deputados, 'Projeto de Lei Complementar N° 135, de 2020', Atividade Legislativa, 2020, <https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=2262099>.

⁴³ Agência CNI de Notícias, 'Aprovação Do Projeto Que Libera Recursos Do FNDCT Assegura o Principal Instrumento de Fomento à Inovação No Brasil, Avalia CNI', Agência CNI de Notícias, 13 August 2020, <https://noticias.portaldaindustria.com.br/posicionamentos/aprovacao-do-projeto-que-libera-recursos-do-fndct-assegura-o-principal-instrumento-de-fomento-a-inovacao-no-brasil-avalia-cni/>.

⁴⁴ De Negri, 'Por uma Nova Geração de Políticas de Inovação no Brasil'.

⁴⁵ Fernanda de Negri and Flávia D. H. S. Squeff, 'O Mapeamento Da Infraestrutura Científica e Tecnológica No Brasil', in *Sistemas Setoriais de Inovação e Infraestrutura de Pesquisa No Brasil*, ed. João Alberto de Negri and Flávia D. H. S. Squeff (Brasília, Brazil: Instituto de Pesquisa Econômica Aplicada, 2016), 15–51, https://www.ipea.gov.br/portal/index.php?option=com_content&view=article&id=27203.

⁴⁶ De Negri, 'Por uma Nova Geração de Políticas de Inovação no Brasil'.

both training high-level researchers and leading research agendas. This scenario suggests that innovation may be stifled by rigid and bureaucratic rules of operation, such as obstacles to the purchase or import of equipment and the hiring of temporary researchers.⁴⁷

Ultimately, there are few examples of research institutions devoted to conducting only cutting-edge research, either basic or applied. De Negri draws attention to the Oswaldo Cruz Foundation (Fiocruz), the Brazilian Agricultural Research Corporation (Embrapa), and some research institutes linked to the MCTI, notably the Brazilian Center for Research in Energy and Materials (CNPEM) and the Aeronautic Institute of Technology (ITA) / Aerospace Technical Center (CTA) complex.⁴⁸

3.4. FINANCING INNOVATION IN BRAZIL

In 2014, the ENCTI 2012-2015 aimed to secure 1.8% of national R&D spending relative to GDP.⁴⁹ In 2022, the ENCTI 2016-2022 hopes this number will reach 2%.⁵⁰ In 2018, Brazil's current President (then, still a candidate) promised to reserve 3% of the GDP for science spending until the end of his mandate.⁵¹ However, Brazil currently invests below 1.3% of its GDP in ST&I.⁵² Estimates for 2018 show that national spending on R&D as a share of GDP was approximately 1.4%. Public expenditures totalled 0.79, with 0.47% federal expenditures and 0.32% state expenditures. Business expenditures totalled 0.60%, with 0.57% from private and state-owned companies.⁵³

After a period of accelerated economic growth between 2010 and 2014, Brazil fell into a serious fiscal crisis, resulting in the drastic decline in ST&I investments. As demonstrated in Figure 2, the budget invested by the FNDTC fell from R\$2.5 billion in 2013 to R\$766 million in 2018, a reduction of around 70%. The National Council for Scientific and Technological Development (CNPq), responsible for funding scholarships and grants, saw its investment drop from R\$2.3 billion in 2016 to R\$1.2 billion in 2019.⁵⁴ In 2018, there were US\$140 billion worth of tax exemptions, worth 3.97% of Brazil's GDP; of this total amount, just 3.6% were for investments in ST&I.⁵⁵ The fiscal crisis has stunted the growth of venture capital funds, which represent just 0.01% of GDP, compared to 0.3% and above in other developed economies like the United States and Israel.⁵⁶

⁴⁷ Ibid.

⁴⁸ Ibid.

⁴⁹ Ministério da Ciência, Tecnologia e Inovação, 'Estratégia Nacional de Ciência, Tecnologia e Inovação 2012–2015', 91-92.

⁵⁰ Ibid, 117-120.

⁵¹ André Bernardo, 'A Ciência Brasileira Terá Vez No Governo Bolsonaro?', *Revisita Galileu*, 3 April 2019, <https://revistagalileu.globo.com/Revista/noticia/2019/04/ciencia-brasileira-tera-vez-no-governo-bolsonaro.html>; Política de CTIE, 'Respostas de Jair Bolsonaro à ABC e SBPC', *Academia Brasileira de Ciências*, 22 October 2018, <http://www.abc.org.br/2018/10/22/respostas-de-jair-bolsonaro-a-abc-e-sbpc/>. ...

⁵² Ministério da Ciência, Tecnologia e Inovações, 'Recursos Aplicados - Indicadores Consolidados', Ministério da Ciência, Tecnologia e Inovações, 2018, https://antigo.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html.

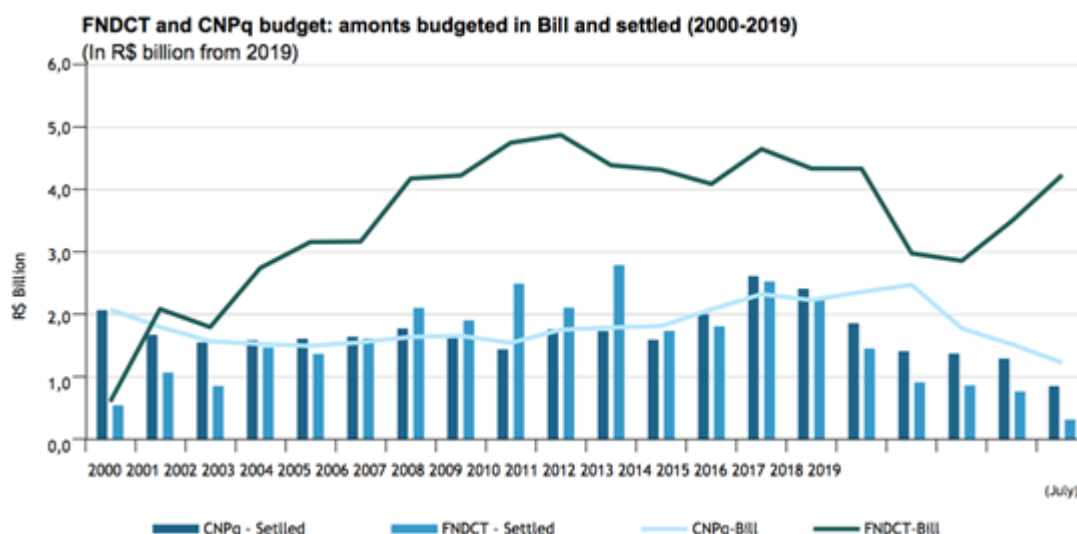
⁵³ Ibid.

⁵⁴ Fernanda de Negri and Priscilla Koeller, 'O Declínio Do Investimento Público Em Ciência e Tecnologia: Uma Análise Do Orçamento Do Ministério Da Ciência, Tecnologia, Inovações e Comunicações Até o Primeiro Semestre de 2019' (Brasília, Brazil: Instituto de Pesquisa Econômica Aplicada, 2019), https://www.ipea.gov.br/portal/images/stories/PDFs/nota_tecnica/190828_NT_48_Diset.pdf.

⁵⁵ Soumitra Dutta, Bruno Lanvin, and Sacha Wunsch-Vincent, eds., *Global Innovation Index 2020*, 13th ed. (Cornell University, INSEAD and the World Intellectual Property Organization, 2020).

⁵⁶ Ibid.

FIGURE 2. FNDCT AND CNPQ BUDGET (2000-2019)



Source: Fernanda de Negri and Priscila Koeller, 'O Declínio do investimento público em ciência e tecnologia'

Brazil's innovation economy faces a wide range of financing challenges. First and foremost, the economic risks associated with innovation funding is particularly high in Brazil due to a collage of economic, political and social uncertainty. Exacerbating this uncertainty is high interest rates, which "negatively affect the willingness of business leaders".⁵⁷ The GII also suggests that Brazil has a deficiency in the talent required to generate the research behind innovation: less than 900 researchers per million inhabitants, which is low compared to the averages of other developed countries.⁵⁸ CNI also draws attention to the information asymmetries that exist between investors and inventors, reducing incentives for collaboration. As a result, national and international banks are reluctant to fund innovation projects.⁵⁹

⁵⁷ Robson B. de Andrade, 'Financing Innovation in Brazil', in *Global Innovation Index 2020*, ed. Soumitra Dutta, Bruno Larvin, and Sacha Wunsch-Vincent, 13th ed. (Cornell University, INSEAD and the World Intellectual Property Organization, 2020), 149.

⁵⁸ Ibid, 149.

⁵⁹ Ibid, 149.

TABLE 2. RESOURCES APPLIED IN BRAZIL'S MAIN INNOVATION PROGRAMS AND POLICIES (2018)

Program/Policy	Funding agency	Resources available (US\$ millions PPP)
Subsidized credit	BNDES	889
	FINEP	1,200
	Total	2,089
Tax breaks for innovation	"Lei do Bem" (Law of Good)	1,052
	Informatics Law	2,837
	Other tax incentives	1,151
	Total	5,040
Mandatory R&D investments	ANEEL	432
	ANP	996
	Total	1,428
Government budget allocations for R&D (excluding general university funds)	Central government	6,786
	States	1,819
	Total	8,605

Source: De Andrade, 'Financing Innovation in Brazil', 149.

Noting Brazil's continuous improvement in the innovation financing ecosystem, CNI spotlights several challenges and opportunities. Namely, tax incentives clearly reduce the cost of business and incentivize investment. "It is essential to create permanent evaluation mechanisms" to lead to continuous improvement in incentives and maintain investor confidence during fiscal crises.⁶⁰ De Andrade's analysis also notes that credit financing could help contribute to better innovation financing. Further, there are a range of legal and regulatory measures that Brazil should pursue to stimulate venture capital markets in order to generate investment and interest in innovation, and the possibility of expanding mechanisms for public co-investment to reduce overall risk.

Generally, while international investors benefit from innovations in entrepreneurial finance with an unprecedented diversity and amount of opportunities for investment – across different stages of a companies' life cycle – many funding gaps remain.⁶¹ As Brazil is a developed economy, innovation financing is constrained by a variety of obstacles explained in this section. To combat these funding gaps, Brazil must continue and deepen its existing innovation financing initiatives.

⁶⁰ Ibid, 154.

⁶¹ Peter Cornelius, 'Sources of Funding and Entrepreneurship', in *Global Innovation Index 2020*, ed. Soumitra Dutta, Bruno Lanvin, and Sacha Wunsch-Vincent, 13th ed. (Cornell University, INSEAD and the World Intellectual Property Organization, 2020), 84.

4. BRAZIL: INTERNATIONAL PERSPECTIVES

This section provides insights from literature about the state of Brazil's innovation system produced by international organizations operating in the region, such as the Organisation for Economic Cooperation and Development (OECD) and the Inter-American Development Bank (IDB), in addition to selected private international corporations with notable research capacities, such as Deloitte and McKinsey and Company. This section includes both a general summary of insights (highlighting several key dynamics from across the literature) and insights organized into this report's four thematic areas: infrastructure and institutions, technology performance, talent, and Brazil's innovation system.

4.1. TRENDS IN INTERNATIONAL RESEARCH

In a comparative global perspective, Brazilian innovation is praised for moderate yet skewed performance. Namely, while Brazilian innovation excels in certain areas, its overall performance is hindered by poor performance in other areas. This dynamic of unequal development and skewed performance emerges across the literature produced by international organizations and firms.

To provide an example, in the *European Innovation Scoreboard 2020*, Brazil is considered a *Moderate Innovator*. The report notes a strong trajectory of improvement from 2012 onwards. Compared to the European Union (EU) benchmark, Brazil's noted strengths are in marketing, organizational innovation and trademark applications.⁶² Other contextual indicators suggest that, compared to the EU, Brazil boasts higher levels of entrepreneurship, although R&D spending is still below the EU average.⁶³ Consequently, the framework report notes that the EU maintains a strong performance lead over Brazil.

Reviewed literature highlights another evident dynamic in Brazil's innovation system. In sum, while much digital progress has been recorded, digital development is often hindered by offline insufficiencies and inefficiencies. Namely, Brazil's E-Digital Plan (Brazil's Digital Transformation plan, composed of the National Internet of Things Plan, the Science at School Programme and the *Brasil Conectado* program) wins plaudits across the literature. However, several reports note that offline barriers still hinder digital development, and by consequence, the country's innovation system. For instance, reports note the difficulty of registering patents⁶⁴ or creating businesses,⁶⁵ among other governance inefficiencies and bureaucratic obstacles.

The literature points to a third dynamic: notably, the recorded deficiencies and poor performance in Brazil's ICT sector is a unique opportunity for growth. Both international organizations and corporations note that Brazil's chronic underinvestment in ICTs offers both local and international investors lucrative economic opportunities,⁶⁶ as demand for ICT goods and services outpaces the sector's current capacity to provide.

A well-researched report by Deloitte on digital transformation in Brazil refers to the E-Digital Plan objectives in order to highlight a variety of growth opportunities in the country's ICT sector, noting that: "the ICT sector is an enabler of economic progress and also an important

⁶² Hugo Hollanders and et al, 'European Innovation Scoreboard 2020' (Luxembourg: European Commission, 2020), 27.

⁶³ Ibid, 29.

⁶⁴ Nicola Calicchio et al, 'Brazil Digital Report' (McKinsey & Company; Brazil at Silicon Valley, April 2019), http://www.abragames.org/uploads/5/6/8/0/56805537/brazil_digital_report.pdf, 73.

⁶⁵ Deloitte, 'Insights about Digital Transformation and ICT Opportunities for Brazil Report and Recommendations' (Deloitte, January 2019), <https://www2.deloitte.com/content/dam/Deloitte/br/Documents/technology-media-telecommunications/ICT-insights-report-eng.pdf>.

⁶⁶ Ibid.

driving force for the development of the global digital economy.”⁶⁷ Brazil is one of the world’s major smartphone markets; accordingly, meeting the demand of Brazil’s most prominent ICT sub-sector (with 43.5% of the sector’s revenue in 2017) is an investment opportunity.⁶⁸ More generally, IDB Invest highlights opportunities to invest in infrastructure.⁶⁹

These three dynamics (moderate innovation performance undermined by skewed performance in ICT sub-sectors; digital progress hindered by offline barriers; investment opportunities in ICT deficiencies) emerge across the literature and generally define the approach of international organizations and firms to Brazilian innovation. Several other organizations have located these dynamics and insights in the context of COVID-19.⁷⁰

4.2. INNOVATING IN BRAZIL

This sub-section organizes the insights offered by international organizations and firms by thematic area: infrastructure and institutions, technology performance, talent, and Brazil’s innovation system.

4.2.1. INFRASTRUCTURE AND INSTITUTIONS

Generally, despite noted progress in some areas, international reports note that Brazil faces significant institutional challenges that hinders its infrastructural development, and consequently, innovation system. The Global Infrastructure Hub Outlook estimates that closing Brazil’s “infrastructure investment gap” requires an average investment of US\$110 billion a year until 2040.⁷¹ The OECD’s latest Latin American Economic Outlook also recognizes that despite Brazil’s efforts to enhance access to communications infrastructure and services, a significant digital divide persists.⁷²

IDB Invest identifies Brazil’s main infrastructural challenges. In addition to poor performance in the transport, water and sanitation sector, Brazil’s energy and social infrastructure sector faces unique challenges, such as a forecasted increase in electricity demand that the country will not be able to keep up with: for instance, 1.4 million people still require electricity in the North and Northeast regions of Brazil, and alleviating this issue requires additional investments of US\$100 million a year until 2030.⁷³

Other identified challenges include regulatory uncertainty, which hinders investment due to investor confidence and fears of the increased politicization of regulatory agencies. The report also notes that major scandals like the Car Wash affairs have had a negative impact on investor confidence.⁷⁴ In addition to regulatory uncertainty, IDB Invest draws attention to complex bureaucratic mechanisms and a multi-layer governance system that reduces the opportunities for future public-private partnership (PPP) concessions, and causes delays and increases costs in projects already on the road.⁷⁵ Generally speaking, IDB Invest identifies “capacity constraints” – such as a Federal PPP law that allows federative units to enact its own PPP framework – that hinders private participation in public sector projects.

⁶⁷ Ibid, 13.

⁶⁸ Ibid, 30.

⁶⁹ Castillo and Plasencia, ‘Building BIG: Brazil’s Challenges and Opportunities in Infrastructure’.

⁷⁰ OECD, *Latin American Economic Outlook 2020: Digital Transformation for Building Back Better* (Paris: OECD Publishing, 2020), <https://doi.org/10.1787/e6e864fb-en>.

⁷¹ Castillo and Plasencia, ‘Building BIG: Brazil’s Challenges and Opportunities in Infrastructure’, 1.

⁷² OECD, *Latin American Economic Outlook 2020*, 278.

⁷³ Castillo and Plasencia, ‘Building BIG: Brazil’s Challenges and Opportunities in Infrastructure’, 4.

⁷⁴ Ibid, 11.

⁷⁵ Ibid, 11.

An International Monetary Fund (IMF) working paper echoes these findings, identifying “infrastructure bottlenecks” as a key obstacle to growth, with negative impacts on market efficiency, export performance, domestic integration and productivity more generally.⁷⁶ The working paper identifies “infrastructure gaps”, benchmarked against the Brazilian economy’s main competitors. While Brazil’s electricity supply and ICT infrastructure is close to the expected value for its income group, its roads, railroads, ports and airports are “significantly” below the predicted value, “with the largest gaps in road and port infrastructure.”

According to the IMF working paper, this gap reflects “a prolonged period of low infrastructure investment”, dropping from 5.2% of GDP in the early 1980s to 2.25% of GDP in 2013.⁷⁷ The decline in infrastructure investment has led to a variety of financial sustainability challenges that impact Brazilian infrastructure. On the one hand, private sector investment has not yet “filled the space vacated by the public sector”;⁷⁸ on the other hand, while the Brazilian Development Bank (BNDES) has always been a major infrastructure financier, Law 13/483 (2017) mandates that BNDES’s subsidized interest rate (Taxa de Juros de Longo Prazo - TJLP) will be replaced by a market-based long-term interest rate. However, the adoption of Basel III “might impact the capacity of the banking sector to increase its portfolio in the infrastructure sector... Brazil will need to attract more international infrastructure developers with technical and financial capabilities that will complement the local market supply.”⁷⁹

Brazil’s infrastructural challenges gain a new urgency given the extent of demographic changes, population growth and urbanization; as of 2020, Brazil’s rate of urbanization stands at 84.4%, with an urban population of over 160 million. Director Cesar Cunha Campos at FGV Projetos commented in 2015 that the rapid and continuous expansion of Brazil’s urban population is a stress for transport infrastructure. While Brazil has enacted world-leading measures to improve urban mobility, such as the Bus Rapid Transport exclusive corridors system, there is much room for improvement in integrated planning, “supported by clear public policies, new technologies and ways to safeguard the environment, is the path towards sustainable mobility in cities in Brazil, as elsewhere.”⁸⁰

Improving Brazil’s urban mobility and urban-rural infrastructural connections is an important action point that several reports converge on, particularly given the emergence of urban centers as major innovation and startup hubs.⁸¹

As reported by the Brazil Institute at the Wilson Center in February 2020, by the end of the year, the Brazilian government expects to have completed 18 projects in order to sell public property, including PPPs, concessions and leases, a total of USD\$6.4 billion in investment.⁸² The report notes efforts by the Ministry of Infrastructure to improve the country’s railway network, with investment encouraged into the Ferrogrão ‘Grain-Way’ project that aims to extend the 177-kilometer railway between Lucas do Rio Verde and Sinop to the Miritituba port, 933 kilometers away.⁸³ Additionally, the report praises the highway concessions in the public consultation stage, such as the Dutra highway between São Paulo and Rio de Janeiro, managed until the end of the year by Concessionária Rodovia Presidente Dutra S/A (Nova Dutra).⁸⁴

⁷⁶ Mercedes Garcia-Escribano, Carlos Goes, and Izabela Karpowicz, ‘Filling the Gap: Infrastructure Investment in Brazil’ (International Monetary Fund, July 2015).

⁷⁷ Ibid, 11.

⁷⁸ Ibid, 12.

⁷⁹ Castillo and Plasencia, ‘Building BIG: Brazil’s Challenges and Opportunities in Infrastructure’, 12.

⁸⁰ Cesar Cunha Campos, ‘Business Brief: Innovation and Urban Mobility in Brazil’, OECD, n.d., <http://www.oecd.org/brazil/innovation-urban-mobility-brazil.htm>.

⁸¹ Calicchio et al, ‘Brazil Digital Report’, 93.

⁸² The Brazilian Report, ‘Brazil’s Infrastructure for Sale in 2020’, Wilson Center, 19 February 2020, <https://www.wilsoncenter.org/blog-post/brazils-infrastructure-sale-2020>.

⁸³ Ibid.

⁸⁴ Ibid.

The IDB Invest report highlights these significant opportunities for investment, praising the Brazilian government's steps to enable private investment in infrastructure. Report authors Paula Castillo and Felipe Ezquerro Plascencia identify several forthcoming investment opportunities, best managed under the guidance of the IDB and similar bodies. Strengthening infrastructure governance (including capacity to identify, structure and monitor projects under PPPs or concessions) is identified as an opportunity for growth, enabled by long-term strategic and integrated infrastructure planning exercises, such as the provision of trainings in project finance, cost-benefit analysis, and adequate studies in early project stages. Additionally, the report recommends Brazil leverages opportunities to improve risk identification and allocation, and advances accountability and transparency mechanisms.⁸⁵ Another opportunity identified by the report is the chance to fill the PPP capacity gap with targeted training, such as the CP3P Preparation,⁸⁶ in order to spur strategic local investments in infrastructure and generate investment knowledge.

4.2.2. TECHNOLOGY PERFORMANCE

While Brazil has made much progress in technology performance in recent years, the reports reviewed note that there are several deficiencies in the ICT sector, with performance and competitiveness impacted accordingly. Notably, while the OECD's most recent survey praises Brazil's technology in a wide variety of technology indicators – from its improvement in the E-Government Development Index⁸⁷ to its steady rise in open data indicators – their research suggests that Brazil's technology performance is well below the OECD average.⁸⁸ Regionally, Brazil underperforms on ICTs compared to economies such as Costa Rica and Uruguay. Generally speaking, there is a disjuncture in the technology performance of Brazil's public and private sectors, and further splinters in performance among them. Brazil's high-tech exports as a share of total manufactured exports rose to 13% in 2018, above the regional average of 8.6% but below the OECD average (15.1%).⁸⁹

As noted by McKinsey and Company, the Brazilian consumer “is ready for digital disruption”, but “digital inclusion has only just begun.” Namely, more than two out of three Brazilians have access to smart-phones and the Internet, and Brazilians rank second in the world in using social media platforms like Facebook, Instagram and WhatsApp.⁹⁰ However, Internet speeds are still slower than most developed economies; smartphones are among the devices with high penetration in Brazil, but as mentioned by the Deloitte report, there is “still room to increase penetration across devices.”⁹¹ This report's findings are echoed by the UN Conference on Trade and Development's B2C E-Commerce Index, which notes a constantly high support for e-commerce among Brazilian consumers: above the regional average but below the OECD average.⁹²

Reports note a wide variety of initiatives that aim to spearhead digital transformation at the federal and state levels. Notably, Brazil's E-Digital aims to de-bureaucratize governance and improve the digital efficiency of the public sector, address the growing digital divide and contribute to a data-driven economy with digitally-ready individuals and firms. The plan and associated digital governance initiatives (coordinated by the Ministry of Science, Technology, Innovation and Communication) wins plaudits across the literature, and with good reason.

According to recent OECD analysis, Brazil has risen from 0.57 in 2008 to 0.73 in 2018 on the E-Government Digital Index (which measures an economy's capacity and willingness to use

⁸⁵ Castillo and Plascencia, 'Building BIG: Brazil's Challenges and Opportunities in Infrastructure'.

⁸⁶ Marcos Siqueira, 'Filling the Local PPP Capacity Gap in Brazil: How the CP3P Program Can Help', World Bank, 14 September 2020, <https://blogs.worldbank.org/ppps/filling-local-ppp-capacity-gap-brazil-how-cp3p-program-can-help>.

⁸⁷ 'E-Government Development Index (EGDI)', UN E-Government Knowledgebase, n.d., <https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index>.

⁸⁸ OECD, *Latin American Economic Outlook 2020*.

⁸⁹ Ibid, 279.

⁹⁰ Calicchio et al, 'Brazil Digital Report', 28.

⁹¹ Ibid, 47.

⁹² OECD, *Latin American Economic Outlook 2020*, 278-279.

ICTs): above the Latin American average of 0.65, although well below the OECD average of 0.82.⁹³ From a digital inclusion standpoint, initiatives like *Brasil Conectado* have evidently had a positive impact: the number of students per computer rose from 3.7 in 2015 to 6.0 in 2018.⁹⁴

Considering this data, the OECD also notes Brazil's willingness to cooperate on digital research and development on the international level, with an ongoing agreement with the EU on 5G vision, standards and spectrum, based on a 2008 framework for scientific and technology cooperation.⁹⁵

Brazil's technology performance is also judged on readiness for the disruption of future technologies, such as IoT. According to research produced by IDB Invest, GSMA and Frost and Sullivan in 2019, Brazil's industrial IoT revenue is projected to reach USD\$3.293 billion in 2021, with emerging opportunities in agriculture, smart cities and in the automotive and manufacturing sector. However, the IoT ecosystem in Brazil is "still fragmented"; innovators and investors alike encounter the challenge of coordinating and integrating capabilities in order to provide efficient end-to-end service solutions enabled by IoT within and across a variety of actors. The report praises the National Plan of IoT, proposed by a decree in June 2019 and notes that improved and increased connectivity "presents a wealth of possibilities" for IoT national development and sustained innovations.⁹⁶

Most research reviewed notes that the current deficiencies in technology performance (and indeed, in infrastructural capacity) presents local and international investors with a wide range of opportunities. Namely, researchers at Deloitte note that the smartphone market is a strategic sub-sector,⁹⁷ as "Brazil will be among the five major smartphone markets by 2025, with 200 million mobile connections."⁹⁸ Mobile telephony is Brazil's most prominent ICT sub-sector and accounted for 43.5% of the sector's revenues in 2017. According to the Deloitte report, addressing the emerging gap between supply and demand represents an opportunity to improve both Brazil's technology competitiveness and social welfare, as investments in areas prioritized by the E-Digital Plan "can speed up Brazil's development and address current gaps."⁹⁹

In addition to highlighting the opportunities offered by investing in Brazil's smartphone market and connectivity landscape, the aforementioned Deloitte hones in on other priorities in Brazil's E-Digital Plan that, with targeted investments, hold promise for catalyzing wide-scale digital transformation: 5G, optical fiber, cloud, safe city and digital talent.¹⁰⁰

4.2.3. TALENT

The literature agrees that Brazil faces a talent retention "brain drain" issue, similar to other BRICS economies.¹⁰¹ Additionally, most reports note that Brazil faces a deficiency in digital skills. However, generally speaking, the literature also recognizes that because the preferred Brazilian work culture is low-stress, high-energy and open to change,¹⁰² there are significant

⁹³ Ibid.

⁹⁴ Ibid.

⁹⁵ Ibid.

⁹⁶ IDB Invest, GSMA, and Frost and Sullivan, 'Prepare for the Internet of Things Disruption: Focus on Latin America' (Inter-American Investment Corporation, 2019), 2-3.

⁹⁷ Deloitte, 'Insights about Digital Transformation and ICT Opportunities for Brazil', 18.

⁹⁸ Ibid, 13.

⁹⁹ Ibid, 37.

¹⁰⁰ Ibid, 39.

¹⁰¹ De Andrade, 'Financing Innovation in Brazil'; Roy Maurer, 'Think Local: Retain Top Talent in the BRICs', SHRM, 12 February 2014, <https://www.shrm.org/resourcesandtools/hr-topics/global-hr/pages/local-retain-top-talent-brics.aspx>.

¹⁰² Paula Caligiuri, 'Differentiating for Success: Securing Top Talent in the BRICs' (EY, n.d.), [https://www.ey.com/Publication/vwLUAssets/EY-Securing-top-talent-in-the-BRICs/\\$FILE/EY-Securing-top-talent-in-the-BRICs.pdf](https://www.ey.com/Publication/vwLUAssets/EY-Securing-top-talent-in-the-BRICs/$FILE/EY-Securing-top-talent-in-the-BRICs.pdf).

opportunities for growth. 80% of teachers in Brazil report being open to change in terms of technology use.¹⁰³

Across the public and the private sector, research gathered from international organizations and firms suggests that Brazil's talent landscape is not particularly well-equipped for digital development. There is a gap between achieving Brazil's digital future and the current skills level of its workforce, in terms of both digital skills and knowledge-intensive practices.¹⁰⁴ In 2016, only around 20% of the Brazilian workforce performed highly knowledge-intensive jobs, well below the OECD average of over 35%.¹⁰⁵ 41% of Brazilian employers note that their difficulties filling available positions is due to the lack of "hard skills" across sectors.¹⁰⁶

Some reports attest Brazil's moderate technology competitiveness to the education sector, which suffers from a regionally normal yet globally concerning deficiency in the use and access of ICTs; for instance, only 41% of lower secondary teachers can use ICTs.¹⁰⁷ As a result, Brazil lags behind in the total number of STEM graduates; indicators suggest this will not change in the near future,¹⁰⁸ particularly as public spending on education is higher than the regional average, suggesting that "Brazil has been spending inefficiently... the ICT skills gaps in Brazil are getting bigger and bigger."¹⁰⁹

The Talent Shortage Survey in 2016 identifies that Brazilian employees are, generally speaking, "low skilled and require substantial support from the public and private sectors to provide training programs."¹¹⁰ To push Brazil to become "the talent hub of Latin America" and leverage talent as a core driver of digital transformation, Deloitte offers the following operational recommendations:¹¹¹

- Stimulate cooperation with private sector and education institutions;
- Create study groups to define future jobs;
- Create and incentivize research institutes;
- Improve financial and professional recognition of teachers;
- Promote events to stimulate "STEM adhesion";
- Include building digital talent in ICT emerging tech initiatives.

¹⁰³ OECD, 'Making the Most of Technology for Learning and Training in Latin America', OECD Skills Studies (Paris: OECD, 2020), <https://www.oecd.org/brazil/making-the-most-of-technology-for-learning-and-training-in-latin-america-ce2b1a62-en.htm>, 13.

¹⁰⁴ Deloitte, 'Insights about Digital Transformation and ICT Opportunities for Brazil'.

¹⁰⁵ Ibid, 86.

¹⁰⁶ Ibid.

¹⁰⁷ OECD, 'Making the Most of Technology for Learning and Training in Latin America'.

¹⁰⁸ Calicchio et al, 'Brazil Digital Report', 77.

¹⁰⁹ Deloitte, 'Insights about Digital Transformation and ICT Opportunities for Brazil', 87.

¹¹⁰ Ibid, 85.

¹¹¹ Ibid, 84, 93-94.

EY reports include surveys about talent from BRICS countries and identifies five strategies for Brazil to retain its top talent. Brazilian respondents favor a high-energy and socially-oriented culture, particularly given the entrepreneurial “spirit” of Brazil, with 39% of the workforce between 18 to 64 years old running their own businesses at some point, despite a short business mortality.¹¹² Recommendations for firms in Brazil include:¹¹³

- Accommodate different career goals, and focus on high-potential programs to establish new ventures and launch new projects;
- Build a differentiated employer brand by country and profession, and specifically emphasize corporate social responsibility as an integral element;
- Develop the behavioral styles of co-workers and leaders to enhance engagement. Because Brazilian respondents emphasize having inspiring, motivated and social colleagues, firms should acquire and develop these traits, and embed them in internal and external communications programs.
- Craft work environments to match country preferences; for Brazil, this preference is low-stress, comfortable and high-energy.
- Finally, tailor compensation and benefits to individual and cultural differences; offer Brazilian employees clear career paths with attractive future earning potential.

4.2.4. BRAZIL’S INNOVATION SYSTEM

Research produced by international organizations and firms focus on aspects of the innovation system including innovation hubs, startups, patents and policy innovation, to name a few. Generally speaking, the research reviewed agrees that Brazil’s innovation system is concentrated around urban hubs, and that despite progress in the digital development of business and trade, the ease of innovating and participating in the digital economy is hindered by offline barriers.

A recent report produced by Sao Paulo Tech found that the state of Sao Paulo concentrated about 83% of all national investment in tech-based startups in the past few months,¹¹⁴ with over 3,300 startups and over 25 incubators.¹¹⁵ Additionally, Sao Paulo is such a significant hub that it attracted more funding than entire countries in the region; in the same period, Sao Paulo attracted more investment in their tech startup ecosystem than Chile, Colombia, Argentina and Mexico. In addition to Sao Paulo, Santa Catarina, Minas Gerais, Rio de Janeiro, Parana, Rio Grande do Sul, Pernambuco, Bahia and Distrito Federal are noted innovation hubs, with far fewer startups, incubators, accelerators and higher education institutions than Sao Paulo, however.

As noted by the 2019 Doing Business Report (which gauges how easy it is to start a new business in a country), Brazil is below the Latin American and Caribbean average, ranking in 124th position.¹¹⁶ While the World Economic Forum notes that Brazil has improved offline barriers to innovation, from digitizing business creation with an online portal to grant commercial licenses, new obstacles have emerged: for instance, transferring business ownership became comparably more challenging and more tax burdensome, and the opening hours of the business registration agency were limited. Deloitte’s research agrees that “despite the initiatives to reduce bureaucracy, there are still barriers to start a new business in the country.”¹¹⁷

¹¹² Calicchio et al, ‘Brazil Digital Report’, 66.

¹¹³ Maurer, ‘Think Local: Retain Top Talent in the BRICs’.

¹¹⁴ Angelica Mari, ‘The Brazil Tech And Innovation Round-Up: Report Examines São Paulo Startup Investment, Digital Citizen Services Increase, Surveillance Gets Challenged’, Forbes, 24 April 2020, <https://www.forbes.com/sites/angelicamarideoliveira/2020/04/24/the-brazil-tech-and-innovation-roundup-report-examines-so-paulo-startup-investment-digital-citizen-services-increase-surveillance-gets-challenged/#6dc5c3573928>.

¹¹⁵ Calicchio et al, ‘Brazil Digital Report’, 94.

¹¹⁶ ‘Brazil: Doing Business 2019’ (World Bank, 2019).

¹¹⁷ Deloitte, ‘Insights about Digital Transformation and ICT Opportunities for Brazil’, 35.

4.3. THE IMPACT OF COVID ON FUTURE READINESS IN BRAZIL

In the first half of 2020, the COVID-19 pandemic crisis induced declines of more than 20% in global output in some advanced and emerging economies, a contraction that would have been much larger had no policy support been issued in these economies. Global economic prospects slowly returned to nearly pre-pandemic levels after the lockdown measures and the initial businesses reopening occurred. However, the pace of recovery lost steam over the summer, particularly with the onset of second and even third waves.

