Chapter 5

UNLEASHING DIGITAL INNOVATION

After two years of recession in 2015 and 2016, the Brazilian economy was gradually recovering, when the coronavirus (Covid-19) outbreak hit. The economy is projected to contract by more than 9.1% during 2020 in the double-hit scenario, which assumes a second lockdown in Brazil at the end of the year. The recovery in 2021 would be moderate in this scenario, with projected growth of 2.4%. In the single-hit scenario, the economy is projected to contract by 7.4% during 2020, followed by an expansion of 4.2% in 2021. As lockdown measures are eased and activity resumes, the economy is projected to recover slowly and partially, but some jobs and firms will not be able to survive. Unemployment is predicted to reach historic highs before receding gradually (OECD, 2020a).

As productivity growth has remained stagnant and a declining working age population limits the prospects for further growth, Brazil may need to change its economic model. The digital transformation can offer new pathways for growth, through new and improved products and services, the improvement of traditional ones, and the creation of new business models. Digital innovation also has the potential to contribute to solving Brazil's most pressing social challenges, such as the efficiency of the health system, more sustainable agriculture, and urban mobility and security, to name a few.

This chapter examines the key features of the Brazilian system for science, technology and innovation. The first section provides an overview of its main strengths and weaknesses, and the policy responses adopted in recent years to overcome its main challenges. The second section looks at policies and instruments the country is devising to foster digital innovation.

Innovation in the Brazilian economy

Innovation is mostly state driven

Investment in knowledge is key to driving and adapting to the digital transformation. Brazil has made significant progress over the past two decades in modernising its policies and institutions to support R&D and innovation. It has succeeded in placing itself at the frontier of innovation in some "islands of productive excellence", such as oil and gas, aviation, agriculture, and the health sectors (Mazzucato and Penna, 2016). However, the overall innovation system continues to underperform and innovation activities have not resulted in productivity gains, competitiveness enhancement or a stronger presence in the global value chain (World Economic Forum, 2018).

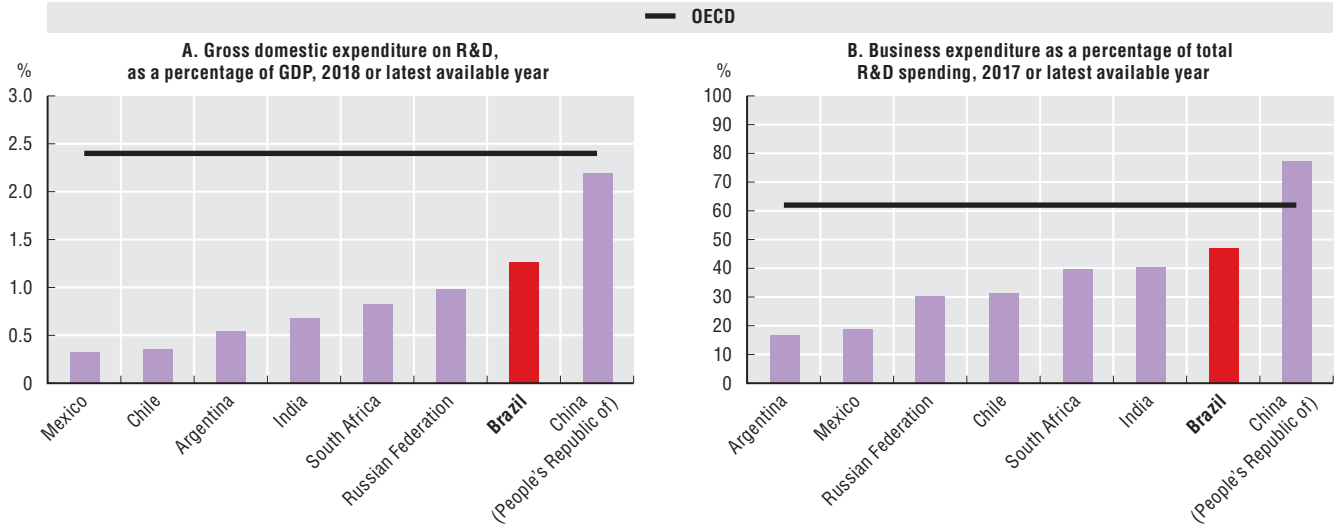
In 2017 (latest available year), investment in R&D amounted to 1.26% of gross domestic product (GDP), higher than in other Latin American and Caribbean countries, but below most OECD countries (Figure 5.1A). The National Strategy for Science, Technology and Innovation (Estratégia Nacional de Ciência, Tecnologia e Inovação, ENCTI) 2016-2022 has set the ambitious target to increase R&D expenditure to 2% of GDP by 2022 (MCTIC, 2016). This target, however, may not be met, given the downward trajectory in spending in R&D since 2016. Economic recession and fiscal austerity have impacted the financing of R&D and innovation in the country. The adoption of a new fiscal rule in the federal Constitution in December 2016, which establishes a zero real growth for federal "discretionary expenses" for 20 years, maintains those expenditures at 2016 levels, with adjustments only allowed for inflation. This rule, therefore, limits public investment in R&D and innovation; the main agencies financing research in the country have all seen a decrease in their budget in recent years (Figure 5.7).

The gap with developed and emerging economies concerns in particular the source of funding for R&D (Figure 5.1B). Across OECD economies, businesses are the main source of R&D expenditure, with an average contribution of 62%. In Brazil, business expenditure represents only about half of total R&D. The contribution of the ICT sector, accounting for about 15% of the total R&D business expenditure in 2014 (the latest year for which data are available), is also much lower than the OECD average (35%) (Figure 5.2).

Data from the 2016 Brazilian Business R&D and Innovation Survey (Pesquisa de Inovação, PINTEC) show that only 36% of surveyed firms declared that they carried out innovations between 2012 and 2014. Firms in the ICT sector showed a higher propensity to innovate, particularly in products, whereas firms in the other sectors mostly report process-oriented innovations (Figure 5.3). Most of innovations,

however, involve the adoption of existing technologies, as only a relatively small share of them are new to the Brazilian market. Firms in the ICT manufacturing and services sub-sectors have shown slight improvements over the years, compared to an overall deterioration in the innovative capacity of firms and of those in the telecommunications sub-sector (Figure 5.4).

Figure 5.1. R&D expenditure in Brazil, the OECD and selected countries

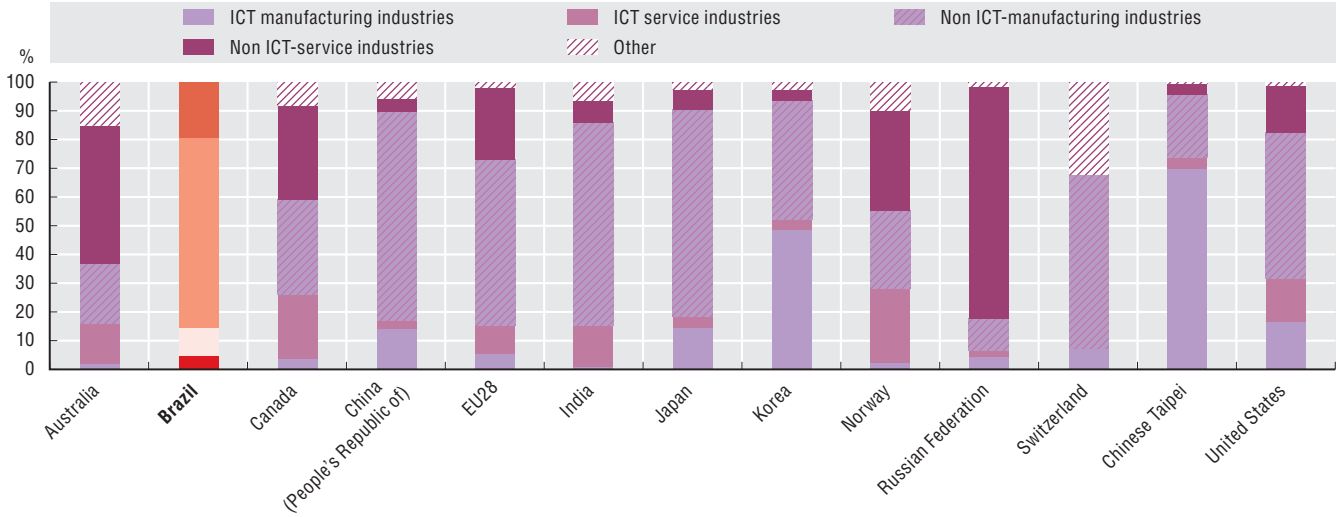


Notes: R&D = research and development; GDP = gross domestic product. Panel A: Data for India refer to 2015. Data for Argentina and South Africa refer to 2016. Data for Brazil and Chile refer to 2017. Panel B: Data for India and South Africa refer to 2016.

Sources: OECD (2020b), *Main Science and Technology Indicators* (database), *http://oe.cd/msti* (accessed in March 2020); data for Brazil are from MCTIC (2019a), *Indicadores Nacionais de Ciência, Tecnologia e Inovação 2018*, *https://www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html*; data for India are from Ministry of Science and Technology (2017), *Research and Development Statistics 2017-18*.

Figure 5.2. Business R&D of the ICT sector in Brazil and selected countries, 2016 or latest available year

As a share of total business R&D expenditure

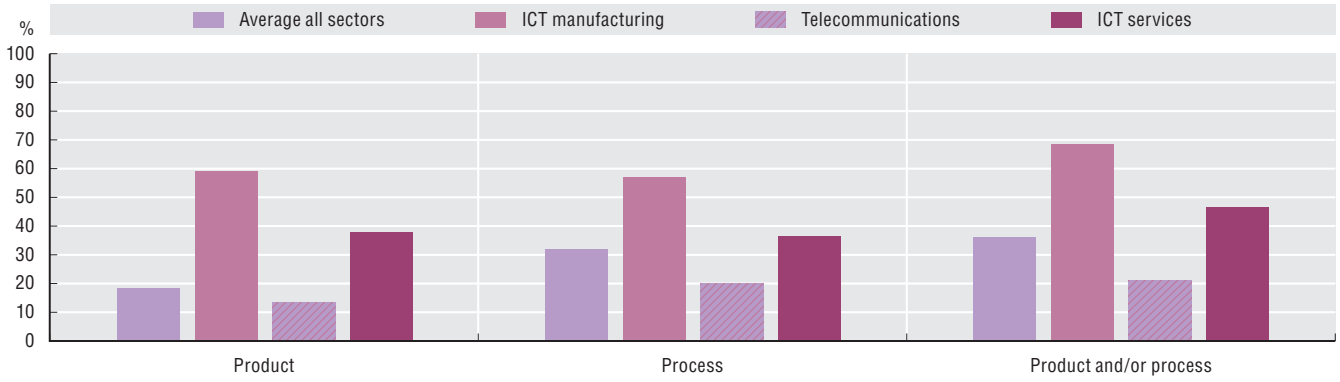


Notes: BERD = business expenditure on research and development; ICT = information and communication technology. "Other" includes: Agriculture, mining and quarrying, energy and construction. Data for India refer to 2013, for Brazil to 2014 and for Switzerland to 2015. "Other" includes non-ICT service industry for Brazil and service industries (ICT and non-ICT) for Switzerland.

Source: Mas et al. (2019), *2019 PREDICT Key Facts Report. An Analysis of ICT R&D in the EU and Beyond*, *https://doi.org/10.2760/06479*.

Figure 5.3. Innovative firms in Brazil, by sector, 2014

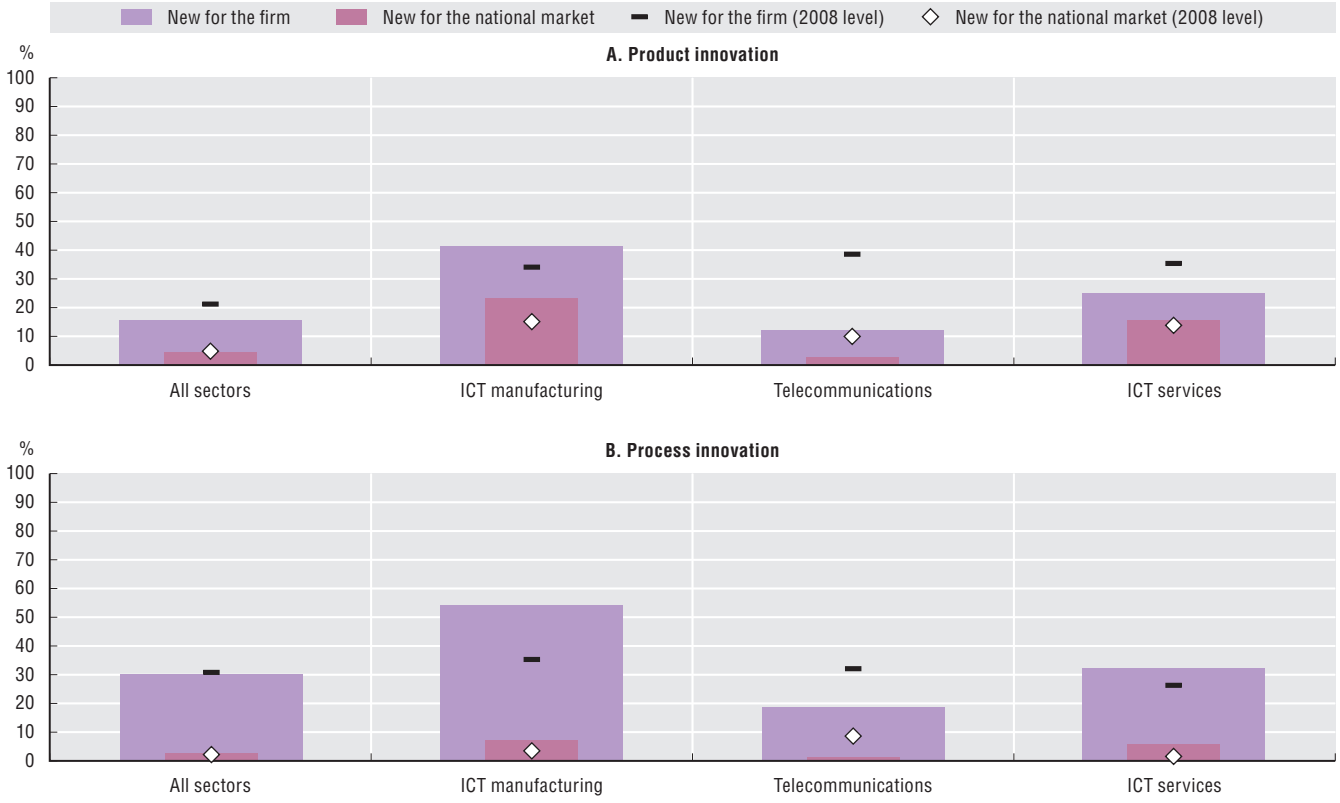
As a percentage of all firms



Note: ICT = information and communication technology.

Source: IBGE (2016), *Pesquisa de Inovação 2014*.

Figure 5.4. Novelty of innovation in Brazilian firms, by sector, 2008 and 2014



Note: ICT = information and communication technology.

Sources: IBGE (2016), *Pesquisa de Inovação 2014*; IBGE (2010), *Pesquisa de Inovação 2008*.

The business environment affects firms' investment decisions and innovative behaviour

Structural conditions in the overall economy affect firms' decisions to invest in innovation. Brazilian enterprises operate within an economic environment that incurs high costs, referred to as "Brazilian cost" (*custo Brasil*) (Dutz, 2018). This is the result of insufficient infrastructure, a complex taxation system with both high levels of taxation and compliance costs, high entry barriers and insolvency costs, and limited access to finance, especially for smaller enterprises. The lack of skills of the working population and the low quality of the education system also hinder the development of more knowledge-intensive

activities. Brazil's tariffs on imported goods, including for ICT goods, further raise the cost of inputs (OECD, 2019a). Finally, support to existing industry structures has been found to inhibit the reallocation of resources towards more productive uses and to reduce incentives for innovation (OECD, 2018a).

All of the above factors tend to discourage competition, innovation and, ultimately, the digital transformation of the country, as they favour incumbents and hinder experimentation with new ideas, technologies and business models, which are the drivers of productivity growth in the digital age (OECD, 2019b). For enterprises to invest in digital technologies, reforms are needed in the above-mentioned policy areas to strengthen incentives to innovate.

Brazil has recently approved several new measures, such as the Declaration of Rights of Economic Freedom (Declaração de Direitos de Liberdade Econômica, Law 13.784 of 20 September 2019), the launch of the Growth Routes Plan (Rota da crescimento) in 2020, and Ordinance 2.023 of 12 September 2019, eliminating import tax on 34 IT and telecommunication goods. The country is also discussing a comprehensive tax reform. These are crucial in fostering an environment conducive to innovation.

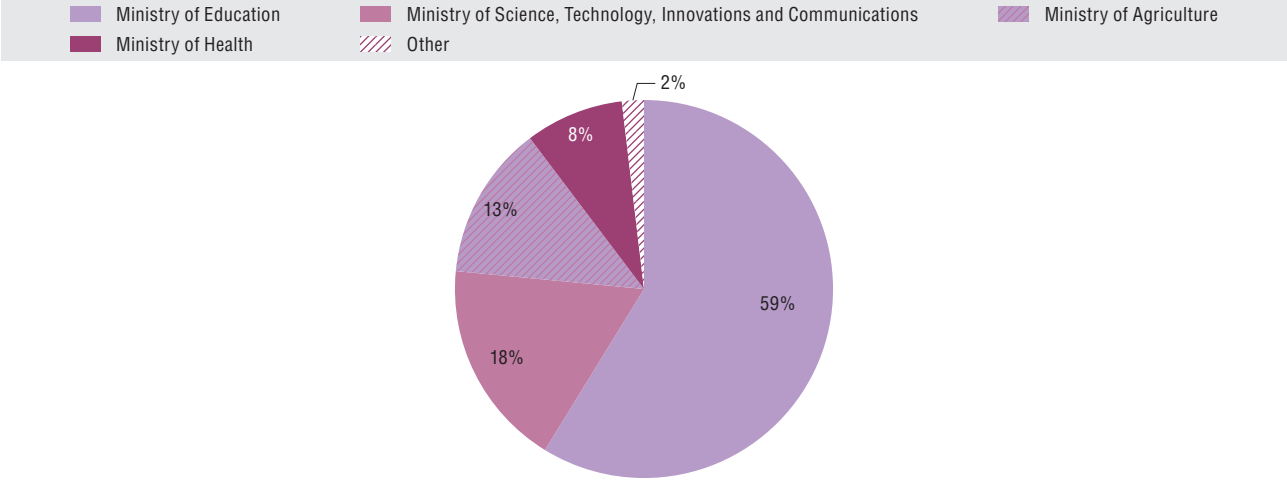
Public funding of R&D is decreasing, thus calling for prioritisation

The federal government is the main contributor to the budget, although over the past decade, state research foundations (Fundações de Amparo à Pesquisa, FAPs), and in particular that of the State of São Paulo (FAPESP), have increased their funding of research. The majority of the federal budget for R&D is allocated to the Ministry of Education (MEC) to fund education and research in federal public universities. Most of the remaining budget finances "not-oriented" R&D (De Negri and Tortato Rauen, 2018), with the exception of agriculture and health, which receive a significant proportion of it (Figure 5.5).