In many cases, government aid has maintained and even stabilized household income levels, enabling spending on durable goods to return to original rates faster than expected. Nonetheless, spending on services that require face-to-face, human interaction remain limited, in addition to international mobility and travel. For many export-oriented economies, this state of affairs will hinder the return to normality, particularly without private sector investment in recovery and lower overall levels of international trade.¹¹⁸

Brazil's economy was recovering slowly from recession when the COVID-19 outbreak hit. As proposed by the OECD Economic Outlook in December 2020, Brazil's economic activity will still fall short of pre-pandemic levels by late 2022, although GDP growth is projected to reach 2.6% in 2021 and 2.2% in 2022. The outlook praised Brazil's "strong fiscal and monetary response", which "managed to prevent a sharper economic contraction".¹¹⁹

To mitigate against the negative long-term economic impacts of the crisis, the outlook notes that Brazil should undergo structural reforms to improve the investment climate and improve competition, and support opportunities for professional training and reskilling for Brazilian workers.¹²⁰ An earlier outlook from 2020 projected the Brazilian economy will recover slowly and partially; some jobs and firms will be unable to survive the onslaught of stress as a result of the pandemic. Critically, consumer and businesses confidence and expectations declined.¹²¹

Fiscal, monetary and structural policy support needs to be maintained to preserve confidence and limit uncertainty, and evolve and adapt based on underlying economic conditions. Many central banks announced further policy easing in 2020. Changes to policy frameworks are also being introduced to reassure investors that policy rates remain low for a long time.¹²²

Many countries' announcements of additional fiscal measures are welcome; the aim must be to avoid premature budgetary tightening in a time of immense economic fragility. Crucially, strong fiscal support should not prevent the necessary adjustments to key emergency programs – including job retention schemes and income support measures – to limit the long-lasting costs from the crisis and encourage the reallocation of resources towards expanding, promising sectors. Improving global co-operation to keep borders open, encourage the free flow of trade, investment and – importantly – medical equipment is more important than ever: not only to fight the virus, but also to speed up global economic recovery.¹²³

¹¹⁸ OECD et al, *Latin American Economic Outlook 2020*.

¹¹⁹ OECD, 'Brazil'.

¹²⁰ Ibid.

¹²¹ OECD et al, *Latin American Economic Outlook 2020*.

¹²² Ibid.

¹²³ Ibid.

5. BRAZIL: A PERSPECTIVE FROM THE PRIVATE SECTOR

This section presents the recommendations from CNI and MEI that focus on the Brazilian innovation system. This section refers to the diagnoses and proposals extracted from CNI and MEI studies, especially the MEI Agenda 2019–2020,¹²⁴ the CNI Strategy Map for Industry 2018–2022,¹²⁵ and the CNI Special Survey: Industry 4.0,¹²⁶ as well as documents from the MEI Meetings and Dialogues.¹²⁷

5.1. GENERAL CONCERNS AND DIAGNOSIS

Despite some notable advances, industry and entrepreneurial sectors have been concerned with current Brazil's Innovation System. The Entrepreneurial Mobilization for Innovation (MEI), an initiative of the National Confederation for Industry (CNI) that seeks to increase innovation capacity, points out that most Brazilian companies are unprepared for changes in global competitiveness and their profound impacts on the economy, particularly the manufacturing industry. Brazil has long-standing difficulties planning and executing long-term projects, and its governance models are often approached in a fragmented or even superficial manner.

According to MEI, in order for Brazil to overcome this situation, the country needs to adopt a ST&I prioritization agenda. This is crucial for Brazil to transition to a digital economy, with ICTs at its core and digital transformations throughout all stages of production and value chains. The proposals defended by MEI are organized into six thematic axes: ST&I policy and governance, regulating ST&I, financing ST&I, improving human resources, global insertion of local industry through innovation, and fostering innovative entrepreneurship.

5.2. ST&I POLICY AND GOVERNANCE

The prioritization of ST&I must happen with a broad, well-structured and long-term national innovation policy that serves as the main axis of an economic development project.¹²⁸ This national innovation policy must be able to survive changes in government. MEI proposes that Brazil learns from global leaders like Germany, the US and China, who – besides investing more than 2% of GDP in R&D activities, compared to Brazil's 1.3% – have implemented national strategies for the development of advanced manufacturing and transitions to the digital economy.

MEI points out that Brazil's ST&I strategy must pay attention to two fundamental aspects: governance of innovation ecosystem actors at the strategic level of government and the

¹²⁴ Confederação Nacional da Indústria, 'Agenda Da Mobilização Empresarial Pela Inovação: 2019-2020' (Confederação Nacional da Indústria, 2018), <http://www.portaldaindustria.com.br/publicacoes/2018/12/agenda-da-mei-2019-2020/>. MEI Agenda 2019–2020 is the main source used in this section.

¹²⁵ Confederação Nacional da Indústria, '2018-2022 Strategy Map for Industry' (Brasília, Brazil: Confederação Nacional da Indústria, March 2018), <https://www.portaldaindustria.com.br/publicacoes/2018/10/strategy-map-industry/>.

¹²⁶ Confederação Nacional da Indústria, 'Industry 4.0: A New Challenge for Brazilian Industry', Special Survey, CNI Indicators (Brasília, Brazil: Confederação Nacional da Indústria, April 2016), <https://www.portaldaindustria.com.br/statistics/special-survey-industry-4-0/>.

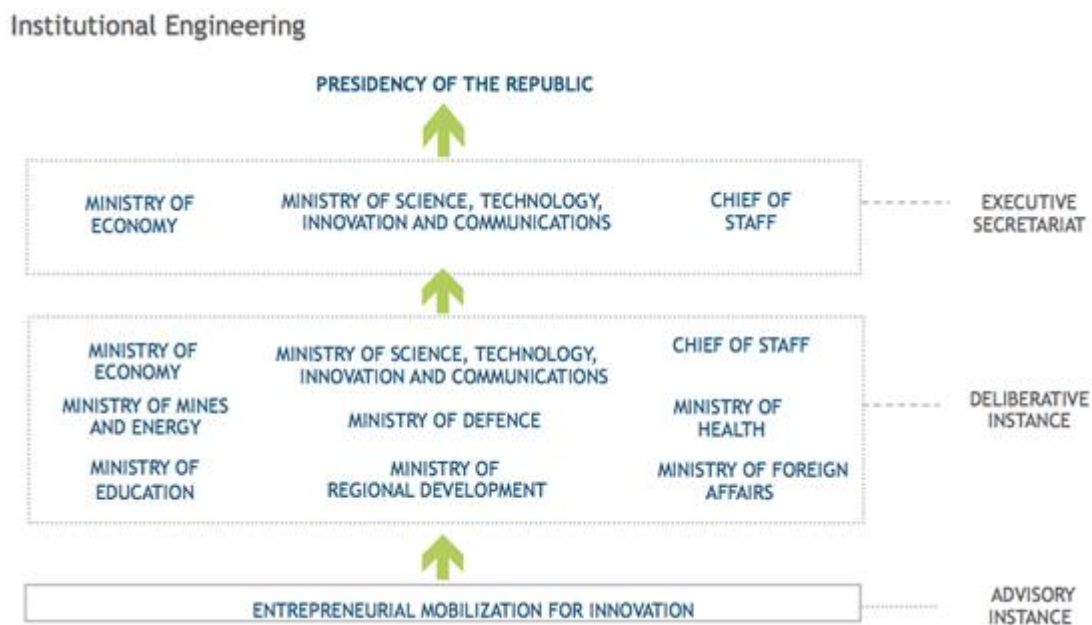
¹²⁷ Find notes from meetings and dialogues online at : <http://www.portaldaindustria.com.br/cni/canaais/mei/biblioteca/downloads/>.

¹²⁸ Brazil has implemented two ST&I national strategies: the ENCTI 2012–2015 and the ENCTI 2016–2022. However, MEI points out that, despite the innovation agenda having gained prioritization in government programs, Brazil has not advanced “in building a robust national strategy for ST&I, with well-founded investment priorities, long-term goals, and the means possible to achieve the proposed objectives” (translation by report authors). Confederação Nacional da Indústria, 'Agenda Da Mobilização Empresarial Pela Inovação: 2019-2020', 17-19.

Additionally, in 2019 a public consultation was launched in Brazil by MCTIC to collect contributions around a National Innovation Policy, MEI presented its recommendations, arguing that the PNI has goals, clarity of available resources, implementation schedules, and a system for monitoring and evaluating the program. Diego Abreu, 'MEI Apresenta Sugestões à Proposta Da Política Nacional de Inovação', Agência CNI de Notícias, 2 December 2019, <https://noticias.portaldaindustria.com.br/noticias/inovacao-e-tecnologia/mei-apresenta-sugestoes-a-proposta-da-politica-nacional-de-inovacao/>.

existence of shared goals with private sectors and clear definition of counterparts. Concerning governance, MEI advocates for a governance model with a strong central core of decision-making power, which enables the policy to establish direct and strong links with the highest levels of government, similar to the US' Office for Science and Technology Policy and Japan's Council for Science, Technology and Innovation. This requires the promotion of institutional engineering aimed at interministerial articulation and the reduction of coordination failures. MEI suggests the following outline:¹²⁹

FIGURE 3. MEI'S INSTITUTIONAL MAP OF INNOVATION POLICYMAKING IN BRAZIL



Source: Entrepreneurial Mobilization for Innovation (MEI), 'Agenda 2019 - 2020'¹³⁰

Ultimately, Brazil's national innovation strategy must be shared and executed between the business and industrial sectors. Both sectors must be empowered in the elaboration and execution of policy. There must be transparency regarding available resources and the implementation timetable, to ensure that policy actions are implemented predictably and securely. The private sector should play a stronger role as a government ally to foster Brazilian innovation.

¹²⁹ MEI points out that the outline is illustrative. What really matters, according to MEI, is that the future of Brazilian innovation be built through a common national view, commanded by the executive authorities maximums, with actions supported in public-private concertation and significant and predictable allocation of resources.

¹³⁰ Entrepreneurial Mobilization for Innovation (MEI), 'Agenda 2019 - 2020' / National Industry Confederation, Industrial Social Service, National Service for Industrial Apprenticeship, Euvaldo Lodi Institute (Brasília: CNI, 2019). Translated and adapted to English by the authors. *The Ministry of Science, Technology, Innovation and Communications (MCTIC) is the old name of the MCTI. The MCTIC was dismembered and, currently, there are MCTI and the Ministry of Communications (MiniCom) in Brazil.

5.3. REGULATING ST&I

According to MEI, the Brazilian ST&I regulatory environment has always been defined by a high degree of complexity and fragmentation. Although there have been some improvements in recent years – such as the New ST&I Legal Framework – MEI points out that there is still much legal uncertainty and a complexity of bureaucratic procedures that hamper business operations and compromise interactions between the public and private sectors. MEI's main recommendations focus on improving the incentives system and intellectual property legislation, aiming to help companies find support and encouragement for investment in innovation.

First, MEI recommends reducing the bureaucracy of resource execution and accountability for innovative companies. In addition, it is necessary to improve the Law no. 13,655/2018 (which deals with the decision processes of the administrative authorities), giving legal certainty and support to public entrepreneurship and stimulating its application in public management and its adherence to the practices of control bodies.

Advocating for the improvement of the incentive system, MEI defends the increase of the number of companies benefited by the main federal tax incentive mechanism to encourage innovation (the Good Law), which is only possible through the reduction of restrictions imposed by legislation that grants the benefits. This step is crucial to guarantee security for investments in R&D, considering that tax incentives reduce the risk of business investments in innovation activities and the cost of capital. MEI also defends the implementation of a specific legal landmark for startups, which should provide incentives and greater facilities for this type of company.

Finally, MEI points out that Brazil's intellectual property system must be enhanced, especially the agility of the processes granting protection and legal security over intellectual property rights. Brazil should sign international agreements that facilitate the simultaneous filing of trademarks, patents, and industrial designs. Furthermore, it is important to strengthen the system for registering trademarks and patents internally to decrease deadlines for analyzing applications.

5.4. FINANCING ST&I

Brazilian companies point out that financing is one of the main obstacles to innovation. This lack of resources is even greater for the economic subvention system, which has suffered drastically with the budget cuts in the ST&I areas in recent years. The few available resources are applied in a dispersed manner, without the establishment of priority areas or niches of excellence. Due to this, MEI argues that it is necessary to restructure the national innovation financing system.

Public and private investments in ST&I areas must be increased and guaranteed in the long term. As key investments in the country's future, ST&I resources must be spared from cuts and discontinuities. Specifically concerning government policies, the budget allocation for economic subsidies (the application of non-reimbursable public resources directly in companies) demands further attention. In addition to urging Brazil to improve the resources available for subsidization, MEI recommends the establishment of a minimum limit of 20% for credit supply, guaranteeing predictability and long-term stimulus to business innovation projects.

The CNI played an important role in the approval of Bill 135/2020 in the Federal Senate. Alongside with the Brazilian Academy of Sciences (ABC), the National Association for Research and Development of Innovative Companies (ANPEI) and the Brazilian Society for the advancement of Science (SBPC), the CNI published a joint manifesto defending the

approval of the Bill in the Federal Senate, highlighting the importance of the full release of FNDTC resources.¹³¹

One of MEI's objectives for the FNDTC is the reorganization of the Sector Funds management committees to adjust their governance, define priorities, institute mechanisms for monitoring projects and reevaluate the transversal budget allocations. Efforts to preserve and increase ST&I public funds must be accompanied by strategies to leverage private investments, encouraging companies that benefit from the financing granted to raise their investment levels with their own funds or resources from the private financial sector. Private financial agents need to participate more broadly in medium and long-term financing operations, which allows for more robust high-impact projects.

Another priority is to set investment priorities, in order to encourage greater policy effectiveness and enhance the business environment. Encouragement policies need to focus on well-defined situations or problems; these mission-oriented policies give preference to financing projects that involve the development of new technologies or solutions in strategic areas for the country, such as mobility, environmental preservation, and vaccines. This would maximize the efficiency of the resources through the establishment of strategic direction for financing innovation, allowing outcomes that respond directly to Brazil's greatest national challenges.

5.5. IMPROVING HUMAN RESOURCES

The business sector points out that investing in new models of education and training programs enables the development of a competent workforce. However, Brazil continues to record sub-par performance on workforce development and human resources. Besides a low high school completion rate, the national situation is critical in Science, Technology, Engineering, Arts and Mathematics areas (STEAM), with a lack of a qualified workforce prepared for innovation.

Created in 2016, MEI's Engineering/STEAM Working Group aims to strengthen Brazil's STEAM education in order to improve the competitiveness and innovativeness of companies. The Working Group brings together private sector representatives from MEI with representatives from academia, government and civil society.¹³²

According to MEI, it is essential to improve the quality of secondary education not just to increase graduation rates and the rate of enrollment in tertiary education, but also to offer a better education for life. Brazil needs to establish pedagogical policies and guidelines that foster skills and abilities related to creativity, collaborative work, and complex decision-making, which need to be supported by flexible curricular content and by teaching methodologies capable of providing practical experiences to students. Moreover, MEI points out that Brazil's talent must be capable of developing and using technological resources.

MEI argues that Brazil should expand the amount of STEM professionals and increase the availability of master's and doctoral degrees in these areas. Brazil must improve the training of STEM professionals through modernization and greater integration with the productive sector. To this end, in 2019, the Working Group contributed to the revision of the National Curriculum Guidelines on engineering courses, enabling the participation of the private sector.¹³³ Teacher training requires further attention: it is essential to review classroom practices, aligning them with the use of new educational methodologies and technologies.

¹³¹ Agência CNI de Notícias, 'CNI, ABC, Anpei e SBPC Lançam Manifesto Em Favor Da Liberação de Recursos Para Inovação', Agência CNI de Notícias, 2 August 2020, <https://noticias.portaldaindustria.com.br/noticias/inovacao-e-tecnologia/cni-abc-anpei-e-sbpc-lancam-manifesto-em-favor-da-liberacao-de-recursos-para-inovacao/>.

¹³² Find further information about the working group online at: <https://www.portaldaindustria.com.br/cni/canaais/mei/programas-mei/qt-para-o-fortalecimento-da-engenharia/>

¹³³ Ibid.

Regarding international studies, MEI advocates for the greater international mobility of Brazilian students and researchers in addition to a greater stimulus to create programs that attract talent from abroad, which would help build and sustain competitive advantage.

5.6. DRIVING THE GLOBAL ROLE OF BRAZILIAN INDUSTRY

Although Brazil is responsible for the production of a huge variety of goods, there has been no significant progress in the internationalization of its companies. Moreover, Brazil mostly exports low-tech products. MEI advocates for improving the global competitiveness of Brazil by inserting its industry into the global market, through innovation as a strategic axis and vector of support for the country's economic growth.

To meet this goal, MEI proposes improving linkages between Brazilian companies and R&D hubs abroad in order to expand their knowledge about innovation best-practices and new, cutting-edge technologies employed worldwide. Also, MEI proposes expanding the international flow of professionals and the internationalization of support programs to strengthen connections with companies in other countries, both for training purposes and to intensify the ST&I operations.

Integrating Brazil in economic spheres where the country already has the capacity to export products of high added value (such as fintech, healthtech, agritech, foodtech and edtech) is strategic. In other words, MEI defends a greater focus on foreign trade support for activities with greater technological content and innovation. These efforts need to be complemented by a long-term program for the internationalization of innovative companies.

5.7. FOSTERING INNOVATIVE ENTREPRENEURSHIP

Aiming to strengthen the performance of Small and Medium-sized Enterprises (SMEs), and especially high-tech startups, MEI proposes an agenda aimed at fostering innovative entrepreneurship in the country. This agenda should be supported by making resources available for investment and capitalization of SMEs, consolidating innovation environments that incite partnerships between companies, governments, universities, and R&D centers, and improving the integration and coordination of available instruments capable of supporting and implementing innovative ventures.

It is necessary to allocate specific resources for innovative SMEs, which means paying particular attention during the venture's initial stages. Moreover, MEI recommends the creation of fiscal and tax incentives for investment in innovative early-stage ventures, as well as mechanisms to encourage the stock market to invest in innovative SMEs in strategic areas for the country.

Finally, it is also essential to intensify the relationship between large companies and startups to urge corporate accelerators and spaces for innovations. Likewise, MEI recommends improving collaboration between universities and startups to support innovation and entrepreneurship in the national academic environments.

6. INTERNATIONAL BENCHMARKS AND GOOD PRACTICES

Besides providing a glimpse of Brazil's state of *Future Readiness*, this approach works towards identifying a sample of economies that show excellence in some of the areas noted as opportunities for Brazil. These economies, among other traits, display balanced regulatory frameworks, have successful high-skilled worker development and good brain retention programs, and exhibit salient innovation and investment cultures.

This review also offers a deeper look into the instruments and programs that are likely conduits to economies' successful performance in the identified areas. Rather than suggesting the use of these findings for the design of analogous policies and programs in Brazil, these findings are considered as further benchmarks giving alternative perspectives and offering experience to further enrich the recommendations issued in this document. In addition, these insights provide further context to the palette of simulated scenarios later explored in this report. Table 3 shows the list of reviewed economies and the best practice identified per topic.

TABLE 3. REVIEWED ECONOMIES AND IDENTIFIED BEST PRACTICES

Economy	Topics
Australia**	<ul style="list-style-type: none"> • High-skilled worker development and good brain retention; • Bridged knowledge-technology gap; • Trade openness.
Chile	<ul style="list-style-type: none"> • Proper infrastructure; • Balanced regulatory framework; • Innovation and investment culture; • High-skilled worker development and good brain retention.
Germany**	<ul style="list-style-type: none"> • Pro-cluster environment; • High-skilled worker development and good brain retention.
Israel	<ul style="list-style-type: none"> • Exemplary national system of innovation; • Innovation and investment culture; • Private and public sector linkage (Business enterprise expenditure on R&D – BERD – and GERD); • High skilled worker development and good brain retention*; • High-tech and soft-tech innovation exports.
Mexico	<ul style="list-style-type: none"> • Proper infrastructure; • Innovation and investment culture; • High-skilled worker development and good brain retention; • High-tech and soft-tech innovation exports; • Trade openness.
Netherlands**	<ul style="list-style-type: none"> • High-skilled worker development and good brain retention; • Bridged knowledge-technology gap; • Pro-cluster environment; • Trade openness.
Republic of Korea	<ul style="list-style-type: none"> • Exemplary national system of innovation; • Pro-business environment; • IP culture and IP environment; • High-tech and soft-tech innovation exports.

Singapore	<ul style="list-style-type: none"> • Exemplary national system of innovation; • Proper infrastructure; • Balanced regulatory framework; • Innovation and investment culture; • Private and public sector linkage (BERD & GERD); • High-skilled worker development and good brain retention; • High-tech and soft-tech innovation exports; • Bridged knowledge-technology gap; • Trade openness.
Turkey	<ul style="list-style-type: none"> • Proper infrastructure; • Innovation and investment culture; • High-skilled worker development and good brain retention*; • High-tech and soft-tech innovation exports.
USA	<ul style="list-style-type: none"> • Exemplary national system of innovation; • Pro-business environment; • Innovation and investment culture; • Private and public sector linkage (BERD & GERD); • High-tech and soft-tech innovation exports; • High-skilled worker development & good brain retention*; • Pro-cluster environment; • Trade openness.

Source: Research and FRI Database. *Assessment based solely on data.

**Although the cases of Australia, Germany and Netherlands also display Exemplary National Systems of Innovation, these are not reviewed in the next section to accommodate for alternative analysis. See Appendix 3: Technical Notes.

6.1. AUSTRALIA

High-Skilled Worker Development and Good Brain Retention. Australia's high-skilled worker development and good brain retention is promoted in part by the Department of Education and Training, via the *Corporate Plan 2016-2020*. The plan is the Australian government's key planning document and is part of a collection of strategic documents that provide the architecture of the department's funding, operations and performance. The plan's central objective is to enable the delivery of quality higher education, international education, and the type of research that contributes to both local and global economies and society. It also aims to ensure that Australia's workforce has the capability to respond to the needs of current and emerging industries and thus to better contribute to their global competitiveness.¹³⁴

Bridged Knowledge-Technology Gap. As part of these initiatives Australia launched in 2019 a *Global Talent Independent programme* (GTI), designed to attract highly skilled migrants for employment in one of the seven top "future-focused" sectors in the Australian's economy. These include: AGTech, Space and Advanced Manufacturing; FinTec; Energy and Mining Technology; MedTech; Cyber Security and Quantum Information; Advanced Digital; and Data Science and IT.¹³⁵ This effort not only expands the options for high skilled migrants, diversifying from the nearly 37% of these that work in areas associated with finance, but is also helping bridge the knowledge-technology gap locally.

Trade openness. Trade openness is another aspect that contributes to Australia's innovation and thus its *Future Readiness*. Australia promotes strong regional ties and plays

¹³⁴ Australian Department of Education and Training, 'Corporate Plan 2016-2020', Australian Department of Education and Training, 2016, https://docs.education.gov.au/system/files/doc/other/corporate_plan_2016-2020_-_final_0.pdf.

¹³⁵ OECD, *International Migration Outlook 2020* (Paris: OECD Publishing, 2020), <https://doi-org.proxy.library.cornell.edu/10.1787/ec98f531-en>.

an integral role in Asia's dynamic economic growth with exports to partners such as China that are a major contribution to its steady, month-on-month increase in trade surplus.¹³⁶ Australia also makes good use of its strategic location allowing the flow of various resources, including those derived from high-tech. According to the World Bank, Australia's weighted mean applied tariff rate has seen a continuous reduction since 2015 to further promote trade openness.¹³⁷ The country's success is reflected in 28 consecutive years of annual economic growth.

6.2. CHILE

Proper Infrastructure. The Chilean government has a significant interest in large-scale infrastructural investment opportunities, having earmarked USD\$28 billion for investment by 2021 for public-private partnerships, government projects and concession projects.¹³⁸ The Global Infrastructure hub praises Chile's business administration and regulatory quality as key factors for promoting local and international investment in new infrastructure.¹³⁹ The OECD also notes that Chile's infrastructural excellence is the result of a 25-year commitment to building the country's basic infrastructure backbone, a "success [that] can be ascribed, in significant part, to the strength of Chile's institutions and the capacity of its public administration."¹⁴⁰ The OECD study also praises Chile's success in mobilizing private financing with strong concessions models.

Balanced Regulatory Framework. Responsibility for regulatory policy across sectors is shared among Chile's main institutions. Different institutions are responsible for regulatory oversight during different regulatory phases, too. For instance, the General Comptroller and Constitutional Court are responsible for legal scrutiny of regulations, while the Ministerio Secretaría General de la Presidencia de Chile takes responsibility for checking legal quality and procedural requirements. The 2014-2018 National Agenda for Productivity, Innovation and Growth is specifically designed to improve regulatory governance, and introduced the Regulatory Impact Assessment (RIA) tool into its stakeholder projects. Chile's regulatory framework also provides for *ex post* evaluations by the Law Evaluation Department of the Chamber of Deputies.¹⁴¹

Innovation and Investment Culture. Chile has one of Latin America's leading innovation and investment cultures, due to years of targeted investments in innovation and entrepreneurship to create a kind of "Chilecon Valley".¹⁴² In 2010, the Chilean government launched Start-Up Chile as a seed accelerator for entrepreneurs and innovation.¹⁴³ As of 2020, Start-Up Chile is valued at USD\$2.1 billion and hosts 1,960 startups.¹⁴⁴

High-Skilled Worker Development and Good Brain Retention. The OECD records that

¹³⁶ Australian Trade and Investment Commission, 'How Australia's Openness to Trade and Investment Is Driving Our Prosperity', Australian Trade and Investment Commission, 2019, <https://www.austrade.gov.au/news/economic-analysis/how-australias-openness-to-trade-and-investment-is-driving-our-prosperity-part-i>.

¹³⁷ Australia's weighted mean applied tariff has consistently decreased since 2014 from 1.910 to a 0.86% rate in 2018. See Australia's performance on the World Bank World Development Indicators, available at: <https://databank.worldbank.org/source/world-development-indicators#>

¹³⁸ Mauricio Munguia, 'Turning Chile's Infrastructure Challenges into Opportunities', Infrastructure Intelligence, 18 September 2016, <http://www.infrastructure-intelligence.com/article/sep-2016/turning-chile%E2%80%99s-infrastructure-challenges-opportunities>.

¹³⁹ 'Chile – Country Infrastructure Summary', Global Infrastructure Hub, 2020, <https://www.gihub.org/countries/chile/>.

¹⁴⁰ OECD, *Introduction to Public Infrastructure in Chile* (Paris: OECD Publishing, 2017), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjgk5OpvTtAhXvRxUIHVzaDsUQFjAAeqQIBBAC&url=https%3A%2F%2Fwww.oecd-ilibrary.org%2Fintroduction-to-public-infrastructure-in-chile_5if4n5461td.pdf%3FitemId%3D%252Fcontent%252Fcomponent%252F9789264278875-3-en%26mimeType%3Dpdf&usq=AOvVaw2BWJ7AYoBsQQf38fzlr9Zt.

¹⁴¹ OECD, 'Regulatory Policy: Chile', OECD, 2019, <https://www.oecd.org/gov/regulatory-policy/regulatory-policy-chile.htm>.

¹⁴² Darrel M. West and Jack Karsten, 'Start-Up Chile: A "Start-up for Start-Ups" in Chilecon Valley', Brookings, 19 August 2015, <https://www.brookings.edu/blog/techtank/2015/08/19/start-up-chile-a-start-up-for-start-ups-in-chilecon-valley/>.

¹⁴³ Centre for Public Impact, 'Bringing Innovative Entrepreneurs and Startups to Chile', Centre for Public Impact, 31 March 2016, <https://www.centreforpublicimpact.org/case-study/innovation-development-in-chile/>.

¹⁴⁴ Further information about StartUp Chile available online at: <https://www.startupchile.org/>

Chile has made significant progress in worker development.¹⁴⁵ The Chilean government has also made efforts to reduce barriers to foreign entrepreneurs and investors (in 2017, Chile launched the Tech Visa to attract foreign talent) while also empowering local stakeholders to participate. Start-Up Chile offers equity-free grants up to USD\$40,000 for technology entrepreneurs, from Chile and abroad.¹⁴⁶ However, in order to develop and retain local talent, the Chilean government needs to reduce labor market segmentation, promote gender balance, target vulnerable groups with labor market policy initiatives and improve the relevance of the education system.¹⁴⁷

6.3. GERMANY

High-Skilled Worker Development and Good Brain Retention. Germany excels in retaining high-skilled talent, and has taken several steps in the past few years to maintain this excellence by attracting even more foreign talent; for instance, the *Skilled Workers Immigration Act* and the *Act on Temporary Suspension of Deportation for Training and Employment* aim to improve the immigration of skilled workers from third countries.¹⁴⁸ Faced with substantial demographic changes, such as a rapidly ageing population, the German federal government prioritizes expanding its domestic skills base with organizations like the KOFA, which assists small and medium-size enterprises (SMEs) to maintain attractiveness as employers, retain talent and reskill their existing workforce.¹⁴⁹ Other research suggests that Germany has in fact faced a “brain drain” issue since the 1940s: a challenge which has informed long-standing policy commitments to improving the domestic talent landscape, such as lowering taxes and increasing wages, in addition to making the German economy an attractive destination for European and foreign workers.¹⁵⁰ As European Parliament research suggests, Germany and the UK are the two top destinations for young people to move to in order to find jobs and this is due in part to these kinds of initiatives.¹⁵¹

Pro-Cluster Environment. Germany takes clear steps to promote a thriving innovation cluster environment, with around 600 research and innovation networks and clusters.¹⁵² One of Germany’s most well-known promotions of cluster structures is the *Leading-Edge Cluster Competition*, initiated by the Ministry of Research and Education 2007, with a total budget of EURO 600 million to support innovation research and development.¹⁵³ The *Go-Cluster “Exzellent Vernetzt”* program, sponsored by the Ministry of Economics and Technology is also of global renown. The federal government centralizes information about the German research landscape, on its website¹⁵⁴ and on the *Cluster Platform Germany*,¹⁵⁵ which provides information on the one hand, and “aims to initiate an intensive exchange of

¹⁴⁵ OECD, ‘Improving the Skills of Chileans Would Boost Productivity and Inclusive Growth’, OECD, 4 April 2018, <https://www.oecd.org/chile/improving-the-skills-of-chileans-would-boost-productivity-and-inclusive-growth.htm>.

¹⁴⁶ InvestChile, ‘10 Facts about Chile’s Growing Technology Scene’, InvestChile Blog, 27 March 2018, <http://blog.investchile.gob.cl/chiles-growing-technology-scene>.

¹⁴⁷ ‘Policies For More and Better Jobs in Chile’, in *OECD Economic Surveys: Chile 2018* (Paris: OECD Publishing, 2018), https://www.oecd-ilibrary.org/sites/eco_surveys-chl-2018-6-en/index.html?itemId=/content/component/eco_surveys-chl-2018-6-en.

¹⁴⁸ ‘Germany: New Immigration Acts to Attract and Retain Skilled Workers Published’, Global Legal Monitor, 28 October 2019, <https://www.loc.gov/law/foreign-news/article/germany-new-immigration-acts-to-attract-and-retain-skilled-workers-published/>.

¹⁴⁹ ‘Skilled Professionals for Germany’, Federal Ministry for Economic Affairs and Energy, n.d., <https://www.bmwi.de/Redaktion/EN/Dossier/skilled-professionals.html>.

¹⁵⁰ Bharathi S. Gopal, Srimathi Raghuraman, and Seshagiri Rao Chaganty, ‘Brain Drain: A Threat to German Economy?’ (IBS Research Center, 2008), <https://www.thecasecentre.org/main/products/view?id=85726>.

¹⁵¹ Commission for Social Policy, Education, Employment, Research and Culture, ‘Addressing Brain Drain: The Local and Regional Dimension’ (European Committee of the Regions, 2018).

¹⁵² Kate Whiting, ‘Germany Is the World’s Most Innovative Economy’, World Economic Forum, 18 October 2018, <https://www.weforum.org/agenda/2018/10/germany-is-the-worlds-most-innovative-economy/>.

¹⁵³ M Rothgang et al., ‘Cluster Policy: Insights from the German Leading Edge Cluster Competition’, *Journal of Open Innovation: Technology, Market and Complexity* 3, no. 18 (2017).

¹⁵⁴ Further information about innovation clusters in Germany available online at: <https://www.research-in-germany.org/en/infoservice/publications.html>

¹⁵⁵ Available at: <https://www.clusterplattform.de/>

experiences about the introduced measures, their further development and possibilities of impact assessment through a joint effort”, presenting German success stories, too.¹⁵⁶

6.4. ISRAEL

Exemplary National System of Innovation. Israel's Innovation Authority (IIA) develops innovation infrastructure, provides grants and financial support for innovative tech, promotes pro-innovation policies and connects Israeli innovations to other economies.¹⁵⁷ As a result, in 2018 alone, the Innovation Authority saw nearly 3,000 requests submitted for R&D funding and invested in 920 companies, with 1500 innovative projects across sectors including life sciences and advanced manufacturing.¹⁵⁸ Israel's NIS is rooted in four main strategic objectives (2018-2022): ensure sustainable technological leadership in the high-tech industry, to promote innovation with a socio-economic impact, to increase the economic impact of high-tech companies and to support innovation that strengthens productivity and competitiveness. Accordingly, Israel's Innovation Authority wins global plaudits for its progress.¹⁵⁹

Innovation and Investment Culture. There are over 7,700 start-ups in Israel, and over 1,000 concentrated in Tel Aviv, a hub of innovation and entrepreneurship.¹⁶⁰ Recent data suggests that Tel Aviv has the world's highest concentration of start-ups per capita globally.¹⁶¹ These start-ups raised USD\$8.3 billion in 2019 alone, and Israel's Innovation Authority has made tangible efforts to strengthen Israel's innovative culture as a “start-up nation”.¹⁶² “A shared sense of history and community has given Israel a unique culture of innovation.”¹⁶³ As a result, many tech multinationals including Facebook, Amazon and Microsoft have set up R&D labs in the country.¹⁶⁴ Some studies draw attention to the Israeli defence industry as a key driver of innovation, along with other local factors rooted in culture.¹⁶⁵

Private and Public Sector Linkage (BERD and GERD). Israel is a GERD-intensive country. As demonstrated by the GII 2020, Israel ranks first worldwide in innovation linkages, and sub-indicators including university-industry research collaboration and GERD financed by abroad as a percent of GDP. Israel is also the world leader in GERD performed by business as a percent of GDP.¹⁶⁶ The IIA facilitates strong public-private linkages for innovation, with a “reverse innovation model... by understanding the challenge first, and then working backwards to source solutions.” Namely, the IIA invites the private sector to pitch recommendations, and then provides practical tools and funding platforms to facilitate partnerships.¹⁶⁷

¹⁵⁶ ‘Cluster Policy in Germany’, Clusterportal Baden-Württemberg, 2020, <https://www.clusterportal-bw.de/en/cluster-policy/cluster-policy-in-germany/>.

¹⁵⁷ Available at: <https://innovationisrael.org.il>

¹⁵⁸ Israel Innovation Authority, ‘2018-2019 Report’, Israel Innovation Authority, 14 January 2019, <https://innovationisrael.org.il/en/news/israel-innovation-authority-2018-19-report>.

¹⁵⁹ Saemoon Yoon, ‘5 Start-up Hubs to Watch – beyond Silicon Valley’, World Economic Forum, 8 October 2020, <https://www.weforum.org/agenda/2020/10/5-start-up-hubs-to-watch-and-we-don-t-mean-silicon-valley/>.

¹⁶⁰ Israel Ministry of Foreign Affairs, ‘Israel Innovation’, 2018, <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj2P6DwbTtAhWwQkEAHW1LAq8QFIAAegQIBBAC&url=https%3A%2F%2Fmfa.gov.il%2F2FMFA%2FAboutIsrael%2FDocuments%2FIsrael%2520Innovation%25202018.pdf&usq=AOvVaw0qeDKcsRCyHSqEI-I0ihMM>.

¹⁶¹ Deloitte, ‘The Israeli Technological Eco-System: A Powerhouse of Innovation’, Deloitte Perspectives, n.d., <https://www2.deloitte.com/il/en/pages/innovation/article/the-israeli-technological-eco-system.html>.

¹⁶² Yoon, ‘5 Start-up Hubs to Watch – beyond Silicon Valley’.