The National Fund for Scientific and Technological Development (Fundo Nacional de Desenvolvimento Científico e Tecnológico, FNDCT), which is mainly financed by sectoral funds, including ICT, is the main source of funding for R&D, providing financing for public or non-profit research organisations and enterprises. The sectoral funds were established in the early 1990s with the objective to provide expanded and more stable financing to scientific and technological development. Since 2017, an increasing share of the FNDCT has been used as a contingency reserve for the federal budget, decreasing the amount of available resources for R&D (Figure 5.6).

Figure 5.5. Government expenditure in R&D, by ministry, Brazil, 2017

As a share of total federal expenditures in R&D



Source: MCTIC (2019a), *Indicadores Nacionais de Ciência, Tecnologia e Inovação 2018*, *https://www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html*.

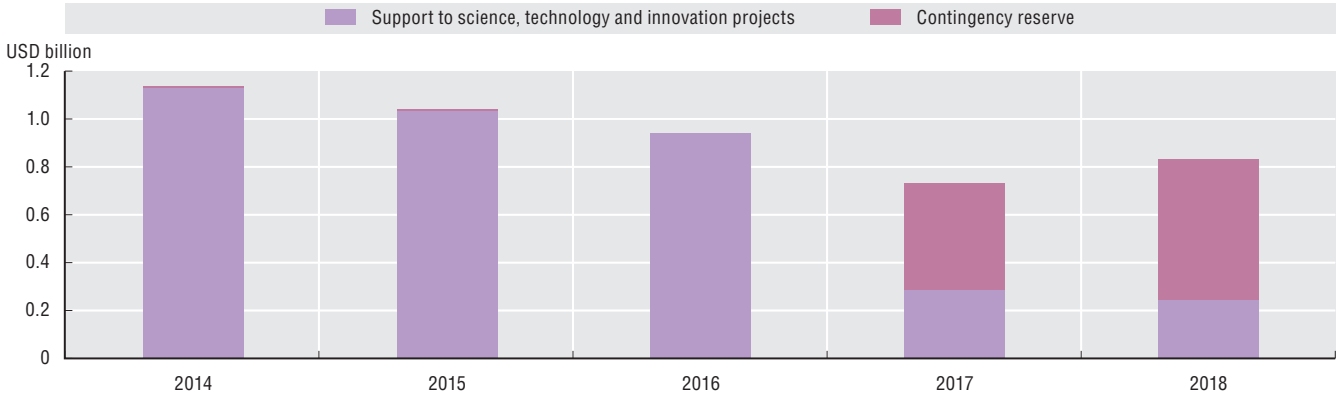
The Ministry of Science, Technology, Innovations and Communications (Ministério de Ciência, Tecnologia, Innovaciones y Comunicaciones, MCTIC) is the main actor providing support to R&D and it leads two main funding agencies. The National Council for Scientific and Technological Development

(Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq) finances research and training through scholarships for graduate students and through research funding programmes. The Brazilian Agency for Innovation and Research (Financiadora de Estudos e Projetos, FINEP) manages the FNDCT and finances R&D and innovation projects in the public and private sectors through grants and credit.

The MEC also provides support by leading the Foundation for the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, CAPES), which awards a large number of scholarships and certifies higher education institutions (HEIs) and graduate programmes. The funding of the CNPq, FINEP and CAPES has decreased in recent years (Figure 5.7), impacting the Brazilian research base, which is mostly concentrated in public universities. The decrease in public resources will require co-ordination of actions and initiatives, prioritisation and stronger, more frequent public-private partnerships. However, the country should also secure funding for basic research, building human capital and investment in key technologies.

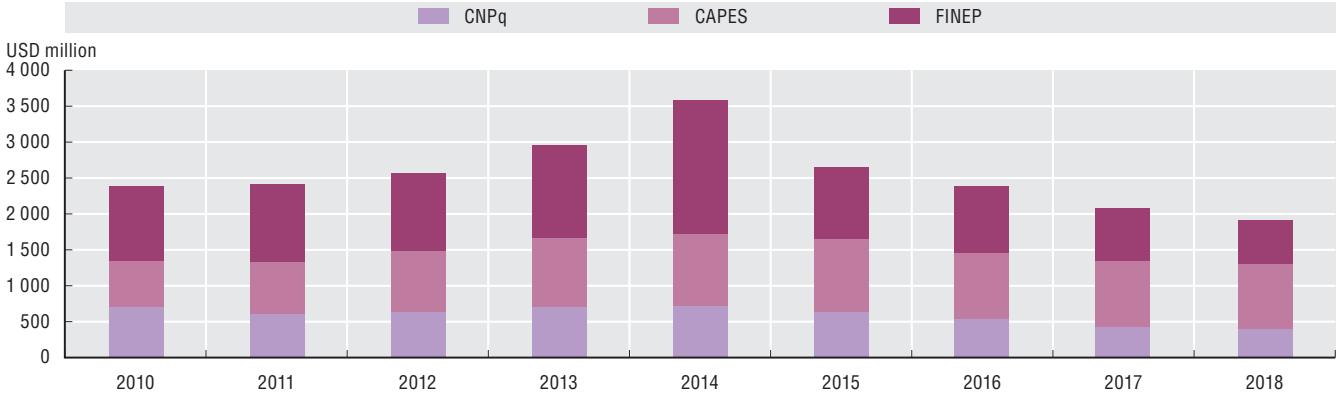
The MCTIC and MEC also finance, together with other sources, the Brazilian Company for Research and Industrial Innovation (Empresa Brasileira de Pesquisa e Inovação Industrial, EMBRAPII), which supports linkages between firms and research centres (Box 5.1). In addition, the Brazilian Development Bank (Banco Nacional de Desenvolvimento Econômico e Social, BNDES) is the main financing agent for development in the country, and provides credit and equity capital for innovation projects and technology acquisition.

Figure 5.6. Budget of the National Fund for Scientific and Technological Development, by destination, 2014-18



Source: MCTIC/FINEP (2019), *Relatório de Gestão do Exercício de 2018*, *www.finep.gov.br/images/a-finep/FNDCT/05_06_2019-Relatorio_de_Gestao_Finep_2018.pdf*.

Figure 5.7. Yearly expenditures of the federal Brazilian agencies fostering R&D, 2010-18



Note: CNPq = National Council for Scientific and Technological Development; CAPES = Foundation for the Coordination for the Improvement of Higher Education Personnel; FINEP = Brazilian Agency for Innovation and Research.

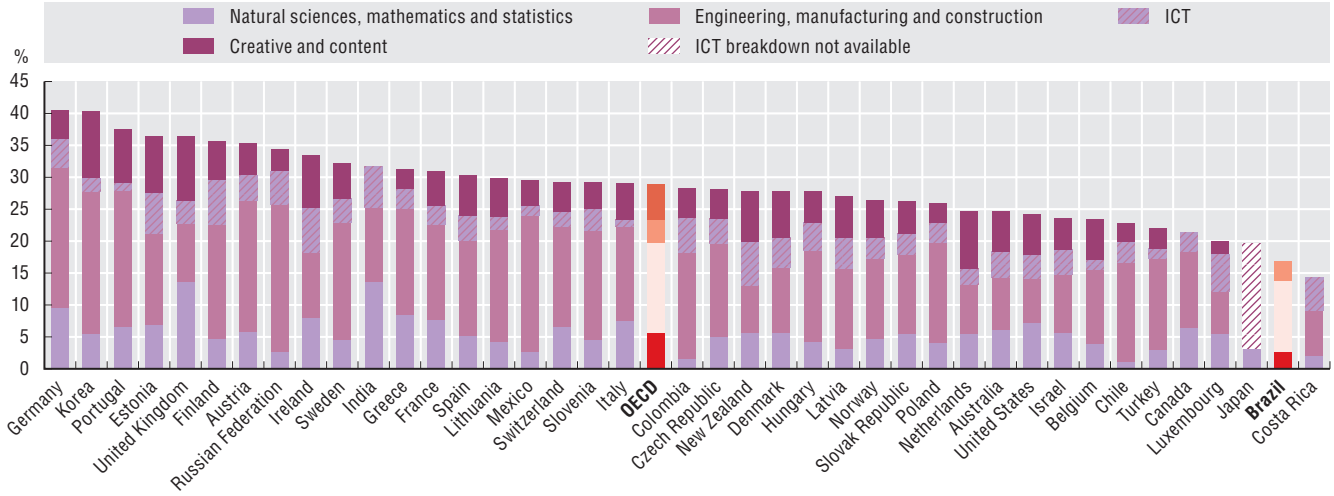
Source: SBPC (2019), *A Política Brasileira de CT&I e as Manifestações da Comunidade Científica*, *http://portal.sbpcnet.org.br/wp-content/uploads/2019/12/cartilha_manifestos_SBPC_online.pdf*.

Human capital is a bottleneck in the innovation system

The Brazilian higher education system includes both public and private universities, and different types of institutions, with the largest majority of them (*faculdades* and *centros universitários*) being education-oriented. Most of the research is carried out in public federal and state universities (*universidades*), together with research centres and non-profit organisations. Over the past decade, Brazil has seen rapid growth in participation in higher education, mostly as a result in expansion of private higher education establishments (OECD, 2018b), which currently represent 88% of the more than 2 530 HEIs (MEC, 2018). This marks a considerable increase in tertiary attainment among the younger generation (25-34 year-olds), from 11% in 2008 to 21% in 2018. Overall, however, the share of graduates among the adult population remains low, at 18%, compared to 39% in OECD countries, but also Latin American countries such as Argentina (36%), Chile (25%), Colombia and Costa Rica (23%) (OECD, 2019c).

Graduates in sciences, engineering and ICTs also represent a lower share of graduates than in developed economies and other Latin American countries (Figure 5.8). Among PhD graduates – whose absolute number has increased fourfold in the past two decades (MEC, 2018) – the preferred specialisations are health and human sciences, whereas engineering increased less than the average (CGEE, 2016). Increasing Masters' and PhD graduates is an objective of the National Education Plan (Plano Nacional de Educação, PNE). Whereas the goal of reaching 60 000 Masters graduates by 2024 was attained in 2018 (64 430 in 2018), the one of achieving 25 000 PhDs was still not realised (22 900).

Figure 5.8. Tertiary graduates in the natural sciences, engineering, ICTs, and creative and content fields of education in Brazil, the OECD and selected countries, 2016



Notes: ICT = information and communication technology. The "Creative and content" field includes arts (including graphic design), journalism and information. For Japan, "Creative and content" fields of education are not presented due to data availability.

Source: OECD (2019a), *Measuring the Digital Transformation: A Roadmap for the Future*, *https://doi.org/10.1787/9789264311992-en*.

Human capital is the most important asset for establishing of a strong ICT sector, as shown by the "Start-up Nation" Israel, which has managed to attract R&D operations from leading ICT multinationals through the presence of highly skilled human capital and government policies. Strong investment in education, especially in maths, is also a core feature of Singapore's success in the digital economy (Getz and Goldberg, 2016). For the Brazilian economy to shift towards higher levels of knowledge intensity, Brazil needs to broaden and deepen its human resource base, by increasing the number of graduates in science, technology, engineering and mathematics (STEM). CAPES has recently announced a change in its funding mechanism, which, among others, will distribute an increased share of scholarships to PhD courses, as compared to Masters. The country may also consider making changes in the distribution of scholarships in relationship to the subject, in favour of STEM degrees. Some countries, given the shortage of talent in these disciplines, particularly those related to digital technologies, are increasing funding for higher education in these fields. Introducing interdisciplinary dual learning programmes may also be an option.

Several OECD countries have included in their national artificial intelligence (AI) strategies specific initiatives to develop AI talent, through the creation of AI Master or PhD programmes, and initiatives to attract, retain and train domestic and international AI talent. Brazil also needs to increase the attractiveness of its HEIs for foreign students, by encouraging the use of English in courses. Canada and France created AI Chairs Programmes to attract and retain top researchers and to train young researchers. The AI Sector Deal in the United Kingdom supports AI fellowship programmes, government-funded PhDs and industry-funded Masters. The AI Technology Strategy in Japan plans to tackle the shortage of AI talent by creating new programmes and providing higher salaries to researchers (Planes-Satorra and Paunov, 2019). Other emerging economies, such as Indonesia, have also increased their support to skills development in key digital technologies in recent years. In 2019, the Indonesian Ministry of Communication and Information funded 25 000 digital talent scholarships in areas such as AI, the Internet of Things (IoT) and cybersecurity, and it has recently announced it will double the number of supported students in 2020.

Brazil should also consider demand-side initiatives to actively orient more students towards STEM disciplines. A few initiatives of this type have been carried out in the country (see Chapter 3). Effective actions in this regard concern early exposure of students to STEM subjects at primary and secondary education levels, including through extra-curricular activities in the form of coding bootcamps, so as to boost their interest in science. Role models are also important, particularly for girls, who usually find it difficult to picture themselves in a STEM career. Girls have a higher fear of failure and less positive attitudes towards competition than boys, which also influences their career choices (Encinas-Martin, 9 March 2020). Exposure to real-world applications of STEM knowledge can change their attitude (Microsoft, 2018). Other actions include initiatives at the higher education level, such as increasing courses in particular subjects, offering scholarships to support students engaging in these disciplines or offering opportunities to a greater number of students to study them. In Sweden, students who did not follow STEM related-courses in secondary education can get a first year with basic knowledge in STEM so that they are eligible to study at university level.

High-quality research is concentrated in a few institutions and fields

Although the number of researchers has seen a threefold increase in the past two decades (MCTIC, 2019a), their proportion in the total employed population is very low compared to OECD countries (Figure 5.9). The increase in the number of researchers has resulted in growth of the country's scientific output, and Brazil currently ranks 11th worldwide in terms of total number of scientific publications. Publications in science and engineering increased at an annual average growth rate of 5.2% between 2000 and 2018 (US National Science Foundation, 2019), although at a lower pace than that of other major emerging economies, such as the People's Republic of China (hereafter "China") (7.8%) and India (10.7%).

There is high variation in the quality of research outputs, with excellence concentrated in a few public universities, mainly in the Southeast region, and in fields of research, which have benefited from targeted sector investment. Medicine and biochemistry are the most influential research areas of publication (Zuniga et al., 2016; Clarivate Analytics, 2018), whereas technological areas are less prominent internationally. Publications on computer science have a higher citation rate compared to the country's overall scientific production, but remain well below the average for OECD countries or other developed and emerging economies (Figure 5.10).

Out of the 197 universities in Brazil, 6 are ranked among the world's top 500, but only 3 in the computer science and engineering field (ShanghaiRanking Consultancy, 2020: the University of São Paulo, the University of Minas Gerais and the University of Campinas, all located in the Southeast region of the country. These are the digital economy poles in Brazil, which have also built large ecosystems of public-private co-operation, and where most of the research infrastructure in ICT is located (De Negri and de Holanda Schmidt Squeff, 2016).

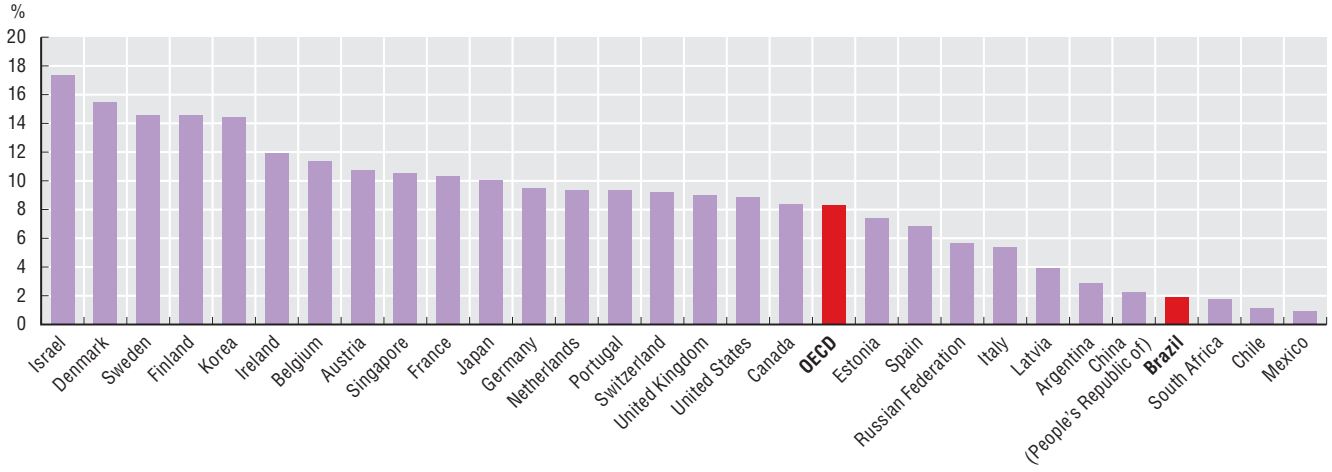
There is a gap between basic and applied research

The increase in scientific publications has not been mirrored by an improvement in patenting activities, with the notable exceptions of the Brazilian high-performing industries, such as aerospace, oil and gas, and agroindustry. Research networks around Embraer (aircraft technologies), Petrobras (oil and gas) and

Embrapa (agriculture) have significant patenting outputs. These exceptional cases are characterised by a long-term involvement of both government and business, as well as specific features, which have been difficult to replicate in other industries (Zuniga et al., 2016).

Figure 5.9. Researchers in Brazil, the OECD and selected countries, 2017 or latest available year

Total researchers in full-time equivalent per 1 000 total employment

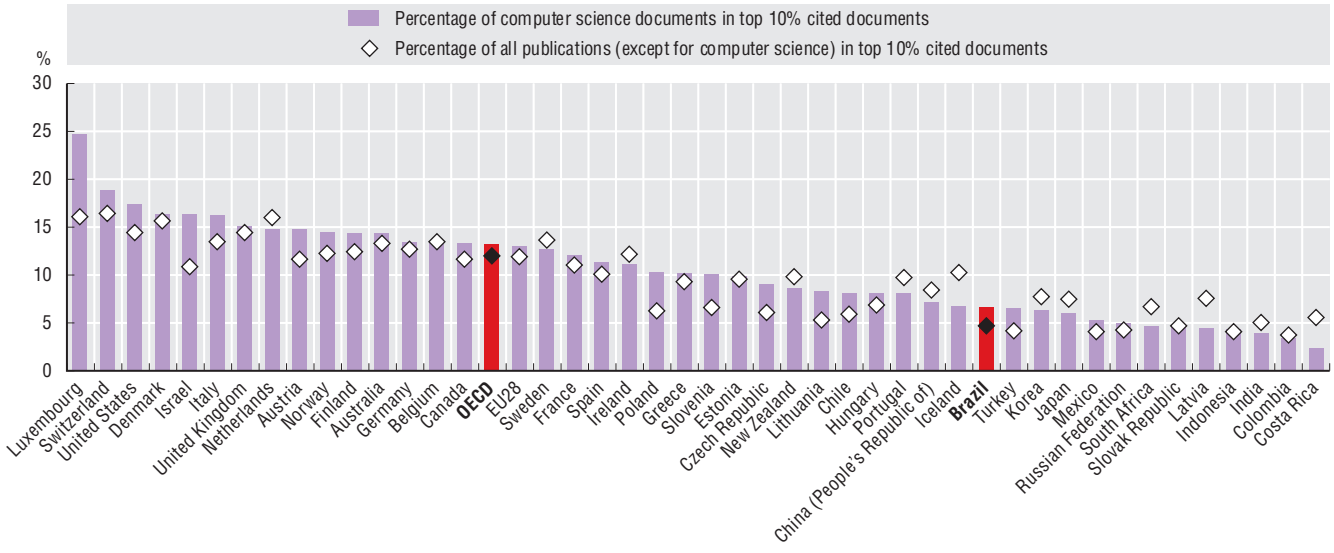


Note: Data for Israel refer to 2012 and for Brazil to 2014.

Sources: OECD (2020b), *Main Science and Technology Indicators* (database), *http://oe.cd/msti* (accessed in March 2020); data for Brazil are from MCTIC (2019a), *Indicadores Nacionais de Ciência, Tecnologia e Inovação 2018*, *https://www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html*.

Figure 5.10. Top 10% most-cited documents in computer science in Brazil, the OECD and selected countries, 2016

As a percentage of documents in the top 10% ranked documents, by field, fractional counts



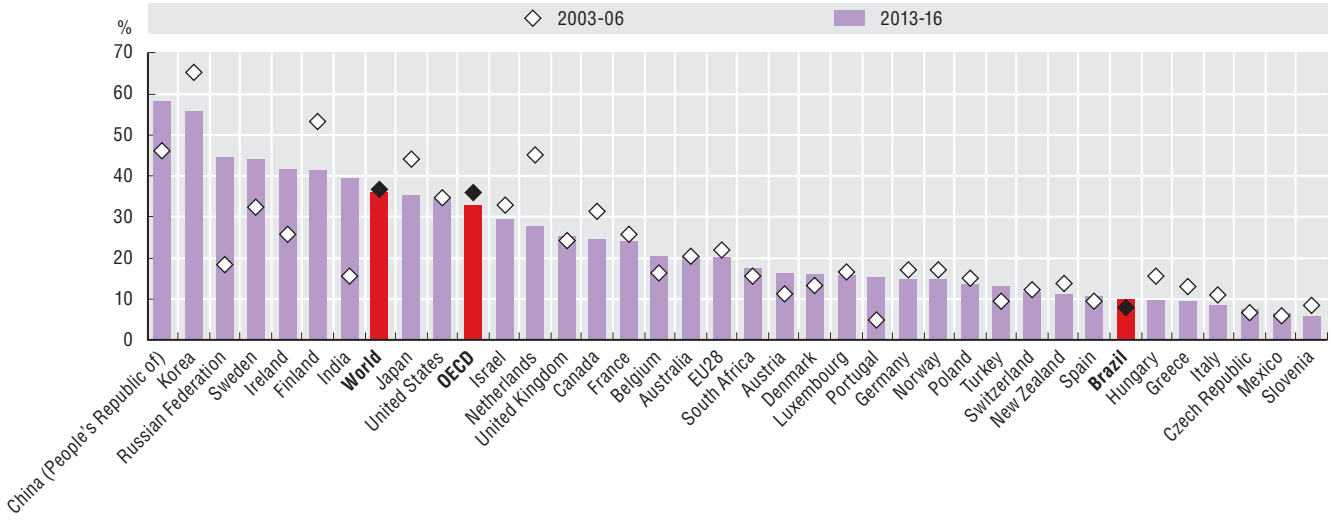
Notes: "Top-cited publications" are the 10% most-cited papers normalised by scientific field and type of document (articles, reviews and conference proceedings). The Scimago Journal Rank indicator is used to rank documents with identical numbers of citations within each class. This measure is a proxy indicator of research excellence. Estimates are based on fractional counts of documents by authors affiliated to institutions in each economy. Documents published in multidisciplinary/generic journals are allocated on a fractional basis to the ASJC codes of citing and cited papers. The field Computer Science comprises the following sub-fields: Artificial Intelligence, Computational Theory and Mathematics, Computer Graphics and Computer-Aided Design, Computer Networks and Communications, Computer Science Applications, Computer Vision and Pattern Recognition, Hardware and Architecture, Human-Computer Interaction, Information Systems, Signal Processing and Software.

Source: OECD (2019a), *Measuring the Digital Transformation: A Roadmap for the Future*, *https://doi.org/10.1787/9789264311992-en*.

The ICT sector does not show the same innovation outputs as the leading sectors. Only 10% of the country's patents were in ICT between 2013 and 2016, compared to about one-third in the OECD and 60% in China (Figure 5.11). Brazil has a revealed technology advantage in biotechnology, but lags behind OECD and BRIICS (Brazil, Russian Federation, India, Indonesia and South Africa) countries in ICTs (OECD, 2016). ICT-related innovations are diffused to other science and technology fields where they can play an important role in further innovation. Brazil has a share comparable to the world average of ICT-related patents in the area of measurement, but also a relative specialisation in control instruments and digital communications, probably in relation to the use of these technologies in sectors such as agriculture and aviation (Figure 5.12).

Figure 5.11. Patents in ICT-related technologies in Brazil, the OECD and selected countries, 2003-06 and 2013-16

As a percentage of total IP5 patent families, by country of ownership

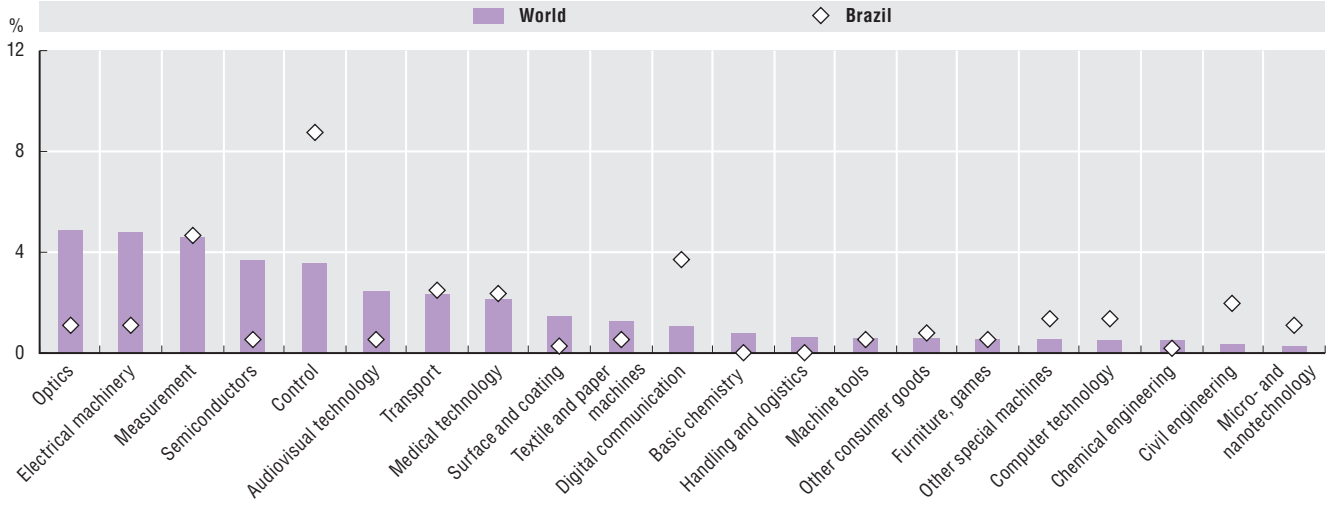


Notes: IP5 = five largest intellectual property offices. Data refer to IP5 families, by filing date, according to the applicants' residence using fractional counts. Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017). Only economies with more than 250 patents families in the periods considered are included. Data for 2015 and 2016 are incomplete.

Source: OECD (2019a), *Measuring the Digital Transformation: A Roadmap for the Future*, *https://dx.doi.org/10.1787/9789264311992-en*.

Figure 5.12. Top technologies combined with ICT-related patent applications, 2014-16

As a percentage of ICT-related patent applications also belonging to other technology fields



Notes: Data refer to IP5 patent families, by filing date, using fractional counts. Patents in ICT are identified using the list of International Patent Classification (IPC) codes in Inaba and Squicciarini (2017). Patents are allocated to technology fields on the basis of their IPC codes, following the concordance provided by WIPO (2013).

Source: OECD (2019d), *STI Micro-data Lab: Intellectual Property Database*, *http://oe.cd/ipstats* (accessed in September 2019).

The low patenting activity is affected by the backlog in the analysis of applications at the National Institute for Patents (Instituto Nacional da Propriedade Industrial, INPI), which results in an average 10-year delay for a patent application to be processed, with peaks of 13 years for pharmaceuticals and telecommunications patents. The INPI has started working on measures to address this problem, including a 25% increase in staff and restructuring of the internal processes. It also has a plan to digitalise its services and expand its IT infrastructure. Patent prosecution highways (PPH), i.e. examining patent applications based on the decisions already published by other jurisdictions programmes, are proving effective in accelerating patenting process, with an increase of 77.4% in the granting of patents in 2018 compared to the previous year. The INPI currently has six PPH programmes in force, for specific fields of technology. To further accelerate patenting processes, the INPI should work towards abolishing the restrictions on the technological fields included in the existing PPH pilot projects (information technology, for instance, is not included in the PPH with the European Patent Office).

Collaboration between enterprises and academia is still limited

Collaboration across sectors and disciplines, and technology transfer from academia to industry, are highly relevant for digital innovation. In Brazil, this relationship, although increasing, is still limited and is often given as another key explanation for the country's low innovation results. Heavy bureaucracy and low incentives in universities (Reynolds and De Negri, 2019), as well as a lack of qualified personnel in firms (Rapini, Chiarini and Bittencourt, 2016) hinder such collaborations.

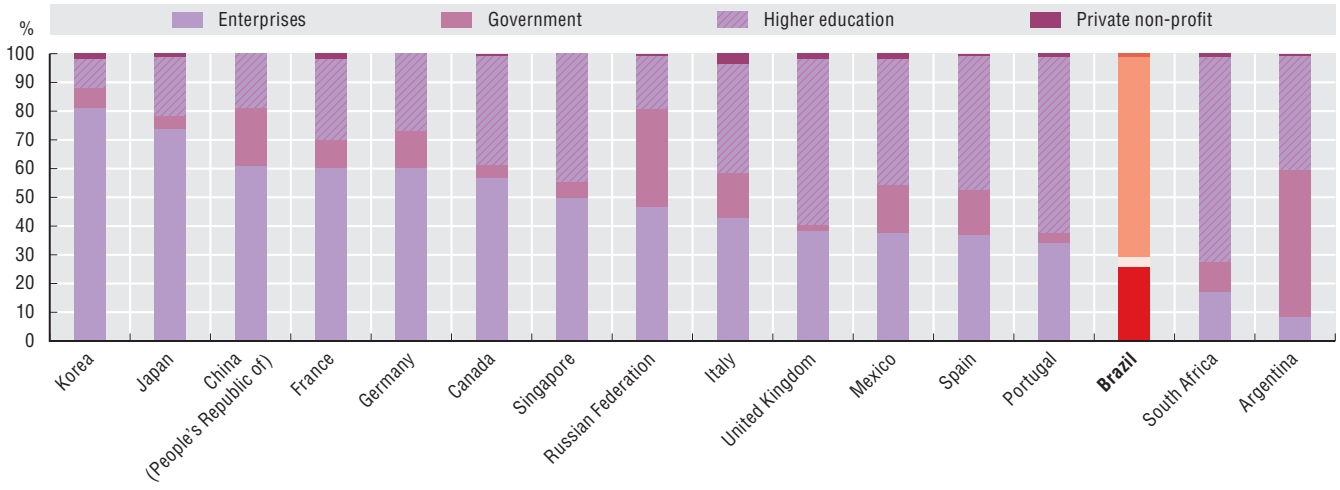
Policies that foster university-industry collaborations have succeeded in stimulating growth in papers co-authored with researchers from industry (2.4% of all scientific publications), but to a level which is still low in international comparisons, e.g. 3.8-4.4% in France, Germany and Korea. Public universities are at the forefront of collaborations with industry, but with an uneven quality of universities and research centres across the country. For instance, São Paulo and Campinas universities have comparable and even higher rates of co-operation with industry than some of the leading universities in the United States (Cruz, 2019). The number of start-ups spun off from these universities is also high: the University of Campinas Unicamp generated over 100 start-ups between 2014 and 2016, most of them in the field of ICT (Cruz, 2019).

Researchers collaborate little with the private sector

A key feature in the Brazilian STI system is the high rate of researchers engaged in careers in academia and government, contrary to those in OECD countries and China, who mostly contribute to R&D innovation in the private sector (Figure 5.13). This seems to be driven by a lack of demand by enterprises, which do not compete with academia in terms of salary (Figure 5.14). Only some state-owned enterprises absorb researchers due to their big research centres, whereas the academic job market remains more attractive to PhD holders, who can benefit from a public servant status and guaranteed tenure after three years. Weak demand of high-skilled workers signals a lack of technology absorption capacity of firms. With regard to digital technologies, Brazilian firms are still at an early stage of adoption. To strengthen this, Brazil needs to reinforce policies for outreach, technology extension and skills for innovation, including managerial skills (see Chapter 3).

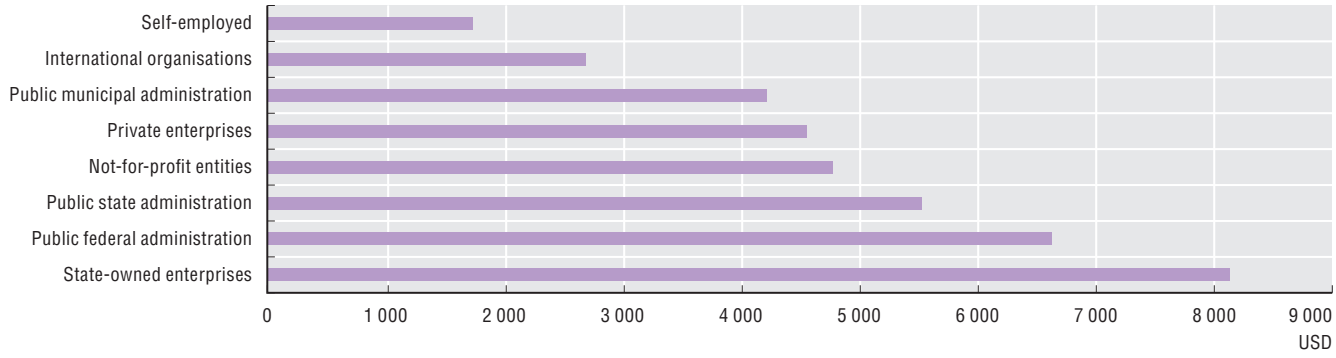
The CAPES system, through which post-graduate courses are evaluated, ascribes the greatest weight to scientific publications. Although patents and technical outputs are also considered in the assessment, there are no metrics on collaboration with industry, or the impact of scientific research on the marketplace, business strategies or public policy (Mazzucato and Penna, 2016). Introducing indicators on research's impact on the economy and society would help focus research towards areas that are better linked to economic, social and commercial applications, and would orient researchers towards perspective careers in the private sector. Higher exposure to the private sector during their studies, for instance allowing business experts to take up teaching assignments, may also increase openness to careers in the private sector, while bringing in knowledge about applications in economic sectors. Promoting an entrepreneurial culture throughout the education system will also be key in altering cultural factors, which influence preference for lifelong careers.

Figure 5.13. Researchers in Brazil and selected countries, by sector, 2017 or latest available year



Sources: OECD (2020b), *Main Science and Technology Indicators* (database), *http://oe.cd/msti* (accessed in March 2020); data for Brazil are from MCTIC (2019a), *Indicadores Nacionais de Ciência, Tecnologia e Inovação 2018*, *https://www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html*.

Figure 5.14. Average monthly remuneration of PhD holders in Brazil, by sector, 2014



Source: CGEE (2016), *Mestres e doutores 2015: Estudos da Demografia da Base Técnico-científica Brasileira*, *https://www.cgee.org.br/documents/10182/734063/Mestres_Doutores_2015_Vs3.pdf*.

Efforts have been made to enhance public-private co-operation and businesses' investment in innovation

In the past 15 years, Brazil has introduced new regulatory measures to enhance firms' collaboration with universities and research centres. The Innovation Law (Lei Federal de Inovação, Law 10.937/04) aimed to facilitate collaboration between academia and industry by formalising the rules for interactions between researchers and firms. The law also created the possibility for the government to provide direct funding to businesses, which was not allowed until then. However, the law did not lead to a straightforward process of co-operation across sectors (Rauen, 2016). The law was profoundly revised in 2016 through the Legal Framework for Science, Technology and Innovation (Marco Legal de Ciência, Tecnologia e Inovação, Law 13.243/16), followed by a regulatory decree two years later (Decreto Federal de Inovação, Decree 9.283/18). The government also created EMBRAPII in 2013, a new "social organisation" – a private non-profit entity which manages public research facilities under contract to federal agencies. Through its agile, flexible and performance-based working model, it may be considered as one of the most effective novelties in the Brazilian innovation system for promoting industry-research collaboration (Box 5.1).

The overall objective of the Legal Framework for Science, Technology and Innovation is to bring more legal clarity to the interactions between the public and private sectors. To this end, a number of provisions specify, for instance, the number of hours that a university professor can spend on non-university activities, or the requirements firms must fulfil in order to rent laboratories in public research institutes. The framework clarifies the management of intellectual property rights generated by academia, by tasking

the technological innovation hubs (*núcleos de inovação tecnológica*, NITs) with this role. NITs, however, are not new institutions to the country, as they were established by the Innovation Law.