¹⁶³ PICTET, ‘An Entrepreneurial Ethos’, The Economist Innovation Matters, n.d., <https://innovationmatters.economist.com/telaviv/culture-of-entrepreneurship>.

¹⁶⁴ David Yin, ‘What Makes Israel's Innovation Ecosystem So Successful’, Forbes, 9 January 2017, <https://www.forbes.com/sites/davidyin/2017/01/09/what-makes-israels-innovation-ecosystem-so-successful/?sh=6ad12d6e70e4>.

¹⁶⁵ Daphna Yeshua-Katz and Dorit Efrat-Treister, “Together in the Tech Trenches”: A View of Israel's Innovation Culture’, *Innovation*, 2019, <https://doi.org/10.1080/14479338.2020.1758565>.

¹⁶⁶ See data for Israel; Dutta, Lanvin, and Wunsch-Vincent, eds., *Global Innovation Index 2020*.

¹⁶⁷ Find more information about the Israeli Innovation Authority online at: <https://innovationisrael.org.il/en/contentpage/israel-innovation-authority>

High Skilled Worker Development and Good Brain Retention. Israel is a world leader in research and development, with great implications for high-skilled worker development. Israel has the world's highest number of engineers per capita and boasts the world's second-highest R&D expenditure rate.¹⁶⁸ Some commentators also note that Israel's mandatory army service and well-organized armed services pipeline helps identify top talent in ST&I.¹⁶⁹

High-Tech and Soft-Tech Innovation Exports. Over 9.2% of Israel's workforce is employed in the high-tech sector,¹⁷⁰ with approximately 321,000 employees. In 2017, Israel high-tech firms raised USD\$5.1 billion, an increase from 22% the previous year,¹⁷¹ with high-tech exports valued at nearly USD\$13 billion dollars in 2018,¹⁷² of a total USD\$114 billion in exports in 2019.¹⁷³

6.5. MEXICO

Proper Infrastructure. Mexico's Infrastructure Plan 2020-2024 was announced by President Andrés Manuel López Obrador in early October, outlining 39 infrastructure projects to boost Mexico's infrastructural sector. This proposal built on a November 2019 announcement of USD\$44 billion worth of funding for Mexico's transportation, energy and communication infrastructure.¹⁷⁴ Policy commitments aside, Mexico has a strong infrastructural groundwork in place, with newly improved national highways, increasingly efficient telecommunications infrastructure, seaport access on both coasts and a well-connected railway service between Mexico and the US (with USD\$1.7 billion worth of planned improvements).¹⁷⁵ Mexico's infrastructural development has strong international linkages. Currently, four of ten investment initiatives received by industrial parks have come from China (37 percent of total foreign investment), with 16 percent from the US.¹⁷⁶

Innovation and Investment Culture. Research produced by Frost & Sullivan declares that Mexico is emerging as "an attractive innovation hub", with increasingly strong performance in R&D funding and venture capital investments.¹⁷⁷ Research suggests that while Mexico does not perform well globally, it has immense potential to create a world-leading innovative culture due to its human capital, strong IP system and clear regulatory frameworks.¹⁷⁸

High-Skilled Worker Development and Good Brain Retention. Mexico has a dedicated agency for developing job skills and competencies, the National Council for the Standardization and Certification of Labor Competencies (CONOCER).¹⁷⁹ CONOCER works across sectors to "develop demand-driven job competencies, and to identify best practices for teaching and certifying the acquisition of those competencies."¹⁸⁰ To this end, as of 2018,

¹⁶⁸ Yaron Daniely, 'Challenging Transformation From Start-Up Nation to Scale-Up Nation', in *Global Innovation Index 2020*, ed. Soumitra Dutta, Bruno Lanvin, and Sacha Wunsch-Vincent, 13th ed. (Cornell University, INSEAD and the World Intellectual Property Organization, 2020).

¹⁶⁹ Julie Ziskind and Anna Brack, 'From Israel's "Start-up Nation", 4 Lessons in Innovation', World Economic Forum, 13 September 2019, <https://www.weforum.org/agenda/2019/09/israel-start-up-nation-innovation>; Yin, 'What Makes Israel's Innovation Ecosystem So Successful'.

¹⁷⁰ PwC and Start-Up Nation Central, 'The State of Innovation' (PwC Israel, April 2019).

¹⁷¹ Ministry of Foreign Affairs, Israel, "Innovation" 2018, 8.

¹⁷² Find relevant indicators online at: <https://tradingeconomics.com/israel/indicators>

¹⁷³ Ibid.

¹⁷⁴ Tetakawi, 'The Advantages of Mexico's Infrastructure Improvements', Tetakawi, 19 December 2019, <https://insights.tetakawi.com/mexico-is-getting-serious-about-infrastructure>.

¹⁷⁵ Ibid.

¹⁷⁶ Mayte Gutierrez Fedowitz, 'Mexico's Infrastructure Plan 2020-2024', National Law Review, 8 October 2020, <https://www.natlawreview.com/article/mexico-s-infrastructure-plan-2020-2024>.

¹⁷⁷ Francesca Valente, 'Higher Technology Investment and Digital Accessibility to Position Mexico as an Innovation Hub by 2025', Frost and Sullivan, 27 January 2020.

¹⁷⁸ Richard Miles, 'How Innovative Is Mexico?', CSIS, 8 February 2019, <https://www.csis.org/analysis/how-innovative-mexico>.

¹⁷⁹ Find further information about CONOCER online at: <https://conocer.gob.mx/>

¹⁸⁰ Mexico Institute, 'Mexico's Workforce Development Outlook: A Conversation with Alberto Almaguer Rocha Managing Director of CONOCER', Wilson Center, 5 March 2018, <https://www.wilsoncenter.org/article/mexicos-workforce-development-outlook-conversation-alberto-almaguer-rocha-managing-director>.

CONOCER had certified over 1.5 million citizens,¹⁸¹ laying strong groundwork for workforce development and brain retention in the future.

High-Tech and Soft-Tech Innovation Exports. In 2019, Mexico's high-technology exports were valued at USD\$73.4 billion.¹⁸² As for soft-tech exports, Mexican companies such as Tecma emphasize the importance of developing competencies in the soft-tech sector, such as excellence in human resources to support Mexico's manufacturing sector.¹⁸³

Trade Openness. Mexico is engaged in several prominent free trade agreements that consistently improve its trade openness and spur innovation. Domestically, the political turnover in 2018 has led to the implementation of several changes to its trade policy, such as changes to most favored nation (MFN) tariffs on textiles and steel and the announcement of a Free Trade Programme in the Isthmus Corridor.¹⁸⁴

6.6. THE NETHERLANDS

High-Skilled Worker Development and Good Brain Retention. The Netherlands is a global leader in high-skilled worker development and brain retention. Intervention programs such as *Vitaal Vakmanschap* (Thriving Professionals)¹⁸⁵ and *Taken van de Toekomst* (Tomorrow's Tasks)¹⁸⁶, spearheaded by the Netherlands Organisation for Applied Scientific Research, are well-known approaches to worker development and retaining talent domestically and attracting foreign talent. Further, the Royal Netherlands Academy of Arts and Sciences has recorded there is no evidence of significant brain drain among the country's top scientific researchers.¹⁸⁷ The same report noted that the Netherlands has strong research infrastructure that retains scientific talent; for instance, the Vidi and Vici scientific grants are highly valued, and 90 percent of researchers with these grants stay in the country long-term.¹⁸⁸ According to a report published by the Amsterdam Economic Board and StartupAmsterdam, the demand of tech talent at the junior level doubled in the 2017, with 26 job vacancy openings per available tech worker at this level.¹⁸⁹

Bridged Knowledge-Technology Gap. Initiatives like 'WeTechRotterdam' aim to boost certain cities in the Netherlands as "a thriving and collaborative tech ecosystem", bridging the gap between knowledge creation and tech innovation.¹⁹⁰ Further, the Government of the Netherlands specifically outlines a Top Sector Alliance for Knowledge and Innovation to encourage knowledge-sharing and "look for ways to get innovative products or services onto the market" by universities, the government, the private sector and research centers.¹⁹¹

Pro-Cluster Environment. The Netherlands' *Brainport Development* aims to strengthen the Eindhoven top technology region, and includes the High Tech Software Cluster, the Augmented Reality and Virtual Reality Cluster, and the Photon Delta Cluster.¹⁹² The sector employs more than 60,000 people, and records an increased competitiveness among its members, particularly in future technologies.

¹⁸¹ Ibid.

¹⁸² Find relevant indicators online at: <https://tradingeconomics.com/mexico/indicators>

¹⁸³ Pablo Zayas, 'Mexico Human Resources – The Key to Manufacturing in Mexico', Tecma University, n.d., <https://www.tecma.com/mexico-human-resources/>.

¹⁸⁴ Adrian B. Vázquez et al., 'International Trade in Goods and Services in Mexico: Overview', Thompson Reuters Practical Law, 2020, <https://uk.practicallaw.thomsonreuters.com/w-009-5137?transitionType=Default&contextData=%28sc.Default%29>.

¹⁸⁵ Further information about *Vitaal Vakmanschap* available online at: <https://buildinghumantalent.nl/thema/vitaal-vakmanschap>

¹⁸⁶ Further information about *Taken Van de Toekomst* available online at: <https://takenvandetoekomst.nl/>

¹⁸⁷ 'Nog Geen Braindrain, Wel Meer Beweging', Koninklijke Nederlandse - Akademie van Wetenschappen, 28 January 2018, <https://www.knaw.nl/nl/actueel/nieuws/nog-geen-braindrain-wel-meer-beweging>.

¹⁸⁸ Ibid.

¹⁸⁹ Sebastiaan van Lunteren and Jair Halevi, 'Fighting the Odds' (Startup Amsterdam, Gemeente Amsterdam, Amsterdam Economic Board, 2018), <https://www.amsterdameconomicboard.com/app/uploads/2017/09/Fighting-the-odds.pdf>.

¹⁹⁰ Further information about WeTech Rotterdam available online at: <https://wetechrotterdam.com/>

¹⁹¹ Government of the Netherlands, 'Encouraging Innovation', Government of the Netherlands, n.d., <https://www.government.nl/topics/enterprise-and-innovation/encouraging-innovation>.

¹⁹² Find further information about innovation clusters in The Netherlands online at: <https://www.clustercollaboration.eu/cluster-networks/brainport-development>

Trade Openness. As data suggests, the Netherlands' prosperity is hinged on its capacity for promoting and attracting international trade. Additionally, its geographic location makes it a European trade hub: Rotterdam is Europe's biggest port, and the Netherlands benefits from being part of the European Union. The country's trade of goods and services is also well diversified across low-tech and high-tech sectors. As a result, the Netherlands wins global plaudits as "one of the most open and outward-oriented economies in the world."¹⁹³

6.7. REPUBLIC OF KOREA

Exemplary National System of Innovation. The ROK's economic transformation from the 1970s onwards was due to heavy government intervention and investment in homegrown innovation and industry.¹⁹⁴ By championing regional innovation and creating regional clusters, with strong linkage between venture capital, R&D institutions and universities, professional services, and entrepreneurial spin-offs (supported by an ecosystem of local and global networks, strong social capital, innovation networks and "venture habitat"),¹⁹⁵ ROK's national system of innovation has won global praise for its high performance. The Bloomberg Innovation Index ranks ROK as the world's most innovative economy.¹⁹⁶

Pro-Business Environment. The World Bank Doing Business 2020 report ranks the ROK 5th globally for the ease of doing business, with a score of 84.0. South Korea records strong performance in Getting Electricity and Enforcing Contracts, both ranked 2nd globally.¹⁹⁷ According to the Business Transformation Index research, it takes two procedures and four days total to establish a business.¹⁹⁸ For foreign businesses, market entry barriers have been significantly lowered since the 1990s, following the trend of ROK's steady liberalization. As a result, the WEF World Competitiveness 2019 report ranks South Korea the 13th most competitive economy worldwide.¹⁹⁹

IP Culture and IP Environment. The ROK is ranked 11th globally for Knowledge and Technology Outputs on the Global Innovation Index 2020, with world-leading performance in the Human Capital and Research pillar.²⁰⁰ The World Intellectual Property Organization provides further information about their comprehensive IP environment and culture.²⁰¹ Additionally, ROK's Intellectual Property Office provides information and guidance for domestic and international individuals and firms, in addition to news and alerts.²⁰²

High-Tech and Soft-Tech Innovation Exports. In 2018, the ROK's high-tech exports reached a total of 36% of total manufactured exports, after a strong trajectory of improvement from 2012 onwards.²⁰³ Although this fell to 32% in 2019, the ROK has a track record of investment in high-tech manufacturing and exports; its ICT industry presents new opportunities for exporters, particularly as ROK's manufacturers seek globally-sourced technologies to innovate.²⁰⁴ The OECD agrees that ROK has been a leader in the

¹⁹³ Nordea, 'Country Profile – Netherlands (Foreign Trade Figures of the Netherlands)', Nordea, 2020, <https://www.nordeatrade.com/en/explore-new-market/netherlands/trade-profile>.

¹⁹⁴ Professor Sam Ock Park, quoted in: Tim Mazzarol, 'Building a National Innovation System: What Can We Learn from Korea?' The Conversation, 10 September 2012. <https://theconversation.com/building-a-national-innovation-system-what-can-we-learn-from-korea-9449>

¹⁹⁵ Ibid.

¹⁹⁶ Michelle Jamrisko, Wei Lu and Aleandre Tanzi, 'South Korea Leads World in Innovation as U.S. Exits Top Ten', Bloomberg, 3 February 2021. <https://www.bloomberg.com/news/articles/2021-02-03/south-korea-leads-world-in-innovation-u-s-drops-out-of-top-10>.

¹⁹⁷ 'Republic of Korea: Doing Business 2020' (World Bank, 2020).

¹⁹⁸ 'South Korea Country Report 2020', BTI Transformation Index, 2020, <https://www.bti-project.org/en/reports/country-report-KOR-2020.html>

¹⁹⁹ World Economic Forum, 'Global Competitiveness Report 2019' (World Economic Forum, 2019).

²⁰⁰ See data for the Republic of Korea, in Dutta, Lanvin, and Wunsch-Vincent, eds., *Global Innovation Index 2020*.

²⁰¹ WIPO, 'Republic of Korea', WIPO Lex IP Portal, n.d., <https://wipolex.wipo.int/en/members/profile/KR>.

²⁰² <https://www.kipo.go.kr/en/MainApp?c=1000>

²⁰³ See relevant World Bank indicators: <https://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS?locations=KR>.

²⁰⁴ Australian Trade and Investment Commission, 'Export Markets: Republic of Korea', Australian Trade and Investment Commission, 2021. <https://www.austrade.gov.au/australian/export/export-markets/countries/republic-of-korea/industries/ICT>.

development of cutting-edge technologies, with an R&D-intensive manufacturing sector that puts the country on the frontiers of emerging technologies.²⁰⁵ Regarding both high-tech and soft-tech exports, the ROK opened a national discussion about creating its R&D Innovation Strategy, to both embrace emerging technologies and adopt a human-centric approach.²⁰⁶ Additionally, ROK's creative economy has been prioritized by the government in recent years; former President Park Geun-hye commented on "the convergence of science and technology with industry, the fusion of culture with industry".²⁰⁷

6.8. SINGAPORE

Exemplary National System of Innovation: Although Singapore is a late-industrializing economy, its national system of innovation wins global plaudits: in 2019, Singapore ranked 14th and 13th globally for its Innovation Ecosystem business dynamism and innovation capability on the World Economic Forum's Global Competitiveness Index (and first overall).²⁰⁸ OECD research suggests that Singapore's national innovation system is "relatively well-endowed", with political stability and long-term policy innovation goals on the one hand, and an attractive market for foreign investment on the other.²⁰⁹ Additionally, Singapore's national system of innovation is well-supported by ICT and logistics infrastructure, and an internationally-renowned education system that produces global talent.²¹⁰

Proper Infrastructure. Singapore's infrastructure performance is "good relative to the developed nation average", with high performance in capital account openness and prevalence of foreign ownership, according to the Global Infrastructure Hub.²¹¹ Further, Singapore's infrastructure is supported by the regional finance hub (Asia's Infrastructure Exchange), described as "the go-to place where infrastructure demand and supply can connect, where infrastructure expertise and financing can be obtained and infrastructure needs are met."²¹² Additionally, Singapore's Smart Nation effort aims to mobilize the country's networks, ICT and data to improve the quality of life and create economic opportunities in transport, home and environment, business productivity, health and enabled ageing, and public sector services.²¹³ In fact, compared to other ASEAN countries, Singapore's infrastructure spending per capita is relatively high, at USD\$2,049 per capita (compared to Malaysia, at USD\$705 per capita).²¹⁴

Balanced Regulatory Framework. In addition to acting as Singapore's central bank, the Monetary Authority of Singapore (MAS) is Singapore's main regulator, and has regulatory oversight over financial services across sectors.²¹⁵ Crucially, MAS updates Singapore's regulatory frameworks to address emerging technologies, such as cryptocurrency (in January this year, MAS launched the Payment Services Act to strengthen consumer protections and promote confidence in using e-payments).

²⁰⁵ OECD, 'Korea Leading in Technologies that have Potential for Future Growth, says OECD', OECD, 19 October 2015, <https://www.oecd.org/science/korea-leading-in-technologies-that-have-potential-for-future-growth.htm>.

²⁰⁶ Tay Tian Wen, 'South Korea Holds Joint Discussion on National Innovation Strategy', Open Gov Asia, 18 June 2018, <https://opengovasia.com/south-korea-holds-joint-discussion-on-national-innovation-strategy/>.

²⁰⁷ OECD Observer, 'Korea Spotlight: Getting Smart: Korea's Creative Economy', *OECD Observer*, Korea 20th Anniversary Edition (2017).

²⁰⁸ World Economic Forum, 'Global Competitiveness Report 2019', 506.

²⁰⁹ OECD, 'Innovation in Southeast Asia: Singapore Innovation Profile' (OECD, 2015), https://read.oecd-ilibrary.org/science-and-technology/innovation-in-southeast-asia/singapore-innovation-profile_9789264128712-10-en

²¹⁰ Ibid.

²¹¹ Global Infrastructure Hub, 'Singapore Summary', Global Infrastructure Hub, 2020, <https://www.gihub.org/countries/singapore/>.

²¹² The World Bank, 'The World Bank In Singapore', The World Bank, 2019, <https://www.worldbank.org/en/country/singapore/overview>.

²¹³ PwC Singapore, 'Understanding Infrastructure Opportunities in ASEAN', Infrastructure Series Report 1 (PwC, n.d.), <https://www.pwc.com/sq/en/publications/cpi-mas-infrastructure-opportunities-in-asean.html>, 14.

²¹⁴ Ibid.

²¹⁵ 'Banking Regulation Singapore', Global Legal Insights, n.d., <https://www.globallegalinsights.com/practice-areas/banking-and-finance-laws-and-regulations/singapore>.

Innovation and Investment Culture. Singapore's innovation and investment culture is of global renown, epitomized by the country's "Home" strategy: "Home for Business. Home for Innovation. Home for Talent."²¹⁶ The "Home" strategy summarized Singapore's approach to creating a culture of innovation: it must be homegrown. For instance, in the early 2010s, Singapore's entrepreneurial environment and start-up scene was "barren", according to one commentator.²¹⁷ Today, some commentators call Singapore an aspiring "Silicon Valley of Southeast Asia",²¹⁸ with thriving home-grown entrepreneurship, the result of targeted innovation policies. Singapore also takes tangible steps to ensure that an innovation and investment culture is continually regenerated through global academic partnerships and excellence; "such is Singapore's allure for future knowledge that some top universities, including Yale University, are now developing separate overseas campuses in Singapore, in much the same way French business school INSEAD set up a Singapore campus back in 2000."²¹⁹

Private & Public Sector Linkage (BERD/GERD). Between 1991 and 2017, Singapore's GERD rose from USD\$800m to USD\$9.1 billion, with a compounded annual growth rate of 10 per cent. Singapore's Economic Survey for Third Quarter 2019 notes that the increase in GERD was made possible by growth in both BERD and Public Expenditure on R&D (PUBERD). In fact, by 2017, BERD accounted for more than half (60 percent) of GERD.²²⁰ Singapore boasts a strong "symbiotic relationship" between the public and the private sectors: "a key factor in transforming Singapore from a third world port city into a world-class metropolis."²²¹ As commented by Dr. See Ngee Huat, Singapore's public-private partnership (PPP) model has the capacity to continually evolve to meet Singapore's emergent demographic challenges, such as an ageing population and rapidly declining birth rate.²²²

High-Skilled Worker Development & Good Brain Retention. While Singapore is by no means immune from brain drain,²²³ the country leads Asia (and ranks 10th globally) for talent competitiveness and ranks as the second most attractive destination for global talent.²²⁴ Singapore boasts a 97.% adult literacy rate,²²⁵ the highest English proficiency rate in Asia,²²⁶ with five in ten workers in high-skilled employment.²²⁷ Additionally, Singapore takes tangible steps to attract foreign talent; in July 2020, the government announced the launch of a new programme to attract more foreigners to work in Singapore, with the removal of a quota limitation for a foreigner's Employment Pass.²²⁸

High-Tech and Soft-Tech Innovation Exports. Singapore's economy relies on both high-tech and soft-tech innovation exports. In 2018, high-technology exports were recorded at 51.72% of the country's total manufactured exports.²²⁹ "Soft" technology exports, such as

²¹⁶ <https://www.edb.gov.sg/>

²¹⁷ Dominic Basulto, 'The Secrets to Singapore's Track Record of Innovation Excellence', Washington Post, 26 May 2015, <https://www.washingtonpost.com/news/innovations/wp/2015/05/26/the-secrets-to-singapores-track-record-of-innovation-excellence/>.

²¹⁸ Newley Purnell, 'Singapore Aims to Become Southeast Asia's Silicon Valley', The Wall Street Journal, 26 February 2014, <https://www.wsj.com/articles/SB10001424052702304071004579406393779804868>.

²¹⁹ Basulto, 'The Secrets to Singapore's Track Record of Innovation Excellence'.

²²⁰ 'Economic Survey of Singapore Third Quarter 2017', Ministry of Trade and Industry Singapore, 2017, <https://www.mti.gov.sg/Resources/Economic-Survey-of-Singapore/2017/Economic-Survey-of-Singapore-Third-Quarter-2017>.

²²¹ See Ngee Huat, 'Public-Private Partnerships in Real Estate: The Singapore Model', ULI Singapore, 9 July 2019, <https://singapore.uli.org/public-private-partnerships-in-real-estate-the-singapore-model/>.

²²² Ibid.

²²³ Yew Chiew Ping and Kwong Kin Ming, 'Commentary: Behind the Brain Drain in Singapore, Hong Kong and Taiwan, Stymied Aspirations and Growing Rootlessness', Channel News Asia, 10 June 2018, <https://www.channelnewsasia.com/news/commentary/brain-drain-hong-kong-taiwan-singapore-aspirations-identity-10314388>.

²²⁴ 'World-Class Talent', Singapore Economic Development Board, 2020, <https://www.edb.gov.sg/en/why-singapore/world-class-talent.html>.

²²⁵ Singapore Department of Statistics (<https://www.singstat.gov.sg/>): Education, Language Spoken and Literacy, Literacy Rate (among residents aged 15 yrs and over), 2019

²²⁶ <https://www.ef.com/wwen/epi/>, 2019.

²²⁷ World Economic Forum, 'The Global Human Capital Report 2017' (World Economic Forum, 2017), <https://www.weforum.org/reports/the-global-human-capital-report-2017>.

²²⁸ 'Why Singapore Turns to Foreign Talent', The ASEAN Post, 3 May 2020, <https://theaseanpost.com/article/why-singapore-turns-foreign-talent>.

²²⁹ Based on World Bank indicators (<https://www.worldbank.org/en/country/singapore/overview>).

exports from Singapore's creative industries, are also world-leading. An early study of Singapore's "creative cluster" (including both cultural, creative and copyright industries) tracks the rise in Singapore's creative industry exports; between 1986 and 2000, the creative industries grew by an average of 17.2 percent a year.²³⁰ Research suggests that the growth of new media technologies promotes artistic involvement in the state-led development of a creative industry.²³¹ Singapore is the first Southeast Asian city to be designated as a UNESCO Creative City of Design. Singapore's Economic Development Board maps a comprehensive strategy for fostering Singapore's Creative Industries. Establishing Singapore as a "home of digital natives" is a core part of the strategy, as is exporting cultural products abroad.²³²

Bridged Knowledge-Technology Gap. The Singaporean government is "committed to investing in continuous training for our workforce to ensure they remain responsive to evolving business needs and rapid technological advancements", with initiatives like SkillsFuture²³³ and TechSkills Accelerator. Singapore Economic Development Board (EDB) declares the government spends more than USD\$1 billion a year on continuing education and training.²³⁴

Trade Openness. Chief Economist and Assistant Managing Director of MAS, Edward Robinson, comments that throughout its short history, Singapore has pursued strong globalization with a high dependence on international trade; "trade openness (as measured by the ratio of exports plus imports to GDP) has been consistently high, staying well above 200% of GDP and reaching a peak of 440% prior to the Global Financial Crisis."²³⁵

6.9. TURKEY

Proper Infrastructure. Turkey's infrastructure excellence, in addition to its strong plan for improvement, improves its capacity to innovate. In January 2020, the Ministry of Transport announced that Turkey has invested over USD\$330 billion in transportation infrastructure over the past 17 years.²³⁶ In the next ten years, Turkey's infrastructure portfolio is expected to grow, with, for instance, the National Train Project planning on extending the country's total railway length to 17,525 kilometers by 2023,²³⁷ the one-hundred year anniversary of the Republic of Turkey. Other 2023 targets include extending conventional railways, motorways and passenger transportation on road and rail.

Innovation and Investment Culture. Turkey has made great strides in the creation of an innovation and investment culture. For example, Turkey's Innovation Week, organized by the Turkish Exporters' Assembly and the Ministry of Commerce aims to foster an innovation ecosystem by showcasing entrepreneurial individuals and ideas. Since 2012, the Innovation Week has hosted over 400,00 visitors from Turkey and abroad.²³⁸ Turkey has also fostered innovation accelerators and incubators to fuel its start-up sector, such as ARI Teknokent and SDG Accelerator, with strong linkages to the country's technical universities.²³⁹

²³⁰ Toh Mun Heng, Adrian Choo, and Terence Ho, 'Economic Contributions of Singapore's Creative Industries', *Economic Survey of Singapore*, First Quarter 2003.

²³¹ Peichi Chung, 'The Creative Industry of Singapore: Cultural Policy in the Age of Globalisation', *Media International Australia* 128, no. 1 (2008): 31–45.

²³² 'Creative Industries', Singapore Economic Development Board, n.d., <https://www.edb.gov.sg/en/our-industries/creative-industries.html>.

²³³ For further information, visit: <https://www.skillsfuture.sg/>.

²³⁴ 'World-Class Talent', Singapore Economic Development Board, 2020, <https://www.edb.gov.sg/en/why-singapore/world-class-talent.html>.

²³⁵ Edward Robinson, 'Globalisation in a Small Open Economy: The Singapore Experience' (BIS, 2017).

²³⁶ Anadolu Agency, 'Turkey Invests \$334B in Transportation Infrastructure', *Hurriyet Daily News*, 10 January 2020, <https://www.hurriyetdailynews.com/turkey-invests-334b-in-transportation-infrastructure-150800>.

²³⁷ Ibid.

²³⁸ Susan Fournané, 'Turkey Innovation Week: Rising e-Exports with Added Value of Innovation', *Interesting Engineering*, 8 May 2019, <https://interestingengineering.com/turkey-innovation-week-rising-e-exports-with-added-value-of-innovation>

²³⁹ Fariba Nawa, 'Istanbul Incubator Fosters Turkey's Tech Ambitions', *The Financial Times*, 19 November 2020, <https://www.ft.com/content/53c81984-f975-11e9-a354-36acbbb0d9b6>.

High-Skilled Worker Development and Good Brain Retention. Research based on current talent trends suggests that automation and digitization may potentially produce 3.1 million jobs by 2030.²⁴⁰ While Turkey's worker development policies have found success, there is room for improvement in their employment and skills strategies according to the OECD.²⁴¹

High-Tech and Soft-Tech Innovation Exports. In 2017, there was a jump to USD\$3.5 billion in high-technology exports from Turkey, which fell to USD\$3.1 billion in 2018,²⁴² and recovered at over USD\$5 billion in 2019.²⁴³ Turkey's soft-tech and cultural exports also receive global praise. According to UNESCO's research, Turkey is one of the world's top-ten exporters of cultural goods.²⁴⁴

6.10. USA

Exemplary National System of Innovation. Support for US innovation is highly decentralized, but the executive wing has the responsibility for selecting innovation priority areas and initiatives, and allocating the budget to be approved by the House of Representatives. This process involves a diversity of non-governmental actors, from the private sector and civil society. To this end, the Office of Science, and Technology Policy (OSTP) – established in 1976 by Law 94/282 – connects the different branches of innovation, from the executive wing to the Defense, Energy and Health ministries.²⁴⁵ Additionally, the US National Network for Manufacturing Innovation (NNMI; Manufacturing USA) was formally established in 2014. The vision for the NNMI Program is US global leadership in advanced manufacturing. To support this vision, the mission of the NNMI Program is “connecting people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth, and strengthening national security.”²⁴⁶

Pro-Business Environment. The US leads the world in entrepreneurship and offers a world-leading pro-business environment across sectors.²⁴⁷ Despite growing challenges from China, the US remains the world's top source of diverse FDI expenditures at over USD\$3.7 trillion, which attracts business from abroad. Domestically, the US is driven by fostering a pro-business environment and obstacles to entrepreneurship with good regulation. For example, the Tax Cuts and Jobs Act (2018) lowered US corporate tax to 21 percent. (Note that there are differences between states; for instance, Virginia, Texas and North Carolina rank highly on the CNBC's *America's Top States for Business* report, while Mississippi, Hawaii and Rhode Island rank poorly, in terms of workforce, economy and infrastructure).²⁴⁸

Innovation and Investment Culture. Much of the US' excellence in innovation and investment is rooted in culture, with some private sector leaders declaring that “America is

²⁴⁰ McKinsey & Company Turkey and McKinsey Global Institute, 'The Future of Work in Turkey' (McKinsey & Company, 28 February 2020), <https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-in-turkey>.

²⁴¹ OECD, 'Employment and Skills Strategies in Turkey' (Paris: OECD, 21 October 2017), <https://www.oecd.org/turkey/employment-and-skills-strategies-in-turkey-9789264279506-en.htm>.

²⁴² Find further relevant indicators online at: <https://tradingeconomics.com/turkey/indicators>

²⁴³ Gokhan Yildiz, 'Turkey's High-Tech Exports Reach Nearly \$5B', AA, 10 December 2019, <https://www.aa.com.tr/en/economy/turkeys-high-tech-exports-reach-nearly-5b/1669636>.

²⁴⁴ UNESCO, 'Cultural Goods, An Economic Driver in the Digital Age', UNESCO, <https://en.unesco.org/news/cultural-goods-economic-driver-digital-age>.

²⁴⁵ Confederação Nacional da Indústria, 'Marco Institucional Da Inovação' (Brasília, Brazil: Confederação Nacional da Indústria, 2016).

²⁴⁶ Manufacturing USA, 'National Network for Manufacturing Innovation (NNMI) Program Strategic Plan', Manufacturing USA, 15 February 2016, <https://www.manufacturingusa.com/reports/national-network-manufacturing-innovation-nnmi-program-strategic-plan>.

²⁴⁷ The Global Entrepreneurship and Development Institute, 'Global Entrepreneurship Index 2018', The Global Entrepreneurship and Development Institute, 2018, <https://thegedi.org/global-entrepreneurship-and-development-index>.

²⁴⁸ CNBC, 'America's Top States for Business in 2019: A Scorecard on State Economic Climate', CNBC, 10 July 2019, <https://www.cnbc.com/2019/07/10/americas-top-states-for-business-2019.html>.

innovation.”²⁴⁹ While many commentators would argue that the US’ innovation and investment culture is rooted in individualism, the free market and liberalism, it is crucial to recognize the extent to which the US government has co-created accelerative and regulatory mechanisms with the private sector to support the growth of this culture. Examples include supporting new, foreign entrants to the economy, introducing venture capital firms to invest in the ICT industry, founding entrepreneurial universities with the Morrill Act (1982) and funding research, and committing to emerging technologies, like the Internet.²⁵⁰ Another enabling process is the US’ public procurement, an instrument that supported many projects in science, technology and innovation. Mission-oriented policies are “instrumentalized by public procurement”, in addition to other supply-and-demand policy instruments, including but not limited to R&D grants for innovators.²⁵¹

Private and Public Sector Linkage (BERD & GERD). In 2018, the GERD in the United States was 2.84% of GDP. The GERD performed by business enterprise was 2.06%, which represents the importance of the private sector in R&D financing in the US.²⁵² Also in 2018, businesses spent \$441 billion on research and development performance, a 10.2% increase from 2017.²⁵³ There are strong public and private sector linkages embedded in the US national innovation system; the Manufacturing USA group has established 14 advanced manufacturing institutes through public-private partnerships,²⁵⁴ and since 2018, the Bureau of Economic and Business Affairs has held a series of Innovation Roundtables with representatives from the US private sector, focused on emerging technology and ICTs.²⁵⁵

High-Tech and Soft-Tech Innovation Exports. Exports of high-tech goods grew rapidly between 2013 and 2018, by 13.4%: more than the rate of total exports. To China, US high-tech exports grew by 41.7% in this period.²⁵⁶ The International Trade Administration has estimated that an average of 5,744 jobs are supported by every \$1 billion in high-tech exports (including direct and indirect employment effects).²⁵⁷ Soft-tech – Monday, 23 Nov.

High-Skilled Worker Development and Good Brain Retention. The US has a wide range of programs and resources for high-skilled worker development and as a result has world-leading brain retention.²⁵⁸ Some sectors shine more than others; in the manufacturing sector, 61% of new jobs were created by international companies.²⁵⁹ US’ brain retention is about maintaining local talent on the one hand, and attracting foreign talent on the other.

Pro-Cluster Environment. The US has a range of successful clusters, linking the public, private and academic sectors.²⁶⁰ For instance, the US Environmental Protection Agency, a

²⁴⁹ Gary Shapiro, ‘America Is Innovation’, Forbes, 24 October 2012, <https://www.forbes.com/sites/garyshapiro/2012/10/24/america-is-innovation/?sh=5151e7575ddf>.

²⁵⁰ Geoffrey Owen, ‘Lessons from the US: Innovation Policy’ (London: Policy Exchange, 2017).

²⁵¹ Maria Carolina Foss, ‘Compras Públicas Como Instrumento de Política de Inovação Orientada à Demanda: Experiências No Brasil, Nos Estados Unidos e Na União Europeia’ Public Procurement as a demand-side policy instrument in Brazil (May 2019), https://www.researchgate.net/publication/333405385_COMPRAS_PUBLICAS_COMO_INSTRUMENTO_DE_POLITICA_DE_INOVACAO_ORIENTADA_A_DEMANDA_EXPERIENCIAS_NO_BRASIL_NOS_ESTADOS_UNIDOS_E_NA_UNIAO_EUROPEIA.

²⁵² Find relevant indicators online at <http://data.uis.unesco.org>

²⁵³ Raymond M. Wolfe, ‘U.S. Businesses Reported \$441 Billion for R&D Performance in the United States During 2018, a 10.2% Increase from 2017’ (National Center for Science and Engineering Statistics, 26 August 2020), <https://nces.nsf.gov/pubs/nsf20316/>.

²⁵⁴ Find further information about Manufacturing USA online at: <https://www.manufacturingusa.com/pages/how-we-work>.