One of the main novelties brought about by the new framework concerning NITs is the possibility for these entities to have their own legal personality, and thus more agility in operating than if they were subject to public sector regulations. This will be particularly important in relation to their hiring capacity, both in terms of the speed of recruiting and in the variety of profiles they will be able to attract. Both the size and composition of technology transfer offices' (TTOs) staff are crucial for them to play a central role in university productivity (Pojo et al., 2016). Staff need to be diversified in terms of background (science, economics, law, etc.), but also have a strong component from the business environment. The Israeli network of TTOs linked to research hubs, which is considered one of the key factors of the country's innovativeness, can be a model in this sense. Business leaders are on the TTOs' boards, so the market dimension is brought to the scientific ecosystem. They can act as intermediaries between researchers and business investors.

Box 5.1. Promoting industry-research collaboration: EMBRAPII, a new player in Brazil's innovation landscape

EMBRAPII is a governmental agency established in 2014. It is funded by the Ministry of Science, Technology, Innovations and Communications and the Ministry of Education, but decides the allocation of its resources independently. Its main objective is to stimulate private-public co-operation by linking research institutions and universities with the industrial sector. EMBRAPII selects private and public research institutions in specific areas of competence ("units"). The selection is based on previous co-operation with businesses, technical capacity and the quality of the research infrastructure. Selected institutions have a six-year agreement with EMBRAPII to undertake innovation projects in co-operation with firms, and are evaluated on a regular basis.

To date, EMBRAPII has 42 accredited units across 5 technological areas, 18 of which are in the Internet of Things and advanced manufacturing (Table 5.4). After accreditation, the institution receives funding from EMBRAPII to be spent exclusively on innovation projects with industry. Firms looking for innovative technological solutions can approach the accredited institutions of their choice and sign a contract with them. EMBRAPII does not interfere in the contract formulation, but supervises its execution. EMBRAPII therefore has a very agile way of working, with minimal bureaucracy. The project costs are shared by EMBRAPII (generally, one-third, through non-refundable grants), the enterprise (at least one-third) and the research institute (in-kind via its infrastructure and personnel).

Micro and small firms can also collaborate with EMBRAPII units and receive financial support for it. The Brazilian Micro and Small Business Support Agency (Serviço Brasileiro de Apoio às Micro e Pequenas Empresas, SEBRAE) can finance up to 70% of a firm's contribution to the project, and 80% for projects carried out in partnership with another firm (a start-up or a large firm).

Out of the 500 firms involved in EMBRAPII's projects since its creation, 42% were small (annual gross billing up to USD 1.2 million, or BRL 4.8 million), 17% medium (USD 1.2 million to USD 76 million, or BRL 4.8 million to BRL 300 million) and 41% large (annual gross billing over USD 76 million, or BRL 300 million). Small firms are increasingly requesting co-operation with EMBRAPII units, particularly for projects focusing on the Internet of Things, health and agriculture.

EMBRAPII appears to be an important institutional innovation in Brazil, both for firms' R&D and for industry-research co-operation. In its five years of existence, the organisation has developed a portfolio of 800 projects, involving 570 firms collaborating with 42 research institutes and universities. The research outputs are also promising, with more than 300 intellectual property applications, and the model is proving effective in bringing researchers closer to the business environment. The units are able to attract talents to work on projects and to retain researchers for further projects, thus also influencing career mindset and research orientations.

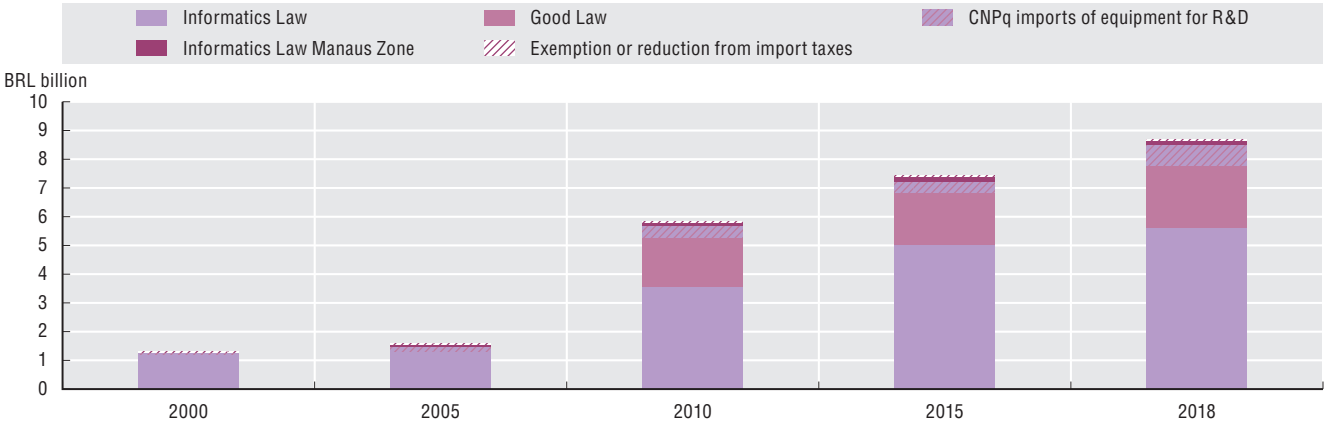
Source: OECD, based on information provided by EMBRAPII and on EMBRAPII (2020), *EMBRAPII*, *www.embrapii.org.br* (accessed in March 2020).

Public support to business R&D has increased, but young and small firms have limited access to it

Brazil has shifted in recent years towards a greater reliance on tax relief *vis-à-vis* direct support for R&D towards the business sector. The foregone revenue through tax incentives for R&D is estimated at about USD 2.4 billion (BRL 8.6 billion) in 2018 (Figure 5.15). Most of these incentives benefit the ICT manufacturing sector through the Informatics Law (see below), and the Good Law, which applies to all sectors. Tax breaks are also granted to universities and research institutions, exempting them from the payment of import duties on purchases of scientific equipment and materials. Another type of tax incentive benefits the ICT firms established in the Manaus Free Trade Zone, through the exemption of federal indirect taxes on sales and import tariffs on inputs.

Figure 5.15. Support to R&D through tax incentives in Brazil, 2000-18

Value of foregone revenues due to tax incentives



Note: Value for 2018 is an estimate.

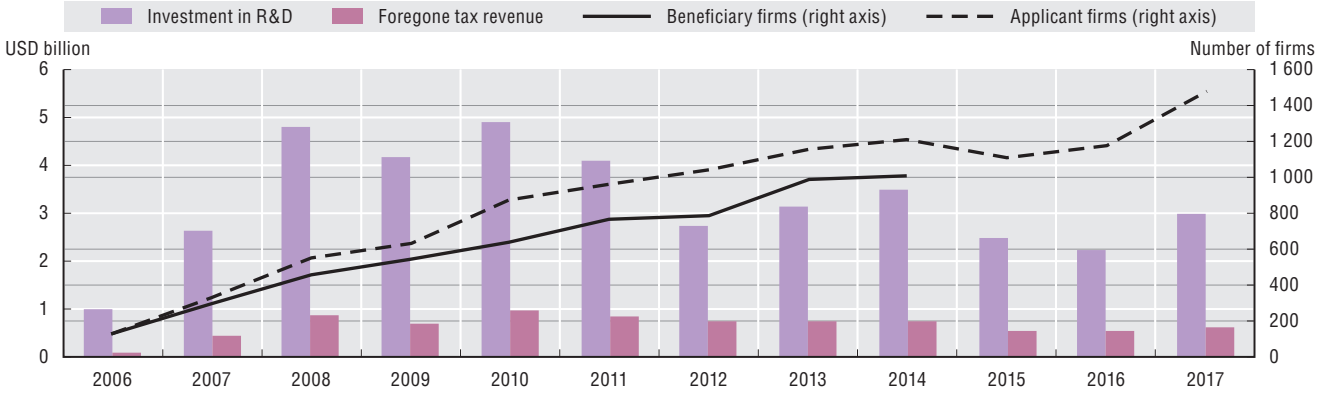
Source: MCTIC (2019a), *Indicadores Nacionais de Ciência, Tecnologia e Inovação 2018*, *https://www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html*.

In 2005, the Good Law introduced a tax incentive for R&D investments available to firms in all sectors (Lei do Bem, Law 11.196/05). The law grants volume-based tax allowances on the corporate income tax for investments made in R&D. Firms can deduct up to 160% of their investment from the taxable base of corporate income, and this rate can increase up to 200% in case new researchers are hired and expenditures are related to patented products. Firms may also benefit from accelerated depreciation and amortisation for the purchase of new equipment and technology, along with a 50% reduction of the tax for industrialised products (Imposto sobre Produtos Industrializados, IPI) rate. Finally, they are also exempted from income tax on any international payments for the registration of intellectual property. Legislation also provides for a super deduction of up to 250% of eligible expenses made available for innovation projects executed by science, technology and innovation institutions (Instituições de Ciência, Tecnologia e Inovação, ICTs). Science, technology and innovation institutions are public or private non-profit legal entities, operating in basic, applied scientific or technological research for the development of new products, services and processes.

Deductible expenses are possible in a number of activities, namely: basic and applied research; experimental development; basic industrial technology; and technical support services. In order to benefit from the incentives, firms must: invest in RD&I activities; operate under the actual income (*lucro real*) tax regime; have earned a profit in the period referring to expenditures; and demonstrate fiscal regularity. The investments do not need prior approval, but activities and expenditures related to R&D and innovation are assessed *ex post* by the MCTIC, which can approve or reject the tax allowance. In 2014, 16% of the applications for the incentive were rejected (MCTIC, 2016).

Although the law has represented a turning point in support to firms through tax incentives compared to previous policies (Colombo, 2016), and despite a growing number of firms which have benefited from the incentive over the years (Figure 5.16), the number of applicants and beneficiaries is rather low. In 2017, only 1 476 firms applied for the incentive, or just over 2% of the potentially eligible firms (Figure 5.16).

Figure 5.16. The Good Law: number of applicant and beneficiary firms, 2006-17



Notes: R&D = research and development. Yearly reports with data on beneficiary firms are only available up to 2014. Investments in R&D are those realised by beneficiary firms for the years up to 2014 and those realised by all applicants for the years 2015-17.

Sources: MCTIC/SETEC (2016), *Relatório Anual de Atividades de P&D (Retificado) 2014. Lei do Bem - Utilização dos Incentivos Fiscais à Inovação Tecnológica – Ano Base 2014: Capítulo III*; CGEE (2018), *Uma Análise dos Resultados da Lei do Bem: Com Base nos Dados do FormP&*, *https://www.cgee.org.br/documents/10182/734063/Mestres_Doutores_2015_Vs3.pdf*; MCTIC (2019a), *Indicadores Nacionais de Ciência, Tecnologia e Inovação 2018*, *https://www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html*.

The lengthy and burdensome application process, coupled with the uncertainty about the outcome may impact negatively on a firm's decision to apply. Kannebley and Porto (2012) pointed to the management and control processes as the main shortcomings of the law. Furthermore, two features of the policy design narrow its scope of application to a small minority of firms. First, as only businesses operating under the actual income tax regime are eligible, micro and small businesses – the majority of Brazilian firms – which typically operate under the deemed profit (*lucro presumido*) or the simplified (Simples Nacional) tax regime, are excluded. Second, the Good Law does not foresee provisions for refund of the tax allowance generated by the R&D expenditures, as it is the case, for instance, for the tax credits in the Informatics Law (see below). It also does not foresee the possibility to deduct the expenses in subsequent years when a profit is generated ("carry forward"). Young firms such as start-ups tend to fall outside the scope of the law, as they generally incur losses in their first years of activity when they perform R&D investments. Indeed, only 2% of the most innovative Brazilian Fintech start-ups used the incentive in 2018 (PwC and ABFintech, 2019). The law foresees an additional mechanism for start-ups to engage in activities. If they provide their services for R&D and innovation activities to a firm that fits the requirements of the Good Law, the revenues obtained from these services are not taxed. However, it is the partner company that benefits directly from the Good Law, as its expenditures are eligible for the tax allowance.

Evaluations of the law carried out to date point to additionality impact on research technical staff and on R&D spending (Kannebley and Porto, 2012; Kannebley, Shimada and De Negri, 2016; Colombo, 2016), and stimulus for firms to intensify their innovation strategies (Kannebley and Porto, 2012). Colombo (2016) also found that the policy has increased the base of firms investing in innovation and innovating, although there was no evidence of impact on firms' productivity or the sales and exports of new products.

Given the positive results of the Good Law, this tax incentive should be extended to a larger number of firms, first through advocacy actions to make the incentive known to a wider number of eligible firms operating in the actual income regime. Increasing clarity about what is included in the scope of the law would help firms to better assess their perspective projects and their potential to be granted the incentive, while making the application process less cumbersome would reduce costs. The MCTIC could also consider the possibility of using external audits from accredited firms to accompany the dossiers, to reduce the internal burden, while having an independent assessment (as is the case for the Informatics Law since 2018, see below). A measure undertaken by the MCTIC to address some of the above points has been the launch in 2019 of a "Guide to the Good Law" (MCTIC, 2019b), which explains the features of the law, including the main reasons which led in the past to rejections. Second, the incentive would benefit from some improvement in its design, such as allowing carry-forward or cash-refund provisions so that young companies can also become eligible. This would benefit smaller

firms in general and would be particularly relevant for start-ups and software development firms. Although the software sector is among those with the most beneficiaries (15% of firms in 2018), they represent only about 5% of the 5 140 firms that are active in software development in Brazil. As 95.5% of them are micro and small enterprises (ABES, 2019), in most cases they likely do not meet the requirements of the law.

Offering carry-forward provisions and cash refunds if there is a negative tax liability is considered an effective measure for stimulating R&D in young innovative companies (Appelt et al., 2016). Tax credit schemes in OECD countries similar to the Good Law provide the opportunity for young innovative firms to receive an immediate refund of the tax credit gained through investments in R&D. France is one of such cases. The country has also recently introduced a new mechanism, which offers preferential tax arrangements for start-ups (Box 5.2). Evidence suggests that the impact of R&D tax incentives in terms of stimulating business R&D is stronger for young companies and SMEs (Ognyanova, 2017).

Box 5.2. Tax incentives supporting start-ups: The French Research Tax Credit and the Young Innovative Enterprise status

In France, the Research Tax Credit (crédit d'impôt recherche, CIR), grants businesses that invest in research a tax credit, which can be offset against the corporation tax they owe. All industrial, commercial or agricultural businesses taxed on the basis of their actual profits (under both the simplified and normal tax regimes) are eligible for the CIR. Scientific or technical research eligible for the scheme includes fundamental and applied research, as well as experimental development.

Since 2013, the Research Tax Credit has been extended to cover certain innovation investments by small and medium-sized enterprises (SMEs). These have to do with operations to design prototypes for new products not yet on the market, or which have superior features.

The CIR is deducted from taxes due by the business. Any remaining non-deducted CIR can be offset against taxes owed for the subsequent three years. The unused portion of the tax credit is refunded after this period. It is immediately refundable for SMEs and Young Innovative Enterprises.

The Young Innovative Enterprises/University status (Régime de la jeune entreprise innovante [JEI] or universitaire [JEU]) grants exemptions from taxes and social security contributions to new businesses (created before 31 December 2022) that invest in R&D.

To have JEI status, at each financial year-end, a business must: be an SME; have been set up for less than eight years; be independent (it must be a minimum 50% owned either by individuals or by certain firms in the venture capital sector, or by research and education institutions, or by non-profit organisations or scientific public interest foundations, etc.); not created out of a merger, restructuring, spin-off or takeover of pre-existing businesses; invest an amount for research representing at least 15% of tax-deductible expenses. To have JEU status, a business does not have to have to meet the criterion for research expenditure, but must fulfil a number of special conditions.

New businesses with JEI status are entitled to exemptions from:

- Personal income tax or corporate income tax: total exemption for the first financial year or the first period when they are taxed on profits (this may not be longer than 12 months), followed by a 50% exemption for the next year when they have a profit.
- The local economic contribution (CET) and property tax for seven years following a decision by the local government.

The exemption from tax on profits can be combined with the CIR and JEIs can also receive an immediate refund of their CIR credits.

Sources: OECD (2020c), *OECD Compendium of Information on R&D tax incentives, 2019*, *http://oe.cd/rdtax (accessed in March 2020)*; Ministère de l'Économie et des Finances (2020), *Innovation: Quels Sont les Aides et Crédits d'Impôt Existants?*, *www.economie.gouv.fr/entreprises/aides-financement-innovation*.

Digital innovation in Brazil

Digital innovation should be at the core of the economic and social agenda

At the federal government level, co-ordination of the research policy is under the responsibility of the MCTIC, the main body of the federal science, technology and innovation (STI) system. Other ministries are involved in the definition and execution of the research budget, including the Ministries of Education, Agriculture, Health, Energy, Economy and Foreign Trade.

The ENCTI 2016-2022 is the medium-term strategic document that sets out the main policy ambitions and provides guidance for the elaboration of STI initiatives. The strategy is based on a fundamental axis: the expansion, consolidation and integration of the National STI System. The strategy also identifies 12 key areas considered to be strategic for the development, autonomy and national sovereignty. Consolidating the digital economy is one of them. The strategy regards ICTs as a set of convergent and enabling technologies with the potential to bring innovation across several sectors. Despite the publication of an action plan in 2018, ENCTI remains an orientation document, lacking a roadmap for implementation. Furthermore, the innovation strategy does not seem to be connected to a broader economic, technological, industrial and social agenda, which would structure innovation efforts around Brazil's most pressing economic and social needs. Such an agenda would set key priorities and mobilise government, academia and the private sector around common goals.

R&D and innovation are "enablers" of the digital transformation in the Brazilian E-Digital Strategy (MCTIC, 2018), which calls for the development of an R&D and innovation policy for the 21st century. Both ENCTI and E-Digital stress the critical importance of R&D and innovation as well as the production of microelectronics, sensors, automation and robotics, supercomputers, artificial intelligence, big data and analytics, high-performance networks, cryptography, 5G networks, and cloud computing. The E-Digital Strategy also identifies priority areas for investment – i.e. security and defence, health, agribusiness and smart cities – along with a list of actions to increase productivity, competitiveness, integration in the global value chain, and thus income and employment. Compared to ENCTI, it nails down more concretely the areas in which digital could be most useful for the national challenges.

As part of the E-Digital Strategy, Brazil adopted (Decree 9.854/19) a National Internet of Things (IoT) Plan in June 2019. The plan's overall objective is to accelerate the uptake of IoT as a tool for the sustainable development of Brazil. The plan focuses on four key horizontal dimensions: 1) innovation and internationalisation; 2) human capital; 3) regulatory safety and privacy; and 4) infrastructure for connectivity and interoperability. It also identifies four key verticals (i.e. applications) regarded as having the largest growth potential in Brazil: agribusiness, smart cities, healthcare and manufacturing, in line with the E-Digital Strategy. The IoT Plan is a good example of a co-ordination effort at the national level, as it was promoted by the MCTIC, supported by BNDES and developed through several rounds of stakeholder interactions. BNDES and FINEP have opened lines of credit and provided grants to support business and academia to develop IoT networking technologies and applications in the priority areas. EMBRAPII is also supporting collaborative research in IoT (see below).

The National AI Strategy is set to promote high public-private co-operation around key national challenges

E-Digital also contains the mandate "to evaluate potential economic and social impact of AI and big data, and to propose policies that maximise effects and minimise negative results". Brazil is currently in the final phases of preparing its National AI Strategy, which has been elaborated through a multi-stakeholder process and has undergone a public consultation (closed in March 2020).

As part of the forthcoming national strategy for AI, the MCTIC and FAPESP, in co-operation with the Brazilian Internet Steering Committee (Comitê Gestor da Internet no Brasil, CGI.br), announced the creation of up to eight applied research centres (centros de pesquisa aplicada, CPA) in AI. These CPAs will be dedicated to applied scientific and technological research oriented to solving real challenges. The first four will focus on healthcare, agribusiness, manufacturing and smart cities, in alignment with the E-Digital Strategy and the IoT Plan. As they will be supported for a period of five years (possibly renewed for another five years, depending on the results achieved), the model ensures predictability of public funding, thus also stimulating the private sector's commitment. Each CPA may receive up to USD 255 000 (BRL 1 million) per year from FAPESP and an additional USD 255 000 from one or more

partner companies. Multinational corporations also see Brazil as a potential AI innovation hub in the future. IBM has established a partnership with FAPESP to launch the first Latin American institution of IBM's AI Horizons Network, with USD 1.3 million (BRL 5 million) per year contributed by each of them.

Public-private partnerships are welcome, as innovation in key technologies such as data analytics and AI requires multidisciplinary and open research infrastructures where stakeholders can work together to advance AI responsibly. However, the rules regulating the CPAs' activities should be carefully designed. Private participation should not be limited to large companies, but needs to be extended to SMEs and start-ups. Setting high co-funding levels for the private sector may discourage the participation of small firms and start-ups; a more inclusive business model is therefore needed. These research centres should stimulate open innovation by establishing mechanisms for interaction of researchers with firms of all sizes and start-ups. The Alan Turing's Institute in the United Kingdom could provide a model for Brazil in this regard (Box 5.3).

Box 5.3. Digital technologies for the public good: The Alain Turing Institute in the United Kingdom

The Alan Turing Institute is the United Kingdom's national institute for data science and artificial intelligence (AI). Founded in 2015, it is an independent private sector legal entity formed as a joint venture between 13 universities. The institute undertakes basic research, and applies its cutting-edge science to real-world problems (revolutionising healthcare; delivering safer, smarter engineering; managing security in an insecure world; shining a light on the economy; making algorithmic systems fair, transparent and ethical; designing computers for the next generation of algorithms; supercharging research in science and humanities; fostering government innovation).

The national dimension of the centre allows delivering benefits that one single university could not deliver alone. The institute is a collaborative hub, with roots in universities and centres of research excellence across the country, counting on scientists from several disciplines and links to a network of industry, public sector and third sector partners. The Turing network encourages direct connections between universities, partners and other communities through a variety of models of engagement, ranging from one-week data study groups to multi-year research programmes, targeted projects and a membership programme for organisations and individuals in data science and AI.

One example of this way of working is the collaboration with the catapult centres, a network of ten physical centres that connect businesses with the country's research and academic communities. Each focuses on a strategic technology area and they offer a space with the facilities and expertise to enable businesses and researchers to collaboratively solve key problems and develop new products and services on a commercial scale. Digital Catapult runs a Machine Intelligence Garage programme to help AI and machine learning businesses gain access to technical expertise, computation power, knowledge and innovation.

Alan Turing and Digital Catapult provided support for nine start-up or scale-up companies to participate in "collaborative hackathons" with the aim to find data science solutions to real-world problems. These week-long events allow organisations to work with the institute, providing the start-ups access to a pool of researchers they may never otherwise have the opportunity to collaborate with.

Source: Alan Turing Institute (2020), *The Alan Touring Institute*, *www.turing.ac.uk*.

E-Digital, the national IoT Plan and the establishment of AI research centres around key areas are a step in the right direction for setting mission-oriented innovation. For the initiatives to deliver, Brazil should make such missions sufficiently granular, so that intermediate goals and deliverables can be set, and involve a wide array of stakeholders, enabling them to develop a shared sense of ownership (Mazzucato and Penna, 2016). The national IoT Plan was elaborated through a wide consultation and stakeholder involvement. The IoT Chamber is the advisory body accompanying its implementation, by monitoring the IoT Plan's initiatives and creating and encouraging partnerships between the public and private sectors. Although the chamber counts on the participation of various ministries (the MCTIC, the

Ministry of Economy, the Ministry of Agriculture, the Ministry of Health and the Ministry of Regional Development), it does not include the participation of stakeholders from businesses, academia or civil society. Involving a broader range of stakeholders is advisable for IoT deployment. Looking forward, a similar AI chamber should oversee and steer the implementation of the National AI Strategy, so that the government interacts with society at large for the advancement of this technology.

Missions are also an integral part of the 9th European Union framework programme for research and innovation, Horizon Europe, which will start in 2021. The programme has established five areas in which missions will be developed (cancer; adaptation to climate change including societal transformation; healthy oceans, seas, coastal and inland waters; climate-neutral and smart cities; soil health and food), with a mandate to solve a pressing challenge in society within a certain timeframe and budget. The European Commission will engage with citizens in a continuous process for the design, monitoring and assessment of the missions. Each of the areas has a mission board tasked with identifying one or more specific missions for implementation under Horizon Europe, i.e. to define specific challenges within the broad areas. The mission boards consist of 15 experts who have been selected through an open call for interest and come from innovation, research, policy making, civil society and relevant organisations. Each mission area also has an assembly that gathers a larger number of high-level experts. The assemblies provide an additional pool of ideas, knowledge and expertise that will be actively called upon to contribute to the success of the missions.

Mission-oriented innovation initiatives should rely on several instruments for their implementation, including demand-side initiatives such as public procurement. In Brazil, despite the conditions set by the new legal framework for innovation for the government to use instruments such as funding or placing direct orders and even minority equity in companies, to date their use has been limited (Tortato Rauen, 2019). High risk aversion among civil servants, who are personally liable for decisions taken as part of their duty, coupled with an increasing scrutiny from the Federal Court of Accounts (Tribunal de Contas da União, TCU), have limited the application of this law. Demand-driven innovation policies require civil servants to have a deep understanding of industries, technologies and markets. Appropriate actions should be taken to strengthen policy intelligence within procuring ministries. One way would be to engage with stakeholders to elaborate roadmaps for developing key technologies in strategic sectors, as suggested above, through formalised settings. BNDES may also provide expertise on the draft calls for tender or contracts. Brazil should also consider reviewing public procurement rules to contract solutions by innovative start-ups, for instance, those providing education services or using public sector data. Such start-ups are flourishing in Brazil and public demand would act as a stimulus for scaling them up.

Data governance frameworks must favour innovation, while respecting privacy

Data fuel innovation in the digital economy. To favour competition and innovation, data access policies should aim to ensure the broadest possible access to data and knowledge. At the same time, they must respect constraints regarding data privacy, ethics, intellectual property rights, and economic costs and benefits (OECD, 2020d). As businesses innovate with data, new policy issues are likely to arise, such as data portability or the treatment of non-personal sensor data, with different challenges at sectoral level (see Chapter 6). For instance, precision agriculture draws mainly on sensor and satellite data, and challenges often relate to data sharing and integration. The retail sector, on the other hand, exploits consumer purchasing and social media data to personalise services; therefore, the main concern is ensuring data privacy.

Brazil passed a General Data Protection Law in 2018. The law creates a normative framework seeking to harmonise and expand the right to personal data protection. However, the delay in establishing a data protection authority, as well as the features such an authority will have, may result in an ineffective application of the provisions (see Chapter 4).

Providing access to data generated by public services can foster data-driven innovation. Concerning policy initiatives for enhancing access to and sharing of data, the "Transparency Law" (Law 12.527/11) regulates access to information from public entities that are part of the direct administration of the executive, legislative, judiciary and public prosecution service. Decree 8.777/16 establishes the Open Data Policy for the Federal Executive Branch. The Ministry of Economy is also working on a "Government as a Platform" project (see Chapter 3), which will provide a legal mechanism by which the private sector

will be able to use public data in a controlled environment. This is a positive initiative, as access to data can enhance public service delivery and facilitate the identification and resolution of emerging governmental and social challenges.

Brazil needs a balanced mix of policy instruments to spur digital innovation

Following the adoption of the E-Digital Strategy and the national IoT Plan, Brazil has been experimenting with new instruments for R&D and innovation in key digital technologies. These remain, however, relatively limited in number and volume of funding, whereas support to the ICT sector is mostly granted through tax incentives (Table 5.1).

Table 5.1. Main instruments supporting R&D and innovation in ICT in Brazil

Instrument	Type	Value (USD)	Type of beneficiary
Informatics Law	Tax credit	1.35 billion of tax credit resulting in 430 million/year in R&D investment (2016 values)	Firms in the ICT sector (manufacturing)
CNPq: Grants for research projects in computing sciences	Grants	3.8 million/year (average 2013-15)	Researchers
CNPq: Technology bonus and grants in advanced manufacturing	Grants (one-off)	547 000 in 2018	Small and medium-sized enterprises in partnership with large firms
BNDES IoT Pilot	Grants (one-off)	8.2 million in 2018	Consortia led by a public institution, with the participation of firms, municipalities and healthcare providers
FINEP IoT	Credit at preferential rate	410.5 million	Medium/large firms in the manufacturing sector
FINEP Inovacred 4.0 Pilot	Credit at preferential rate	50.9 million	Small and medium-sized enterprises in the manufacturing sector
EMBRAPII Programme of National Interest (PPI) in IoT, advanced manufacturing, robotics or mechatronics	Grants conditional to private-public collaboration	15.3 million/year	Firms in all sectors in co-operation with public universities or research centres

Notes: The purpose of the table is illustrative. It only shows programmes that are specifically designed for the ICT sector/digital technologies such as the Internet of Things (IoT) and advanced manufacturing. It does not include information about horizontal programmes, such as traditional credit lines, which may also support ICT innovation.

The Informatics Law needs to be revised

In Brazil, the Informatics Law (Lei de Informática, Law 8.248/91, last amended by Law 13.969/19) provides firms in the ICT manufacturing sector with tax credits for R&D expenditures. The law was issued in the early 1990s after two decades of highly protectionist policies, with the objective of increasing the national manufacturing capacity and generating jobs.

The law provides tax credits as a counterpart to investment in R&D and innovation, which firms can use to reduce the amount due on their corporate income taxes. They also benefit from an exemption on the IPI for intermediate goods used in the production of the incentivised goods.

In order to benefit from the tax credit, firms manufacturing ICT goods specified in the law (Article 16A of Law 8.258/91) must:

- produce according to the basic production process (*processo produtivo básico*, PPB), which is established by the Ministry of Economy and by the MCTIC and defined as "the minimum set of operations at the factory that characterizes the effective industrialization of a given product" [Law 8.387/1991])
- invest a minimum of 4% of their gross turnover from the sales of goods covered by the law and produced according to the relevant PPBs in R&D and innovation activities in the ICT sector
- be accredited by the MCTIC.

Firms have several options to invest in R&D and innovation. Part of the investment has to be directed to accredited STI or public research centres/HEIs, and to the FNDCT. Firms can also finance projects of national interest in the areas of ICT considered as government priorities (Programas e Projetos de

Interesse Nacional nas Áreas de Tecnologias da Informação e Comunicação, PPIs). Examples of such projects are those in IoT and advanced manufacturing under the management of EMBRAPII (see below). For the remaining amount, firms can invest in internal R&D, or, in funds supporting innovative start-ups, among others (Table 5.2).

The tax credit is a multiple of the amount invested, with multipliers varying depending on the firm's location and the object of the R&D and innovation. The credit, as calculated through the multiplier, cannot exceed a given ceiling, expressed as a percentage of the base of the R&D and innovation investment (the gross turnover from the sales of goods covered by the law and produced according to the PPB). Multipliers and related ceilings progressively decrease until 2029.

Multipliers and ceilings are established so that 4% is both the minimum and the maximum percentage of turnover firms would invest in R&D and innovation, as any additional expenditure would lead to a percentage above the ceiling, which will not generate any credit. The only incentive to spend higher percentages of gross turnover in R&D and innovation is for firms that do not fully reach the objectives set by the PPB (but still have to reach a minimum threshold), and can therefore compensate through higher expenditures. This seems to set less stringent local content rules, while strengthening the spending requirement. The Informatics Law has been reformed following a World Trade Organization (WTO) ruling that found it to cause taxation in excess and a less favourable treatment of imported goods (WTO panels WT-DS472 and WT-DS497). Under the previous rules, and until April 2020 (date of entry into force of the new ones), firms benefited from an 80% reduction of IPI on the incentivised products. The tax rate varies by product, and on average the rate applying to the incentivised products is 15%. This therefore made it possible for beneficiary firms to reduce the effective tax burden from 15% to 7%. In its new formulation, the law also maintains a similar or even higher level of reduction in the effective tax burden.

Table 5.2. Options for R&D and innovation spending set by the Informatics Law

% of resources		Modality of investment
4% of gross turnover from sales of ICT goods and services incentivised by the law	**Minimum 1.84%**	Co-operation with science, technology and innovation institutions, or public research centres/ higher education institutes - **Minimum 0.8%**
		Co-operation with science, technology and innovation institutions, or public research centres/ higher education institutes in the North (except Zona Franca de Manaus), Northeast and Central West - **Minimum 0.46%**
		National Fund for Scientific and Technological Development - **Minimum 0.4%**
		Application in Programmes and Projects of National Interest(PPIs) - **Minimum 1.84%**
	Remaining (maximum 2.16%)	Internal R&D and innovation, including outsourced to other firms, research centres or universities
		Support to development programmes for the ICT sector (up to two-thirds of resources)
		Investment funds or other instruments approved by the Securities and Exchange Commission directed at capitalisation of technological firms, or application in government programmes directed at supporting technological firms
		Application in priority programmes
		Application in social organisations that promote or realise projects R&D and innovation in ICT

Sources: Casa Civil (1991), *Lei n. 8.248, de 23 de Outubro de 1991 – Dispõe Sobre a Capacitação e Competitividade do Setor de Informática e Automação, e dá Outras Providências*, *www.planalto.gov.br/ccivil_03/leis/l8248.htm*; Casa Civil (2019), *Lei n. 13.969, de 26 de Dezembro de 2019 – Dispõe Sobre a Política Industrial Para o Setor de Tecnologias da Informação e Comunicação e Para o Setor de Semicondutores*, *www.planalto.gov.br/ccivil_03/_ato2019-2022/2019/lei/L13969.htm*.

The policy is therefore very generous, as it compensates firms with more than what they spent. Investments in R&D from this law are in fact only about one-third of its fiscal cost: in 2016, the lost revenues amounted to USD 1.35 billion (BRL 4.7 billion), while the investment in R&D was USD 430 million (BRL 1.5 billion) (Ministry of Economy, 2019). The law also has a low base of eligible firms, as under the old rules, software fell outside its scope (as it is not subject to the IPI). In this new formulation, while software is included, firms in IT services are still not eligible. As a result, the number of beneficiaries of the Informatics Law is small (673 in 2018) and mostly of medium/large size (54% in 2016), with less than 50 large firms accounting for most of the total volume of tax exemptions (Zuniga et al., 2016). The largest firms benefiting from the law are multinationals, such as Samsung, LG and Hewlett Packard, while Brazilian firms are more numerous, but smaller.

The policy also lacks transparency, as information about its implementation and results is not available in a timely manner. Firms have to submit their annual reports on the fulfilment of the R&D obligation to the MCTIC. Up to 2018, it was the MCTIC's responsibility to examine the annual reports, which resulted in a backlog of reports and approval of incentives. The new law seems to have a more agile application process, although the MCTIC only has 30 days to approve the credits. The MCTIC has introduced changes to improve efficiency, such as increasing electronic systems for the work processes and defining indicators to measure the results of the benefits granted. Establishing a monitoring framework and an evaluation plan is also needed. Using digital technologies can improve monitoring of the policies' outcomes (OECD, 2019e), for instance, by enabling the collection of increasingly granular datasets, which would allow text-mining project descriptions to analyse research subjects, discover patterns and get a more refined understanding of the R&D investments.