²⁵⁵ Learn more about the State Department’s innovation policy: <https://www.state.gov/innovation-policy/>

²⁵⁶ Stephen Ezell and Caleb Foote, ‘How Stringent Export Controls on Emerging Technologies Would Harm the U.S. Economy’ (Washington, DC: Information Technology and Innovation Foundation, May 2019), <http://www2.itif.org/2019-export-controls.pdf>, 6-7.

²⁵⁷ Ibid.

²⁵⁸ Find further information about workforce development online at: <https://blog.dol.gov/category/workforce-development>

²⁵⁹ Global Business Alliance, ‘Developing America’s Workforce’, Global Business Alliance, n.d., <https://globalbusiness.org/our-focus/developing-america-s-workforce>.

²⁶⁰ Martin Neil Bailly and Nicholas Montalbano, ‘Clusters and Innovation Districts: Lessons from the United States Experience’ (Washington, DC: Brookings Institution, 8 May 2018), <https://www.brookings.edu/research/clusters-and-innovation-districts-lessons-from-the-united-states-experience/>.

federal agency, supports the environmental technology innovation clusters to support cross-sectoral collaboration to solve national environmental issues.²⁶¹

Trade Openness. One of the major reasons why the US has reached a high level of market sophistication are its low import tariffs and trade openness. In 2016, import tariffs were lower on average than typical sales taxes in the US.²⁶² In 2019, US trade openness (measured as exporters plus imports as a percent of GDP) was 26.31%, building on years of strong performance in this area.²⁶³

²⁶¹ Find further information about innovation cultures to support environmental action:

https://19january2017snapshot.epa.gov/clusters-program_.html

²⁶² Fernando Leibovici, 'How Open to Trade Is the U.S. Economy?', *Economic Research Federal Reserve Bank of St. Louis Economic Synopses*, no. 21 (2018), <https://doi.org/10.20955/es.2018.21>.

²⁶³ Refer relevant indicators at: https://www.theglobaleconomy.com/USA/trade_openness/.

7. BRAZIL'S FUTURE READINESS: A DATA-BASED ANALYSIS AND APPROACH

7.1. THE INNOVATION, TECHNOLOGY AND TALENT TRIANGLE

Innovation, talent, and technology are critical factors for countries in their efforts to tackle wide-ranging challenges and achieve long-term sustainable development. These factors combine to shape the foundation of *Future Readiness* by leveraging the powerful combination of innovation-talent-technology into a single component, *the ITT triangle* (ITT). *To be future ready, economies need to monitor their respective and collective abilities to master the ITT, identifying their degree of response to paradigm-shifting events such as climate change or the current COVID-19 pandemic.* This conceptual approach contributes to a better understanding of how economies are positioned and how these are harnessing the combined power of these three factors to prepare for a post pandemic global competition.

Relying on the rich information produced by the three indices, created by the founders of the Portulans Institute, each of the three angles of the ITT has been the object of continuous and detailed global monitoring through a specific 'Global Index.'

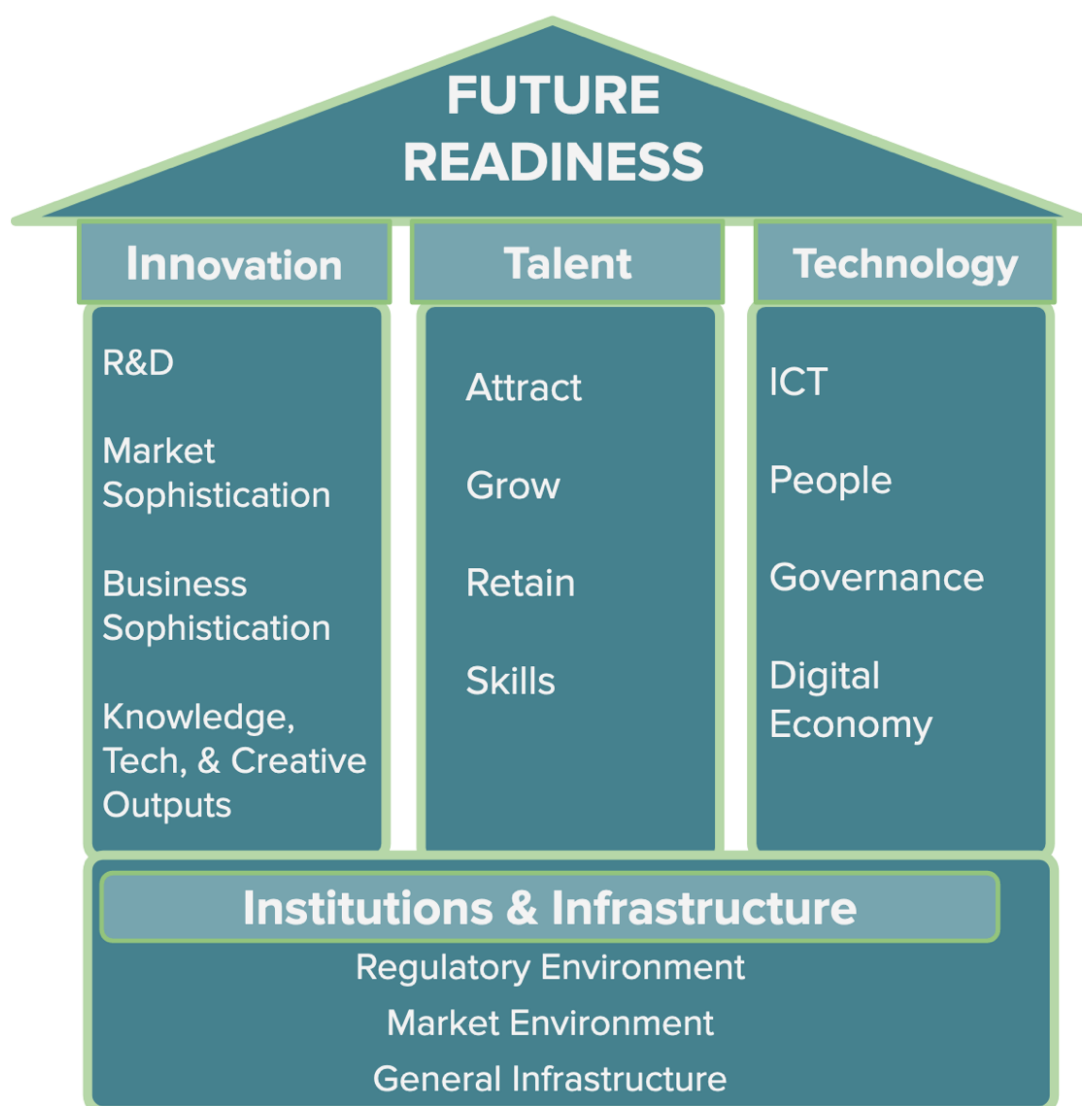
In this context, **Innovation** is the motor that allows economies to stay ahead of the curve in competitiveness and to diversify their markets and adapt to future shocks. As such it remains as the principal ingredient of Future Readiness.

Talent is the intrinsic quality of the human capital that a country hosts, reflecting also its abilities to grow, attract, and retain talent. It captures new generations entering the job market, along with how older generations of workers acquire and master the skills that will help them remain relevant and contributive to local strategies, global priorities and to thrive at professional and personal levels.

Technology comes in the form of information and telecommunication technologies (ICTs) offering powerful tools to better understand the information that can be collected and analyzed. Instruments such as Artificial Intelligence (AI) and Deep Learning (DL) can also help to explore new avenues to identify new solutions to long standing and novel issues alike.

This structure also contemplates an underlying fourth dimension in the form of solid **Institutions and Infrastructure**. This dimension captures how efficiently governance frameworks foster business environments and how infrastructures facilitate the production and exchange of ideas, goods and services and promote growth through improved productivity, reduced transaction costs, better access to markets, and sustainable growth.

FIGURE 4. FUTURE READINESS THEORETICAL FRAMEWORK



This approach is multilayered in rationale and impact. It is rooted in the perspective that public leadership informing complex debates involving the dimensions of innovation, talent, and technology is crucial for countries' ability to face challenges and opportunities. The approach generates analytical insights that may help countries compare their ITT performance to other countries, enabling them to gain a globally competitive edge. Similarly, aware that local business leaders and foreign investors alike need fact-based identifications of strengths and weaknesses of their respective countries to orient their strategic decisions, this approach offers a series of practical tools to enhance their methods. For individuals, analysts, and academics searching for access to a set of straight-forward instruments that may increase their level of shared trust, and remedy the kinds of concerns that derive from higher levels of uncertainty, this approach offers access to top quality data and analyses that may affect their own work and future strategies.

Although it is too soon to estimate the impact of the COVID-19 crisis on the world economy and society in general, economies and regions that prepare for multiple outcomes by identifying assets and liabilities, advantages and obstacles in the three domains of the ITT will be those better prepared to identify successful strategies and goals.

7.2. FUTURE READINESS EVALUATION APPROACH

The next sections present an analysis of Brazil's Future Readiness following a *Future Readiness Evaluation Approach* (FREA). The assessment serves as an additional tool to address the recommendations from CNI and MEI in a more informed manner, and to assist local leadership in their design of a roadmap to enhance the levels of competitiveness and improved performance in a post-COVID-19 economy for Brazil.

7.2.1. THEORETICAL FRAMEWORK

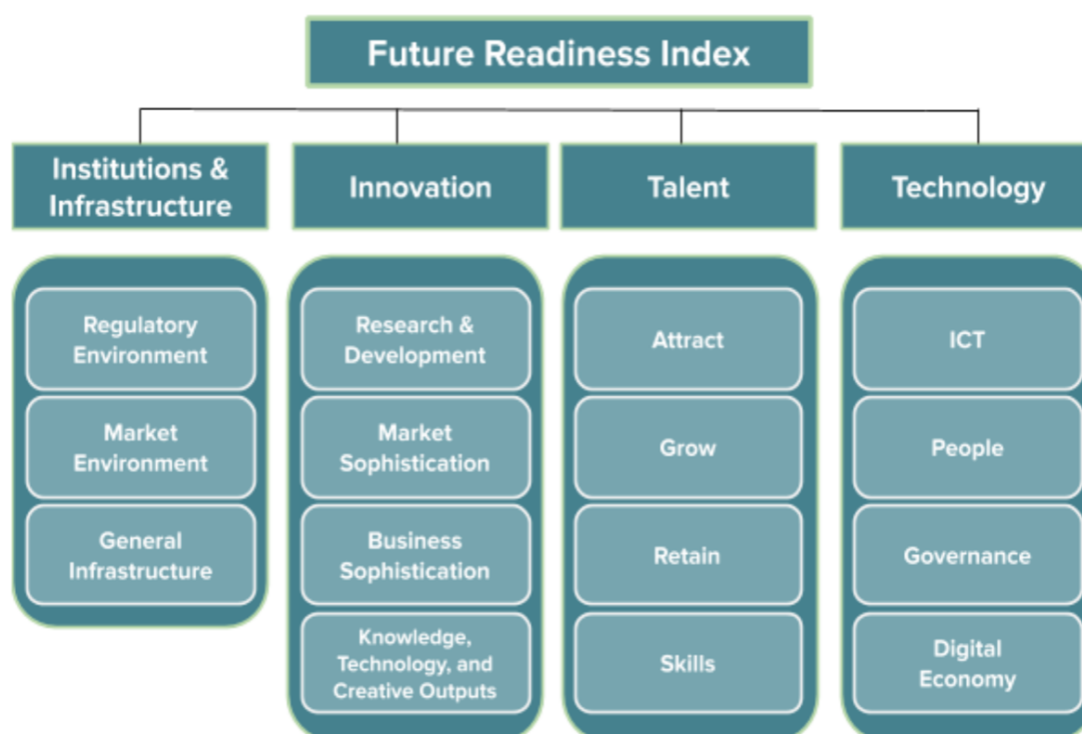
The FREA merges elements of the Global Innovation Index (GII), the Global Talent Competitiveness Index (GTCI), and the Network Readiness Index (NRI) into a single technical review process. This methodology considers the three components of the ITT triangle plus the underlying fourth dimension of institutions and infrastructure to produce a *Future Readiness Index*. The outcome offers a snapshot of Brazil's performance in each of these dimensions as measured by multiple indicators and captures how this economy performs among a selected group of peers through different scenarios within a *Future Readiness* ranking.

7.2.2. THE FUTURE READINESS INDEX

The *Future Readiness Index (FRI)* is shaped by four pillars, each with three to four sub-pillars, and each sub-pillar comprising three to six indicators, for a total of 67 indicators. While all indicators in these sub-pillars come from the three global indices, the mapping is modified in order to avoid overlaps across dimensions.²⁶⁴ Figure 5 describes the FRI structure and components.

²⁶⁴ Depending on its dimension the raw data used in the FRI calculations comes from the latest published database used for each respective parent index. This means that the data for indicators in the ITT Innovation pillar come from the GII; for Talent from the GTCI; for Technology from the NRI; and for Infrastructure and Institutions from the GII and GTCI. This regardless of overlaps and differences in publication date for identical indicators. The sources and definitions for each indicator are found in appendix 4.

FIGURE 5. FUTURE READINESS INDEX STRUCTURE AND COMPONENTS



Similarly to all three parent indices, the FRI benchmarks Brazil's performance as measured by its four pillars against that of other economies in a particular sample. The main group of peers considered in this contrast, defined as the *OECD Plus* group, consists of 47 economies that include the 37 OECD economies plus Argentina, China, Colombia, Costa Rica, Israel, Malaysia, Romania, Russian Federation, Singapore, and South Africa.²⁶⁵ All of the featured economies are either among the high-income or the middle middle-income groups based on the World Bank Income Group Classification and stem from all of the seven regions defined by the United Nations Classification.²⁶⁶

In addition to including a more complete pool of data, comparing Brazil's prowess and existing capacities to those of its regional and global competitors included in this collection is critical. This approach offers proper benchmarks that can help point out areas where economies – most at higher levels of development than Brazil – are progressing, in addition to identifying strategies and instruments they adopt and design to leverage their ITT triangle. This information is crucial for Brazil as it seeks to move in the direction of the planning and

²⁶⁵ This selection narrows down the percentage of missing data to only 1.6% of the sample, equivalent to 51 out of 3,098 data points. Given that Brazil's data coverage is almost complete (97% coverage or 2 out of 67 indicators missing), a more precise picture of its performance is achieved when contrasted to the other economies considered. See footnote 268 for more details on data coverage requirements and signaling.

²⁶⁶ As defined by the World Bank Income Group Classification (July 2019) 35 economies are classified as part of the high-income group; 11 —including Brazil— are in the upper-middle income group; and a single economy is classified as part of the lower middle-income group. Regions are a special classification based on the online version of the United Nations publication Standard Country or Area Codes for Statistical Use, originally published as Series M, No. 49, and now commonly referred to as the M49 standard. The number of economies per region is as follows: Europe (28); Northern America (2); Latin America and the Caribbean (6 including Brazil); Central and Southern Asia (1), South East Asia, East Asia, and Oceania (7); Northern Africa and Western Asia (2); and Sub-Saharan Africa (1). For income group classifications see: <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>. For UN regions see: <https://unstats.un.org/unsd/methodology/m49/>

execution of long-term projects, the development of more harmonious governance models for the local ST&I, and the restructure of the country's national innovation financing system.

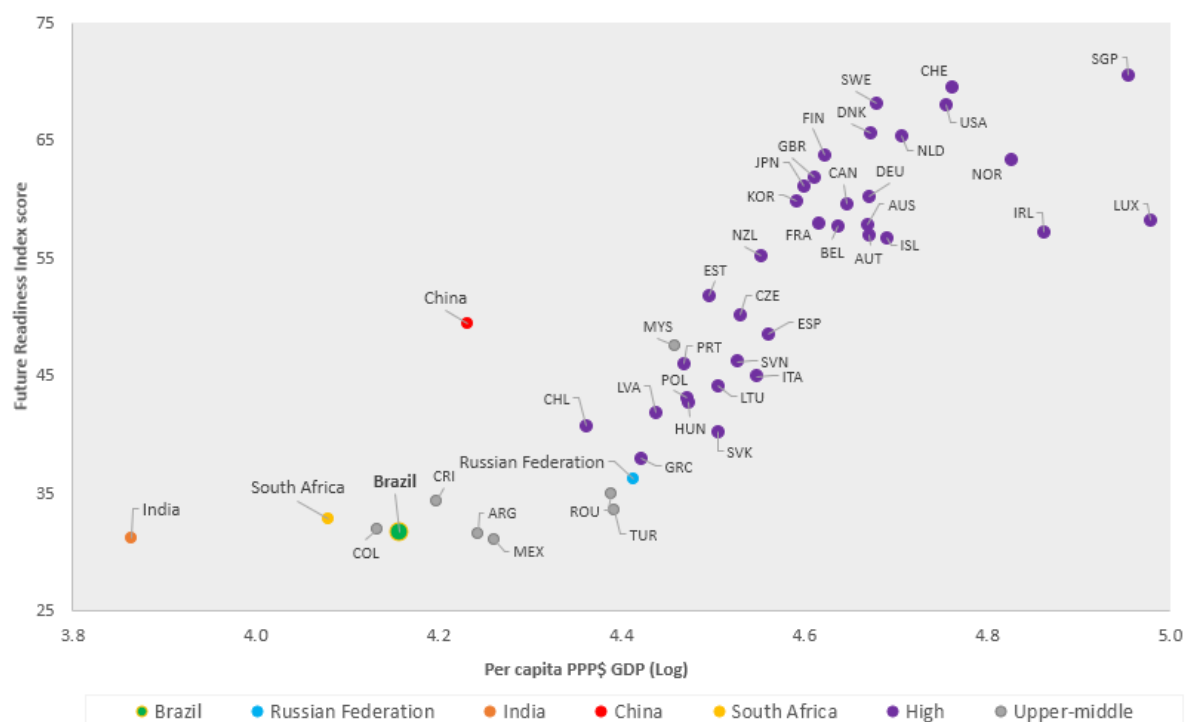
7.3. BRAZIL'S FUTURE READINESS

The first output of this analysis is a scoreboard for Brazil, displaying its overall *Future Readiness* ranking, that of each of the FRI pillars, sub-pillars, and indicators. Likewise, it displays the general strengths and weaknesses for Brazil within this framework and those within its income group, in addition to missing and outdated data. These results capture Brazil's performance within the full sample of economies as well as its outcome when compared to regional or country-specific associations. The full FRI 2020 rankings can be found in appendix 2.

7.3.1. BRAZIL IN THE OECD PLUS GROUP

The findings suggest that Brazil's state of *Future Readiness* is low, ranking at the 44th position. This ranking places Brazil behind all economies in the sample that are at a higher level of development, as measured by their income. With the exception of Chile, most of these are located in Europe and South East Asia, East Asia, and Oceania. Various economies at the same stage of development as Brazil also display a higher ranking. These include most of the other BRICS economies, with the exception of India, and all countries in Latin America and the Caribbean, with the exception of Mexico. Figure 6 shows the position of Brazil compared to all other economies in the sample. Brazil's full country profile, showing the rankings for all components of the FRI is available in appendix 2.

FIGURE 6: FUTURE READINESS INDEX: BRAZIL AND THE BRICS ECONOMIES IN THE OECD PLUS GROUP²⁶⁷



Source: FRI database

Reviewing the components of the ITT, Brazil ranks the highest in Innovation (37th), followed by Talent (41th), and Technology (44th). The fourth underlying dimension comprising Institutions and Infrastructure (46th) is its lowest ranked ITT component, signaled along with Technology as areas requiring further efforts to achieve an enhanced competitiveness for Brazil.

Looking into the elements of these components shows that Business Sophistication (22rd) and R&D (35th), both in the ITT Innovation pillar, and Governance (37th), in the Technology pillar, are Brazil's highest-ranking sub-pillars.²⁶⁸ Conversely, Skills (in the ITT Talent pillar) and Market Sophistication (in the ITT Innovation pillar), both ranked 46th, and General Infrastructure (47th), are those with lowest performance and marked as disadvantages. Regulatory Environment (Institutions and infrastructure) and ICT (Technology), both ranking 45th, are additional areas with opportunity for improvement signaled by the data.

²⁶⁷ The high-income group economies and their ISO3 country code featured in Figure 7 are: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Chile (CHL), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HUN), Iceland (ISL), Ireland (IRL), Israel (ISR), Italy (ITA), Japan (JPN), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Netherlands (NLD), New Zealand (NZL), Norway (NOR), Poland (POL), Portugal (PRT), Republic of Korea (KOR), Singapore (SGP), Slovakia (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE), Switzerland (CHE), United Kingdom (GBR), and United States of America (USA). The upper middle-income group economies are: Argentina (ARG), Colombia (COL), Costa Rica (CRI), Malaysia (MYS), Mexico (MEX), Romania (ROU), and Turkey (TUR); Source: FTI database.

²⁶⁸ This analysis applies the data minimum coverage (DMC) requirement introduced in the GII methodology to ensure that incomplete data coverage does not lead to erroneous conclusions about strengths or weaknesses, or particularly about strong or weak sub-pillar and pillar rankings. More specifically, when economies do not meet the DMC requirement at the sub-pillar level (for sub-pillars with two indicators, the DMC is 2; for three it is 2; for four it is 3; for five it is 4; and for six is 5), they are not attributed a strength or weakness at the sub-pillar. The DMC in the case of pillars with three sub-pillars is 2 sub-pillars with complete data; for those with four sub-pill it is 3. Furthermore, if the economy in question does not meet the DMC requirements at the pillar or sub-pillar level, but it still obtains a ranking higher than or equal to 10 or a ranking equal to or lower than 100 at the pillar or sub-pillar level, for caution this rank is not highlighted as either a strength or a weakness. This study shows that Australia, Brazil, and China are the only economies that show DMC rankings. These are located in the Business sophistication sub-pillar for Australia and Brazil, and in the Technology pillar and ICT, Governance, and Skills sub-pillars for China.

Although the ITT Technology pillar is identified as an area with multiple opportunities for Brazil, a closer review of individual indicators demonstrates that many that are ranked near the top 25 for that economy are located in that pillar. These indicators are E-Participation and Gender Gap in Internet use (both placed 16th), Government online services (18th), Use of Virtual Social Networks (20th), ICT Regulatory Environment (25th), and High-Tech Exports (26th). The ITT Innovation pillar is the component with the second largest number of indicators in the top 25 range, with ICT Services Imports (19th), Global R&D Companies' Average Expenditure (Top 3) and Market Capitalization (both 21st), with Intellectual Property Receipts in the same range (26th).

The ITT Talent pillar has Brazil's highest ranked indicator, the Gender Development Gap (10th), with strong performance in the Use of Virtual Private Networks (23rd) indicator, too. With the exception of the ICT Regulatory Environment and Market Capitalization, the data signals that this cluster of indicators is a key strength for Brazil, in addition to indicators measuring the use of Virtual Professional Networks and the number of Intellectual Property Receipts, particularly among Brazil's income group peers.

Brazil's lowest performances are in the underlying ITT dimension measuring the country's institutional and infrastructural framework. Based on its income group, its performance should be much higher. The Regulatory Environment (45th) and General Infrastructure (47th) sub-pillars show that Government Effectiveness (47th), Regulatory Quality (46th), Corruption (45th), and Gross Capital Formation as a percent of GDP (46th) are some of Brazil's weakest performing indicators. The data also indicates that the Market Sophistication sub-pillar and Applied Tariff Rate indicator's weighted mean (both 46th) are two areas with the most opportunity for improvement.

Back in the ITT Talent pillar, International Students (45th) in the Attract (42nd) sub-pillar and both the Skills (46th) sub-pillar and its indicator Availability of Scientists and Engineers (47th) trail in performance. The pillar measuring Technology reveals that sub-pillar ICT (45th) and its indicator Measuring 4G Mobile Network Coverage (44th) and indicators ICT skills (47th), Government Promotion of Investment in Emerging Technologies (42nd) in the People (43rd) sub-pillar, plus Labor Productivity per Employee (45th) in the sub-pillar measuring Digital economy (42st) record similarly sub-par performances.

Although Brazil's data coverage is among the highest in the sample, the two indicators that are missing – GERD performed by business enterprises, and GERD financed by abroad as a percent of GDP – are highly relevant to better understand the flows of capital going into innovation activities and the degree of sophistication of Brazil's local business environment. Similarly, outdated information offers a partial picture of the more current realities operating within a local ST&I system. For Brazil, information relating to the sub-pillars of General Infrastructure (47th), Retain (42st) as a part of the ITT Talent pillar, and R&D (35th) in the ITT Innovation pillar comes from years that are prior to the mean year for all economies in the sample. More specifically, indicators Electricity Output (41st), Researchers (40th), Gross expenditure on R&D (GERD) (29th), Pension System (36th), and Physician Density (39th) are based on data that is older than desired. It will be important to target these drawbacks to achieve an even more precise measurement of the local state of *Future Readiness* for Brazil. An additional desired outcome of exercises such as this one is to serve as further incentive for the collection and estimation of the most timely and precise data.

7.3.2. BRAZIL IN THE BRICS

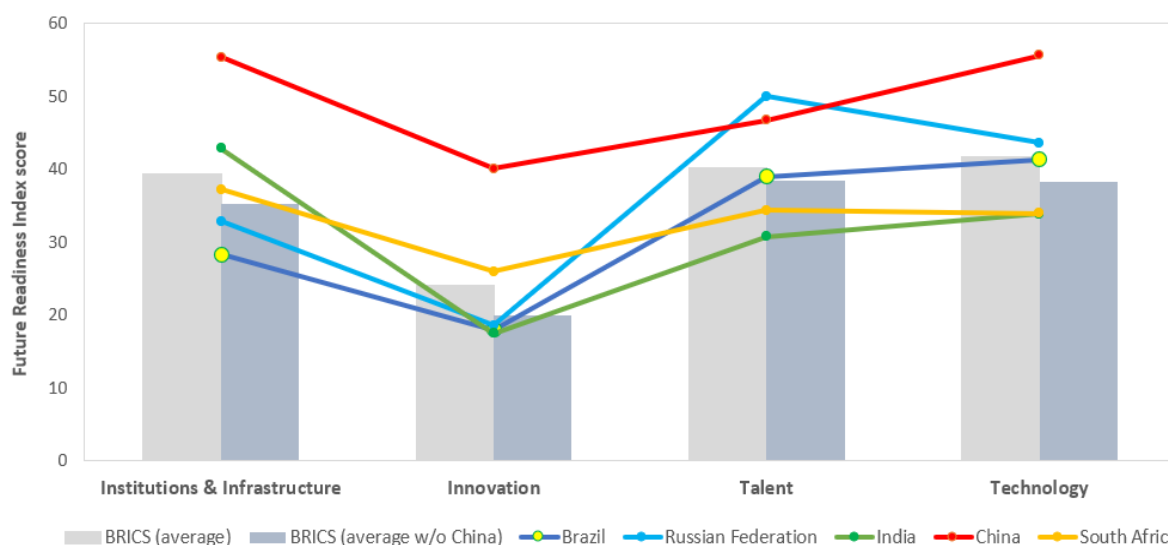
Brazil, Russia, India, China and (since 2011) South Africa compose the group defined as BRICS. The relevance of this group of five major emerging economies rests upon their political, regional, and economic influence. Together, these economies represent over 40% of the population, nearly one quarter of the world's GDP, 30% of the world's territory, and almost 20% of global trade (BRICS-Brazil 2019).

Beginning their dialogue in 2006, the BRICS economies have sought to establish more equitable international governance, developing sectoral cooperation in areas like S&T, trade, energy, health, education, innovation and justice. This association has resulted in the creation of multiple important institutions, including the New Development Bank (NDB) and the Contingent Reserve Arrangement (CRA). Both of these institutions have promoted infrastructure and renewable energy financing projects in the BRICS countries, as well as helping improve the financial stability mechanism for countries affected by crises in their balance of payments. This association and its outcomes serve to further energize local agents of change, particularly those that lead to collective economic development for all member states. However, the data available today suggests that some of these benefits still remain at bay for Brazil.

In the context of *Future Readiness*, Brazil's performance ranks as fourth among the BRICS economies. China leads, followed by the Russian Federation and South Africa. India closes the group after Brazil. As captured in Figure 7, and with the exception of China, most of the middle-income group economies still fall far behind from their more developed counterparts located in the higher income group. Considering Brazil's performance in this scope, the ITT Talent and Technology are its best performing pillars, ranking 3rd above India and South Africa. In the ITT Innovation pillar, Brazil takes the 4th position above India, yet stands behind all of its other peers in Institutions and Infrastructure. At the sub-pillar level, Brazil is 2nd in the group for Grow; in Digital Economy, Attract, Retain, and Research & Development, Brazil ranks 3rd. Brazil's rankings for sub-pillars People and Governance (3rd in both), and Business Sophistication (1st), are less precise due to missing data.²⁶⁹ However, Brazil trails among the BRICS economies in Market Environment, General Infrastructure, Market Sophistication, and in Knowledge, Technology and Creative Outputs. Brazil also stands last in the group in Skills; however, missing data in that series also suggests the need for additional consideration when contemplating this outcome.

²⁶⁹ Caution should be used when reviewing these particular rankings. This is due to the distorting effect that not meeting the DMC may induce in this sample (see footnote 268). Among the BRICS economies only, a total of 14 data points for indicators are missing. China is missing 8 values, the most in the sample (5 in the pillar measuring Technology and 3 in the ITT Talent pillar); Brazil is missing 2 (both in the ITT Innovation pillar); India also 2 (1 missing in the ITT Technology and ITT Innovation pillars); and South Africa and the Russian Federation are missing 1 (1 in the ITT Technology and 1 in ITT Innovation pillars, respectively). Regardless of this caveat the results are sufficiently informative given that the available data in the full 47 economy sample covers 97% of the full data considered (see footnote 265).

FIGURE 7. BRAZIL IN BRICS: PILLARS OF FUTURE READINESS (FRI SCORE)



Source: FRI database

At the indicator level, Brazil takes the top position among its peers in ICT Services Imports, Intellectual Property Receipts, Use of Virtual Professional Networks, and the ICT Regulatory Environment. Brazil also takes the top spot in the Gender Gap in Internet Use; however, given that data is not available for China, India, and South Africa, this outcome is less accurate. Overall, Brazil stands as second-best in a total of 15 indicators, takes the third position 12 times, and the fourth in 19 occasions.²⁷⁰

The areas demanding the most attention, particularly when contrasted to its group peers, are mostly associated with the Institutional and Infrastructure framework and the ITT Innovation component. Brazil shows the lowest performance in Government Effectiveness, Ease of Doing Business, Ease of Resolving Insolvency, and Gross Capital Formation as a percent of GDP. Related to the latter ITT Innovation component, Venture Capital Deals, Applied Tariff Rate, weighted mean, Patent Families (filed in at least two offices), Creative Goods Exports (percent of total trade), and its Global Brand Value reflect the lowest performance within this group. Other indicators in both the ITT Talent and Technology dimensions also lag behind, specifically Employee Development, Ease of Finding Skilled Employees, the Availability of Brazil's Local Scientists and Engineers, ICT Skills, and Cybersecurity.

When reviewing the results of the BRICS within the full sample of economies, China shows the highest performance in all aspects with the exception of the ITT Talent pillar, where the Russian Federation ranks higher. Even when not considering China, the ITT Innovation pillar stands out as the component with two of the best ranks for BRICS due to South Africa's performance near the global top 25 and the Russian Federation's rank in the global top 35 in

²⁷⁰ The indicators in which Brazil takes the 2nd, 3rd, and 4th positions among the BRICS are: (2nd): Political & operational stability (tied with the Russian Federation), Gross expenditure on R&D (GERD), GERD: Financed by business enterprise (% of total GERD), Tolerance of minorities, Gender development gap, Environmental performance, Physician density, GitHub commits, Use of virtual social networks, Government online services, E-Participation, and High-tech exports. It also takes this position in Wikipedia edits, Workforce with tertiary education, and Professionals, however missing data for China makes these rankings less precise; (3rd): Researchers, Global R&D companies, average expenditure top 3, FDI and technology transfer, Tertiary enrolment, and Pension system, Internet access, Firms with website, Internet shopping, Medium and high-tech industry, and Labor productivity per employee. It also takes this post in Adoption of emerging technologies, Legal framework's adaptability to emerging technologies but China's data is missing; (4th): Rule of law, Regulatory quality, Corruption, Competition intensity, Cluster development, Electricity output, GWh/mn pop, Logistics performance, University ranking, Domestic credit to private sector, Market capitalization, PCT international applications by origin, Cultural and creative services exports (% of total trade), International students, Social mobility, Delegation of authority, Brain retention, and in 4G mobile network coverage. It is also 4th in Senior officials and managers and in Government promotion of investment in emerging technologies, yet data for China is also unavailable. As mentioned earlier in this Report Brazil does not have information for indicators GERD performed by business enterprise and GERD: Financed by abroad (% of GDP).

this domain. More moderate results are recorded for some BRICS economies in the ITT Talent pillar, and in the cross-section assessing Institutions and Infrastructure, where the Russian Federation ranks atop of the group in the former (30th) and, when not considering China, India (37th) does the same in the latter. Lastly, aside from China, the lowest reported ranks for BRICS are in both Institutions and Infrastructure and in the ITT Technology pillar.

7.3.3. BRAZIL IN LATIN AMERICA AND THE CARIBBEAN

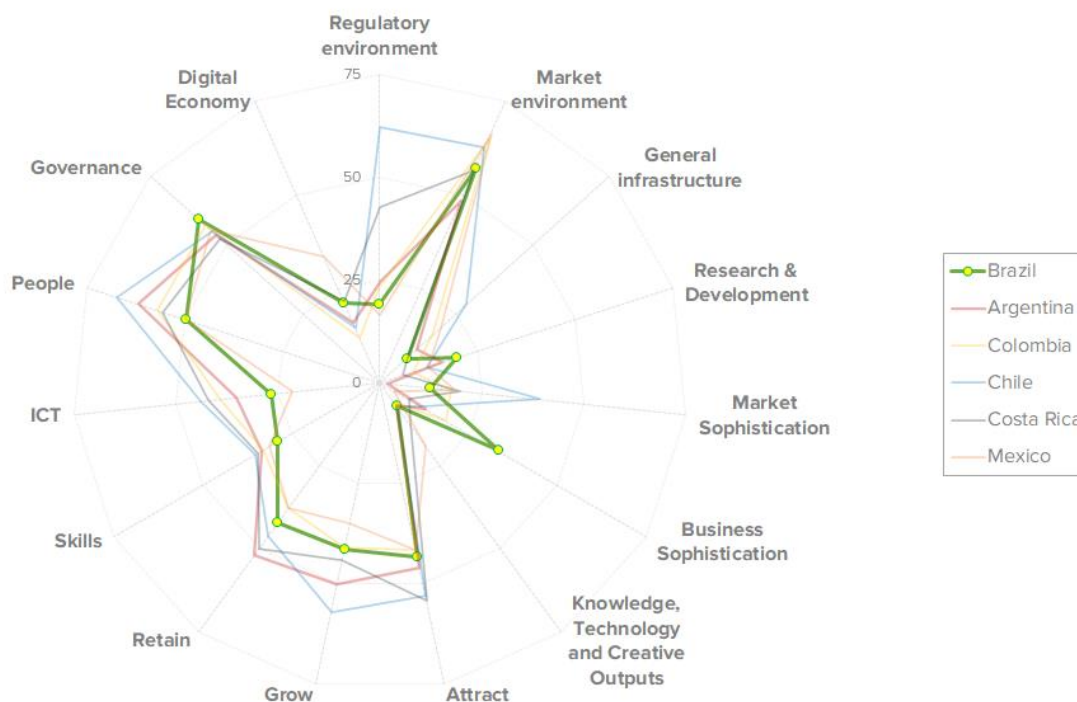
In addition to Brazil, a subgroup of Latin American economies in this sample encompasses Chile as the single economy from the global high-income group, alongside upper middle-income group economies Argentina, Colombia, Costa Rica, and Mexico. Although Brazil performs top in the ITT Innovation pillar in this cluster, it takes the 4th overall position, placed immediately after Colombia and before Argentina and Mexico. This position reflects its untapped potential in the ITT Talent pillar (4th in the group), and in both the ITT Institutions and Infrastructure and Technology pillars (5th). Reviewing the sub-pillar tier, Brazil tops the rankings in Governance as a domain of the ITT Technology pillar and takes the top positions in R&D and in Business sophistication in the sphere of Innovation.²⁷¹

Conversely, in areas associated with the quality of the local institutions and general infrastructure and with Technology, Brazil trails the group. More specifically, Brazil ranks 5th and 6th in Regulatory Environment and General Infrastructure respectively, both aspects associated with the former dimension, and 5th in ICT and People, linked to the latter. Skills (6th) and Market Sophistication (5th) are other drivers within the ITT Talent and Innovation pillars where Brazil also lingers behind.²⁷² Figure 8 displays Brazil's sub-pillar performance contrasted to that of the other economies in the region.