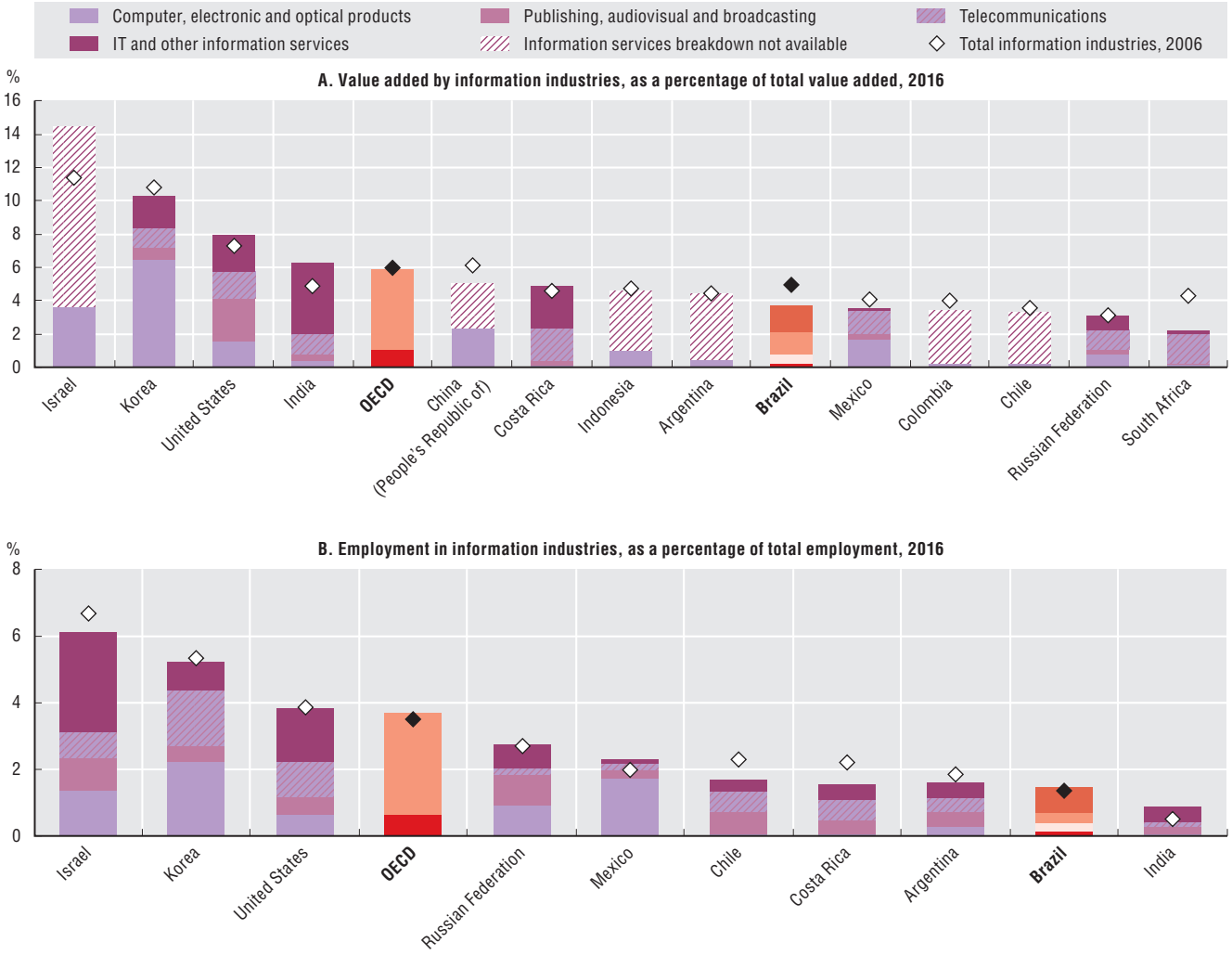
The government has not carried out a formal evaluation of the Informatics Law, as Brazil lacks a regulatory framework for a regular assessment of public policy. Several studies have analysed the effects of the law, sometimes with contrasting findings. Overall, the law has enabled Brazil to build a domestic manufacturing capacity, to generate employment, including of highly skilled workers (more than 7 000 working on R&D). By restricting the eligibility to the tax break to ICT goods produced domestically, the law has succeeded in attracting the world's leading ICT firms to Brazil, with results in employment and improving the sector's added value, which have remained stable over the past years (Figure 5.17). However, as PPBs concern mostly assembly, the productive capacity focuses on the low value-added production phases, and the sector remains dependent on the import of electronic parts and components, including for telecommunications devices. The law has also made it possible for firms outside the Manaus Tax-Free Zone to remain competitive (Prochnik et al., 2015). However, the law did not have an effect on exports, although this was not one of its stated objectives. Unlike Asian countries, where the ICT sector has strong international ties as part of a global value chains, in Brazil, firms usually sell consumer products domestically and are not export-oriented.

By design, the law does not stimulate additionality in R&D investment, as it is rather an instrument to attract foreign direct investment in the country, by offsetting the high taxation. Most of the activities carried out concern the development of existing solutions, such as adaptation to the local market, rather than innovation. Product innovation today in Brazil concerns a few niches, such as banking automation and telecommunications equipment (Barboza, Madeira and Lima, 2017). According to several evaluations, the law has not had any effect on additionality of R&D investments (Kannebley and Porto, 2012) or productivity, but rather hinders the reallocation of resources (Ribeiro, Prochnik and De Negri, 2011).

As the law mandates a minimum share of funding spent in collaborations with institutions accredited by the MCTIC, this spending is actually the main share of the overall investment (Figure 5.18). Over the years, a number of institutions, mainly private, have grown as a result of continuous co-operation with the investing firms. About USD 1.6 billion (BRL 6.2 billion) was spent by firms in collaborative research over the period 2006-17 (ABINEE, 2019). One such institution is CESAR, located in Recife, in the Northeast region of the country. Funding from the law has allowed consolidating the research centre through partnerships with the private sector and in 2000 led to the establishment of Porto Digital, a technological park affiliated with the Federal University of Pernambuco. The park is a cluster of over 300 firms, including multinationals, specialised in ICT and the creative economy (digital games, cine-video-animation, music, design and photography).

Among other institutions benefiting from the law are the CERTI foundation, Instituto Atlântico, and some public research or HEIs, although they are a minority. Several of them are also units selected by EMBRAPII for carrying out projects in IoT and advanced manufacturing (Table 5.4). Some of the main research centres engaging in collaborative research, however, although legally separated entities, are spinoffs of multinationals, such as the Samsung Institute for the Development of Informatics, Eldorado (Motorola), the Flextronics Institute for Technology and Venturus (Sony) (Zylberberg and Sturgeon, 2019). The linkages with the mother company, coupled with efforts to limit engineering mobility across research institutes has reduced the positive externalities of these R&D activities in Brazil (Zylberberg and Sturgeon, 2019). In terms of innovation outputs, collaborative research was less productive than internal one (Figure 5.19).

Figure 5.17. Value added and employment in the ICT sector in Brazil, the OECD and selected countries, 2006 and 2016



Notes: IT = information technology. Information industries cover the following ISIC Rev.4 divisions: Computer, electronic and optical products (26); Publishing, audiovisual and broadcasting (58-60); Telecommunications (61); and IT and other information services (62, 63). For Argentina, Brazil, the People's Republic of China, Colombia, Indonesia and South Africa, the value-added shares refer to 2015. For China and Indonesia, estimates are based on the OECD *Inter-Country Input-Output (ICIO) Database*. For Brazil and India, employment shares refer to 2015.

Sources: OECD (2019a), *Measuring the Digital Transformation: A Roadmap for the Future*, *https://dx.doi.org/10.1787/9789264311992-en*.

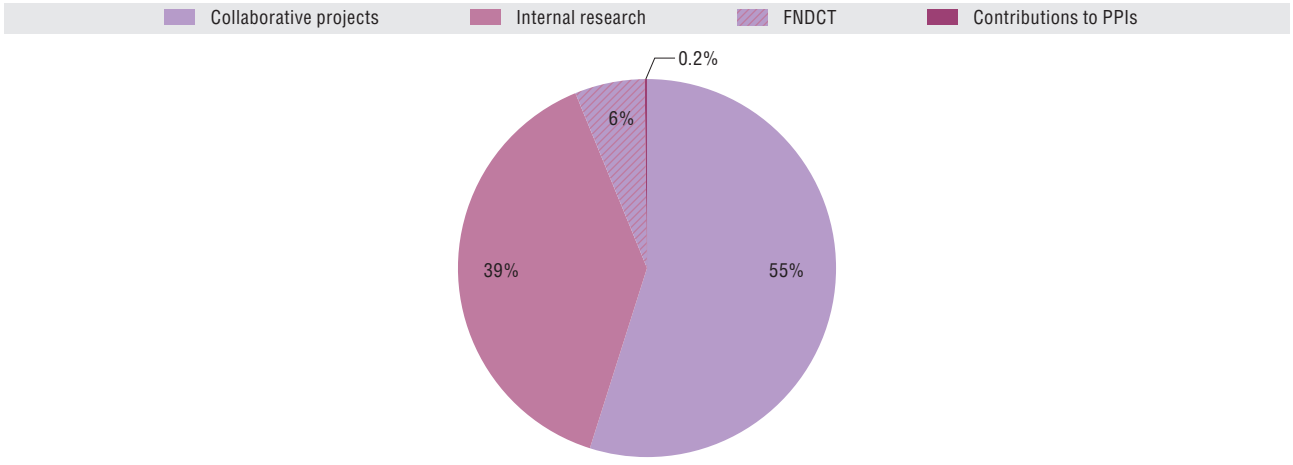
Summing up, the law has succeeded in its industrial objectives, and namely manufacturing capacity and employment, by subsiding firms through lower production costs. However, the policy does not seem to achieve its innovation objectives, which support productivity growth and competitiveness. Several aspects in the policy design should be improved.

First, the law currently favours large, established firms, and does not consider young, innovative companies, such as start-ups and spinoffs. For smaller firms to apply, the minimum threshold for investment may be lowered. Also, the cap on spending, which currently is equal to the minimum required, should be reviewed. Its scope, which has already positively been expanded to include software in the latest reform, should further include the ICT service sector, and also cover ICT-using sectors investing in digital solutions and services. As the next industrial revolution unfolds, manufacturing will be increasingly automated and make extensive use of digital technologies enabled through advanced services. Accordingly, the separation of manufacturing and services will increasingly be blurred and policies will need to be adapted (see Chapter 6).

Second, the definition of PPBs runs against quick developments in ICTs and the very nature of innovation (De Negri and Tortato Rauen, 2018). It does not include obligations for the most sophisticated stages of product manufacturing, thus reducing the high-value content of the domestically manufactured goods. For all of the above reasons, this requirement should therefore be removed. Instead, the law should revise the criteria for the tax incentive and limit it to firms with demonstrated innovation capacity. Favourable tax treatment may also be considered for investments in innovative start-ups. Furthermore, the policy could also pursue the objective of promoting linkages between domestic firms and subsidiaries of foreign multinational enterprises. This would enhance technology transfer, the capability of local firms and their integration in global value chains. Some South-East Asian countries provide good practice in this regard (Box 5.4).

Lastly, funds could be focused on the country's innovation priorities, for instance those set by the national IoT Plan and the National AI Strategy, instead of being dispersed around several, small-scale projects (about 3 000 carried out each year).

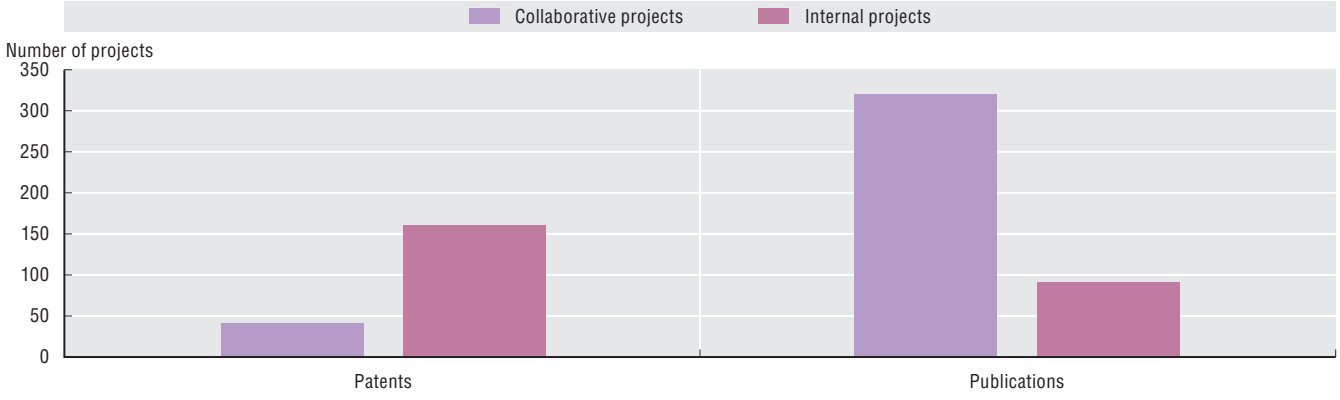
Figure 5.18. R&D expenditures from the Informatics Law, by destination, 2016



Notes: FNDCT = National Fund for Scientific and Technological Development; PPIs = Programmes and Projects of National Interest.

Source: MCTIC (2017), *Relatório de Resultados da Lei de Informática - Lei nº 8.248/91: Dados dos Relatórios Demonstrativos do Ano Base 2016 – Versão 1.*

Figure 5.19. Projects funded through the Informatics Law generating patents and publications, 2016



Source: MCTIC (2017), *Relatório de Resultados da Lei de Informática - Lei nº 8.248/91: Dados dos Relatórios Demonstrativos do Ano Base 2016 - Versão 1.*

The recent reform has responded to the need to ensure legal certainty for the sector, as the law stipulates that incentives will be maintained until 2029. Going forward, Brazil should perform a full-fledged evaluation of the effects of the law, with a focus on the type of innovation financed by the R&D tax credit, i.e. new-to-the-firm, new-to-the-market, etc. Such an evaluation would provide evidence for potential adjustments to the current formulation of the policy. It would also provide an objective and transparent justification for the policy continuation, as well as an opportunity to communicate

broadly about its effects. In parallel, and well before the policy expires, the country should engage in a debate with all stakeholders on the perspective for the ICT sector. As it currently largely depends on public incentives and is one of the sectors with the highest protection from tariff and non-tariff barriers to trade (OECD, forthcoming), the objective should be to make it more competitive and better integrated into the global value chain.

Box 5.4. Tax incentives to foster linkages between subsidiaries of foreign multinational enterprises with domestic firms

Malaysia offers various incentives to encourage linkages between foreign investors and local small and medium-sized enterprises. Under the Industrial Linkage Program, investors can claim tax deductions for costs involved in providing support to local suppliers, including training, product development and testing, and factory auditing to ensure local supplier quality. A Global Supplier Program offers financial and organisational support to multinational enterprises (MNEs), if specialists from their foreign affiliates are seconded to local firms (for up to two years) for the purposes of local upgrading.

Singapore has the Pioneer Certificate Incentive and Development and Expansion Incentive, which encourages foreign MNEs to set up local upstream and downstream activities that are more typically conducted at companies' headquarters. The incentive provided is a corporate tax exemption or a reduced concessionary tax rate on eligible income. Companies that apply for this incentive must commit to upgrading their employment and business investments. The programme intends to foster technology transfers and the scale-up of the local economy.

Similarly, Thailand moved from a system of location-based incentives (economic zones) to an activity- and merit-based one. These new incentives also include the promotion of small and medium-sized enterprise linkages and skills.

Source: OECD (2019f), *OECD Investment Policy Reviews: Southeast Asia*, *www.oecd.org/investment/oecd-investment-policy-review-southeast-asia.htm*.

New approaches are being tested for digital innovation

The CNPq's technological bonuses for advanced manufacturing promote adoption by small and medium-sized enterprises

In 2018, the CNPq launched a call for a "Technology Bonus and Grants in Advanced Manufacture", making financial support available to R&D and innovation projects on solutions for advanced manufacturing projects, processes and services, performed by micro and small businesses in partnership with larger companies. The support includes a technological bonus to help finance the project, combined with grants for training and technology development. This is a new instrument introduced by the legal framework for innovation, intended to pay for sharing and using technological research and development infrastructure, hiring specialised technological services, or technology transfer (when it is merely complementary to those services).

The technology bonus is a valuable addition to the mix of instruments available to enterprises, as the development of solutions requiring digital technologies is often very costly for SMEs and requires training and adaptation of the solution to the specific SME's needs. The recent financial constraints of the CNPq may leave this as a one-off initiative, whereas to achieve sizeable effects, it should be continued on a larger scale in the forthcoming years.

BNDES Internet of Things pilots support real-time testing of solutions

BNDES is a federal public company whose goal is to provide long-term financing for endeavours that contribute to the country's development. It has a range of financial products earmarked for investment projects in areas of strategic priority.

In 2018, BNDES granted USD 8.2 million (BRL 30 million) to co-fund 14 pilots on IoT technology solutions in 3 priority areas: cities, health and agriculture (Table 5.3). Pilots in manufacturing will also be financed, in co-operation with the National Confederation of Industry (Confederação Nacional da Indústria, CNI). The pilots have been selected among over 50 proposals received to the call issued for this initiative, for a proposed investment 8 times higher than the budget initially available (USD 4.1 million, or BRL 15 million), which has since been doubled. The success of the call shows the high interest for IoT in the country, the readiness of the community, as well as the demand for grants to support development efforts. The leading institutions of the projects are public technology institutes, as BNDES can only provide non-reimbursable funding to public institutions, but all the consortia are made up of several private partners, with 11 technologies institutes, more than 70 companies and 6 hospitals overall. Over the two-year implementation period, the IoT pilots are aimed at testing the cost-effectiveness of these solutions in a real setting, with the objective of scaling them up across the country.

Experimentation is key to digital innovation, and in particular for IoT. Pilot tests in IoT are essential to check the seamless integration between the software and hardware components, the behaviour of the system in different connectivity conditions, and the potential security and privacy vulnerabilities. Pilot testing also checks the usability of devices, while gathering users' feedback to integrate them into further developments. Pilots also make it possible to assess performance when the number of users increases. Testing environments where new technology developments can be tested in controlled but near to real-world conditions are increasingly used across OECD countries (OECD, 2019g). The IoT pilots fall in this category and should be replicated. Also, there should be a plan for the follow-up phases of the pilots: government initiatives could provide technical support and funding to municipalities and hospitals to assist in the adoption of tested solutions, for instance as part of the Smart Cities strategy (see Chapter 3). In the United Kingdom, the National Health Service is running IoT pilots in healthcare, through a Test Beds Programme in partnership with industry. Successful innovations are then made available to the National Health Service and care organisations around the country (OECD, 2020d).

FINEP supports the development of IoT solutions and their uptake

FINEP funds several programmes supporting innovation in universities and firms, with funding conditions adjusted to the level of risk of the project, the innovation stage, as well as the profile of the beneficiary organisation. FINEP's support to IoT and Industry 4.0 has increased in recent years as a result of the government's efforts in this area. FINEP's support ranges from grants (Centelha), investments (FINEP Startup) and venture capital funds to support start-ups (Table 5.6), to credit for developing IoT and related technologies in the key four verticals.

As part of the national IoT Plan, FINEP launched the IoT programme in 2018, a new credit line with a budget of USD 410.5 million (BRL 1.5 billion). The action is directed at medium-sized and large firms (with minimum annual revenues of USD 4 million, or BRL 16 million) submitting an investment plan on IoT for at least USD 1.4 million (BRL 5 million). The programme offers preferential credit conditions (1% interest rate, instead of a market rate of 4-5%) to develop digital solutions with applications in industry, health, agriculture and cities based on IoT and other enabling technologies. The initiative supports the development of such solutions with applications in the above areas ("axis 1"); the formulation ("axis 2") and execution ("axis 3") of strategic business digitalisation plans in firms. These are business plans developed by a specialised company on how to integrate enabling technologies into the firm's production process and indicating the priorities for adoption.

Within the overall FINEP IoT programme, in September 2019 the agency also launched the USD 51 million (BRL 200 million) pilot Inovacred 4.0, specifically aimed at supporting the deployment and use in manufacturing and agriculture of advanced manufacturing solutions in SMEs. The initiative was prepared in partnership with the National Confederation of Industry, the Ministry of Economy and the MCTIC, and is the first of the Brazilian Chamber of Industry 4.0, formed by more than 30 entities representing the government, businesses and academia.