²⁷¹ Once again caution is suggested when reviewing these particular rankings. This is due to the distorting effect that not meeting the DMC may induce in Brazil's outcome for Business sophistication (see footnote 265).

²⁷² Brazil is 3rd in Knowledge, Technology and Creative Outputs (ITT Innovation) and in Digital economy (ITT Technology); and 4th in Attract, Grow, and Retain (ITT Talent); and Market environment (underlying ITT dimension, Institutions and infrastructure).

FIGURE 8. BRAZIL IN LATIN AMERICA AND THE CARIBBEAN: AREAS OF FUTURE READINESS (FRI SCORE)



Source: FRI database

A closer look at the indicators in these domains places Brazil ahead in the ITT Innovation pillar compared to its peers, with a top position in GERD, Global R&D Companies' Average Expenditure, venture capital (VC) Deals, ICT Services Imports, and IP Receipts. Government Online Services and E-Participation are another two indicators associated with the ITT Technology pillar where Brazil achieves the highest position in the group. In addition to leading in these areas, Brazil ranks second-best in multiple others also linked to the ITT Innovation and Technology pillars.²⁷³ A highlight is the fact that Brazil's most common position within this group is 3rd. It ranks in that position in 20 indicators and more than half of these are associated with the ITT Talent domain. Similarly, but from an inverse perspective, the 6th position is the next most commonly obtained by Brazil, doing so on 11 occasions. The indicators where this is the case, however, are more evenly distributed among all four scopes of the ITT.²⁷⁴

Reviewing the results of the other economies in this regional sample demonstrates that Chile's outcome is the most productive in all areas. Chile's best performance is displayed in indicators in the ITT Institutions and Infrastructure and Technology pillars, areas where Chile amasses the most top ranks within the sample. Chile ranks above most of its peers in multiple indicators in Talent and Innovation, too. Costa Rica's indicators associated with the

²⁷³ In the ITT Innovation pillar, these measure the number of researchers, the quality of universities, market capitalization of traded companies, the percentage of GERD financed by business enterprise, patents filed in at least two offices, PCT international applications by origin, and Creative goods exports. In Institutions and infrastructure in Cluster development. Those indicators associated with the ITT Technology pillar are GitHub commits, cybersecurity, ICT regulatory environment, and medium and high-tech industry.

²⁷⁴ Brazil ranks 6th in three indicators in the I&I pillar (Government effectiveness, Regulatory quality, and Gross capital formation as percentage of GDP); one in the ITT Innovation pillar (Applied tariff rate, weighted mean); three in Talent (Brain retention, Ease of finding skilled employees, Availability of scientists and engineers); and four in the ITT Technology pillar (Use of virtual social networks, ICT skills, Government promotion of investment in emerging technologies, and Labor productivity per employee).

ITT Talent pillar display the highest ranks yet, although its performance trails in R&D, and in Governance as part of the ITT Technology pillar compared to the rest. Colombia does well in Business Sophistication, Market Environment and General Infrastructure in Institutions and Infrastructure, and in ICT, People, Governance and Technology. However, Colombia trails in most aspects of the ITT Talent pillars and in some linked to the ITT Innovation pillar (R&D and Knowledge, Technology and Creative Outputs). Lastly, Argentina shows the most positive results in these innovation domains while Mexico does so in the ITT Talent pillar.

8. FREA IN ACTION: SCENARIOS AND SIMULATED OUTCOMES

In addition to offering a snapshot of *Future Readiness* within various contexts a feature of the FRI model is scenario analysis. Using algorithm-based forecasting and relying on the economic concept of *ceteris paribus*, this mechanism helps simulate the outcome of four hypothetical scenarios for Brazil —one for each of the ITT components.²⁷⁵ These scenarios inspect areas where Brazil displays room for improvement and are designed by taking into account the views and recommendations from the private sector and international organizations and factors identified via research and data as assisting other economies achieve good performance in those particular domains.

Each scenario consists of a series of tests in which forecast values for Brazil are introduced into the FRI model while keeping all other factors constant. The outcome of each scenario produces a simulated (or “what if?”) FRI result for Brazil deriving from its initial general 44 ranking among 47 economies (full rankings and Brazil’s country profile are available in appendix 1 and 2). Findings derived from these simulated outcomes offer additional information to enrich the recommendations presented in this document. This section presents the results for each individual scenario as well as those obtained when all scenarios are applied simultaneously.

8.1. STRENGTHENED INNOVATION

Findings confirm that some of the most competitive global economies commit sizable quantities of financial resources to R&D and benefit from highly trained and readily available human resources. Among other outcomes, these factors appear to be key in the development of new markets including those for innovation- and tech-based services. Consequently, these can be signaled as catalysts for entrepreneurship and essential to boost economic development locally.²⁷⁶

This scenario explores the effect of improving measurable efforts in both the number of researches and the amount of financial resources available in the form of GERD and venture capital as measured by the number of private equity deals. An expansion of the less tangible yet equally pivotal exports of a line of both innovation- and tech-based services abroad is also reviewed. In addition, the effect of including data on GERD performed by business enterprises and financed by abroad is reviewed independently from all previous tests. This last assessment shows the effect that these variables would have in the assessment of Brazil’s innovation prowess as measured by the FRI.

This scenario departs from the propositions listed below. In this and subsequent scenarios these premises are treated as independent tests. Collectively, the result of each of these tests comprises the outcome of the overall scenario under review.²⁷⁷

8.1.1. UPDATED AND ENHANCED BODY OF ACTIVE RESEARCHERS

²⁷⁵ While data for all other economies is kept constant (*ceteris paribus*), the values used in each test for Brazil are forecast values for the year 2020. Forecasts are produced using the additive error, additive trend, and additive seasonality (AAA) version of the Exponential Smoothing (ETS) algorithm. In each of these procedures the predicted value for Brazil is a continuation of the historical values in the specified target date, which should be a continuation of the timeline for the selected indicator. For each test either the forecast, lower confidence bound, or the upper confidence bound value is used as specified. Forecast values represent the average of the lower and upper confidence bound values.

²⁷⁶ Most variables arguably have some “optimal” value which can differ between countries. Therefore expansion beyond such levels can be inefficient or even counter-productive. Identifying such “optimal” values for Brazil is beyond the scope of this analysis.

²⁷⁷ In general, the outcome of each scenario is measured by Brazil’s variation in overall FRI ranking derived from running all tests simultaneously. In cases when the effect is not evident at this macro level, the outcome is assessed based on a more granular review of other FRI component rankings.

Currently, the available data for full-time equivalent (FTE) researchers per million inhabitants shows that in Brazil there were roughly 888 researchers per million habitants in the year 2014.²⁷⁸ This test introduces a hypothetical scenario where the number of researchers is nearly 35% higher at 1,197 researchers per million persons. This departure represents an annualized growth of 5.1% if this variation was reflecting the period between 2014 and 2020.

8.1.2. INCREASED GROSS EXPENDITURE ON R&D (GERD) AS A PERCENT OF GDP

Brazil's GERD as a percent of GDP is reported in 2017 at 1.26% based on UIS data. Alternatively, this test proposes a GERD of 1.46%.²⁷⁹ This variation entails a growth of nearly 16% from the original value reported and an annualized increase of slightly above 5.0%, if this variation was measuring the period between 2017 and 2020.

8.1.3. HIGHER VOLUME OF VENTURE CAPITAL DEALS

The number of venture capital deals reported within a calendar year for Brazil varies historically. For the year 2019 the reported number of deals was 67.²⁸⁰ Based on upper confidence bound forecast values this assessment puts forward an alternative total of 94 deals for the same period, reflecting nearly a 41% increase from the original number reported. For the calculations of this variation the GDP for Brazil remains at the levels reported for 2019 as used throughout the FRI.

8.1.4. EXPAND CULTURAL AND CREATIVE SERVICES EXPORTS

Policies to improve and expand cultural and creative services exports in any economy depend on efforts on various fronts. On the one hand, these rely on those targeting an expansion of the provision of multiple technology-laden services such as information, advertising, market research, audiovisual, and heritage and recreation services.²⁸¹ On the other hand, these also depend on initiatives to enhance the overall state of trade openness as a benchmark for these. Furthermore, given their nature, an expansion of these services would also demand efforts in areas linked to talent development and to the access of both public and private funding.

While a substantial and timely expansion of the exports of these services has more to do with global demand, the production of this type of services relies more on endogenous production cycles. This test departs from the assumption that enhancing and expanding the quality and quantity of cultural and creative services can improve the potential for higher levels of global demand for these. Thus, while each of the cultural services components reflect upper confidence bound values, those for total trade are kept at the same levels used in the original calculations of this indicator and throughout the FRI model.

²⁷⁸ The formula to calculate the full-time equivalent (FTE) is as follows: Total working hours per year is calculated considering 8 hours in a day, five days in a week, and 52 weeks in a year. The reported figure represents the forecast value for Y2020 using data from 2009-2014.

²⁷⁹ The reported figure represents the upper confidence bound value for Y2020 using data from 2009-2017.

²⁸⁰ Number based on Thomson Reuters Eikon data on private equity deals, per deal, with information on the location of investment, investment company, investor firms, funds, and crowdfunding, among other details. The series corresponds to a query on venture capital deals from January 1, 2019 to December 31, 2019 for Brazil. The reported figure represents the upper confidence bound value for Y2020 using data from 2015-2019.

²⁸¹ A large percentage of these services can be cataloged as digitally delivered and have been matched to EBOPS categories (see Law No. 27430/2017, Senado y Cámara de Diputados de la Nación Argentina, 2017 for a detailed concordance between firms and the digitally delivered services). For example, information services have been matched with web hosting services for information, images, video or other content that can be stored, including cloud computing (i.e. Google Storage or iCloud) as well as with subscription services to digitised versions of newspapers/magazines. Audio-visual and related services with streaming services such as transmission or digital distribution of multimedia content through the Internet (i.e. Spotify and Netflix). Remote education services (i.e. OpenEnglish) have been assigned to other personal, cultural and recreational services; Companies such as Instagram, Facebook and Twitter have been assigned to advertising services, market research and public opinion surveys based on their revenue stream. Source: OECD (2020) Handbook on Measuring Digital Trade, Version 1. <https://www.oecd.org/sdd/its/Handbook-on-Measuring-Digital-Trade-Version-1.pdf>.

These premises could be somewhat analogous to a situation where a global economy is bouncing back to a steady state of economic recovery and where, from one perspective, the global demand for cultural services became steeper during the pandemic due to their intangible nature while, from a different one, the overall demand for all products and services as measured by total trade still has not experienced a thorough recovery.

More specifically, the Extended Balance of Payments Services Classification EBOPS 2010 codes each cultural services as SI3 Information services; code SJ22 Advertising, market research, and public opinion polling services; code SK1 Audiovisual and related services; and code SK23 Heritage and recreational services. These variables as measured by the FRI suggest that Brazil's information services (SI3) are close to \$53.8 million; for advertising, market research, and public opinion polling services (SJ22) these are \$935.6 million; for audiovisual and related services (SK1) \$153.23 million; and for code SK23 Heritage and recreational services (SK23) \$43.30 million.

The forecasted values for these components reflecting the upper confidence bounds are: SI3 \$56.88 million; for SJ22 \$1,072.27; SK1 \$366.62; and SK23 \$47.48. Conversely, the value for total trade remains at \$161,027 million.²⁸²

8.1.5. INNOVATION SCENARIO ASSESSMENT

As expected, the use of the forecast values in this scenario's multiple tests confirm that Brazil's competitiveness as measured by the FRI would be stronger in those examined areas linked to innovation. Yet, this progress would not build up enough momentum to be reflected in Brazil's overall FRI rankings. Still, this collection of tests to accomplish the target of improving its innovation capacity. Under this scenario Brazil's performance in Innovation moves ahead by two positions to 35th. This is due to improved outcome in R&D (ranking in this scenario 33rd instead of 35th) assisted by both a GERD as a percentage of GDP of 1.5% similar to that of Canada and Malaysia (ranked 24th from 29th) and by a volume of researchers per population of 1,197 per thousand population (moving from 40th to 29th) that is above that of Argentina and trailing the number reported for China.

A higher number of venture capital deals and an expansion of creative services exports also assist with this improvement in Innovation. A higher number of venture capital deals offers a VC deals-to-GDP ratio for Brazil that is above that of economies at a higher stage of development like Hungary and Chile and behind that of the Russian Federation. This variation would improve Brazil performance in this indicator by one position placing it as 35th. Similarly, improvements in the production and quality of cultural and creative services leading to higher demand for these abroad would translate into Brazil becoming the 29th economy in this area with a ratio of these services to total trade that is above that of China, the Republic of Korea, Japan, and Chile.

The results of these tests suggest that a scenario where stronger outputs in key areas of innovation would translate into a higher degree of global competitiveness for Brazil. These findings also imply that the tests comprising this scenario alone (and under the estimated parameters) would not translate directly into a higher *Future Readiness* designation for that economy. Yet, the scenario's overall positive outcome points towards its effectiveness and to the possibility that when applied in conjunction with other positive outcome scenarios, Brazil's could indeed reflect an improvement both in particular domains and in overall performance.

²⁸² The reported figures for SI3, SJ22, and SK1 show calculations using the upper confidence bound values for Y2020 using data from 2014-2018. The figure for SK23 shows calculations using the upper confidence bound value for Y2020 and data from 2015-2018.

8.1.6. ADDITIONAL INDEPENDENT TEST: IMPROVING MISSING DATA

Data for GERD performed by business enterprises and GERD financed by abroad is neither produced nor compiled for Brazil. Yet, the use of proxies for both variables helps visualize where Brazil's scale of *Future Readiness* would have been had this information been available. Forecast values based on those of Turkey (similar size economy) and Singapore (economy at a higher level of development) help explore both median and high-performance scenarios.

Using data for Turkey to forecast values, the percentages for GERD performed by business enterprises and GERD financed by abroad are 0.88% and 0.046%, respectively. Under this case the outcome places Brazil as 23rd in former, signaling also this indicator as a strength, and 34th in the latter. These alternative rankings affect Brazil's outcome in Business sophistication by reducing its performance by five positions down to 30th. This variation also alters its results in Innovation moving its ranks from 37th to 42nd. The overall effect alters Brazil's FRI ranking by two positions placing it at 46th now below Argentina and India and only above Mexico.

The outcome shows more favorable results when assessing the effect that these variables have on Brazil's performance when using forecast values based on Singapore. In this scenario, Brazil shows 1.35% as the proportion of GERD performed by business enterprises and 0.17% as that of GERD financed by abroad. In this context Brazil ranks 16th and 21st, respectively, and both areas are signaled as global strengths. Yet, Brazil still drops three positions in Business sophistication to 25th but remains as the 37th economy in Innovation. The cumulative effect of these values places Brazil as the 45th economy, down from 44th, switching places with Argentina.

Overall, these estimations rather than suggesting a negative connotation, emphasize the importance of data completeness when producing a robust picture of Brazil's innovation and competitiveness capabilities. For this reason, it would be of great value for this and other assessments to pursue the development and compilation of these data for Brazil in the near future.

8.2. IMPROVED TALENT

Talent is identified as a key catalyst for job creation, innovation, and ultimately, economic growth. The rapid pace at which technology and development structures are evolving has promoted a redesign of conventional paths to help energize entrepreneurial talent. Nobel strategies affect all aspects of talent competitiveness, including education, skilling and skills updating, attracting and retaining talent, and fostering cooperation and co-creation. Encouraging foreign or returning talent to stay and contribute to long-term local objectives are also among the goals of these strategies. While talent issues are prevalent concerns for both firms and nations, urban areas are increasingly playing more central roles as entrepreneurial talent hubs, offering innovative talent strategies, often ahead of any that the wider national states can propose.

This section examines various factors that can serve as conduits to expand, attract, and retain skilled workforce in Brazil. These factors include a higher percentage of students enrolled in tertiary programs; a more attractive and competitive pension system that reflects a stable local financial sector; an enhanced environmental health and ecosystem vitality as a determining factor for talent retention; and ultimately a higher perception of the availability of skilled workers.

8.2.1. INCREASED TERTIARY ENROLMENT

In Brazil the reported ratio of total tertiary enrolment, regardless of age, to the population of the age group that officially corresponds to the tertiary level of education is around 50.5% for the year 2016. This ratio entails that the number of students in all tertiary education programs and that for the school age population enrolled in tertiary education, both regardless of sex, were close to 8.3 and 16.5 million, respectively. This test proposes a forecast value for 9.3 million students enrolled in tertiary programs and a total school age population for that educational level at 16.9 million. Together these produce a tertiary enrollment ratio of 54.72%, suggesting an increase in values of 8.3% from the reported value for 2016.²⁸³

8.2.2. UPGRADED PENSION SYSTEM

The percentage of active contributors to a pension scheme in the labor force that are at least of 15 years of age is currently reported at close to 52.5%. This test proposes an estimate of 64.3% representing a close to 30% expansion.²⁸⁴

8.2.3. EXPANDED ENVIRONMENTAL PROTECTION

The Environmental Protection Index (EPI) offers a snapshot of the state of sustainability using 32 performance indicators across 11 issue categories, ultimately ranking economies based on environmental health and ecosystem vitality. Due to its underlying methodology and data variations between versions it is neither recommended to assemble the scores from previous and the current release into a time series. Thus, the values used in this scenario are the assessed scores for both components of the EPI 2018, each with an expansion of 10%.²⁸⁵ Given that the composition of the EPI score considers a different percentage for each of these components (40% for environmental health and 60% for ecosystem vitality), the resulting forecast value for Brazil used in this test is 66.77 rather than 60.7. This score would place Brazil's performance above that of economies at higher stages of development like Chile and the Russian Federation yet still below economies labelled as highly biodiverse like Costa Rica and Australia.

8.2.4. INCREASED AVAILABILITY OF SCIENTISTS AND ENGINEERS

This test explores a general improved perception towards the availability of scientists and engineers in the local workforce. While an exploration of this indicator may appear frail, the qualitative nature of this indicator would entail sufficient policy efforts to alter not only the qualitative perception of sectors demanding skilled workers but to do so via a quantitative improvement in the availability of workers with these skills. Currently this perception in Brazil stands at 3.4 on a scale from 0 to 7. Using the updated values for this indicator found in the latest update of the World Economic Forum Global Competitiveness Index a forecast value is set at 3.88.²⁸⁶

8.2.5. TALENT SCENARIO ASSESSMENT

Collectively the tests in this scenario have a positive impact on Brazil's competitiveness as measured by its overall FRI ranking. Improved performance in both Growth (up one position to 37th) – achieved through a higher number of tertiary enrolled students (up one spot to

²⁸³ The reported figure represents the forecast value for the enrolment in tertiary education, all programs, both sexes (number) and school age population, tertiary education both sexes for Y2020 using data from 2010-2018.

²⁸⁴ In December 2020, the International Labour Organization (ILO) reported at 52.47% the percentage of total active contributors to an old age contributory scheme in percentage of the economically active population in Brazil for the year 2015. Source ILO Social Security Expenditure Database. <https://www.ilo.org/sesame/IFPSES.SocialDBExp>.

²⁸⁵ Note that the EPI 2020 was published after the publication of the GTCI 2020. Based in this fact and to echo the principle of data collection stated in footnote 251, the value was kept as reflected in that report. Due mainly to the referred changes in methodology between versions the value for Brazil in the EPI 2020 was not used to produce the used estimation. The value for Brazil in the EPI 2020 is 51.2 with scores of 49.7 and 52.2 for Environmental Health and Ecosystem Vitality, respectively.

²⁸⁶ The reported figure represents the forecast value for the availability of scientists and engineers for Y2020 using data from 2011 and 2018.

37th)— and in Retain (up three to 39th) – fueled by a pension system that is perceived as more attractive (up to post to 34th) and a higher environmental performance (up nine to 30th) –, plus an enhanced perception of the accessibility to scientists and engineers (up eight to 39th), Brazil becomes the 43rd FRI economy. This ranking places it above Colombia and below South Africa.

8.3. BETTER TECHNOLOGY

Technology can be defined as a collection of methods, traits, and processes applied to achieve specific goals or to produce and provide goods or services. It can also be outlined as the knowledge of tools and procedures or even as the information that can be integrated into processes or machines to generate automation. When technology is applied collectively in the transformation of inputs to produce specific outcomes these mechanisms are referred to as technological systems. Innovation derived from technology is thus perceived as a leading instrument of social progress and a known driver of economic development. Yet, experience shows that the forward push that accompanies some technologies may also heighten worries and doubts in individuals and groups of these, as previously observed in cases such as nuclear energy, modern biotech, and more recently in social media or 5G implementation.²⁸⁷

Research shows that some of the main causes for such push backs might be rooted in a reluctance towards governmental institutions, regulatory authorities, and technical advisory boards. In general, regulators need to consider to a meaningful extent social goals and concerns as earlier as possible in the development process, especially those coming from the private and industrial sectors.²⁸⁸ Therefore promoting the advancement of emerging technologies while preventing or mitigating potential negative effects is a critical challenge for any government working on the design of balanced and efficient ST&I policies.

This section examines factors linked to a particular technology and to the promotion and governance of new technologies. The first analysis reviews the outcome of having a higher percentage of inhabitants out of the total population who are within range of an advanced mobile cellular signal, in this case 4G; the second explores the effect of having a government that is perceived as fostering investment in emerging technologies; the last reviews the outcome of having a legal framework that is perceived as highly adaptable to emerging technologies.

8.3.1. IMPROVED 4G MOBILE NETWORK COVERAGE

Based on data from the International Telecommunications Union (ITU) the percentage of people out of the total population who are within range of an advanced mobile cellular signal in Brazil, subscribers or not, is 83%. Although this percentage may be perceived as high, it lags behind economies to which Brazil is often contrasted, like Turkey (93%), Colombia (98%), and India (94%). This test presents a value that serves as a proxy for enhanced 4G broadband cellular network technology coverage.

As this indicator was recently created by ITU for its most recent version of the *ICT Development Index*, an estimation for Brazil based on time series and forecast values is not possible at this time. Rather, the value used in this test is defined using estimations for connected, coverage and usage gaps in Latin America and the Caribbean developed by the Global System for Mobile Communications Association (GSMA). The values, presented in ITU's *Last-Mile Internet Connectivity Toolkit*, identify the geographic limits of network

²⁸⁷ OECD, *OECD Science, Technology and Innovation Outlook 2020: Times of Crisis and Opportunity* (Paris: OECD Publishing, 2020), <https://doi.org/10.1787/75f79015-en>.

²⁸⁸ OECD, 'Technology Governance' (Paris: OECD, 2020), <http://www.oecd.org/sti/science-technology-innovation-outlook/technology-governance/>.

infrastructure in relation to the location of population.²⁸⁹ These suggest that 53% of the population in the region is connected, 39% is within a usage gap, and 8% fall within a coverage gap.²⁹⁰ Using these parameters the value used in this test for Brazil equates to the sum of both the 'connected' and 'usage gap' percentages, thus leading to a coverage of 92%. When contrasted to the current percentage this value represents nearly a 11% increase in coverage.

8.3.2. ENHANCED GOVERNMENT'S PROMOTION OF INVESTMENT IN EMERGING TECHNOLOGIES

This test reviews a higher perceived promotion of investment in new technologies from behalf of the government. The test relies on a newly introduced indicator produced by the World Economic Forum (WEF) that focuses on five main technologies: Artificial Intelligence and Machine Learning, Robotics, App- and web-enabled markets, Big data analytics, and Cloud computing. Given the novelty of this indicator and thus the absence of complete time series to produce forecast values, the score used in this test is calculated using both actual and alternate values.

Brazil's score in this test is obtained using a weighted scheme that combines its existing 2019 score and a predicted score for 2020. This calculation follows the weighted two-period methodology followed to produce the score of indicators used in the calculations of the Global Competitiveness Index 4.0. These calculations lead to a score of 3.44 for Brazil in this test, an expansion of nearly 24% from its 2.78 score for 2019. Refer to appendix 3 for more details on the methodology followed to arrive at this score.

8.3.3. IMPROVED LEGAL FRAMEWORK'S ADAPTABILITY TO EMERGING TECHNOLOGIES

This test reviews a perceived higher adequacy of the legal framework when adapting to emerging technologies. Similarly, this test reviews a newly introduced indicator produced by the WEF that focuses also on the five main technologies mentioned in the previous section, thus the same methodology described in section 8.3.2 is applied to produce Brazil's alternative score.²⁹¹ In this case the outcome leads to a score of 3.76 for Brazil in this test, an expansion of nearly 5% from the 2019 score that is 3.60.

8.3.4. TECHNOLOGY SCENARIO ASSESSMENT

These tests applied as a single scenario bring out a positive outcome for Brazil like that of the scenario assessing Talent. Brazil's competitiveness is improved by better performance in both ICT (up four positions to 41st) – due to an enhanced 4G mobile network coverage (up five to 39th) – and in People (up one to 42nd) – due to an enhanced government's promotion of investment in emerging technologies (up thirteen positions to 29th). This assessment, however, does not reflect improvement in the legal framework's capacity to adapt to new technologies (34th), suggesting that a quantifiable expansion on that front demands more

²⁸⁹ITU, 'The Last-Mile Internet Connectivity Toolkit: Solutions to Connect the Unconnected in Developing Countries' (Draft, 2020), <https://www.itu.int/en/ITU-D/Technology/Documents/RuralCommunications/20200120%20-%20ITU%20Last-Mile%20Internet%20Connectivity%20Toolkit%20-%20DraftContent.pdf>.

²⁹⁰ Connected refers to the segment of population who have used internet services on a mobile device (consuming mobile data); usage gap refers to the segment of population that live within the footprint of a mobile broadband network but are not using mobile internet; and coverage gap refers to the population that do not live within the footprint of a mobile broadband network. Ibid.

²⁹¹ Brazil's existing 2019 score and predicted score for 2020 are 3.06 and 3.89, respectively; the average and standard deviation of the available scores for middle-income economies used for the 2020 score calculations are 3.59 and 0.30, respectively; the respondent's sample size in 2019 was 231 and the forecast value for 2020 is 244 (see previous footnote); the discount factor α is 0.6; and the weights for 2019 and 2020 are 0.44 and 0.55, respectively.

impactful actions to effectively translate into tangible perceived improvements. The overall effect of this scenario places Brazil as the 43rd FRI economy by improving its ranking by one position, placing it above Colombia and before South Africa.

8.4. UNDERLYING DIMENSION: SOLID INSTITUTIONS AND INFRASTRUCTURE

Institutional frameworks that preserve and strengthen key public functions, such as finance, procurement, and property protection, and ensure its citizens access to derived services and the full coat of civil and human rights are staples of competitive economies. Equally as important are the infrastructures that these institutions help design and implement.

Economies at higher levels of development generally display a multitude of institutional and normative mechanisms that guide technological development and are effective at governing scientific and entrepreneurial activities. As a result, these display sophisticated infrastructures that facilitate the flow of resources and loop back into the innovation system via enhanced productivity, efficiency, and sustainable development. Conversely, in some economies at lower levels of development, the absence of solid institutions and competent and inclusive public sectors often compromise the prospect of economic growth and reduce public trust in government. As a consequence, these lack the more developed infrastructures noted in their more advanced counterparts.

Therefore, nurturing a clear, efficient, and accountable institutional framework that attracts business and fosters growth by providing good governance and the appropriate degree of protection and incentives is crucial to innovation.

This section reviews the effect of higher government effectiveness, improved regulatory quality, and less corruption. It also explores the result of curbing some of perceived factors impeding the rise of a more dynamic business environment locally.

8.4.1 INCREASED GOVERNMENT EFFECTIVENESS

Government effectiveness encompasses perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Brazil's value for this indicator in 2018 is -0.44.²⁹² This test proposes an alternative value of -0.06 capturing an increase of 87%.²⁹³

8.4.2. BETTER REGULATORY QUALITY

Regulatory quality is perceived as the ability of the government to formulate and implement sound policies and regulations that permit and promote private-sector development. Brazil's value for this indicator in 2018 was -0.31.²⁹⁴ This test proposes an alternative value of -0.21 showing an increase of 34%.²⁹⁵

8.4.3. REDUCED CORRUPTION

²⁹² The latest Worldwide Governance Indicators (WGI) shows a value of -0.18 for Brazil in 2019 for this indicator. This value is used in the forecast value calculations performed for this test.

²⁹³ This figure represents the upper confidence bound value for Y2020 using data from 2010-2019.

²⁹⁴ The latest WGI shows an updated 2018 value of -0.32 for Brazil for this indicator. This data also shows a value of -0.17 for Brazil in 2019 for this indicator. Both values are used in the forecast value calculations performed for this test.

²⁹⁵ This figure represents the upper confidence bound value for Y2020 using data from 2010-2019.

Corruption is measured by the Corruption Perceptions Index (CPI) as the perceptions of business people and country experts of the level of corruption in the public sector.²⁹⁶ Brazil's value for this indicator is 35 for the year 2018.²⁹⁷ Given that forecasting yields the same value as that currently displayed by Brazil, the used proxy for this test is 48.²⁹⁸ This variation suggests an increase in the outcome of this index of 34%.

8.4.4. CUTTING RED-TAPE (IMPROVING THE EASE OF DOING BUSINESS)

The Ease of Doing Business Index (DBI) aggregates a country's percentile rankings on 10 topics covered in the World Bank's Doing Business report series. The topics are starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency. Brazil's current value for this indicator is 60.01 that corresponds to the score of the DBI 2019.²⁹⁹ This test proposes an alternative value of 71.5 for this indicator. This higher ranking indicates that the regulatory environment is more conducive to setting up business.

The value used in this test was produced by using the Ease of Doing Business score calculator 2019 and applying a 30% improvement across all aspects considered. appendix 3 (Technical Note) shows the changes in the components of the DBI.

8.4.5. INSTITUTIONS AND INFRASTRUCTURE SCENARIO ASSESSMENT

A scenario where key institutional and infrastructure aspects of Brazil are improved produces also a favorable result for Brazil similar to that obtained by scenarios assessing Talent and Technology. In this case, Brazil's performance is boosted by an improved Regulatory environment (up one position to 43rd) and a more efficient Market environment (up three to 41st). More specifically, reinforced outputs for Government effectiveness (up four positions to 43rd), Regulatory quality (one to 45th), and Corruption (up ten to 35th) are behind the advancement of a more efficient regulatory environment. Similarly, an environment more conducive to innovation and business captured by a higher ease of doing business (up six to 40th) helps improve the market landscape in Brazil. Again, the resulting effect of this scenario places Brazil as the 43rd FRI economy.

8.5. SCENARIO: ENCOMPASSING ITT POLICY

The individual outcome of these scenarios suggests that improvements in the performance of particular indicators do not have homogeneous effects. On the one hand, simultaneous improvements in key indicators associated with Talent, Technology, or the underlying dimension assessing Institutions and Infrastructure appear to convert each of these areas into individual drives of overall improvement. On the other, similar efforts to boost performance solely based on the assessed elements of Innovation seem to demand more robust tactics if this area is sought as one to single handedly induce overall improvement.

Given these initial findings it comes as no surprise that the joint effect of applying all these scenarios simultaneously translates into a positive collective effect on Brazil's competitiveness as assessed by the FRI model. Yet, the degree of such a positive outcome as evidenced by an upward movement of three positions placing Brazil as the 41st economy

²⁹⁶ Given that the CPI scores are comparable year on year since 2012, historic data series can be used to forecast values without the need to deconstruct its parts to do so.

²⁹⁷ The CPI 2019 presents a 2019 value of 35 for Brazil. This value is used in the forecast value calculations mentioned in this test.

²⁹⁸ This proxy shows the average of all 12 middle-income economies with a value for this indicator plus one standard deviation of that sample. The sample includes Brazil.

²⁹⁹ The DBI 2020 is now available and shows a score for Brazil of 51.9. This is a score reduction of 14%.

among all considered does come as a better than anticipated outcome. Although the complexity and nature of index analysis makes it difficult to determine the synergies produced between the elements and tests in each of these scenarios, it becomes clear that when these are applied in tandem the outcome is much more productive than any achieved individually.³⁰⁰

This trajectory towards higher competitiveness also holds when Brazil's performance is assessed under these scenarios including the estimated forecast values for the two missing variables for Brazil, GERD performed by business enterprises and GERD financed by abroad. In this scenario Brazil positions itself between the 41st and the 42nd spot, depending on the performance scenario forecasting factors.³⁰¹

These results suggest that efforts to boost Brazil's innovation-driven competitiveness in the context of Future Readiness could benefit more from the development, application, and management of more holistic and sector-encompassing policies. These policies, rather than aiming at each of the ITT components individually or pursuing different implementation cycles for each component, could concurrently consider all the elements of the ITT and be applied jointly. Furthermore, these findings reinforce the importance of having full data when it comes to producing more valid and precise performance assessments, regardless of any initial adjustment shocks derived from the introduction of these.

Overall, these results help enrich the recommendations and conclusions deriving from this Report and can offer additional pointers towards the design and implementation of more wholesome and encompassing innovation policy frameworks for Brazil.

³⁰⁰ Alternative analysis like Principal Components Analysis (PCA) can shed more information about the strength and dominance of each of the components of the FRI. However that type of analysis is beyond the scope of this Report.

³⁰¹ As presented in section 8.1.6 forecast values for GERD performed by business enterprises and GERD financed by abroad come, depending on the focus of the scenario, from estimates based on Turkey and Singapore values (see section 8.1.6 for details on these values). When using Singapore's forecast values Brazil achieves the 41st position; when using those from Turkey, Brazil ranks 42nd.

9. RECOMMENDATIONS

This section presents a set of decurrent general and component-specific recommendations based on the findings from the research process sustaining this Report. Although these are arranged and presented in this section as either general recommendations or associated to an ITT domain, the intersecting nature of some recommendations allows them to go beyond their assigned scopes and thus be relevant in more than one domain. We note, however, that these are not exhaustive, and that further additional guidelines should be drawn from the lessons and data gathered. The objective of these recommendations is to assist decision makers in the design and promotion of policies and best practices to improve Brazil's innovation-based competitiveness at the local, regional, and global stages.

GENERAL RECOMMENDATIONS

A Future Readiness Evaluation Approach captures a snapshot of Brazil's relatively structured ST&I policy framework. Yet a comprehensive, overarching long-term national strategy to guide these policies in a more holistic manner – in a way that does not drastically change with new governments – remains absent. This is surprising given the relevance of ST&I in the Brazilian Constitution, which frames public incentives in ST&I as the core enabler of economic development and the principal tool to tackle issue-specific social challenges. Although existing policies display sufficient institutional and societal linkage, these have not yet become impactful enough to induce the sought transformations.

The following general recommendations encompass a wider vision of innovation targeting some of its broader objectives. These recommendations also offer insightful perspectives to assist policymakers in making informed innovation policy decisions. Thus, Brazil should:

9.1. ESTABLISH SOLID BRIDGES BETWEEN PUBLIC AND PRODUCTIVE SECTORS

The National Innovation Policy – outlining the governance of Brazil's innovation ecosystem – is supported by actors at various strategic levels of government. In general, the policy shares the goals of the private sector. Yet a few shortcomings identified by research and data point to minor disconnections between the public and private/productive sectors in Brazil's systems of innovation and suggest that the institutional framework in place has yet to achieve its full maturity. ***Building the necessary connections between these sectors is fundamental to achieving these objectives, along with higher levels of productivity.***

9.2. OUTLINE MISSION ORIENTED POLICIES

Mission-oriented policy aims at issue-specific social challenges and demands the interaction of multiple sectors to solve

particular problems. By developing a targeted focus on issues, novel types of collaborations emerge between public and private actors to address them, creating a more suitable environment for knowledge spillovers than any fostered exclusively by a sectoral approach. ***A shared perspective coming from the private sector highlights the importance of partnering in multi-stakeholder groups for the design of mission-oriented policies and strategies, to leverage both efforts and investment mechanisms in order to advance innovation locally.***

9.3. DEVISE INTERSECTIONAL RATHER THAN SINGLE DOMAIN POLICIES

Although Innovation and Technology are the two ITT domains that demonstrate the highest number of strengths for Brazil, neither can be signaled as displaying a

flawless performance.³⁰² The underlying ITT dimension comprising Institutions and infrastructure, on the other hand, encompasses the most areas of opportunity for Brazil as measured by relative weaknesses. In particular, government effectiveness assessed by, among other things, the quality of public and civil service and the quality of policy formulation and implementation is an area in which Brazil trails behind other economies at similar stages of development. Brazil trails similarly in regulatory quality, as measured by the government's ability to formulate and implement the sort of sound policies and regulations that permit and promote private-sector development. ***Rather than aiming at ITT components individually or pursuing different implementation cycles for each component, policies should concurrently consider all the elements of the ITT and be applied jointly.***

9.4. IDENTIFY AND COLLECT DATA TO BETTER SUPPORT THE DESIGN OF MISSION-ORIENTED POLICIES

The Report's findings reinforce the importance of complete data coverage when it comes to producing a more precise Future Readiness Assessment for Brazil. At this time, outlining a full picture of the state of R&D funding in Brazil is complex and partial given the absence of data to measure how much of GERD is performed by the business enterprise and how much is financed from abroad. This information, along with any that could lead to the production of novel indicators assessing the state of innovation financing in Brazil, should be pursued and compiled in the near future.³⁰³ ***The benefit from having complete and more precise information would help induce the kind of mission-oriented investments that lead to the creation of new technological opportunities and market landscapes in Brazil.***

³⁰²In Innovation the Applied tariff rate, weighted mean, and in Technology the 4G mobile network coverage, ICT skills, Government promotion of investment in emerging technologies, and labor productivity per employee are identified as weaknesses for Brazil. See the full Country Profile in appendix 2 for more details.

³⁰³ The scope and reach of novel data on the state of local finance for innovation could further explore topics such as origin of funds, type of funds, speed of funds disbursement, when in the innovation value chain funds are focused, among others.

IMPROVING INNOVATION

Stronger public private partnerships, efficient and cost-effective intellectual property protection systems, innovative entrepreneurship actions, and more sophisticated investments frameworks are among the proposed actions aimed at promoting innovation. The next recommendations are specific examples targeting this area. Thus, Brazil should:

9.5. INCREASE GROSS DOMESTIC EXPENDITURE ON R&D

Brazil's GERD as a percentage of GDP is about 1.3%, ranking as the highest among its regional peers and second behind China among the BRICS economies.

However, this investment rate remains low when contrasted to the rates of economies at higher stages of development. These economies, on average, display a GERD of approximately 2.1% of their GDP.

Similarly, while the percentage of GERD that is financed by Brazil's government amounts to nearly 50% of its total GERD, this figure represents only about 0.63% of Brazil's GDP. Concurrently, the private sector's willingness to invest in innovation and R&D is often curtailed by the high cost of financial resources and the myriad of risks linked to these activities.

Available data suggests that the segment of GERD financed by the business sector, and the expenditure in R&D by Brazilian R&D-intensive companies is relatively low when contrasted to that of other economies at similar stages of development. To mitigate this, it is imperative to ensure consistency in the availability and reliability of funding sources to maintain the continuity of these efforts and to produce significant and long-lasting results. **A position from the private sector highlights the need to expand rather than just preserve the current levels of GERD – especially those coming from the government. In doing so, this recommendation highlights the fundamental role that the public sector plays in ensuring the stability of and timely access to these resources. It also emphasizes the importance of having a deeper understanding of GERD and its key role for local innovation, especially for projects with multiple rounds of funding.**

9.6. FOSTER AN INNOVATION INVESTMENT CULTURE VIA VENTURE AND RISK CAPITAL MARKETS

Similarly, research also demonstrates that a country's innovation strategy dilutes when investors are not supported by a strong innovation ecosystem that looks both outwards – to foreign investment – and inwards – to homegrown ideas and talent.

Although Brazil's market value of listed domestic companies – a measurement of local investment – is between that of Germany and New Zealand, other forms of investment and resource transferring – such as the number of venture capital deals and FDI and technology transfer – are still far from levels seen in those economies at the top of the *Future Readiness* rankings developed in this Report.

In particular, the low output revealed by data on VC deals may suggest the absence of a comprehensive, fuller venture and risk capital investment culture locally. **Thus, the country should foster an innovation investment culture based on venture and risk capital markets through various actions, including: adequate taxation and tax incentives; better regulation for entrepreneurial capital; a reduction of the timelines for opening and closing as well as for organizational changes for companies; and through the design of better investors guidelines for responsibility of debts incurred by start-ups. Improving investment exit mechanisms, like the development of secondary markets, and those that help share risks, such as expanding public-private co-investment in venture capital funds, are additional steps that can assist in the pursuit of this objective.**

9.7. PROMOTE THE PRIVATE SECTOR'S ENGAGEMENT IN INNOVATION AND ENTREPRENEURSHIP

Investors across sectors and at different investment stages face regulatory uncertainty and the absence of safeguards that can help them navigate a complex and at times corrupt multi-layered bureaucracy. In addition, venture projects frequently encounter economic sustainability issues as well as appraisal challenges. In general, the Brazilian regulatory environment is perceived as dense, slow, and expensive by local and international stakeholders alike, yet research suggests that these limitations are felt most acutely by international investors.³⁰⁴ Brazil's low performance in the 'Ease of Doing Business' Index confirms the perception that the local environment is less conducive for businesses, due to the absence of a well-established regulatory environment. Similarly, modest year-on-year variation in gross capital formation as a percentage of GDP confirms the low investment rates perceived locally. ***Simplifying and clarifying Brazil's legal and regulatory environments, and developing mechanisms that ensure and improve investor confidence in higher-risk ventures is essential for the expansion of local entrepreneurship and innovation.***

9.8. FOSTER AN IP CULTURE BASED ON INTERNATIONAL GUIDELINES FOR INTANGIBLE CREATIONS

Brazil's IP displays decent levels of internationalization. Its ranking in the charges for the use of intellectual property (as a percentage of total trade) suggests that receipts are being issued between residents and non-residents for the use of proprietary rights. In this case, IP includes patents, trademarks, copyrights, industrial processes, and designs. The demand for some forms of IP – including trade secrets, franchises, and for licenses to reproduce and/or distribute copyrights on books and manuscripts, computer software, cinematographic works, sound recordings, and even on live performances and television, cable, or satellite broadcasts – may signal an area of untapped potential for Brazil, especially when considering that its creative goods exports still show room for expansion. Furthermore, data shows that while Brazil's medium and high-tech industry is well positioned internationally, its industry for cultural and creative services exports trails behind. ***Engaging in additional efforts not only to further expand the internationalization of its high- and medium high-tech industry but also that of softer innovation-based products and services – including those derived from culture and tradition – can further tap Brazil's potential to develop a lively and fully active IP Culture.***

³⁰⁴ Castillo and Plasencia, 'Building BIG: Brazil's Challenges and Opportunities in Infrastructure'.

IMPROVING TALENT

The increased capacity of professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems – including business management – feeds into the innovation system by improving Brazil's talent landscape. Increased productivity and efficiency, lower transaction costs, better access to markets, and sustainable growth are some of aspects addressed in the recommendations presented in this section. Thus, Brazil should:

9.9. TAILOR A TALENT-FIRST INNOVATION STRATEGY

While standards of global competitiveness collectively demand the ability to adapt and leverage technological change in favor of local market development and expansion, the global talent landscapes are rapidly evolving into pools of versatile and technologically-savvy workers. Yet, even well-rounded innovating economies under-perform in the creation, attraction, and retention of highly skilled labor relative to expectations based on their state of economic development. Although some factors (such as the reduction of a gender development gap, measured by individual health, knowledge, and living standards, and social mobility) are clear signals of positive brain retention efforts, other more general issues (such as a lack of understanding of work culture, or the absence of domestic long-term opportunities) may have led to the modest skilled worker retention levels observed locally.

To improve this trajectory, public-private efforts should develop programs to attract and retain individuals with an expertise in strategic management and higher-level skills in emerging technologies and STEM related occupations. Additional programs can be designed to target workers in areas linked to soft innovation and in sectors projected to experience low displacement, like healthcare and creative and arts management. In addition to technical excellence, the design of such programs should consider workforce transition and new skill development timelines, in addition to other factors

such as the quality of pension systems, gender wage gaps, urban density, and the scope and reach of local environmental protection.

9.10. ADAPT TO THE RAPIDLY CHANGING GLOBAL TALENT LANDSCAPE

Both the data and literature agree on the existence of a knowledge-technology gap in Brazil. While the quality of local universities is well recognized, local labor productivity is generally perceived as disconnected from the demand for workforces specialized in areas like ICTs, new technologies and applied research. These findings may also point at the disjunction between the high demand for high-tech products and services, and the availability of the local high-skilled workforce required to produce these at the forecasted pace. Nevertheless, the data also suggests that parts of the population already demonstrate mid- and mid-high proficiency in some of the more basic uses of ICTs (use of internet, online shopping, use of virtual professional networks, etc.), hinting at a higher than anticipated willingness to learn and adapt to changes in both technology and laborhand demand. Tapping into these abilities to generate further synergies could be just what is required to adapt local laborhand to the fast-paced global talent landscapes.

University and industry partnerships can be promoted to help design a curriculum that focuses on the specific requirements of the ICT industry. Harnessing the vast higher education institutional network operating in Brazil, short-term certification and technical diploma issuing programs can be offered both in vivo and online to help fill identified gaps in technical

and other high-tech related service provision.

IMPROVING TECHNOLOGY

In this section, recommendations are focused on improving the technology supporting the local innovation ecosystem and its actors, the country's digital transformation and the absorption of Fourth Industrial Revolution Technologies. Thus, Brazil should:

9.11. LEAD INNOVATION AND TECHNOLOGICAL CHANGE BY EXAMPLE

Findings point at a disconnection between the pace at which new technologies are promoted and adopted by the government, and the way in which local bureaucracies are adapting to the demand for and provision of quality services associated with these changes. This possibly hinders the pace at which local technological change advances. **Governments at all levels should more actively harness new technologies and serve as an example by providing 'a vote of confidence' in front of the local user population.**

9.12. EXPAND LOCAL DIGITAL DEVELOPMENT FRONTIERS

Data and literature points to an infrastructure gap, most evident in ICTs. In particular, Brazil's online government services are well positioned based on international standards: yet elements such as its logistics performance, 4G mobile network coverage, and Internet access (as measured by the share of households with access at home via a fixed or mobile network) remain low. The performance below expectations in the latter two parameters is particularly noteworthy when considering that Brazil is one of the world's biggest smartphone markets, with demand projected to rise by 20% between 2017 and 2025.³⁰⁵ Regardless, Brazil displays the potential for improvement,

reflected by its positive ICT regulatory environment, by strong company willingness to adopt emerging technologies, and its expansion and promotion of cybersecurity technology and efforts. The quality, relevance, and usefulness of government's online services as measured by e-participation and a minimal gender gap in Internet use further adds to this identified potential. These findings point to limitations but equally signal development and investment opportunities for local and international actors alike in ICT. **To foster an expansion of digital development frontiers, Brazilian authorities should lift any barriers to the implementation of new technologies and facilitate the execution of innovation projects through the promotion of initiatives that further facilitate their deployment. In conjunction with these initiatives, the government should implement projects that uphold environmental protection and public safety, plus initiatives underlining the importance and timely adoption of such technologies.**

9.13. RAMP UP THE DESIGN OF TECHNOLOGICAL REGULATORY FRAMEWORKS

Brazil's public and private sectors seem to display different technological adoption paces. Data confirms that the government under-promotes the use of new technologies (i.e. AI, robotics, app- and web-enabled markets, big data analytics, and cloud computing) and thus lags behind in the design and setting of the adequate regulatory frameworks. The

³⁰⁵ Deloitte, 'Insights about Digital Transformation and ICT Opportunities for Brazil Report and Recommendations'.

private sector, on the other hand, adopts and adapts to these same technologies at a faster rate. In doing so, companies compensate for the lack of public sector promotion of new technologies via tech transfer and using international financial resources. This also suggests a higher awareness of the key role that FDI and other sources of venture funding play in

bringing new technology investment opportunities into the country. **Thus, promoting the swift enactment of regulation would not only help promote these technologies but also help create an innovation funding environment that appears not to be yet fully developed in Brazil.**

IMPROVING INSTITUTIONS AND INFRASTRUCTURE

Fostering the frameworks that attract business and promote growth through good governance, appropriate protection and incentives, as well as proper communication, transport, and energy infrastructures are among the points considered in the recommendations presented in this section. These aim also at ways to ease the production and exchange of ideas, services, and goods in Brazil targeting also a reduction of the perceived bureaucratic burdens and perverse incentives like corruption. Thus, Brazil should:

9.14. REDUCE RED-TAPE AND CORRUPTION AT ALL LEVELS

Administrative bureaucracy and corruption still impede government effectiveness and work to curtail the state's regulatory quality. For instance, international organizations praise programs such as *E-Digital* and associated programs like *Brasil Conectada*, yet note that these and other similar programs remain hindered by "offline" bureaucracies and other inefficiencies, still dragging draconian red-tape methods into modern day administration. Data also confirms that the degree of corruption engrained in Brazil's public sector is perceived as quite high by business people and country experts. **To reduce red-tape and curb corruption, this Report recommends formulating realistic targets and timelines for administrative simplification strategies at all levels of government; revamping multi-level coordination and extortion reporting mechanisms; increasing stakeholders involvement; and accelerating the adoption of online government services. Additionally, to restore possibly eroded confidence in authorities, it is key to design plans to suppress the potential for political**

corruption and promote the integrity of political systems.

15. PROMOTE REGIONAL LINKAGE AND CLUSTER DEVELOPMENT

Research and data concur that the essential elements for cluster development currently present in Brazil could expand beyond São Paulo and can assist in the creation of additional hubs for innovation. However, the slow flow of resources, including knowledge, may work against local competitiveness via multiple roadblocks, such as high trade barriers. **To encourage the formation of localized innovation and entrepreneurship ecosystems in Brazil, authorities should develop mechanisms to boost collaboration among government agencies, academic institutions, industry, and civil society organizations. Examples of these are linking agencies and secondary financial markets. Regional linkage, on the other hand, can be enhanced via the design of policies and programs to improve regional investment and collaboration, like tax incentives, reduced tariffs, and eased restrictions for high-skilled worker cross-border movement.**

10. CONCLUSIONS

This Report uses the Future Readiness Evaluation Approach (FREA) model, created by Portulans Institute, a vast literature review, data-based projection scenarios and various countries' comparative benchmarks (Brazil compared to OECD, BRICS, Latin America and Caribbean, and over 10 other countries), to generate recommendations for improving Brazil's competitiveness in innovation, technology and talent (the 'ITT' triangle). FREA is based on indicators from three influential global reports, which were created and are co-authored by Portulans co-founders: the Network Readiness Index, the Global Talent and Competitiveness Index and the Global Innovation Index.

The factors that hinder Brazil's competitiveness range from institutional and infrastructural limitations to shortcomings in talent, investment decay, and the perceived untapped potential for innovative cultural goods and services exports. These weaknesses signal areas for opportunity for pro-innovation actors from the public and private sectors to orchestrate lasting, sustainable progress for a more advanced state of future readiness.

The *recommendations* generated by this Report's unique methodological and analytical approach are grouped into five thematic areas, addressing Brazil's under-performance on the general policy level, within its innovation system, talent landscape, technology development and sub-par institutions and infrastructure.

Additionally, these recommendations identify some areas of improvement as, in fact, *areas of opportunity* for investment, driven by strong, coordinated policy initiatives. On the general policy and macro level, Brazil must establish solid institutional bridges between the public and productive sectors (1) and outline mission-oriented policies (2), in addition to designing and promoting intersectional rather than single-domain policies (3). For all ITT areas, the Report recommends that Brazil makes tangible efforts to collect better and more accurate data to support policymaking (4). On the innovation front, the Report leverages data and research insights to recommend increasing gross domestic expenditure on R&D (5), foster an innovation culture using venture and risk capital markets (6), promote the private sector's engagement in innovation and entrepreneurship (7) and finally, foster an IP culture based on international guidelines (8). Turning to Brazil's talent landscape, actors from the public and private sectors should pioneer and tailor a talent-first innovation strategy (9) that can adapt to the rapidly changing global talent landscape (10). Given the existing technological disconnect present in Brazil, the Report recommends Brazil leads innovation and technological change by example (11) and works to expand digital development frontiers (12), in conjunction with ramping up the design of technological regulatory frameworks (13). Lastly, to improve institutions and infrastructure, Brazil needs to make solid efforts to reduce corruption and red-tape at all levels (14) and promote regional linkage and cluster development for innovation (15).

The definition and implementation of coordinated, future-oriented plans and policies to address noted challenges and limitations will help Brazil achieve the economic recovery it requires in the post-pandemic global ecosystem. Indeed, the proposed actions offer the opportunity, if properly maneuvered, for Brazil to distinguish itself in terms of future readiness on the global economic stage.³⁰⁶ As proposed by the OECD Economic Outlook in December

³⁰⁶ Brazil's GDP % change estimates for 2020, currently revised upwards 0.9% by the OECD to about negative 5.6%. OECD, *OECD Economic Outlook, Interim Report September 2020* (Paris: OECD Publishing, 2020), https://www.oecd-ilibrary.org/economics/oecd-economic-outlook/volume-2020/issue-1_34ffc900-en.

Furthermore, the fact that some economies at a higher level of development are at the brink of having to implement contingency measures once again reinforces this opportunity. On October 19, 2020 CNN reported that early on that day there were more than 8 million cases and over 219,000 coronavirus deaths in the US, according to data from Johns Hopkins University. Health experts say the predicted fall surge is here, and rising cases across the US appear to bear that out. CNN, 'October 19

2020, Brazil's economy was in the recovery stages from a recession when the COVID-19 outbreak occurred. While Brazil's economic activity recovered in part, it will still fall short of pre-pandemic levels by late 2022.³⁰⁷ Faced with uncertainties about prospects for recovery, building *future readiness* with the 'ITT' triangle front-and-center of new policy is a strategic imperative, and will enable Brazil to thrive and grow in a post-pandemic global economy.

Coronavirus News', CNN, 20 October 2020, https://edition.cnn.com/world/live-news/coronavirus-pandemic-10-19-20-intl/h_d4c07deb3044866fb57399809efbe590.

³⁰⁷ OECD, 'Brazil'.

APPENDICES

A1. FUTURE READINESS INDEX 2020 RANKINGS

The FRI 2020 ranks the Future Readiness of 47 economies: 35 economies are among the high-income group and 11 are part of the upper middle-income country group, which includes Brazil. India is the single lower middle-income economy in this cluster. Europe is the most represented region with 28 economies; followed by South East Asia, East Asia, and Oceania with 7 countries included in the model; Latin America and the Caribbean with 6 countries represented; Northern America and Northern Africa and Western Asia with 2 countries represented each; and Sub-Saharan Africa and Central and Southern Asia with one each.

The selection of this group is justified on multiple accounts ranging from size and data completeness to remarkable performance in particular areas. However, a crucial factor for this selection – technical and design guidelines aside – is the fact that, collectively, this cluster is a more condensed and rigorous benchmark for Brazil's competitiveness than any featured in other indices.

TABLE A.1.1. FUTURE READINESS INDEX 2020 RANKINGS

Economy	Income group	Region	FRI	Institutions & Infrastructure	Innovation	Talent	Technology
Singapore	HI	SEAO	1	2	10	1	1
Switzerland	HI	EUR	2	11	1	4	8
Sweden	HI	EUR	3	3	3	8	4
United States of America	HI	NAC	4	13	2	2	6
Denmark	HI	EUR	5	6	6	12	3
Netherlands	HI	EUR	6	9	7	6	5
Finland	HI	EUR	7	4	11	10	9
Norway	HI	EUR	8	1	20	7	2
United Kingdom	HI	EUR	9	20	9	14	7
Japan	HI	SEAO	10	5	4	23	21
Germany	HI	EUR	11	7	12	19	14
Republic of Korea	HI	SEAO	12	15	5	31	11
Canada	HI	NAC	13	10	16	9	15
Luxembourg	HI	EUR	14	23	14	11	16
France	HI	EUR	15	18	13	20	12

Australia	HI	SEAO	16	14	22	3	17
Belgium	HI	EUR	17	17	18	15	13
Ireland	HI	EUR	18	19	21	5	10
Austria	HI	EUR	19	12	17	17	20
Iceland	HI	EUR	20	16	19	13	19
Israel	HI	NAWA	21	27	8	18	24
New Zealand	HI	SEAO	22	8	26	16	22
Estonia	HI	EUR	23	21	24	21	18
Czech Republic	HI	EUR	24	22	25	28	23
China	UM	SEAO	25	24	15	36	31
Spain	HI	EUR	26	25	28	26	25
Malaysia	UM	SEAO	27	30	23	32	26
Slovenia	HI	EUR	28	28	30	29	28
Portugal	HI	EUR	29	26	31	24	34
Italy	HI	EUR	30	34	27	33	30
Lithuania	HI	EUR	31	36	36	22	27
Poland	HI	EUR	32	31	33	35	32
Hungary	HI	EUR	33	33	32	40	29
Latvia	HI	EUR	34	32	41	27	35
Chile	HI	LCN	35	29	38	34	37
Slovakia	HI	EUR	36	35	42	39	33
Greece	HI	EUR	37	44	34	25	38
Russian Federation	UM	EUR	38	45	35	30	40
Romania	UM	EUR	39	38	43	43	36
Costa Rica	UM	LCN	40	41	46	37	39
Turkey	UM	NAWA	41	39	40	44	42
South Africa	UM	SSF	42	40	29	46	46
Colombia	UM	LCN	43	42	45	42	43
Brazil	UM	LCN	44	46	37	41	44
Argentina	UM	LCN	45	47	47	38	41
India	LM	CSA	46	37	39	47	47

Mexico	UM	LCN	47	43	44	45	45
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Note: World Bank Income Group Classification (July 2019): LI = low income; LM = lower-middle income; UM = upper-middle income; and HI = high income.

Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia, East Asia, and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

A2. BRAZIL: COUNTRY PROFILE

As reviewed in the Report, Brazil ranks 44th out of 47 mapped economies in the FRI 2020. In this model, Brazil's competitiveness is contrasted to a group of "star" economies that include the 37 OECD member countries, in addition to various high performers highlighted by their achievement in either the GII, GTCI, or NRI indices. Additional economies included in the model are Argentina, China, Colombia, Costa Rica, Israel, Malaysia, Romania, Russian Federation, Singapore, and South Africa.

These initial results hint at lower levels of competitiveness for Brazil, placing it behind all high-income economies and many at similar stages of development (e.g. Colombia, Turkey, the Russian Federation, Malaysia, China) and others much smaller relative to domestic market scale (e.g. Costa Rica, Romania, and South Africa).

This model also succeeds in assessing the effect that improvements in key areas measured by particular indicators (e.g. higher government funding for ST&I, more talent development, better infrastructure, enhanced environmental protection, etc.) have on Brazil's output. The results show that, when these changes are applied together, these render an overall FRI ranking improvement of three positions for Brazil, placing it as the 41st FRI economy (see Brazil's Country Profile, Table A.2.2., appendix 2). This shift is particularly impressive given the previously described features of the country sample and FRI model – a compact elite group of high-performing economies assessed at nearly full data coverage. In other words, a variation of this magnitude achieved within such a highly competitive group of economies is significant. Consequently, these results also capture the importance of defining and applying policies to lead to the improvements described in the model. Inaction, or actions to further curtail these areas, may result in stagnation and development opportunity loss.

TABLE A.2.1. BRAZIL COUNTRY PROFILE IN THE FUTURE READINESS INDEX 2020

Brazil

Future Readiness Index (out of 47)	44
Population (millions)	211.05
GDP (US\$ billions)	3456.36
GDP per capita, PPP\$	14371.62
Income group	Upper-middle
Region	LCN

		Score/Value	Rank		
1	Institutions & Infrastructure	28.3	46	!	#
1.1.	Regulatory environment	19.1	45	!	
1.1.1	Government effectiveness	0	47	!	#
1.1.2	Rule of law	18.8	43		
1.1.3	Political & operational stability	17.4	40		
1.1.4	Regulatory quality	8.5	46	!	#
1.1.5	Corruption	35	45	!	
1.2.	Market environment	57.1	44		
1.2.1	Competition intensity	68.2	41		
1.2.2	Ease of doing business	60	46	!	#
1.2.3	Ease of resolving insolvency	50.4	42		
1.2.4	Cluster development	49.7	32		
1.3.	General infrastructure	8.7	47	!	
1.3.1	Electricity output, GWh/mn pop	\$ 2 816.20	41		
1.3.2	Logistics performance	15.8	42		
1.3.3	Gross capital formation, % GDP	15.7	46	!	#
2	Innovation	18.0	37		
2.1.	Research & Development	19.2	35		
2.1.1	Researchers	\$ 887.7	40		
2.1.2	Gross expenditure on R&D (GERD)	\$ 1.3	29		
2.1.3	Global R&D companies, average expenditure top 3	2.7	21	@	
2.1.4	University ranking	42.7	27		
2.2.	Market Sophistication	12.3	46	!	
2.2.1	Domestic credit to private sector	61.8	33		
2.2.2	Market capitalization	45.9	21		
2.2.3	Venture capital deals	0.02	36		
2.2.4	Applied tariff rate, weighted mean	8.00	46	!	#
2.3.	Business Sophistication	33.4	[22]	@	~
2.3.1	GERD performed by business enterprise	n/a	n/a		
2.3.2	GERD: Financed by business enterprise (% of total GERD)		47.5	28	
2.3.3	GERD: Financed by abroad (% of GDP)	n/a	n/a		

2.3.4	Patent families filed in at least two offices	0.1	42	
2.3.5	ICT services imports	1.7	19	@
2.4.	Knowledge, Technology and Creative Outputs	7.2	41	
2.4.1	PCT international applications by origin	0.2	41	
2.4.2	Cultural and creative services exports (% of total trade)	0.5	34	
2.4.3	Creative goods exports (% of total trade)	0.3	41	
2.4.4	Intellectual property receipts	0.3	26	@ ~
2.4.5	Global brand value, top 5.000 / bn PPP\$ GDP	33.8	33	
3	Talent	39	41	
3.1.	Attract	43.4	42	
3.1.1	FDI and technology transfer	58.8	37	
3.1.2	International students	0.2	45	!
3.1.3	Tolerance of minorities	30	38	
3.1.4	Social mobility	47.7	38	
3.1.5	Gender development gap	80.1	10	@
3.2.	Grow	41.5	38	
3.2.1	Tertiary enrolment	50.5	38	
3.2.2	Employee development	46.5	39	
3.2.3	Delegation of authority	56.6	34	
3.2.4	Use of virtual professional networks	321.4	23	@ ~
3.3.	Retain	42.3	42	
3.3.1	Pension system	\$ 52.5	36	
3.3.2	Brain retention	39.4	35	
3.3.3	Environmental performance	60.7	39	
3.3.4	Physician density	\$ 1.9	39	
3.4.	Skills	28.7	46	!
3.4.1	Ease of finding skilled employees	38.6	44	#
3.4.2	Workforce with tertiary education	20.7	40	
3.4.3	Professionals	11	39	
3.4.4	Senior officials and managers	4.5	32	
3.4.5	Availability of scientists and engineers	39.8	47	! #
4	Technology	41.3	44	
4.1.	ICT	35	45	!
4.1.1	Internet access	60.8	43	
4.1.2	4G mobile network coverage	83.1	44	
4.1.3	GitHub commits	12.7	38	
4.1.4	Wikipedia edits	46.4	41	
4.1.5	Adoption of emerging technologies	48.1	35	
4.2.	People	49.7	43	
4.2.1	Use of virtual social networks	66	20	@
4.2.2	ICT skills	34.8	47	! #
4.2.3	Firms with website	52.9	41	
4.2.4	Government online services	87.1	18	@
4.2.5	Government promotion of investment in emerging technologies	29.7	42	!

4.3.	Governance	59.3	37	
4.3.1	Cybersecurity	57.7	39	
4.3.2	Internet shopping	15.1	42	
4.3.3	ICT regulatory environment	88.5	25	
4.3.4	Legal framework's adaptability to emerging technologies	43.4	34	
4.3.5	E-Participation	90.5	16	@
4.3.6	Gender gap in Internet use	1	16	@
4.4.	Digital Economy	21.3	42	
4.4.1	Medium and high-tech industry	35.4	30	
4.4.2	High-tech exports	13	26	@
4.4.3	Labor productivity per employee	30 877.40	45	!

@ indicates a strength, and ! indicates a weakness.

~ indicates an income group strength, and # indicates income group weakness.

§ indicates that the economy's data are older than the base year.

Square brackets [] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level (see footnote 268 for more details).

LCN refers to Latin America and the Caribbean.

TABLE A.2.2. BRAZIL: COUNTRY PROFILE SCENARIOS FUTURE READINESS INDEX 2020

Brazil

Future Readiness Index (out of 47)

44

Population (millions)

211.05

GDP (US\$ billions)

3456.36

GDP per capita, PPP\$

14371.62

Income group

Upper-middle

Region

LCN

	Score/Value	Rank		
1 Institutions & Infrastructure	31.4	46	!	
1.1. Regulatory environment	25.4	42		
1.1.1 Government effectiveness	7.9	43	!	
1.1.2 Rule of law	18.8	43	!	
1.1.3 Political & operational stability	17.4	40		
1.1.4 Regulatory quality	12.2	45	!	
1.1.5 Corruption	48	35		
1.2. Market environment	60	41		
1.2.1 Competition intensity	68.2	41		
1.2.2 Ease of doing business	71.6	40		
1.2.3 Ease of resolving insolvency	50.4	42		
1.2.4 Cluster development	49.7	32		
1.3. General infrastructure	8.7	47	!	
1.3.1 Electricity output, GWh/mn pop	\$ 2.816.20	41		
1.3.2 Logistics performance	15.8	42		
1.3.3 Gross capital formation, % GDP	15.7	46	!	#
2 Innovation	18.7	35		
2.1. Research & Development	21.2	33		
2.1.1 Researchers	\$ 1.196.30	39		
2.1.2 Gross expenditure on R&D (GERD)	\$ 1.5	24	@	
2.1.3 Global R&D companies, average expenditure top 3	2.7	21	@	
2.1.4 University ranking	42.7	27		
2.2. Market Sophistication	12.7	46	!	
2.2.1 Domestic credit to private sector	61.8	33		
2.2.2 Market capitalization	45.9	21		
2.2.3 Venture capital deals	0	35		
2.2.4 Applied tariff rate, weighted mean	8	46	!	#
2.3. Business Sophistication	33.4 [22]	@	~	

2.3.1 GERD performed by business enterprise	n/a	n/a	
2.3.2 GERD: Financed by business enterprise (% of total GERD)		47.5	28
2.3.3 GERD: Financed by abroad (% of GDP)	n/a	n/a	
2.3.4 Patent families filed in at least two offices		0.1	42
2.3.5 ICT services imports		1.7	19 @
2.4. Knowledge, Technology and Creative Outputs		7.6	41
2.4.1 PCT international applications by origin		0.2	41
2.4.2 Cultural and creative services exports (% of total trade)		0.6	29
2.4.3 Creative goods exports (% of total trade)		0.3	41
2.4.4 Intellectual property receipts		0.3	26 @ ~
2.4.5 Global brand value, top 5.000 / bn PPP\$ GDP		33.8	33
3 Talent		40.8	41
3.1. Attract		43.4	42
3.1.1 FDI and technology transfer		58.8	37
3.1.2 International students		0.2	45 !
3.1.3 Tolerance of minorities		30	38
3.1.4 Social mobility		47.7	38
3.1.5 Gender development gap		80.1	10 @
3.2. Grow		42.5	37
3.2.1 Tertiary enrolment		54.7	37
3.2.2 Employee development		46.5	39
3.2.3 Delegation of authority		56.6	34
3.2.4 Use of virtual professional networks		321.4	23 @ ~
3.3. Retain		47	39
3.3.1 Pension system	§	64.3	34
3.3.2 Brain retention		39.4	35
3.3.3 Environmental performance		66.8	30 ~
3.3.4 Physician density	§	1.9	39
3.4. Skills		30.3	46 !
3.4.1 Ease of finding skilled employees		38.6	44 ! #
3.4.2 Workforce with tertiary education		20.7	40
3.4.3 Professionals		11	39
3.4.4 Senior officials and managers		4.5	32
3.4.5 Availability of scientists and engineers		48.1	39
4 Technology		42.7	41
4.1. ICT		37.8	41
4.1.1 Internet access		60.8	43 !
4.1.2 4G mobile network coverage		92	39

4.1.3 GitHub commits	12.7	38	
4.1.4 Wikipedia edits	46.4	41	
4.1.5 Adoption of emerging technologies	48.1	35	
4.2. People	51.9	42	
4.2.1 Use of virtual social networks	66	20	@
4.2.2 ICT skills	34.8	47	! #
4.2.3 Firms with website	52.9	41	
4.2.4 Government online services	87.1	18	@
4.2.5 Government promotion of investment in emerging technologies	40.7	29	
4.3. Governance	59.8	36	
4.3.1 Cybersecurity	57.7	39	
4.3.2 Internet shopping	15.1	42	
4.3.3 ICT regulatory environment	88.5	25	
4.3.4 Legal framework's adaptability to emerging technologies	46.2	30	
4.3.5 E-Participation	90.5	16	@
4.3.6 Gender gap in Internet use	1	16	@
4.4. Digital Economy	21.3	42	
4.4.1 Medium and high-tech industry	35.4	30	
4.4.2 High-tech exports	13	26	@
4.4.3 Labor productivity per employee	30.877.40	45	!

@ indicates a strength, and ! indicates a weakness.

~ indicates an income group strength, and # indicates income group weakness.

§ indicates that the economy's data are older than the base year.