Overall, between 2018 and January 2020, FINEP contracted more than USD 356.5 million (BRL 1.4 billion) in projects supporting IoT and Industry 4.0. This offer of credit at a preferential rate plays a key role in the Brazilian system for innovation, given the absence of long-term credit markets. FINEP's portfolio of financed projects is a good indication of the use of ICT solutions across the economy, given that all the projects, except one, are in sectors other than ICT. Projects involving IoT solutions, for instance, are in the manufacturing of motor vehicles, machine manufacturing for agriculture and the plastic industry.

Table 5.3. BNDES Internet of Things pilot projects

Lead institution	Area/project	City or municipality/state
	Health	
Centre for Studies and Advanced Systems of Recife (CESAR)	Monitoring of inventory and automation of requests for replacement of oxygen cylinders, monitoring of consumption and registration of dosage.	Recife/Pernambuco
Hospital das Clínicas, USP Medical School (HCFMUSP)	1. Monitoring of hospital assets (infusion pumps, stretchers, wheelchairs and ambulances). 2. Screening for diabetic retinopathy by teleophthalmology.	São Paulo/São Paulo
Technological Integrated Systems Laboratory (LSI-TEC)	1. Remote monitoring for sepsis control in children with cancer. 2. Remote monitoring applied to sleep quality.	São Paulo/São Paulo
Pontifical Catholic University (PUC-Rio)	Development of solutions for a "Digital Hospital" involving automated and intelligent management of assets, patients, health agents, procedures and medical records.	Rio de Janeiro/Rio de Janeiro
National Research Network (RNP)	Remote monitoring of obese children and adolescents.	Fortaleza/Ceará
Federal University of Rio Grande do Sul	Remote monitoring of patients with hypertension.	Porto Alegre/Rio Grande do Sul
	Agriculture	
Telecommunications Research and Development Centre (CPqD)	Optimisation in the use of agricultural machinery, rainfall monitoring, pest management and precision livestock techniques for the welfare of cattle.	Diamantino/MatoGrosso, Correntina/Bahia, Pradópolis/São Paulo and Lucas do Rio Verde/ MatoGrosso
Embrapa Informática	Pest and machinery management, animal welfare monitoring in dairy cattle farming and use of IoT systems for crop-livestock-forest integration.	Carazinho/Rio Grande do Sul, Santa Maria do Pará/Pará, Castanhal/Pará, Barbalha/Ceará, Valença/Rio de Janeiro, São Carlos/São Paulo, São João da Boa Vista/São Paulo, Itatinga/ São Paulo, Sinop/MatoGrosso, Recanto das Emas/Distrito Federal, Parai/Rio Grande do Sul, Bom Despacho/Minas Gerais; Boa Esperança/ Minas Gerais, Passos/Minas Gerais and Cel. Pacheco/Minas Gerais
Foundation for Technological Innovations (FITEC)	Integrated data platform (climate, soil, management, machinery, energy efficiency and water efficiency) for monitoring and recommendations on the use of natural resources, inputs and machinery.	Uberlandia/Minas Gerais
PUC-Rio	Optimisation of energy resources, natural resources, agricultural inputs, agricultural machinery, in addition to solutions aimed at small agricultural producers.	Holambra/São Paulo and Santiago do Norte/ MatoGrosso
	Cities	
CPqD	1. Use of cameras and computer vision for public security. 2. Advanced climate prediction. 3. Provision of the shared electric vehicle service. 4. Complete remote management platform for public lighting.	Campinas/São Paulo
National Institute of Telecommunications Foundation (FINATEL)	Implementation of remote management in the intelligent lighting network and integration with video surveillance for public security.	Santa Rita do Sapucaí/Minas Gerais, Caxambu/ Minas Gerais and Piraí/Rio de Janeiro
FITEC	Implementation of a public lighting network enabling IoT solutions, such as smart dumps, video surveillance for public security, civil defence and electronic parking meters.	Mar de Espanha/Minas Gerais
Instituto Atlântico	Implementation of public lighting networks that enable IoT solutions, aiming at reducing travel time, increasing the attractiveness of public transport and increasing the surveillance capacity for public security.	Fortaleza/Ceará, Juazeiro do Norte/Ceará and Petrópolis/Rio de Janeiro
Technological Integrated Systems Laboratory (LSI-TEC)	Use of Single Board Computer "Labrador" for: 1) intelligent control of the traffic light network in the city of São Paulo; and 2) monitoring of crime situations and threats to urban security.	São Paulo/São Paulo

Source: BNDES (2020), *BNDES*, *www.bndes.gov.br*.

EMBRAPII fosters collaborative research in the Internet of Things and advanced manufacturing

EMBRAPII is the co-ordinator of one of the Programmes and Projects of National Interest (PPIs) in IoT and Advanced Manufacturing. Since December 2018, firms financing PPIs have become eligible for the tax incentives under the Informatics Law; the 2019 reform of the law further expands the possibility to finance PPIs. Potentially all of a firm's R&D and innovation expenditure can contribute to PPIs (Table 5.2). The resources from the PPI are used as a financial counterpart for EMBRAPII according to its

model (Box 5.1). By September 2019, over 520 projects in ICT (robotics, mechatronics, IoT and advanced manufacturing) had been launched through EMBRAPII, fostering collaboration among firms and the 18 research units (Table 5.4), for a total of USD 191.5 million (BRL 752 million). The projects have resulted in 128 intellectual property applications.

Some of the projects supported by EMBRAPII also involve more than one unit, or more than one firm, establishing partnerships to find solutions to more difficult challenges. Groups of units are therefore developing into innovation hubs, with their own specialisation, and spread across the country. This network of hubs should be strengthened and formalised, to become a reference for firms seeking support for their innovation efforts. In digital innovation, collaboration from different disciplines is often necessary, and having a network of excellence centres would ease the research for competences in a certain field.

These units also have infrastructures and demonstration facilities for them to evolve as testbeds for technologies, for firms, in particular SMEs, to pilot solutions before their adoption. Several countries are building such collaborative systems, to leverage existing knowledge and make it available to a large number of firms, and to link established companies with researchers or start-ups. The initiative "Testbeds for Industry 4.0", launched in May 2019 (see Chapter 6), which involves also EMBRAPII's units, goes in this direction.

Table 5.4. EMBRAPII's units for the Internet of Things and advanced manufacturing, 2019

Specialisation	Institution	City	State	Region
Optical communications	CPqD	Campinas	São Paulo	Southeast
Printed electronics	CSEM	Belo Horizonte	Minas Gerais	Southeast
Software for cyber-physical systems	DCC/UFMG	Belo Horizonte	Minas Gerais	Southeast
Internet and mobile computing equipment	Eldorado	Campinas	São Paulo	Southeast
Intelligent automotive systems	IFMG	Formiga	Minas Gerais	Southeast
Biophotonics and instruments	IFSC/USP	São Carlos	São Paulo	Southeast
Digital communications and radio frequency	INATEL	Santa Rita do Sapucaí	Minas Gerais	Southeast
Computational engineering solutions	TECGRAF/PUC RJ	Rio de Janeiro	Rio de Janeiro	Southeast
Software and automation	CEEI/UFCG	Campina Grande	Paraíba	Northeast
Embedded systems and digital mobility	IFCE	Fortaleza	Ceará	Northeast
Manufacturing systems	IFPB	João Pessoa	Paraíba	Northeast
Connected products	CESAR	Recife	Pernambuco	Northeast
Technology in health	IFBA	Salvador	Bahia	Northeast
Integrated manufacturing	SENAI/CIMATEC	Salvador	Bahia	Northeast
Intelligent systems	CERTI	Florianópolis	Santa Catarina	South
Embedded systems	ISI-SE	Florianópolis	Santa Catarina	South
Sensor systems	ISI METALMECÂNICA	São Leopoldo	Rio Grande do Sul	South
Embedded electronics	LACTEC	Curitiba	Paraná	South
Systems for manufacturing automation	INDT	Manaus	Amazonas	North

Notes: CPqD = Telecommunications Research and Development Centre; CEEI/UFCG = Electrical Engineering and Computing Centre/Federal University of Campina Grande; CERTI Foundation = Centres of Reference in Innovative Technologies; CESAR = Centre for Studies and Advanced Systems of Recife; CSEM = Swiss Centre for Electronics and Microtechnics; DCC/UFMG = Department of Computer Science/Federal University of Minas Gerais; IFBA = Federal Institute of Education, Science and Technology of Bahia; IFCE = Federal Institute of Education, Science and Technology of Ceará; IFMG = Federal Institute of Education, Science and Technology of Minas Gerais; IFPB = Federal Institute of Paraíba; IFSC/USP = Institute of Physics of São Carlos/University of São Paulo; INATEL = National Institute of Telecommunications; INDT = Institute of Technological Development; ISI METALMECÂNICA = SENAI Institute of Innovation in Metal-Mechanics Integrated Solutions; ISI-SE = SENAI Institute of Innovation in Embedded Systems; LACTEC = Institute of Technological Development; SENAI/CIMATEC = SENAI Integrated Campus of Manufacturing and Technologies; TECGRAF/PUC RJ = Institute of Technical-Scientific Software Development/Pontifical Catholic University of Rio de Janeiro.

Source: EMBRAPII (2020), *EMBRAPII*, *www.embrapii.org.br*.

If EMBRAPII's units scale up and network, the organisation will need to be able to ensure support to the current units, and possibly to increase their number to ensure greater thematic and geographic coverage. This will require additional resources, as, despite its success, funding remains limited, at USD 63.6 million per year (BRL 250 million). In this regard, the recent reform of the Informatics Law

goes in the right direction, although the choice of funding destination is left to the firms, and therefore it is not foreseeable how this will impact PPIs' funding. As stressed above, in order to maximise the R&D and innovation investment from the Informatics Law, the MCTIC may become more stringent in terms of the funding destination, directing them to the innovation priorities set by the government.

Box 5.5. Linking competences in networks and diffusing them to firms: The role of digital innovation hubs

Digital innovation requires a high degree of co-operation across sectors and disciplines. In OECD countries, initiatives promoting this type of interaction are flourishing. Several instruments are used to this end, for instance clusters, grants conditional on collaboration, innovation hubs and innovation grants.

For example, since 2016, the European Commission has been promoting the establishment of digital innovation hubs across the European Union, in most cases with technical universities or research organisations at their core. Digital innovation hubs offer firms, especially small and medium-sized enterprises (SMEs), access to technology testing, financing advice, market intelligence and networking opportunities. These hubs also play a role in strengthening employees' preparedness to work with new technologies, by offering access to training and skills development. The European Commission also offers funding to SMEs to test and implement digital technologies. The "technological bonuses" available in Brazil could be used in this sense.

The Digital Hub Initiative in Germany supports the establishment of digital hubs across the country that connect medium-sized businesses and larger firms with new innovation partners from the scientific and start-up communities. Hubs aim to foster networking and co-operation within and between hubs, and are expected to serve as platforms for engaging in dialogue with global market leaders and foreign investors. There are currently hubs in 12 cities, each focusing on a particular industry (e.g. Internet of Things and Fintech hub in Berlin, artificial intelligence hub in Karlsruhe, digital chemistry and digital health hub in Ludwigshafen/Mannheim). The I 4.0-Testumgebung (I 4.0 Testbed) aims at improving the innovation potential of SMEs to test products, components and digital processes in real-life conditions. Aside from the infrastructure, the SMEs have access to expert knowledge that help them further develop their digital technologies with the right tools.

Sources: Planes-Satorra and Paunov (2019), "The digital innovation policy landscape in 2019", *https://doi.org/10.1787/6171f649-en*; European Commission (2020), *Digital Innovation Hubs (DIHs) in Europe*, *https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs*; Digital Hub Initiative (2020), *The Digital Hub Initiative*, *www.de-hub.de*.

The policy mix in support of digital innovation is dominated by tax incentives, which currently mostly favour large incumbents and do not yet provide a suitable mechanism for smaller and younger firms. While seeking possibilities for making these mechanisms more effective in promoting innovation across firms of all sizes, Brazil should also rebalance the policy mix towards instruments supporting diffusion across firms, higher risk innovation, experimentation and collaboration across sectors.

The main research agencies in Brazil have shown dynamism in recent years in supporting new digital technologies, in particular advanced manufacturing and IoT solutions. Such co-ordination of efforts, which follows from the government's action in promoting the IoT Plan and advanced manufacturing as priorities, is a good example of aligning instruments to reach the set objectives. However, these initiatives remain dispersed and without predictability of funding. Co-ordination of the instruments and among institutions should be enhanced to articulate the innovation ecosystem and increase linkages among projects and teams.

Brazil should also take advantage of the existing innovation ecosystems, by establishing a network of competence centres, to avoid dispersing resources and make excellence spill-over to a broader community. In line with a definition of the key challenges and objectives to achieve, the available instruments should be clearly structured and the MCTIC should be the central entry point to innovators, with a centralised list of opportunities. Israel has recently restructured its offer of incentives and grants to fit the needs of the various target groups (Box 5.6).

Box 5.6. Making support instruments fit to their audience: Israel's innovation divisions

In 2016, a new authority was established in Israel, the Israel Innovation Authority (IIA). It replaced the Office of the Chief Scientist as the main Israeli government body that promotes and supports R&D, innovation and technology collaboration. The IIA provides a variety of practical tools and funding platforms aimed at addressing the dynamic and changing needs of the local and international innovation ecosystems. In 2017, the IIA formulated its strategy for 2018-23. This strategy formulates its vision to transform the Israeli innovation system from the start-up phase to the innovation-based growth phase, and increase the social and economic impact of the Israeli innovation system.

In order to meet the various needs of its wide range of clients, the IIA has developed a new internal structure focused on six primary innovation divisions. Each division offers a unique "toolbox" of customised and comprehensive incentive programmes. These divisions thus serve as a launch pad for successful innovative projects, providing entrepreneurs and companies with the most relevant plan for them to realise and implement their ideas, develop their products, and mobilise private investment. There are six innovation divisions: 1) Start-Up; 2) Growth; 3) Technological Infrastructure; 4) Advanced Manufacturing; 5) Societal Challenges; and 6) International Collaboration.

Source: OECD/EC (2020), *STIP Compass*, *https://stip.oecd.org/stip.html*.

Support to innovative entrepreneurship

A rising start-up scene

Brazil hosts one of the most active high-tech entrepreneurial communities in Latin America. An estimated 10 000 start-ups operate in the country (ABStartups and Accenture, 2018), mostly active in professional services, telecommunications, media and telecom, and finance. These start-ups flourish by developing new business models enabled by digital technologies, offering products and services based on data analytics (37% of all start-ups), the cloud (23%) and AI (14%) (ABStartups and Accenture, 2018). Brazilian start-ups are increasingly attracting investors: in 2018, eight of them became "unicorns", i.e. privately held start-up companies with a valuation of USD 1 billion or above (Table 5.5).

Brazilian start-ups are particularly successful in Fintech, edtech, health, agritech and mobility. In particular, Brazil has seen many new Fintech companies develop in recent years, with different target groups and business models. Both the high concentration and the high cost of services of Brazilian banks, which offered the opportunity to new entrants to provide new services, and regulatory changes encouraging competition have contributed to this success (see Chapter 6). Brazil has been highly responsive to innovative developments in this field. The Securities and Exchange Commission of Brazil (Comissão de Valores Mobiliários, CVM) has launched an experimental regulatory framework for the securities market, which encourages innovation in financial technology. The sandbox provides a controlled environment for businesses to test innovative products and services without incurring the regulatory consequences of pilot projects (see Chapter 6).

São Paulo is the biggest hub for start-ups in Brazil and the host city of most unicorns. The country, however, has several other hubs for start-ups, mostly concentrated in eight states and the Federal District. These hubs are becoming increasingly specialised, e.g. São Paulo on Fintech, Florianópolis on Industry 4.0 and automation, and Recife (CESAR, Porto Digital) on gaming. ANPROTEC, the Brazilian Association of Science Parks and Business Incubators, estimates that there are 369 incubators and 35 accelerators in Brazil. Public initiatives in support of technology parks date back to the 1980s, when researchers funded by the CNPq launched incubators attached to federal universities with a technological specialisation. In the 2000s, FINEP and the CNPq substantially increased their investments in technology parks. From 2006, as a result of the Good Law, the number of technological parks started to increase. In 2017, there were 43 technological parks in the country, up from 10 in 2000 (MCTIC, 2019c).

Table 5.5. Brazilian unicorns, 2019

Company (year of establishment)	Value (USD billion)	Headquarters	Sector	Description
Nubank (2013)	10	São Paulo	Fintech	Nubank is the largest Fintech in Latin America. It also has an engineering office in Berlin and an office in Mexico City. Among the company's products are NuConta (a digital account), an international credit card, both without fees, and personal loans. The company's distinguishing feature is that it offers a credit card entirely controlled via a mobile app.
iFood (2011)	1	Campinas	Food delivery	Food delivery platform.
Loggi (2013)	1	São Paulo	Logistics	This start-up is attempting to secure next-day delivery anywhere in Brazil. Businesses use Loggi's "logistics-as-a-service" platform to send out delivery requests, which automatically calculates the route and price.
QuintoAndar (2013)	1	São Paulo	House rental	QuintoAndar focuses on real estate rentals. It manages the rent payment to the landlord, exempting the tenant from presenting a guarantor, surety bond or deposit. The company eliminates the use of notary offices by using digital signatures, and claims that it can, due to the simplified process, rent real estate ten times faster than traditional real estate.
PagSeguro (2006)	14.5	São Paulo	Fintech	Online or mobile payment-based e-commerce service for commercial operations. It intermediates payment between sellers and buyers by offering a billing option via email for traders who do not have a site or a well-structured e-commerce. The company has agreements with several banking institutions so that sellers can offer buyers different payment methods. The service offers over 25 payment methods. PagSeguro also mediates disputes between sellers and buyers.
Ascenty (2010)	1.8	São Paulo	Data centre	The largest data centre in Latin America. It currently has 18 data centres around the world.
Arco (2006)	2.2	Fortaleza	Education	The platform offers basic education programmes for learning and development.
StoneCo (2012)	9.9	São Paulo	Fintech	Customer-oriented tailored payment solutions for businesses.
Gympass (2012)	1.1	New York (founder from Minas Gerais)	Health and fitness	Gympass allows users to access a global network of gyms and studios in 15 different countries. Companies pay a monthly fee for their employees to access the platform.
99 (2012)	1	São Paulo	Transport	Transportation network company acquired by DiDi.

Note: This table also includes public companies (Arco, PagSeguro and StoneCo).

The government has launched several initiatives to support start-ups in the past decade (Table 5.6). These initiatives are under the responsibility of different ministries (the MCTIC and Ministry of Economy) and depend on various agencies and private sector organisations for their implementation. They are designed to support start-ups at different phases of their development, and have different objectives and type of support. The Centelha programme assists entrepreneurs in turning their ideas into start-ups, through training, financial and technical support. Startup Brazil, BNDES Garagem and InovAtiva are all accelerator programmes. InovAtiva is an online programme and thus has the largest outreach. Interesting initiatives are those related to open innovation, i.e. calls with a technological challenge, which start-ups have to solve for medium/large companies. One of them, Programa Conexão Startup Indústria 4.0, focuses specifically on advanced manufacturing solutions.

All of these programmes show the interest in innovative entrepreneurship in Brazil. Some are very similar and run the risk of overlapping, yet a large supply is important to meet the growing demand. Given the variety of programmes in place, it would be useful to create a one-stop shop for start-ups. A review of the available programmes could also help streamline the offer and identify possible gaps.

Brazilian start-ups are mostly male businesses, as both the founders and the employees are mainly men. Until recently, the country lacked a programme for start-ups focused on strengthening innovative entrepreneurship among women. A pilot initiative jointly managed by the MCTIC, FINEP and the city of São Paulo has recently been launched. "Innovative Women" (Mulheres Inovadoras) will target 300 entrepreneurs and accelerate 20 start-ups. This initiative intervenes at the acceleration phase of an already existing company. While this may help start-ups founded or led by women entrepreneurs to grow, support may also be needed in stimulating entrepreneurial skills at earlier stages, or in securing funds in more mature phases.

Table 5.6. Programmes supporting start-ups in Brazil, 2019

Programme (year of launch)	Objectives	Supervising institution	Other implementing institutions	Cumulated funding to date	Start-ups supported to date
		Promotion of start-ups			
"Spark" Program – National Innovative Enterprise Support Programme (Programa Centelha) (2018)	Organised in three phases, the programme aims at transforming innovative ideas into projects by offering training, financial resources and technical support. It involves a network of local, mostly public, institutions active in innovation and technological research.	MCTIC	FINEP	USD 10.4 million (BRL 41 million)	31 contracted projects
		Acceleration			
Startup Brasil – National Start-up Acceleration Programme (2012)	Public-private partnership aiming to support newly founded Brazilian tech-based companies. Selected start-ups are awarded USD 50 000 (BRL 200 000) for R&D support and go through a one-year acceleration programme. The programme offers partnerships with accelerators; research, development and innovation scholarships; a 12-month visa for foreign entrepreneurs; international hubs; and access to investors and target markets.	MCTIC	Softex, CNPq, Ministry of Foreign Affairs and private accelerators	USD 89 million (BRL 350 million)	200
InovAtiva Brasil Acceleration Programme (Programa de Aceleração InovAtiva Brasil) (2013)	Large-scale online mentoring programme for innovative, Brazilian-based businesses in any productive sector.	Ministry of Economy	SEBRAE, CERTI, SENAI and a private mentoring network	USD 2.5 million (BRL 10 million)	2 000 have received training >800 have presented their solutions to investors and large companies
BNDES Garagem – Support to Start-up Development (2018)	Acceleration programme in co-operation with the private sector. It includes an incubation module ("Creation") that aims at creating start-ups and an "Acceleration" module focused on existing start-ups with revenues up to USD 4 million (BRL 16 million). The priority industries include health and well-being, social and environmental sustainability, the creative economy, safety, financial solutions, education, the Internet of Things and blockchain.	BNDES	Private firms	USD 2.5 million (BRL 10 million)	79 Given the high oversubscription of high-quality projects, it is foreseen to support through a platform about additional 300 applications
		Open innovation and linkages start-ups/larger firms			
Startup-Industry Connection Programme (Programa Conexão Startup Indústria 4.0) (2017)	It supports open innovation in the start-up ecosystem and connects start-ups with real demands from industry. It also promotes direct assistance by associating local innovative environments with international counterparts.	Ministry of Economy	ABDI		27
Startup Connection	It connects medium and large industrial companies, which define technological challenges, with start-ups, which apply to provide solutions. Start-ups receive USD 7 000 (BRL 30 000) in grants to finance their proof of concepts, but only after their idea is validated by the large company that has set the challenge. Additional grants of up to USD 15 000 (BRL 60 000) are awarded for product development after the validation of the proof of concept.	MCTIC	ABDI, Softex and the CNPq		
SEBRAE Nexos (2019)	It connects medium- and large-sized companies with technology-oriented start-ups through open calls for innovation. Medium- and large-sized companies define the technological domains of the calls, while start-ups are invited to develop products and services in the fields of the calls. Start-ups can use resources owned by large companies as well as those owned by incubators and accelerators involved in the programme. The government invests in the start-ups based on the achievement of development milestones, with investments of USD 25 500-64 000 (BRL 100 000-250 000). Large companies have to match government funding.	FINEP	ANPROTEC		

Table 5.6. Programmes supporting start-ups in Brazil, 2019 *(cont.)*

Programme (year of launch)	Objectives	Supervising institution	Other implementing institutions	Cumulated funding to date	Start-ups supported to date
	Support to internationalisation				
StartOut Brasil Programme (2017)	Insertion of Brazilian start-ups in international innovative environments.	Ministry of Economy	Apex, ANPROTEC, SEBRAE and the Ministry of Foreign Affairs	USD 610 000 (BRL 2.4 million)	110

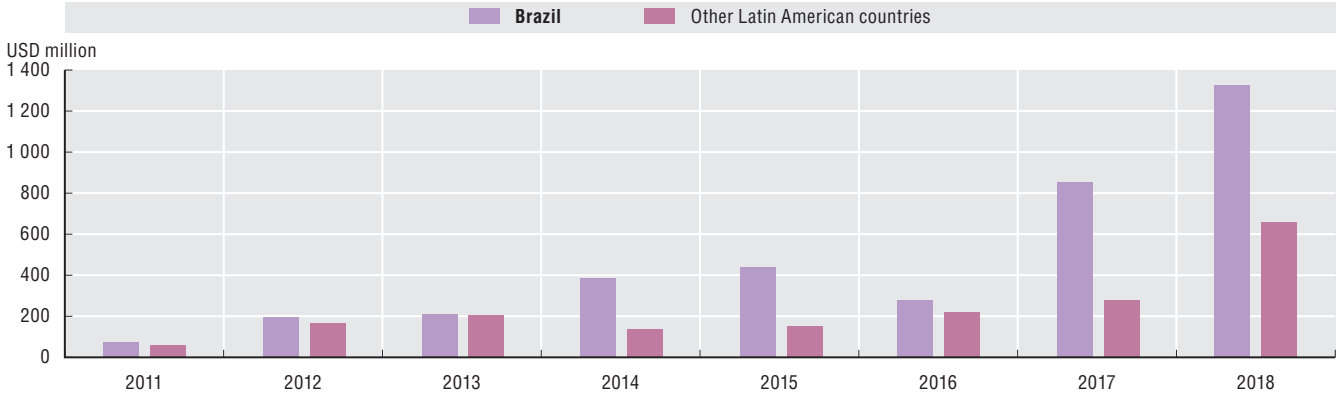
Notes: ABDI = Brazilian Industrial Development Association; ANPROTEC = Brazilian Association of Science Parks and Business Incubators; Apex = Brazilian Agency of Promotion of Exports and Investments; BNDES = Brazilian Development Bank; CERTI = Centres of Reference in Innovative Technologies; CNPq = National Council for Scientific and Technological Development; FINEP = Brazilian Agency for Innovation and Research; MCTIC = Ministry of Science, Technology, Innovations and Communications; SEBRAE = Brazilian Micro and Small Business Support Agency; SENAI = National Service for Industrial Training. USD figures are based on the 2019 exchange rate.

Source: OECD, based on MCTIC, FINEP, BNDES, Ministry of Economy and OECD (2020f), *SME and Entrepreneurship Policy in Brazil 2020*, *https://doi.org/10.1787/cc5feb81-en*.

Venture capital and equity financing should be further developed

Venture capital (VC) is one of the main funding mechanisms for disruptive technologies. In 2016, new regulation was introduced which has improved the legal protection for angel investors with the market recording fast growth in the following two years. VC investments in Brazilian start-ups doubled in 2018, reaching USD 1.3 billion, i.e. about two-thirds of the VC raised in Latin America in the same year (Figure 5.20). Although it is growing fast, the VC market only represents 0.06% of GDP, compared to 0.55% in the United States or 0.18% in Canada (OECD, 2020e).

Figure 5.20. Venture capital investments in Brazilian and Latin American start-ups, 2011-18



Source: OECD, based on LAVCA (2020), *LAVCA's Annual Review of Tech Investment in Latin America*, *www.lavca.org*, LAVCA (2019), *LAVCA's Annual Review of Tech Investment in Latin America*, *www.lavca.org* and LAVCA (2016), *Latin America Venture Capital: Five-Year Trends*, *www.lavca.org*.

Public funding institutions (namely, BNDES and FINEP) have also set up their own programmes to promote the development of the VC market in the country. BNDES is currently the main investor in seed capital and VC. The main seed capital funds are Criatec I, II and III and Primatec, all supporting small innovative companies with high growth potential with annual revenues up to USD 4 million (BRL 16 million). The three funding cycles together add up to USD 124.5 million (BRL 489 million), mostly in digital technologies, agro-businesses, nanotechnology, biotechnology and advanced materials (OECD, 2020f). The first two editions of Criatec invested in 72 companies, leading to 60 patents. The Primatec Fund is dedicated to seed VC investments in start-ups in a group of incubators and technology parks, known as Rede Primatec. It is funded by BNDES and FINEP, with a capital of USD 25.5 million (BRL 100 million). It focuses on investments in ICTs, the energy sector and creative industries, as well as socially responsible start-ups.

BNDES' Angel Co-investment Fund (Fundo de Coinvestimento Anjo) was introduced in 2018. In its first phase, its objective is to support about 100 start-ups with an annual income of up to USD 255 000 (BRL 1 million), with an investment ticket of USD 25 500-127 000 (BRL 100 000-500 000) per beneficiary, matched by VC funds for the same amount.

FINEP Startup was launched in 2017 with the objective to support small technology-based companies (annual revenues up to USD 1.2 million, or BRL 4.8 million) in the final stages of product development or that need to gain production scale. Calls are opened in specific sectors and technologies, including agritech, Fintech, healthtech, blockchain, AI, IoT, advanced manufacturing, and augmented and virtual reality technologies. The maximum investment for each start-up is USD 255 000 (BRL 1 million). FINEP Startup also encourages applicants to look for private investors, as those showing a letter of commitment from a business angel earn points in the selection, proportionate to the amount committed. After its first three calls, FINEP Startup has invested in or approved for investment 51 start-ups, for a total of USD 10 million (BRL 40 million). Out of these start-ups, 9 are active in IoT, 5 in AI, 2 in advanced manufacturing, 2 in virtual and augmented reality, and 1 in smart cities. Finally, since 2003, FINEP has supported 33 investment funds, in more than 220 companies and with USD 1.3 billion (BRL 5 billion) committed, resulting in an external funding of BRL 6.62, for each Brazilian real contributed by FINEP.

One of the obstacles to the VC and equity funding market in Brazil has been the lack of a legal provision for the "corporate veil", i.e. the assumption that the liability of the managers or shareholders of a company does not extend beyond the value of their shares. The absence of the "corporative veil" drastically increases the risk and uncertainty of VC investments.

Law 13.874/2019 of September 2019 establishes the Declaration of Economic Freedom Rights, marking progress in this direction. The law brings legal clarity on the applicable cases of disregard of legal entity (*desconsideração da personalidade jurídica*) and clarifies the nature of investment funds, allowing limited liability of their investors to the value of their shares. The Securities and Exchange Commission has to issue a regulation for this rule to also become operational for pre-existing contracts. However, this measure is a significant step towards enlarging the VC market in the country.

A legal framework for start-ups and innovative entrepreneurship is being developed

Among the main challenges for start-ups, the National Strategy for Digital Transformation points out the lack of skilled workers, notably computer programmers, the lack of entrepreneurial attitudes, bureaucratic and lengthy procedures for company registration and liquidation, a rigid labour law, and a complex and expensive web of state and federal taxes.

Interviews with some leading start-ups have confirmed that human capital is a key challenge, due to the limited availability of skilled workers at home and visa requirements making it difficult to hire from abroad. However, the main challenges reported by start-ups seem to be regulations, red tape in opening or closing a business, as well as the level of taxation (ABStartups and Accenture, 2018).

One of the first actions undertaken under the E-Digital Strategy has been elaborating a proposal for a legal framework for start-ups and innovative enterprises by the Sub-committee of the Inter-ministerial Committee for Digital Transformation (CITDigital). The proposal, which has been open to public consultation, focuses on four key areas for start-up development: 1) business environment; 2) work relations; 3) investment; and 4) public procurement. Brazil currently lacks a legal definition for start-ups and the consultation invites suggestions about the criteria defining a start-up, e.g. age, turnover, number of employees, R&D investment. The proposal also includes six "blocks" with concrete legislative proposals to amend existing legislation, with the following objectives:

- **Block A: Establish a new company model: the *sociedade anônima simplificada* (SAS)**. The two types of company models in Brazil are limited liability companies (*empresa de responsabilidade limitada*) and corporations (*sociedad anônima*). This block proposes the introduction of a simplified corporation for companies with capital less than USD 4 million (BRL 16 million) that would allow start-ups to receive external funding, while having simpler reporting requirements.
- **Block B: Clarify joint liability**. Despite being companies with a high risk of failure, start-ups have several joint liabilities. This proposal aims at introducing legal certainty on the joint liabilities in case of business failure.

- **Block C: Extend the simplified tax regime (Simples Nacional)**. This proposal aims at conciliating a company model able to issue stock options with the simplified fiscal regime.
- **Block D: Facilitate investment in R&D and innovation**. This proposal aims at expanding the sources of funding for start-ups. It introduces the possibility for sectors that have legal obligations to invest in R&D (oil and gas, electric sectors) to fulfil their duty by investing resources in equity funds or equity investment funds in categories associated with R&D and innovation.
- **Block E: Clarify the legal nature of stock options plans**. Stock options are an important talent retention mechanism, particularly for start-ups, which have fewer resources available for hiring employees. This proposal aims to give companies greater certainty on their legal nature.
- **Block F: Introduce a test for public procurement of innovative solutions**. Start-ups are seldom hired by the public administration, as they do not comply with legal requirements, such as previous experience to show their capabilities. This proposal introduces the Collaboration Term for Innovation Test (*Termo de Colaboração para Teste de Inovação*), the testing of innovative solution by start-ups prior to purchase by the public administration.

The legal framework for start-ups is a comprehensive proposal, built through consultation of interested parties. The MCTIC is analysing the inputs received during the consultation and will put forward a revised legislative text.

By creating a legal framework for start-ups, Brazil would follow in the footsteps of a number of countries that have already introduced specific legislation for start-ups or innovative entrepreneurship, such as Italy (Startup Act 172/2012) and Argentina (Entrepreneurs' Law of 2016). Some provisions improving the business environment have been introduced by recent legislation. For instance, Law 13.874/2019 has introduced the provision to constitute individual limited companies (*sociedade limitada unipessoal*). Although this does not fully reflect the proposal in "Block A", it introduces a new business typology, which addresses start-ups' needs. Other provisions, such as the legal clarity on the applicable cases of disregard of legal entity and the definition of the nature of investment funds mentioned above, are also positive elements to improve the legal environment and the investment options for start-ups. The Declaration of Economic Freedom Rights also reduces red tape for a number of operations, and therefore is likely to improve the business environment in Brazil.

Box 5.7. Policy recommendations to strengthen digital innovation in Brazil

Strengthen the role of innovation in the country's economic and social agenda

- Orient public support to digital innovation towards mission-oriented research, building on the model of the National IoT Plan.
- Ensure adequate, stable and predictable publicly funded resources for research in ICT.
- Develop clear roadmaps for advancement in key digital technologies, such as artificial intelligence and data analytics, in co-ordination with sectoral ministries and private stakeholders.
- Build capacity in the public sector to procure high-tech innovative solutions, borrowing expertise from businesses and institutions, e.g. BNDES.
- Increase legal guarantees for public servants contracting procurement for innovation.

Reinforce the human resource base for digital innovation

- Revise the current distribution of CAPES scholarships to increase the share of funding to support STEM graduates and PhDs in engineering, natural sciences and ICT. Increase the offer of Master and PhD programmes in these disciplines, in co-operation with the private sector.
- Increase the attractiveness of Brazil's higher education institutions for foreign students by encouraging the use of English in courses.
- Include indicators on the economic and social impact of research among the evaluation criteria of academic researchers.
- Increase knowledge and expertise transfer from business to academia, for instance by encouraging business experts to participate in technology transfer offices and in teaching.

Box 5.7. Policy recommendations to strengthen digital innovation in Brazil *(cont.)*

Reform the Informatics Law to strengthen its support to innovation

- Reform the Informatics Law so as to strengthen its support for innovation. In particular: remove the "basic production process" specifications; limit the eligibility for financial credit to firms with demonstrated innovation capacity or investing in innovative start-ups; extend the incentive to ICT services and to firms investing in R&D in digital technologies across all sectors; revise the calculation of the tax credit to incentivise R&D expenditures above the minimum threshold set by the law; better align the R&D investments in collaborative research to the innovation agenda.
- Carry out a full-fledged evaluation of the Informatics Law.
- Make an *ex ante* impact assessment of the phasing-out of the Informatics Law and engage stakeholders in discussions about future scenarios for the ICT sector in Brazil.
- Make more use of digital tools to monitor the Informatics Law, as well as for the implementation of other public policies.

Strengthen instruments for diffusion of digital innovation

- Increase co-ordination among FINEP and BNDES on the financing of innovation projects, and among these institutions and EMBRAPII, to strengthen the innovation ecosystem.
- Increase funding to EMBRAPII, including by increasing compulsory funding from the Informatics Law to programmes and projects of national interest.
- Identify and strengthen innovation hubs for experimentation and technological transfer to small and medium-sized enterprises, for instance by developing EMBRAPII units to be testbeds for digital technologies. Identify an appropriate co-financing model for the private sector.
- Establish and strengthen public-private partnerships for the advancement of artificial intelligence in a trustworthy way, ensuring participation by small and medium-sized enterprises and start-ups.

Adapt instruments and legal provisions to increase the participation of start-ups in innovative activities

- Consider introducing cash-refund or carry-forward provisions in the Good Law, to make it more suitable for young innovative firms.
- Introduce the possibility for the government to procure innovative solutions from start-ups.
- Establish a one-stop shop where start-ups can access information on existing support programmes. Evaluate the current programmes to streamline the offer and scale up the most successful initiatives.
- Strengthen programmes for start-ups targeting female entrepreneurship.

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Note

Israel

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.