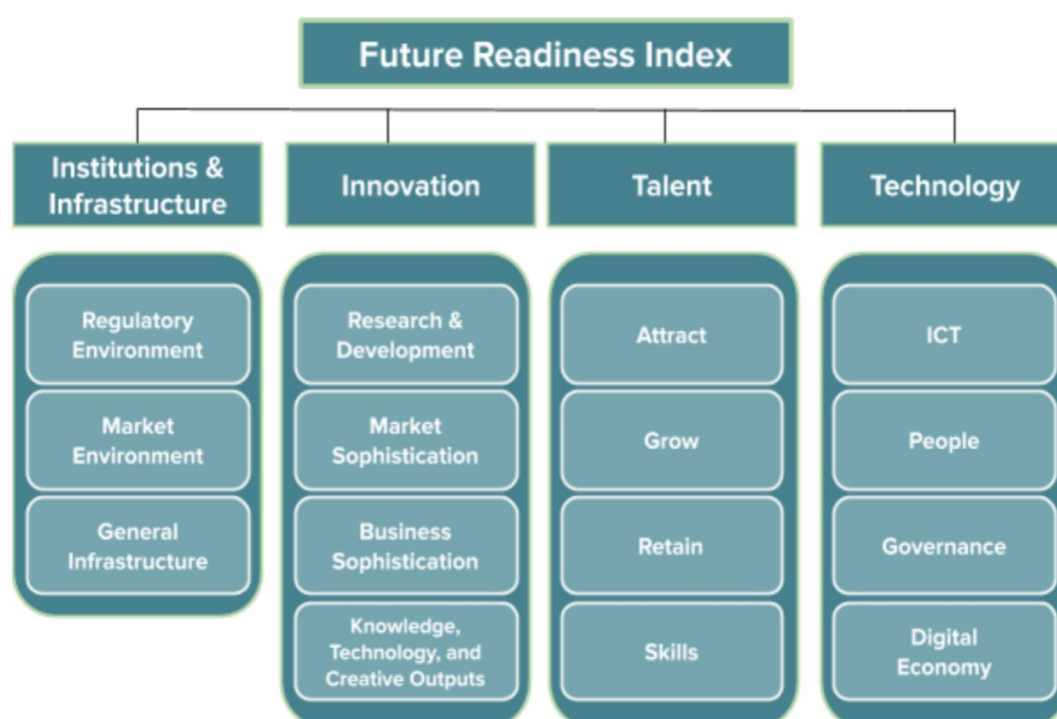
Square brackets [] indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level (see footnote 268 for more details).

LCN refers to Latin America and the Caribbean.

A.3.1. THE FUTURE READINESS INDEX (FRI) COMPOSITION

The FRI relies on four pillars, one divided into three sub-pillars and three into four, of which include three to six individual indicators. Sub-pillar scores are calculated using the weighted average of its individual indicators. Pillar scores are calculated using the weighted average of its sub-pillar scores. **The FRI score is the average of all pillar scores.** Figure A.3.1. shows the FRI structure and composition.

FIGURE A.3.1. FUTURE READINESS INDEX STRUCTURE AND COMPONENTS



The notion of weights as important coefficients was reviewed in detail and determined by the Portulans Institute research team to ensure a high statistical coherence of the model, following international best practices.³⁰⁸ Economy rankings are provided for indicators, sub-pillars, pillars, and index scores.

A.3.2. THE FRI MODEL INDICATORS

The FRI model includes 67 indicators. The detailed definitions and specifications are covered in appendix 4 (Sources and Definitions). In particular 26 indicators come from the Global Innovation Index, 18 from the Network Readiness Index, and 23 from the Global Talent and Competitiveness Index.³⁰⁹ The FRI indicators fall into three categories:

1. Quantitative/objective/hard data (36 indicators),
2. Composite indicators/index data (17 indicators), and

³⁰⁸ Best practices are based on the recommendations from the JRC-COIN audit standards. These include the Join Research Center (JRC) Statistical Audio of the 2020 Global Innovation Index and 2020 Network Readiness Index: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020-appendix5.pdf.

³⁰⁹ See footnote 264.

3. Survey/qualitative/subjective/soft data (14 indicators).

For the sake of transparency and replicability of results, no additional effort was made to fill missing values. Missing values are indicated with “n/a” and are not considered in the sub-pillar score.

A.3.2.1. HARD DATA

Hard data (36 indicators) are drawn from a variety of public and private sources. These include, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Intellectual Property Organization (WIPO), the World Bank, the World Trade Organization, Wikimedia Foundation, GitHub, and Brand Finance, among others.

Indicators are often correlated with population, gross domestic product (GDP), or some other size-related factor. They require scaling by a relevant size indicator for economy comparisons to be valid. Most indicators are either scaled at source or do not need to be scaled; for the other indicators, the scaling factor was chosen to represent a fair picture of differences between economies. Scaling affected 33 indicators and is divided into four groups:

1. Indicators scaled by GDP in current US\$: 1.3.3, 2.1.2, 2.2.1, 2.2.2, 2.3.1 and 2.3.3.³¹⁰
2. The count variables 2.2.3, 2.3.4, 2.4.1 and 2.4.5 are scaled by GDP in purchasing power parity current international dollars. Like in the parent indices, this choice of denominator was dictated by a willingness to appropriately account for differences in development stages; in addition, scaling these variables by population would improperly bias results to the detriment of economies with a youth-dominated or ageing population.³¹¹
3. Variables 1.3.1, 2.1.1, 4.1.4 and 4.2.1 are scaled by a measure of population. Total population is used for 1.3.1, 2.1.1 and 4.2.1 and population 15–69 years old for 4.1.4.³¹²
4. Sectoral indicators 2.3.5, 2.4.2, 2.4.3, 2.4.4 and 4.4.2 were scaled by total trade. Other sectoral indicators are scaled by the total or partial counts of the unit used to measure the particular statistic. Indicator 4.4.1 is scaled by total value added; 2.2.4 is scaled by all products; 2.3.2 by total GERD; 3.1.2 by total tertiary enrollment; 3.2.1 by total enrollment; 3.2.4 is scaled per thousand labor force; 3.3.1 per contributors above the age of 15; 3.3.4 per thousand people; 3.4.2 and 3.4.3 per labor force; 3.4.4 per total employment; 4.1.1 all households; 4.1.2 total population within range; and 4.2.3 by total firms.³¹³

A fifth group of hard data compiles number indicators. Only three indicators featured in the FRI fall in this category:

5. Number indicators are 4.1.3, 4.3.6 and 4.4.3.³¹⁴

³¹⁰ [iii] These indicators are gross capital formation (1.3.3); gross expenditure on R&D (GERD) (2.1.2); domestic credit to private sector (2.2.1); market capitalization (2.2.2); GERD performed by business enterprise (2.3.1); and GERD financed by abroad (2.3.3).

³¹¹ These count variables are mainly indicators that increase disproportionately with economic growth. They include: joint venture/strategic alliance deals; (2.2.3) patent families filed in two or more offices (2.3.4); PCT international applications by origin (2.4.1); and global brand value, top 5000 (2.4.5).

³¹² These variables are electricity output (1.3.1); researchers (2.1.1); Wikipedia yearly edits (4.1.4), and Use of virtual social networks (4.2.1).

³¹³ ICT services imports (2.3.5); cultural and creative services exports (2.4.2); creative goods exports (2.4.3); Intellectual property receipts (2.4.4), and high-tech exports (4.4.2) were scaled by total trade. The other sectoral indicators are: medium-high-tech industry (4.4.1); applied tariff rate, weighted mean (2.2.4); GERD: financed by business enterprise (2.3.2); International students (3.1.2); Tertiary enrolment (3.2.1); Use of virtual professional networks (3.2.4); Pension system (3.3.1); Physician density (3.3.4); Workforce with tertiary education (3.4.2); Professionals (3.4.3); Senior officials and managers (3.4.4); Internet access (4.1.1); 4G mobile network coverage (4.1.2); and Firms with website (4.2.3).

³¹⁴ Numeric indicators are: GitHub commits (4.1.3) and Labor productivity per employee (4.4.3). Gender gap in Internet use (4.3.6) displays a ratio.

A.3.2.2. COMPOSITE INDICATORS

Composite indicators (17 in total) are collected from specialized agencies and academic institutions, like the World Bank, the UN Public Administration Network (UNPAN), and Yale University.³¹⁵ Only indices with a narrow focus were selected.³¹⁶

A.3.2.3. SURVEY DATA

Survey data (14 in total) are drawn from the World Economic Forum's Executive Opinion Survey (EOS) with one exception coming from the World Bank's Global Findex database. Survey questions are drafted to capture subjective perceptions on specific topics; four EOS questions were retained to capture phenomena strongly linked to innovative activities for which hard data are nonexistent or have low coverage for the included economies.³¹⁷

A.3.3. DATA SELECTION AND COUNTRY COVERAGE

A.3.3.1. DATA SELECTION

For each economy, the data used in the FRI calculations comes directly from the latest published version of each parent index. In particular, 26 indicators come from the 2020 Global Innovation Index, 18 from the 2020 Network Readiness Index, and 23 from the 2019 Global Talent and Competitiveness Index.³¹⁸ Additional cut-off year limits beyond those reflected in each individual publication are not enforced regardless of overlaps and differences in publication date for identical indicators featured in more than one index.

Following GII/NRI/GTCI policy and practice standards, country-produced data – *including data based on ministry-provided information* – is not used in the FRI calculations *regardless of more recent publication*. The only data that reflects more up-to-date information is the one used to produce the assessed scenarios for Brazil presented in *Chapter 8. FREA in Action*:

³¹⁵ These indicators are: government effectiveness (1.1.1); rule of law (1.1.2); political & operational stability (1.1.3); regulatory quality (1.1.4); corruption (1.1.5); ease of doing business (1.2.2); ease of resolving insolvency (1.2.3); logistics performance (1.3.2); global R&D companies, average expenditure top 3 (2.1.3); university ranking (2.1.4); tolerance of minorities (3.1.3); gender development gap (3.1.5); environmental performance (3.3.3); government online services (4.2.4); cybersecurity (4.3.1); ICT regulatory environment (4.3.3); E-Participation (4.3.5).

³¹⁶ Statisticians discourage the use of an "index within an index" on two main grounds: the distorting effect of the different computing methodologies used and the risk of duplicating variables. The normalization procedure partially solves any distorting effect of the different computing methodologies. Any additional disadvantage is outweighed by the model's design and focus on multi-dimensional phenomena that can hardly be captured by a single indicator

³¹⁷ These indicators are: competition intensity (1.2.1); cluster development (1.2.4); FDI and technology transfer (3.1.1); social mobility (3.1.4); employee development (3.2.2); delegation of authority (3.2.3); brain retention (3.3.2); ease of finding skilled employees (3.4.1); availability of scientists and engineers (3.4.5); adoption of emerging technologies (4.1.5); ICT skills (4.2.2); government promotion of investment in emerging technologies (4.2.5); Internet shopping (4.3.2); and legal framework's adaptability to emerging technologies (4.3.4).

³¹⁸ Indicators coming from the GII are: government effectiveness (1.1.1), rule of law (1.1.2), political & operational stability (1.1.3), regulatory quality (1.1.4), ease of resolving insolvency (1.2.3), electricity output, Gwh/mn pop (1.3.1), logistics performance (1.3.2), gross capital formation, % GDP (1.3.3), researchers (2.1.1), gross expenditure on R&D (GERD) (2.1.2), global R&D companies, average expenditure top 3 (2.1.3), domestic credit to private sector (2.2.1), market capitalization (2.2.2), venture capital deals (2.2.3), applied tariff rate, weighted mean (2.2.4), GERD performed by business enterprise (2.3.1), GERD: financed by business enterprise (% of total GERD) (2.3.2), GERD: financed by abroad (% of GDP) (2.3.3), patent families filed in at least two offices (2.3.4), ICT services imports (2.3.5), PCT international applications by origin (2.4.1), cultural and creative services exports (% of total trade) (2.4.2), creative goods exports (% of total trade) (2.4.3), intellectual property receipts (2.4.4), global brand value, top 5,000/bn PPP\$ GDP (2.4.5), and Wikipedia edits (4.1.4). Indicators coming from the NRI are: internet access (4.1.1), 4G mobile network coverage (4.1.2), GitHub commits (4.1.3), adoption of emerging technologies (4.1.5), use of virtual social networks (4.2.1), ICT skills (4.2.2), firms with website (4.2.3), government online services (4.2.4), government promotion of investment in emerging technologies (4.2.5), cybersecurity (4.3.1), internet shopping (4.3.2), ICT regulatory environment (4.3.3), legal framework's adaptability to emerging technologies (4.3.4), E-participation (4.3.5), gender gap in internet use (4.3.6), medium and high-tech industry (4.4.1), high-tech exports (4.4.2), and labor productivity per employee (4.4.3). From the GTCI those indicators are: competition intensity (1.2.1), ease of doing business (1.2.2), cluster development (1.2.4), university ranking (2.1.4), FDI and technology transfer (3.1.1), international students (3.1.2), tolerance of minorities (3.1.3), social mobility (3.1.4), gender development gap (3.1.5), tertiary enrolment (3.2.1), employee development (3.2.2), delegation of authority (3.2.3), use of virtual professional networks (3.2.4), pension system (3.3.1), brain retention (3.3.2), environmental performance (3.3.3), physician density (3.3.4), ease of finding skilled employees (3.4.1), workforce with tertiary education (3.4.2), professionals (3.4.3), senior officials and managers (3.4.4), and availability of scientists and engineers (3.4.5).

Scenarios and Simulated Outcomes. This data reflects the most recently available for Brazil for each respective source, with a cut-off date of December 1, 2020.

A.3.3.2. COUNTRY COVERAGE

In addition to serving as a proper benchmark for Brazil, the selection of 47 economies covered in FRI is also based on individual economies' performances in the three parent indices and data coverage. The main group of economies considered is defined as the 'OECD Plus' group, consisting of the 37 OECD economies plus Argentina, China, Colombia, Costa Rica, Israel, Malaysia, Romania, Russian Federation, Singapore, and South Africa. All of the featured economies are either among the high-income or the middle middle-income groups based on the World Bank Income Group Classification. The featured economies stem from all of the seven regions defined by the United Nations Classification.³¹⁹

This selection narrows down the percentage of missing data to only 1.6% of the sample, equivalent to 51 out of 3,098 data points. In the particular case of Brazil, data coverage is almost complete with a 97% coverage or 2 out of 67 indicators missing. A more precise picture of its performance is achieved when contrasted to the other economies considered.

A.3.4. TREATMENT OF SERIES WITH OUTLIERS

Potentially problematic indicators with outliers that could polarize results and unduly bias the rankings were treated according to the rules listed below.

A.3.4.1. FIRST RULE: SELECTION

Problematic indicators were identified by skewness or kurtosis. The problematic indicators had either:

- an absolute value of skewness greater than 2.25, or
- a kurtosis greater than 3.5.³²⁰

A.3.4.2. SECOND RULE: TREATMENT

Series with one to five outliers were winsorized; the values distorting the indicator distribution were assigned the next highest value, up to the level where skewness and/or kurtosis entered within the ranges specified above. This affected 8 indicators; 6 out of the 36 hard data indicators and 2 out of the 17 composite indicators.³²¹

³¹⁹ As defined by the World Bank Income Group Classification (July 2019) 35 economies are classified as part of the high-income group; 11 —including Brazil— are in the upper-middle income group; and a single economy is classified as part of the lower middle-income group. Regions are a special classification based on the online version of the United Nations publication Standard Country or Area Codes for Statistical Use, originally published as Series M, No. 49, and now commonly referred to as the M49 standard. The number of economies per region is as follows: Europe (28); Northern America (2); Latin America and the Caribbean (6 including Brazil); Central and Southern Asia (1), South East Asia, East Asia, and Oceania (7); Northern Africa and Western Asia (2); and Sub-Saharan Africa (1). For income group classifications see:

<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>. For UN regions see: <https://unstats.un.org/unsd/methodology/m49/>

³²⁰ Based on: R. A. Groeneveld and G. Meeden, 'Measuring Skewness and Kurtosis', *The Statistician* 33 (1984): 391–99. Groeneveld and Meeden's study sets the criteria of absolute skewness above 1 and kurtosis above 3.5. The skewness criterion was relaxed to account for the small sample at hand and to echo the GII methodology.

³²¹ This distributional issue affects the following variables: Electricity output, GWh/mn pop (1.3.1), Global R&D companies, average expenditure top 3 (2.1.3), Venture capital deals (2.2.3), Applied tariff rate, weighted mean (2.2.4), GERD: Financed by abroad (% of GDP) (2.3.3), International students (3.1.2), 4G mobile network coverage (4.1.2), and ICT regulatory environment (4.3.3), all displaying 1 outlier. For the case of 4.3.3 Winsorization was applied in the lower end of the distribution. This means that the lower value was transformed to the second-lowest value available. In all other cases the highest value was transformed to that of the second-highest value available.

Generally, series with five or more outliers and skewness and/or kurtosis beyond the borders specified above are brought within range after multiplication by a given factor f and transformation by natural logs. No indicator in this exercise fell in this category.

A.3.4.3. NORMALIZATION

The 67 indicators were then normalized into the [0, 100] range, with higher scores representing better outcomes. Normalization was according to the min-max method; where the min and max values were given by the minimum and maximum indicator sample values respectively. The exception for index and survey data, for which the original series range of values was kept as min and max values (for example, [0, 10] for the Fund for Peace, Fragile States Index; [1, 7] for the World Economic Forum Executive Opinion Survey questions; [0, 100] for World Bank's World Governance Indicators; etc.). The following formula was applied:

Goods: $\text{economy value} - \min / \max - \min \times 100$

Bads: $\max - \text{economy value} / \max - \min \times 100$

A.3.5. ADDITIONAL DATA METHODOLOGY AND TECHNICAL SPECIFICATIONS

A.3.5.1. IDENTIFIED BEST PRACTICES

In addition to literature and other technical sources review, the outline of identified best practices relies as well on the data and outcome of the FRI analysis. Table A3.1 shows a non-exhaustive list of the main indicators considered to significantly signal noteworthy performance on each of the identified best practices benchmarks.

TABLE A.3.5.1. IDENTIFIED BEST PRACTICES AND SOURCE IN THE FRI INDICATORS

Identified Best Practices	Indicators*					
Exemplary National System of Innovation	Overall FRI rank					
Proper infrastructure	2.2.4 Government online services	1.3.2 Logistics performance				
Balanced regulatory framework	1.1.1 Government effectiveness	1.1.4 Regulatory quality	1.1.5 Corruption			
Innovation and investment culture	3.1.1 FDI and technology transfer	4.2.1 Domestic credit to private sector	4.2.2 Market capitalization	4.2.3 Venture capital deals over billion PPP\$ GDP		
Private and Public sector linkage (BERD & GERD)	3.1.1 FDI and technology transfer	4.1.2 Gross expenditure on R&D (GERD)	4.1.3 Global R&D companies average expenditure top 3	4.3.1 GERD performed by business enterprise	4.3.2 GERD: Financed by business enterprise (% of total GERD)	4.3.3 GERD: Financed by abroad (% of GDP)
High-skilled worker development & good brain retention	2.2.2 ICT skills	2.4.3 Labor productivity per employee	3.4.5 Availability of scientists and engineers	4.1.1 Researchers		
High-tech and soft-tech innovation exports	2.4.2 High-tech exports	4.4.2 Cultural and creative services exports (% of total trade)	4.4.3 Creative goods exports (% of total trade)			
Bridged knowledge-technology gap	2.2.4 Government online services	2.2.1 Use of virtual social networks	2.3.5 E-Participation	2.3.6 Gender gap in Internet use skills	2.1.3 GitHub commits	2.1.4 Wikipedia edits
Trade openness	4.2.4 Applied tariff rate weighted mean					
Pro-cluster	1.2.4 Cluster development					

Pro-business environment	1.2.2 Ease of doing business	1.3.3 Gross capital formation % GDP				
IP culture & Environment	4.3.4 Patent families filed in at least two offices	4.4.1 PCT international applications by origin	4.4.4 Intellectual property receipts			
*These lists are not exhaustive. Some indicators fall into more than one category.						

A.3.5.2. METHODOLOGY TO DEVELOP ESTIMATIONS FOR INDICATORS

(Produced by the World Economic Forum)

This example presents the calculations for the indicator measuring the government promotion of investment in emerging technologies. This same process is followed to produce the estimations for the indicator that measures the legal framework's adaptability to emerging technologies.

The 2020 score for Brazil represents the average of the values of the eleven middle-income economies featured in the FRI with data for this variable plus one standard deviation of that sample.³²² These values are 3.32 and 0.56, respectively, and lead to an estimated, rounded-up score of 3.89.

Following a weighting scheme, both the 2019 score (2.78) and the 2020 estimation (3.89) for Brazil are combined using the formula:³²³

$$q_{i,c}^{2019-20} = W_c^{2019} + q_{i,c}^{2019} + W_c^{2020} + q_{i,c}^{2020} \quad (1)$$

where $q_{i,c}^t$ is Brazil's score i in year t , with $t = 2019, 2020$;

W_c^t is the weight applied to Brazil's score in year t .

The weights for each year are then calculated using the following formulas:

$$W_c^{2019} = \frac{(1 - \alpha) + \frac{N_c^{2019}}{N_c^{2019} + N_c^{2020}}}{2} \quad (2a)$$

and

$$W_c^{2020} = \frac{\alpha + \frac{N_c^{2020}}{N_c^{2019} + N_c^{2020}}}{2} \quad (2b)$$

³²² In these calculations, the value for Brazil is also considered.

³²³ World Economic Forum, 'Appendix B. The Executive Opinion Survey: The Voice of the Business Community', in *The Global Competitiveness Report 2019* (Geneva: World Economic Forum, 2019), 633–39.

where N_c^t is the number of respondents for Brazil in year t , with $t = 2019, 2020$. The factor α is the discount factor that accounts for temporality and is set at 0.6.

More specifically, in Brazil respondent's sample size in 2019 was 231 and the forecast value for 2020 is 244.³²⁴ Using $\alpha = 0.6$ as a discount factor and applying equations (2a) and (2b) produces 0.408 and 0.591 as weights for 2019 and 2020, respectively. The final score for Brazil is then calculates as:

$$(0.408 \times 2.78) + (0.591 \times 3.89) = 3.44$$

TABLE A.3.5.2. EASE OF DOING BUSINESS ESTIMATIONS FOR BRAZIL (USING THE DB19 SCORE CALCULATOR)

	<i>Original Values</i>			<i>Estimations</i>		
Economy	Brazil	Brazil Rio de Janeiro	Brazil São Paulo	Brazil	Brazil Rio de Janeiro	Brazil São Paulo
Procedures - Men (number)	11	10	11	7	7	7,7
Score	43,47059	47,05882	41,17647	62,19412	64,70588	60,58824
Time - Men (days)	20,5	23,5	18,5	14,3	16,45	12,95
Score	79,94975	76,88442	81,90955	86,11558	83,96985	87,48744
Cost - Men (% of income per capita)	5,0	6,6	3,9	3,5	4,6	2,8
Score	97,51162	96,70816	98,02531	98,25814	97,69571	98,61772
Procedures - Women (number)	11	10	11	7	7	7,7
Score	43,47059	47,05882	41,17647	62,19412	64,70588	60,58824
Time - Women (days)	20,5	23,5	18,5	14,3	16,45	12,95
Score	79,94975	76,88442	81,90955	86,11558	83,96985	87,48744
Cost - Women (% of income per capita)	5,0	6,6	3,9	3,5	4,6	2,8
Score	97,51162	96,70816	98,02531	98,25814	97,69571	98,61772
Paid-in Min. Capital (% of income per capita)	0,0	0,0	0,0	0,0	0,0	0,0
Score	100,00000	100,00000	100,00000	100,00000	100,00000	100,00000
Score Average	80,23299	X	X	86,64196		
Score Average Rounded	80,23	X	X	86,64		
Ease of starting a business score	80,23	80,16	80,28	86,64	86,59	86,67
Ease of Starting RANK	140	140	140	91	91	91
Procedures (number)	19,2	18	20	13,5	13	14
Score	43,12000	48,00000	40,00000	66,18400	69,60000	64,00000
Time (days)	434	481	404	304	336,7	282,8
Score	0,00000	0,00000	0,00000	19,93631	10,46110	25,99424
Cost (% of warehouse value)	0,7	0,6	0,8	0,5	0,4	0,6
Score	96,31404	97,19000	95,75400	97,41983	98,03300	97,02780
Building quality control index (0-15)	9,0	9,0	9,0	11,7	11,7	11,7
Score	60,00000	60,00000	60,00000	78,00000	78,00000	78,00000

³²⁴ This figure represents the forecast value for Y2020 using data from 2016-2019.

Score Average	49,85851	X	X	65,38503		
Score Average Rounded	49,86	X	X	65,39		
Ease of dealing with construction permits score	49,86	51,30	48,94	65,39	64,02	66,26
Ease of Construction RANK	175	175	175	119	119	119
Procedures (number)	4	4	4	3	3	3
Score	83,33333	83,33333	83,33333	100,00000	100,00000	100,00000
Time (days)	64,4	62	66	45,1	43,4	46,2
Score	79,80870	80,86957	79,13043	88,21391	88,95652	87,73913
Cost (% of income per capita)	52,5	48,9	54,8	36,8	34,2	38,4
Score	99,35176	99,39642	99,32320	99,54623	99,57750	99,52624
Reliability of supply and transparency of tariff index (0-8)	6,0	6	6	7,8	8	8
Score	75,00000	75,00000	75,00000	97,50000	97,50000	97,50000
Score Average	84,37345	X	X	96,31504		
Score Average Rounded	84,37	X	X	96,32		
Ease of getting electricity score	84,37	84,65	84,20	96,32	96,51	96,19
Ease of getting electricity RANK	40	40	40	8	8	8
Procedures (number)	13,6	13	14	9,5	9	10
Score	0,00000	0,00000	0,00000	28,94167	32,50000	26,66667
Time (days)	31,4	41,5	25	22,0	29,05	17,5
Score	85,43780	80,62201	88,51675	89,95000	86,57895	92,10526
Cost (% of property value)	3,6	3,5	3,6	2,5	2,5	2,5
Score	76,30801	76,4974035	76,18692572	83,41561	83,54818245	83,33084801
Quality of land administration index (0-30)	13,8	13,5	14,0	17,9	17,6	18,2
Score	46,01667	45,00000	46,66667	59,82167	58,50000	60,66667
Score Average	51,94062	X	X	65,53224		
Score Average Rounded	51,94	X	X	65,53		
Ease of registering property score	51,94	50,53	52,84	65,53	65,28	65,69
Ease of Property RANK	137	137	137	80	80	80
Credit information index	8	8	8	8	8	8
Legal rights index	2	2	2	3	3	3
Sum getting credit	10	10	10	11	11	11
Score Average	50,00000	X	X	55,00000		
Score Average Rounded	50,00	X	X	55,00		
Ease of getting credit score	50,00	50,00	50,00	55,00	55,00	55,00
Ease of Credit RANK	99	99	99	85	85	85
Disclosure index (0-10)	5	5	5	7	7	7
Score	50,00000	50,00000	50,00000	65,00000	65,00000	65,00000
Director liability index (0-10)	8	8	8	10	10	10
Score	80,00000	80,00000	80,00000	100,00000	100,00000	100,00000
Shareholder suits index (0-10)	4	4	4	5	5	5
Score	40,00000	40,00000	40,00000	52,00000	52,00000	52,00000

Shareholder rights index (0-10)	7	7	7	9	9	9
Score	70,00000	70,00000	70,00000	91,00000	91,00000	91,00000
Ownership and control index (0-10)	6	6	6	8	8	8
Score	60,00000	60,00000	60,00000	78,00000	78,00000	78,00000
Corporate transparency index (0-10)	9	9	9	10	10	10
Score	90,00000	90,00000	90,00000	100,00000	100,00000	100,00000
Strength of minority investors protection index (0 -10)	6,5	6,5	6,5	8,1	8,1	8,1
Score Average	65,00000	X	X	81,00000		
Score Average Rounded	65,00	X	X	81,00		
Strength of minority investors protection index score	65,00	65,00	65,00	81,00	81,00	81,00
Ease of Protecting Minority Investors RANK	48	48	48	7	7	7
Payments (number)	9,6	9	10	6,7	6	7
Score	88,98333	90,00000	88,33333	93,78833	94,50000	93,33333
Time (hours)	1958	1 958	1 958	1371	1 371	1 371
Score	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Total tax and contribution rate (% of profit)	65,1	65,7	64,7	45,6	46,0	45,3
Score	40,82368	39,73226	41,52147	72,03767	71,37534	72,46113
Time to comply with VAT refund (hours)	NO REFUND	NO REFUND	NO REFUND	NO REFUND	NO REFUND	NO REFUND
Score	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Time to obtain VAT refund (weeks)	NO REFUND	NO REFUND	NO REFUND	NO REFUND	NO REFUND	NO REFUND
Score	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
Time to comply with corporate income tax correction (hours)	39,0	39,0	39,0	27,3	27,3	27,3
Score	31,19266	31,19266	31,19266	52,66055	52,66055	52,66055
Time to complete a corporate income tax correction (weeks)	86,6	86,6	86,6	60,6	60,6	60,6
Score	0,0	0,00000	0,00000	0,0	0,00000	0,00000
Postfiling index (0-100)	7,80	7,80	7,80	13,17	13,17	13,17
Score Average	34,40	X	X	44,75		
Score Average Rounded	34,40	X	X	44,75		
Ease of paying taxes score	34,40	34,38	34,41	44,75	44,76	44,74
Ease of Taxes RANK	184	184	184	176	176	176
Time to export: Border compliance (hours)	49	49	49	34	34	34
Score	69,78398	69,78398	69,78398	79,03746	79,03746	79,03746
Time to export: Documentary compliance (hours)	12	12	12	8	8	8
Score	93,49112	93,49112	93,49112	95,62130	95,62130	95,62130
Cost to export: Border compliance (US\$)	862,0	862	862	603,4	603	603
Score	18,68335	18,68335	18,68335	43,07834	43,07834	43,07834
Cost to export: Documentary compliance (US\$)	226,4	226	226	158,5	158	158

Score	43,40278	43,40278	43,40278	60,38194	60,38194	60,38194
Time to import: Border compliance (hours)	30,0	30	30	21,0	21	21
Score	89,60573	89,60573	89,60573	92,83154	92,83154	92,83154
Time to import: Documentary compliance (hours)	24	24	24	17	17	17
Score	90,37657	90,37657	90,37657	93,38912	93,38912	93,38912
Cost to import: Border compliance (US\$)	375,0	375	375	262,5	263	263
Score	68,75000	68,75000	68,75000	78,12500	78,12500	78,12500
Cost to import: Documentary compliance (US\$)	106,9	107	107	74,9	75	75
Score	84,72222	84,72222	84,72222	89,30556	89,30556	89,30556
Score Average	69,85197	X	X	78,97128		
Score Average Rounded	69,85	X	X	78,97		
Ease of trading across borders score	69,85	69,85	69,85	78,97	78,97	78,97
Ease of Trading RANK	106	106	106	75	75	75
Quality of judicial processes index (0-18)	13,1	14,0	12,5	17,0	18,2	16,3
Score	72,69444	77,77778	69,44444	94,50278	101,11111	90,27778
Time (days)	731	731	731	512	512	512
Score	49,91803	49,91803	49,91803	67,89344	67,89344	67,89344
Cost (% of claim)	22,0	24,0	20,7	15,4	16,8	14,5
Score	75,38020	73,11586	76,82790	82,79989	81,21485	83,81327
Score Average	65,99756	X	X	81,73204		
Score Average Rounded	66,00	X	X	81,73		
Ease of enforcing contracts score	66,00	66,94	65,40	81,73	83,41	80,66
Ease of Contracts RANK	48	48	48	3	3	3
Recovery rate (cents on the dollar)	14,6	14,6	14,6	19,0	19,0	19,0
Score	15,71118	15,71118	15,71118	20,42454	20,42454	20,42454
Strength of insolvency framework index (0-16)	13,0	13,0	13,0	16,0	16,0	16,0
Score	81,25000	81,25000	81,25000	100,00000	100,00000	100,00000
Score Average	48,48059	X	X	60,21227		
Score Average Rounded	48,48	X	X	60,21		
Ease of resolving insolvency score	48,48	48,48	48,48	60,21	60,21	60,21
Ease of Resolving Insolvency RANK	77	77	77	51	51	51

A.4. SOURCES AND DEFINITIONS

This appendix provides for each of the 67 indicators included in the Future Readiness Index (FRI), its title, description, definition, and source. For all 47 economies in this assessment the values used are the same as those used in the most recent editions of the NRI, GTCI, and GII for each indicator. The year provided next to the indicator description corresponds to the year when data were most frequently available for economies. Of the 67 indicators, 36 variables are hard data, 17 are composite indicators from third-party data providers, marked with (*), and 14 are survey questions from the World Economic Forum's Executive Opinion Survey (EOS), marked with (†). In some cases, additional markings are provided at the end of the indicator description. Instances marked with superscript "a" signal indicators that were assigned half weights and those marked with superscript "b" are indicators where higher scores indicate poorer outcomes, commonly known as "bads." Details on those indicators received special treatment by way of scaling during computation to be comparable across economies are also provided in this appendix.

1. Institutions & Infrastructure

1.1. Regulatory environment

1.1.1 Government effectiveness

Government effectiveness index^{*a} | 2018

Index that reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Scores are standardized.

Source: World Bank, Worldwide Governance Indicators, 2019 update.
(<http://info.worldbank.org/governance/wgi/#home>).

1.1.2 Rule of law

Rule of law index^{*a} | 2018

Index that reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Scores are standardized.

Source: World Bank, Worldwide Governance Indicators, 2019 update.
(<http://info.worldbank.org/governance/wgi/#home>).

1.1.3 Political & operational stability

Political, legal, operational or security risk index^{*ab} | 2019

Index that measures the likelihood and severity of political, legal, operational or security risks impacting business operations. Scores are annualized and standardized.

Source: IHS Markit, Country Risk Scores, aggregated for end Q1, Q2, Q3, and Q4 2019.
(<https://ihsmarkit.com/industry/economics-country-risk.html>).

1.1.4 Regulatory quality

Regulatory quality index^{*a} | 2018

Index that reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private-sector development. Scores are standardized.

Source: World Bank, Worldwide Governance Indicators, 2019 update.
(<http://info.worldbank.org/governance/wgi/#home>).

1.1.5 Corruption Corruption Perceptions Index* | 2018

The Corruption Perceptions Index aggregates data from a number of different sources that provide perceptions of business people and country experts of the level of corruption in the public sector.

Source: Transparency International, The Corruption Perceptions Index 2018
(<http://www.transparency.org/research/cpi>)

1.2. Market environment 1.2.1 Competition intensity Competition intensity† | 2018

Average answer to the question: In your country, how intense is competition in the local markets? [1 = not intense at all; 7 = extremely intense]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey (2017–18).
(<http://reports.weforum.org>).

1.2.2 Ease of doing business Ease of doing business index* | 2018

The ease of doing business index aggregates a country's percentile rankings on 10 topics covered in the World Bank's Doing Business report series. The topics are: starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency. A high ranking indicates that the regulatory environment is more conducive to setting up business.

Source: World Bank, Doing Business 2019: Training for Reform.
(<http://www.doingbusiness.org/en/reports/global-reports/doing-business-2019>).

1.2.3 Ease of resolving insolvency Ease of resolving insolvency (score)* | 2019

The ranking of economies on the ease of resolving insolvency is determined by sorting their scores. These scores are the simple average of the scores for the recovery rate and the strength of insolvency framework index. The recovery rate is recorded as cents on the dollar recovered by secured creditors through reorganization, liquidation, or debt enforcement (foreclosure or receivership) proceedings. The calculation takes into account the outcome: whether the business emerges from the proceedings as a going concern or the assets are sold piecemeal. Then the costs of the proceedings are deducted (1 cent for each percentage point of the value of the debtor's estate). Finally, the value lost as a result of the time that the money remains tied up in insolvency proceedings is taken into account, including the loss of value due to depreciation of a hotel's furniture. The strength of the insolvency framework index is based on four other indices: commencement of proceedings index, management of debtor's assets index, reorganization proceedings index, and creditor participation index.

Source: World Bank, Doing Business 2020, Comparing

Business Regulation in 190 Economies, 2020
(<https://www.doingbusiness.org/en/reports/global-reports/doingbusiness-2020>).

1.2.4 Cluster development Cluster development[†] | 2018

Average answer to the question: In your country, how widespread are well-developed and deep clusters (geographic concentrations of firms, suppliers, producers of related products and services, and specialized institutions in a particular field)? [1 = nonexistent; 7 = widespread in many fields] The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey 2017–2018
(<http://reports.weforum.org>)

1.3. General infrastructure

1.3.1 Electricity output, GWh/mn pop. Electricity output (GWh per mn population)^a | 2017

Electricity production, measured at the terminals of all alternator sets in a station. In addition to hydropower, coal, oil, gas, and nuclear power generation, this indicator covers generation by geothermal, solar, wind, and tide and wave energy, as well as that from combustible renewables and waste. Production includes the output of electric plants that are designed to produce electricity only as well as that of combined heat and power plants. Electricity output in GWh is scaled by population.

Source: International Energy Agency (IEA) World Energy Balances on-line data service, 2019 edition (2017–18). (<https://www.iea.org/reports/world-energy-balances-2019>).

1.3.2 Logistics performance Logistics Performance Index^{*a} | 2018

A multidimensional assessment of logistics performance, the Logistics Performance Index (LPI) ranks 160 countries combining data on six core performance components into a single aggregate measure—including customs performance, infrastructure quality, and timeliness of shipments. The data used in the ranking comes from a survey of logistics professionals who are asked questions about the foreign countries in which they operate. The LPI's six components are: (1) the efficiency of customs and border management clearance ("Customs"); (2) the quality of trade and transport infrastructure ("Infrastructure"); (3) the ease of arranging competitively priced shipments ("International shipments"); (4) the competence and quality of logistics services ("Services Quality"); (5) the ability to track and trace consignments ("Tracking and tracing"); and (6) the frequency with which shipments reach consignees within scheduled or expected delivery times ("Timeliness"). The LPI consists therefore of both qualitative and quantitative measures and helps build profiles of logistics friendliness for these countries.

Source: World Bank and Turku School of Economics, Logistics Performance Index 2018; Arvis et al., 2018, Connecting to Compete 2018: Trade Logistics in the Global Economy—The Logistics Performance Index and its Indicators.
(<https://openknowledge.worldbank.org/bitstream/handle/10986/29971/LPI2018.pdf>).

1.3.3 Gross capital formation, % GDP Gross capital formation (% of GDP) | 2019

Gross capital formation is expressed as a ratio of total investment in current local currency to GDP in current local currency. Investment or gross capital formation is measured by the total value of the gross fixed capital formation and changes in inventories and acquisitions less

disposals of valuables for a unit or sector, based on the System of National Accounts (SNA) of 1993.

Source: International Monetary Fund, World Economic Outlook Database, October 2019 (PPP\$ GDP). (<https://www.imf.org/external/pubs/ft/weo/2019/02/weodata/index.aspx>).

2. Innovation

2.1. Research & Development

2.1.1 Researchers

Researchers, full-time equivalent (FTE) (per million population) | 2018

Researchers per million population, FTE. Researchers in R&D are professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students (ISCED97 level 6) engaged in R&D are included. Data collected from UNESCO Institute for Statistics, Eurostat, and OECD Main Science and Technology Indicators.

Source: UNESCO Institute for Statistics, UIS online database; Eurostat, Eurostat database, 2020; OECD, Main Science and Technology Indicators MSTI database, 2020 (2010–18). (<http://data.uis.unesco.org>; <https://ec.europa.eu/eurostat/data/database>; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

2.1.2 Gross expenditure on R&D (GERD)

Gross expenditure on R&D (% of GDP) | 2018

Total domestic intramural expenditure on R&D during a given period as a percentage of GDP. “Intramural R&D expenditure” is all expenditure for R&D performed within a statistical unit or sector of the economy during a specific period, whatever the source of funds. Data collected from UNESCO Institute for Statistics, Eurostat, and OECD Main Science and Technology Indicators. Source: UNESCO Institute for Statistics, UIS online database; Eurostat, Eurostat database, 2020; OECD, Main Science and Technology Indicators MSTI database, 2020 (2009–19). (<http://data.uis.unesco.org>; <https://ec.europa.eu/eurostat/data/database>; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

2.1.3 Global R&D companies, average expenditure top 3

Average expenditure of the top 3 global companies by R&D, mn US\$* | 2019

Average expenditure on R&D of the top three global companies. If a country has fewer than three global companies listed, the figure is either the average of the sum of the two companies listed or the total for a single listed company. A score of 0 is given to countries with no listed companies.

Source: European Commission, The 2019 EU Industrial R&D Investment Scoreboard. (<https://iri.jrc.ec.europa.eu/scoreboard/2019-eu-industrial-rd-investment-scoreboard>).

2.1.4 University ranking

Average score of the top 3 universities at the QS world university ranking* | 2019

Average score of the top three universities per country. If fewer than three universities are listed in the QS ranking of the global top 1000 universities, the sum of the scores of the listed universities is divided by three, thus implying a score of zero for the non-listed universities.

Source: QS Quacquarelli Symonds Ltd, QS World University Ranking 2019/2020, Top Universities. (<https://www.topuniversities.com/qs-world-university-rankings>).

2.2. Market Sophistication

2.2.1 Domestic credit to private sector Domestic credit to private sector (% of GDP) | 2018

“Domestic credit to private sector” refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of non-equity securities, and trade credits and other accounts receivable that establish a claim for repayment. For some countries, these claims include credit to public enterprises. The financial corporations include monetary authorities and deposit money banks, as well as other financial corporations where data are available (including corporations that do not accept transferable deposits but do incur such liabilities as time and savings deposits). Examples of other financial corporations are finance and leasing companies, money lenders, insurance corporations, pension funds, and foreign exchange companies.

Source: International Monetary Fund, International Financial Statistics and data files; and World Bank and OECD GDP estimates; extracted from the World Bank’s World Development Indicators database (2010-2018). (<http://data.worldbank.org/>).

2.2.2 Market capitalization Market capitalization of listed domestic companies (% of GDP, three-year average) | 2018

Market capitalization (also known as “market value”) is the share price times the number of shares outstanding (including their several classes) for listed domestic companies. Investment funds, unit trusts, and companies whose only business goal is to hold shares of other listed companies are excluded. Data is the average of the end of year values for the last three years with the exception of Romania (averages for two years: 2010 and 2011).

Source: World Federation of Exchanges database; extracted from the World Bank’s World Development Indicators database (2011–18). (<http://data.worldbank.org/>).

2.2.3 Venture capital deals/bn PPP\$ GDP Venture capital per investment location: Number of deals (per billion PPP\$ GDP) | 2019

Thomson Reuters Eikon data on private equity deals, per deal, with information on the location of investment, investment company, investor firms, funds, and crowdfunding, among other details. The series corresponds to a query on venture capital deals from January 1, 2019 to December 31, 2019. The data are reported per billion PPP\$ GDP.

Source: Thomson Reuters Eikon, Private Equity screener; International Monetary Fund, World Economic Outlook Database October 2019 (PPP\$ GDP).
(<https://eikon.thomsonreuters.com/index.html>;
<https://www.imf.org/external/pubs/ft/weo/2019/02/weodata/index.aspx>).

2.2.4 Applied tariff rate, weighted mean Tariff rate, applied, weighted average, all products (%)^{a,b} | 2018

“Weighted mean applied tariff” is the average of effectively applied rates weighted by the product import shares corresponding to each partner country. Data are classified using the Harmonized System of trade at the six- or eight-digit level. Tariff line data were matched to Standard International Trade Classification (SITC) revision 3 codes to define commodity groups and import weights. To the extent possible, specific rates have been converted to their ad valorem equivalent rates and have been included in the calculation of weighted mean tariffs. Effectively applied tariff rates at the six- and eight-digit product level are averaged for products in each commodity group. When the effectively applied rate is unavailable, the most favored nation rate is used instead.

Source: World Bank, based on data from United Nations Conference on Trade and Development’s Trade Analysis and Information System (TRAINS) database and the World Trade Organization’s (WTO) Integrated Data Base (IDB) and Consolidated Tariff Schedules

(CTS) database; extracted from World Bank's World Development Indicators database (2015–18). (<http://data.worldbank.org/>).

2.3. Business Sophistication

2.3.1 GERD performed by business enterprise

GERD performed by business enterprise (% of GDP) | 2018

Gross expenditure on R&D performed by business enterprise as a percentage of GDP. For the definition of GERD see indicator 4.1.2.

Source: UNESCO Institute for Statistics, UIS online database; Eurostat, Eurostat database, 2019; OECD, Main Science and Technology Indicators MSTI database, 2019 (2010–19). (<http://data.uis.unesco.org>; <https://ec.europa.eu/eurostat/data/database>; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

2.3.2 GERD: Financed by business enterprise (% of total GERD)

GERD: Financed by business enterprise (% of total GERD) | 2017

Gross expenditure on R&D financed by business enterprise as a percentage of total gross expenditure on R&D. For the definition of GERD see indicator 4.1.2.

Source: UNESCO Institute for Statistics, UIS online database; Eurostat, Eurostat database, 2019; OECD, Main Science and Technology Indicators MSTI database, 2019 (2009–18). (<http://data.uis.unesco.org>; <https://ec.europa.eu/eurostat/data/database>; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

2.3.3 GERD: Financed by abroad (% of GDP)

GERD: Financed by abroad (% of GDP) | 2017

Percentage of gross expenditure on R&D financed by abroad (billions, national currency)—that is, with foreign financing as a percentage of GDP (billions, national currency). For the definition of GERD see indicator 4.1.2.

Source: UNESCO Institute for Statistics, UIS online database; Eurostat, Eurostat database, 2019; OECD, Main Science and Technology Indicators MSTI database, 2019 (2010–18). (<http://data.uis.unesco.org>; <https://ec.europa.eu/eurostat/data/database>; https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

2.3.4 Patent families filed in at least two offices

Number of patent families in at least two offices (per billion PPP\$ GDP) | 2016

A “patent family” is a set of interrelated patent applications filed in one or more countries or jurisdictions to protect the same invention. Patent families containing applications filed in at least two different offices is a subset of patent families where protection of the same invention is sought in at least two different countries. In this report, “patent families data” refers to patent families containing applications filed in at least two IP offices; the data are scaled by PPP\$ GDP (billions). A “patent” is a set of exclusive rights granted by law to applicants for inventions that are new, non-obvious, and industrially applicable. A patent is valid for a limited period of time (generally 20 years) and within a limited territory. The patent system is designed to encourage innovation by providing innovators with time-limited exclusive legal rights, thus enabling them to appropriate the returns from their innovative activity.

Source: World Intellectual Property Organization, Intellectual Property Statistics; International Monetary Fund, World Economic Outlook Database, October 2019 (PPP\$ GDP). (<http://www.wipo.int/ipstats/>; <https://www.imf.org/external/pubs/ft/weo/2019/02/weodata/index.aspx>).

2.3.5 ICT services imports

Telecommunications, computers, and information services imports (% of total trade)^a | 2018

Telecommunications, computer and information services as a percentage of total trade according to the Organisation for Economic Cooperation and Development (OECD)'s Extended Balance of Payments Services Classification EBOPS 2010, coded SI: Telecommunications, computer and information services. See indicator 2.4.2 for a definition of total trade.

Source: World Trade Organization, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments and International Investment Position Manual and Balance of Payments database (2015-18) (<https://data.wto.org> ; <http://www.oecd.org/std/its/EBOPS-2010.pdf>).

2.4. Knowledge, Technology and Creative Outputs

2.4.1 PCT international applications by origin

Number of Patent Cooperation Treaty applications (per billion PPP\$ GDP)^a | 2019

A PCT application refers to an international patent application filed through the WIPO-administered Patent Cooperation Treaty (PCT). The PCT system makes it possible to seek patent protection for an invention simultaneously in a number of countries by filing a single international patent application. The origin of PCT applications is defined by the residence of the first-named applicant. Data is available only for those economies which are PCT Contracting States. Data are scaled by PPP\$ GDP (billions).

Source: World Intellectual Property Organization, Intellectual Property Statistics; International Monetary Fund, World Economic Outlook Database, October 2019 (PPP\$ GDP). (<http://www.wipo.int/ipstats/>; <https://www.imf.org/external/pubs/ft/weo/2019/02/weodata/index.aspx>).

2.4.2 Cultural and creative services exports (% of total trade)

Cultural and creative services exports (% of total trade)^a | 2018

Creative services exports (% of total exports) according to the Extended Balance of Payments Services Classification EBOPS 2010—that is, EBOPS code SI3 Information services; code SJ22 Advertising, market research, and public opinion polling services; code SK1 Audiovisual and related services; and code SK23 Heritage and recreational services as a percentage of total trade. See 2.4.2 for a definition of total trade. Data for the United States of America (U.S.) was obtained from the Bureau of Economic Analysis (BEA), Table 2.1 U.S. Trade in Services, by Type of Service. The following BEA categories are used: Audio-visual and related products (including Movies and television programming, Books and sound recordings, and Broadcasting and recording of live events); Information Services; Advertising; and Sports and performing arts. Source: World Trade Organization, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments and International Investment Position Manual and Balance of Payments database; Bureau of Economic Analysis (BEA) released October 2019. (2011-18). (<https://timeseries.wto.org/>; <http://www.oecd.org/std/its/EBOPS-2010.pdf>; <https://apps.bea.gov/itable/index.cfm>).

2.4.3 Creative goods exports (% of total trade)

Creative goods exports (% of total trade)^a | 2018

Total value of creative goods exports (current US\$) over total trade. Creative goods as defined in the 2009 UNESCO Framework for Cultural Statistics, Table 3, International trade of cultural goods and services based on the 2007 Harmonised System (HS 2007). For the definition of total trade, see indicator 2.4.2.

Source: United Nations, Comtrade database; 2009 UNESCO Framework for Cultural Statistics, Table 3, International trade of cultural goods and services based on the 2007

Harmonised System (HS 2007); World Trade Organization, Trade in Commercial Services database, itself based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments and International Investment Position Manual and Balance of Payments database (2012-18). (<http://comtrade.un.org/>; <http://uis.unesco.org/sites/default/files/documents/measuring-cultural-participation-2009-unesco-framework-for-cultural-statistics-handbook-2-2012-en.pdf>; https://www.wto.org/english/res_e/statistics_e/tradeserv_stat_e.htm; <https://www.oecd.org/sdd/its/EBOPS-2010.pdf>).

2.4.4 Intellectual property receipts

Charges for use of intellectual property, i.e., receipts (% total trade, three-year average) | 2018

Charges for the use of intellectual property not included elsewhere receipts (% of total trade), average of three most recent years or available data. Value according to the Extended Balance of Payments Services Classification EBOPS 2010—that is, code SH charges for the use of intellectual property not included elsewhere as a percentage of total trade. Receipts are between residents and non-residents for the use of proprietary rights (such as patents, trademarks, copyrights, industrial processes, and designs including trade secrets, franchises), and for licenses to reproduce or distribute (or both) intellectual property embodied in produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights (such as for live performances and television, cable, or satellite broadcast). For definition of total trade see indicator 2.4.2.

Source: World Trade Organization, Trade in Commercial Services database, based on the sixth (2009) edition of the International Monetary Fund's Balance of Payments and International Investment Position Manual and Balance of Payments database (2010-2018) (<https://data.wto.org/>; <http://www.oecd.org/std/its/EBOPS-2010.pdf>).

2.4.5 Global brand value, top 5,000 / bn PPP\$ GDP

Global brand value of the top 5,000 brands (% of GDP) | 2019

Sum of Global Brand Values, top 5,000 as a percentage of GDP. 2020 rankings based on 2019 data. Brand Finance calculates brand value using the Royalty Relief methodology, which determines the value a company would be willing to pay to license its brand as if it did not own it. The methodology is compliant with industry standards set in ISO 10668. ISO This approach involves estimating the future revenue attributable to a brand and calculating a royalty rate that would be charged for the use of the brand. Brand Finance's study is based on publicly available information on the largest brands in the world. This indicator assesses the economy's brands in the top 5,000 global brand database and produces the sum of the brand values corresponding to that economy. This sum is then scaled by GDP. A score of 0 is assigned where there are no brands in the country that make the Top 5000 ranking. A score of n/a is assigned where Brand Finance has been unable to determine if there are brands from the country that would rank within the Top 5000 due to data availability limitations.

Source: Brand Finance database; International Monetary Fund, World Economic Outlook Database, October 2019 (2019). (<https://brandirectory.com/>; <https://brandfinance.com/knowledge-centre/>; <https://www.imf.org/external/pubs/ft/weo/2019/02/weodata/index.aspx>).

3. Talent

3.1. Attract

3.1.1 FDI and technology transfer
FDI and technology transfer[†] | 2018

Average answer to the question: To what extent does foreign direct investment (FDI) bring new technology into your country? [1 = not at all; 7 = to a great extent]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey. (2017–2018). (<http://reports.weforum.org>).

3.1.2 International students

International students Tertiary inbound mobility ratio (%) | 2017

Tertiary inbound mobility ratio refers to the number of students from abroad studying in a given country as a percentage of the total tertiary enrolment in that country.

Source: UNESCO Institute for Statistics, UIS.Stat. (<http://data.uis.unesco.org/>).

3.1.3 Tolerance of minorities

Tolerance of minorities Discrimination and violence against minorities^b | 2019

Tolerance of minorities is based on the Group Grievance indicator included in the Fragile States Index published by The Fund for Peace. Group Grievance 'focuses on divisions and schisms between different groups in society—particularly divisions based on social or political characteristics—and their role in access to services or resources, and inclusion in the political process'. Its dimensions include post-conflict response, equality, divisions, and communal violence. It is measured on a scale of 0 (low pressures) to 10 (very high pressures).

Source: The Fund for Peace, Fragile States Index 2019. (<https://fragilestatesindex.org/>).

3.1.4 Social mobility

Social mobility[†] | 2018

Average answer to the question: In your country, to what extent do individuals have the opportunity to improve their economic situation through their personal efforts regardless of the socioeconomic status of their parents? [1 = not at all; 7 = to a great extent] The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey. (2017–2018). (<http://reports.weforum.org>).

3.1.5 Gender development gap

Gender development gap Gender Development Index* | 2017

The Gender Development Index (GDI) refers to disparities between women and men in three basic dimensions of human development—health, knowledge, and living standards. Based on the same methodology and component indicators as the Human Development Index (HDI), the GDI is a direct measure of gender gap showing the female HDI as a percentage of the male HDI.

Source: United Nations Development Programme (UNDP), Human Development Indices and Indicators: 2018 Statistical Update. (<http://hdr.undp.org/en/content/genderdevelopment-index-gdi>).

3.2. Grow

3.2.1 Tertiary enrolment

Tertiary enrolment (%) | 2018

Tertiary enrolment refers to the ratio of total tertiary enrolment, regardless of age, to the population of the age group that officially corresponds to the tertiary level of education. Tertiary education, whether or not to an advanced research qualification, normally requires as a minimum condition of admission the successful completion of education at the secondary level. The tertiary level is based on International Standard Classification of Education (ISCED) levels 5–8.

Source: UNESCO Institute for Statistics, UIS.Stat (<http://data.uis.unesco.org/>).

3.2.2 Employee development

Employee development[†] | 2018

Average answer to the question: In your country, to what extent do companies invest in training and employee development? [1 = not at all; 7 = to a great extent]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement the The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey. (2017–2018). (<http://reports.weforum.org>)

3.2.3 Delegation of authority

Delegation of authority[†] | 2018

Average answer to the question: In your country, to what extent does senior management delegate authority to subordinates? [1 = not at all; 7 = to a great extent]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey. (2017–2018). (<http://reports.weforum.org>)

3.2.4 Use of virtual professional networks

Use of virtual professional networks LinkedIn users (per 1,000 labour force) | 2018

LinkedIn users refers to the number of registered LinkedIn accounts per 1,000 labour force (15–64 years old).

Source: Data on LinkedIn users kindly provided by LinkedIn. Data on labour force are sourced from the International Labour Organization, ILOSTAT. (<https://ilostat.ilo.org/>).

3.3. Retain

3.3.1 Pension system

Pension system Workforce contributing to pension system (%) | 2015

Pension system refers to old-age effective coverage in terms of contributors. It is reported as the percentage of people who are 15 years old or above who contribute to a pension scheme.

Source: International Labour Organization, World Social Protection Report 2017–19 (<https://www.social-protection.org>)

3.3.2 Brain retention[†] Brain retention | 2018

Average answer to the question: To what extent does your country retain talented people? [1 = not at all—the best and brightest leave to pursue opportunities abroad; 7 = to a great extent—the best and brightest stay and pursue opportunities in the country]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey. (2017–2018). (<http://reports.weforum.org>)

3.3.3 Environmental performance Environmental performance Environmental Performance Index* | 2018

The Environmental Performance Index (EPI) ranks how well countries perform in two fundamental dimensions of sustainable development: environmental health and ecosystem vitality. Indicators in the EPI measure how close countries are to meeting internationally established targets or, in the absence of agreed-upon targets, how they compare relative to the best performing countries.

Source: Wendling, Z. A., Emerson, J. W., Esty, D. C., Levy, M. A., de Sherbinin, A., et al. (2018). 2018 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy (<https://epi.envirocenter.yale.edu/>)

3.3.4 Physician density Physicians (per 1,000 people) | 2016

Physician density refers to the number of medical doctors (physicians), including generalist and specialist medical practitioners, per 1,000 people.

Source: World Bank, World Development Indicators based on World Health Organization, Global Atlas of the Health Workforce; OECD; and country data (<http://data.worldbank.org/data-catalog/world-development-indicators>)

3.4. Skills

3.4.1 Ease of finding skilled employees Ease of finding skilled employees[†] | 2018

Average answer to the question: In your country, to what extent can companies find people with the skills required to fill their vacancies? [1 = not at all; 7 = to a great extent]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness. Source: World Economic Forum, Executive Opinion Survey. (2017–2018) (<http://reports.weforum.org>).

3.4.2 Workforce with tertiary education Labour force with tertiary education (%) | 2018

Workforce with tertiary education refers to the percentage of the labour force (above 15 years old) whose highest educational attainment is at the tertiary level. The tertiary level is based on International Standard Classification of Education (ISCED) levels 5–8.

Source: International Labour Organization, ILOSTAT. (<https://ilostat ilo.org/>).

3.4.3 Professionals Professionals (%) | 2018

Professionals refers to the number of professionals as a share of the total workforce. The employment by occupation is based on the International Standard Classification of Occupation (ISCO) Revision 2008 (data based on ISCO Rev. 1988 is used for those countries where ISCO Rev. 2008 is not available). It includes physical, mathematical, and engineering science professionals; life science and health professionals; teaching professionals; and other professionals (business, legal, archivists, librarians, social science, religious professionals, writers, and creative or performing artists).

Source: International Labour Organization, ILOSTAT. (<https://ilostat.ilo.org/>).

3.4.4 Senior officials and managers

Legislators, senior officials, and managers (%) | 2018

This variable measures the percentage of legislators, senior officials, and managers within total employment. The employment by occupation is based on the International Standard Classification of Occupation (ISCO) Revision 2008 (data based on ISCO Rev. 1988 is used for those countries where ISCO Rev. 2008 is not available).

Source: International Labour Organization, ILOSTAT. (<https://ilostat.ilo.org/>).

3.4.5 Availability of scientists and engineers

Availability of scientists and engineers[†] | 2018

Average answer to the question: In your country, to what extent are scientists and engineers available? [1 = not at all; 7 = widely available]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey. (2017–2018). (<http://reports.weforum.org>).

4. Technology

4.1. ICT

4.1.1 Internet access

Estimated proportion of households with Internet access at home (%) | 2018

This is the share of households with Internet access at home via a fixed or mobile network. A household with Internet access is defined as the Internet being available for use by all members of the household at any time. This indicator can include both estimates and survey data corresponding to the proportion of individuals using the Internet based on results from national household surveys. The number should reflect the total population of the country or at least individuals of 5 years and older.

Source: International Telecommunication Union (ITU), *ITU World Telecommunication/ICT Indicators database 2019*. (<http://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx>).

4.1.2 4G mobile network coverage

Population covered by at least an LTE/WiMAX mobile network (%) | 2018

This indicator measures the percentage of inhabitants out of the total population who are within range of an advanced mobile cellular signal, such as LTE/LTE-Advanced and mobile WiMAX/WirelessMAN networks, irrespective of whether they are subscribers.

Source: International Telecommunication Union (ITU), *ITU World Telecommunication/ICT Indicators database 2019*. (<http://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx>).

4.1.3 GitHub commits

GitHub commits per 1,000 population | 2018

GitHub is the world's largest host of source code, and a commit is the term used for a saved change on this platform. Thus, GitHub commits refers to the number of commits on the GitHub website that are publicly available. One limitation of the data is that only a minority of GitHub users are geolocated, and therefore the indicator does not concern all commits. However, as pointed out by Ojanperä, Graham, and Zook (2019), this limitation probably does not entail any geographic bias, and the indicator is therefore "an appropriate, if imperfect, proxy for otherwise hard to measure programming skills."

Source: Gousios, Georgios. (2013) The GHTorrent dataset and tool suite. MSR 2013: 233-236. Data accessed through Google BigQuery. Data on population are sourced from World Development Indicators (<http://data.worldbank.org/data-catalog/world-development-indicators>).

4.1.4 Wikipedia edits

Wikipedia yearly edits by country (per million population 15–69 years old) | 2019

Data extracted from Wikimedia Foundation's internal data sources. Data reflects economies with more than 100,000 edit counts in 2019; The data exclude both contributions to the extent that is identifiable in the data sources. Data are reported per million population 15–69 years old. Data from China are treated as missing and considered "n/a".

Source: Wikimedia Foundation; United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects: The 2019 Revision (population). (<https://wikimediafoundation.org>; <https://esa.un.org/unpd/wpp/>).

4.1.5 Adoption of emerging technologies

Average answer to survey questions concerning the extent to which companies adopt five types of emerging technology[†] | 2018–19

The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement The Global Competitiveness Report in assessing issues that drive national competitiveness. The data refer to the simple mean of the average answers to a similarly worded question regarding five different emerging technologies: In your country, to what extent are companies adopting Artificial intelligence|Robotics|App- and web-enabled markets|Big data analytics|Cloud computing? (1: not at all; 7: to a great extent - on par with the most technologically advanced economies)

Source: World Economic Forum, Executive Opinion Survey. (2018–2019). (<http://reports.weforum.org>).

4.2. People

4.2.1 Use of virtual social networks

Number of active social media users (% of population) | 2019

This indicator refers to the penetration of active social media users, expressed as a percentage of total population. The original data come from a variety of sources, including company statements and reports in reputable media.

Source: We Are Social and Hootsuite (2020) Global Digital Report 2020. (<https://wearesocial.com/digital-2020>).

4.2.2 ICT skills ICT skills[†] | 2018-19

Average answer to the question: In your country, to what extent does the active population possess sufficient digital skills (e.g. computer skills, basic coding, digital reading)? [1 = not at all; 7 = to a great extent]. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement *The Global Competitiveness Report* in assessing issues that drive national competitiveness.

Source: World Economic Forum, Executive Opinion Survey. (2018–2019). (<http://reports.weforum.org>).

4.2.3 Firms with website Firms with website (% of total) | 2019

The data for this indicator are based on enterprise surveys conducted by the OECD and the World Bank. The former source is used for OECD countries and accession countries or key partners, while the latter source is used for all other countries.

Source: OECD, ICT Access and Use by Businesses, *OECD Telecommunications and Internet Statistics* (database). (<https://doi.org/10.1787/9d2cb97b-en>); World Bank, *Enterprise Surveys*. (www.enterprisesurveys.org).

4.2.4 Government online services Government Online Service Index* | 2020

The Government Online Service Index (OIS) is one of the three main components of the E-Government Development Index (EGDI) constructed and published by the United Nations Department of Economic and Social Affairs. The OIS assesses the quality of a government's delivery of online services on a 0-to-1 (best) scale. The assessment is carried out by researchers, who evaluate "each country's national website in the native language, including the national portal, e-services portal, and e-participation portal, as well as the websites of the related ministries of education, labor, social services, health, finance, and environment, as applicable."

Source: United Nations Department of Economic and Social Affairs (UNDESA), UN E-Government Knowledgebase. (<https://publicadministration.un.org/egovkb/en-us/>).

4.2.5 Government promotion of investment in emerging technologies Government promotion of investment in emerging technologies

Average answer to survey questions concerning the extent to which governments foster investment in five types of emerging technology[†] | 2018–19

The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement *The Global Competitiveness Report* in assessing issues that drive national competitiveness. The data refer to the simple mean of the average answers to a similarly worded question regarding five different emerging technologies: In your country, to what extent does the government foster investment (public and private) in Artificial intelligence and machine learning|Robotics|App- and web-enabled markets|Big data analytics|Cloud computing? (1: not at all; 7: to a great extent)

Source: World Economic Forum, Executive Opinion Survey. (2018–2019). (<http://reports.weforum.org>).

4.3. Governance

4.3.1 Cybersecurity

Global Cybersecurity Index* | 2018

The Global Cybersecurity Index (GCI) provides a measure of the level of cybersecurity commitment of countries. It is a composite index made up of 25 indicators that are distributed across five main pillars: Legal Measures, Technical Measures, Organizational Measures, Capacity Building Measures, and Cooperation Measures. Scores are standardized to a scale of 0 to 1.

Source: ITU (2019) *Global Cybersecurity Index (GCI) 2018*. (https://www.itu.int/dms_pub/itu-d/opb/str/D-STR-GCI.01-2018-PDF-E.pdf).

4.3.2 Internet shopping

People who used the Internet to buy something online in the past year (%)[†] | 2017

This indicator refers to the percentage of respondents aged at least 15 years old who have used the Internet in the past year to buy something online. The data stem from a triennial survey that is carried out in more than 140 economies.

Source: World Bank, *Global Findex* database. (<https://globalfindex.worldbank.org/>).

4.3.3 ICT regulatory environment

ICT Regulatory Tracker* | 2018

This indicator is based on a composite index—the *ICT Regulatory Tracker*—that provides a measure of the existence and features of ICT legal and regulatory frameworks. The index covers 50 indicators that are distributed across four pillars: Regulatory Authority, Regulatory Mandate, Regulatory Regime, and Competition Framework. Scores are standardized to a scale of 0 to 2.

Source: International Telecommunication Union (ITU), *ICT Regulatory Tracker 2018*. (<https://www.itu.int/net4/itu-d/irt/>).

4.3.4 Legal framework's adaptability to emerging technologies[†]

Legal framework's adaptability to emerging technologies | 2018–19

Average answer to survey questions concerning the extent to which the legal framework is adapting to five types of emerging technology. The World Economic Forum's Executive Opinion Survey (EOS) is conducted on an annual basis to gather information from business leaders on topics for which hard data sources are scarce or nonexistent. It is part of the effort to supplement *The Global Competitiveness Report* in assessing issues that drive national competitiveness. The data refer to the simple mean of the average answers to a similarly worded question regarding five different emerging technologies: In your country, how adequately is the legal framework adapting to Artificial intelligence|Robotics|App- and web-enabled markets|Big data analytics|Cloud computing? (1: not at all; 7: to a great extent - the legal framework is up-to-date)

Source: World Economic Forum, Executive Opinion Survey. (2018–2019). (<http://reports.weforum.org>).

4.3.5 E-Participation

E-Participation Index ^a | 2020

The E-Participation Index assesses, on a 0-to-1 (best) scale, the quality, relevance, and usefulness of government websites in providing online information and participatory tools and

services to their citizens. Within the E-Participation Index, countries are benchmarked in three areas: e-information, e-consultation, and e-decision-making. As such, the index indicates both the capacity and the willingness of the state in encouraging the citizen to promote deliberative, participatory decision-making in public policy and of the reach of its own socially inclusive governance program.

Source: United Nations Department of Economic and Social Affairs (UNDESA), UN E-Government Knowledgebase. (<https://publicadministration.un.org/egovkb/en-us/>).

4.3.6 Gender gap in Internet use

Difference between female and male population in using the Internet | 2019

This indicator refers to the share of, respectively, women and men in a country that use the Internet. Scores are calculated as the ratio of the share related to the female population over the share related to the male population.

Source: International Telecommunication Union (ITU), ITU World Telecommunication/ICT Indicators database 2020. (<http://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx>).

4.4. Digital Economy

4.4.1 Medium and high-tech industry

Proportion of medium- and high-tech industry value added in total value added (%) | 2016

This indicator refers to the percentage of the value added of medium and high-tech industry out of the total value added of manufacturing. The manufacturing sector relates to sector D in the International Standard Industrial Classification of all Economic Activities (ISIC) revision 3 (1990) or sector C in ISIC revision 4 (2008). The definition of medium- and high-tech industry is based on the R&D intensity of economic activities. See United Nations (2019) or Galindo-Rueda & Verger (2016) for details on the classification.

Source: United Nations Industrial Development Organization (UNIDO), *UNIDO CIP 2018 Database* (<https://stat.unido.org>), sourced from United Nations, *Open SDG Data Hub* (<http://www.sdg.org>). United Nations (2019), *Metadata for Indicator 9.b.1 Proportion of medium and high-tech industry value added in total value added*. (<https://unstats.un.org/sdgs/metadata/files/Metadata-09-0B-01.pdf>). Galindo-Rueda, F. and F. Verger (2016). OECD Taxonomy of Economic Activities Based on R&D Intensity, *OECD Science, Technology and Industry Working Papers*, 2016/04, OECD Publishing, Paris. (<http://dx.doi.org/10.1787/5jlv73sqgp8r-en>).

4.4.2 High-tech exports

High-tech net exports (% of total trade) | 2018

High-technology manufactured exports (% of total exports of manufactured goods) | 2019

High-value exports refers to high-technology manufactures (electronic and electrical and other), as calculated according to the Lall classification, out of all exports of manufactured goods.

Source: World Bank, World Development Indicators. (<http://data.worldbank.org/data-catalog/world-development-indicators>). The classification of exports is based on Lall, S. (2000), *The Technological Structure and Performance of Developing Country Manufactured Exports*, *Oxford Development Studies*, 28(3), 1985–1989.

4.4.3 Labor productivity per employee

Labor productivity per person employed (2019 US\$) | 2019

The Conference Board provides two calculations of its estimates on output, labor, and labor productivity: an original version based on official GDP data and an adjusted version based on GDP growth and levels that take into account rapidly falling ICT prices. *Labor productivity per employee* is based on the estimates of the adjusted version.

Source: The Conference Board, Total Economy Database™ (Adjusted version).
(www.conference-board.org/data/economydatabase).

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A6. AUTHORS

Prof. Soumitra DUTTA, Professor of Management, Cornell SC Johnson College of Business; Co-Founder and President, Portulans Institute.

Dr. Rafael ESCALONA REYNOSO, Senior Research Associate and Data Scientist, Portulans Institute.

Carolina ROSSINI, Founding CEO, Portulans Institute.

Isabella WILKINSON, Policy and Research Associate, Portulans Institute.

Victor PARAVIN, Project Research Assistant, Portulans Institute.

A7. CONTRIBUTORS

NATIONAL CONFEDERATION OF INDUSTRY - BRAZIL (CNI)

Gianna SAGAZIO, Innovation Director.

Cândida OLIVEIRA, Innovation Executive Manager.

Julieta Costa CUNHA, Industrial Development Specialist.

Marcos ARCURI, Industrial Development Specialist.

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