Arranjos espontâneos "sufocados": forças e deficiências da política brasileira para a digitalização industrial

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Resumo: Este artigo mapeia e analisa as políticas recentes de digitalização industrial no Brasil até 2022. Mais especificamente, analisa três estratégias do governo federal - a Estratégia Brasileira de Transformação Digital, o Plano Nacional de IoT e a Estratégia Brasileira de Inteligência Artificial -, e os programas de políticas de digitalização industrial de cinco organizações governamentais - o Banco Nacional de Desenvolvimento Econômico e Social (BNDES), a Agência Brasileira de Inovação (FINEP), o Serviço Nacional de Aprendizagem Industrial (SENAI), a Empresa Brasileira de Pesquisa e Inovação Industrial (EMBRAPII) e a Agência Brasileira de Desenvolvimento Industrial (ABDI). A pesquisa teve duas etapas: a primeira consistiu em uma análise de documentos e dados (alguns não publicamente disponíveis) relacionados a essas políticas; na segunda etapa, foram realizadas 12 entrevistas semiestruturadas com oficiais governamentais brasileiros de alto e médio nível para validar as descobertas e obter perspectivas internas sobre as políticas. As estratégias do governo federal são analisadas em termos de seus processos de formulação, implementação e (quando aplicável) avaliação. Os programas das organizações governamentais são analisados usando uma estrutura analítica original com duas dimensões: funções do sistema de inovação e tipos de instrumentos de política utilizados. Isso permite a identificação de pontos fortes, fraquezas, sobreposições e lacunas no cenário de política de digitalização industrial no Brasil. A principal conclusão é que as estratégias federais não foram eficazes na coordenação dos esforços de atores públicos e privados no Brasil, e, portanto, as organizações públicas têm atuado por meio de "arranjos espontâneos" entre elas. Esses arranjos conferiram alguma racionalidade ao sistema de políticas, mas lacunas, sobreposições, e problemas em programas específicos persistem. Em adição, esses arranjos têm sido "sufocados" pela falta de recursos dedicados às atividades de ciência, tecnologia e inovação (CT&I) no país nos últimos anos e por um contexto macroeconômico adverso. Embora existam alguns estudos sobre programas específicos de digitalização industrial, este é o primeiro trabalho acadêmico que analisa todo o cenário de política de digitalização industrial de um país, sendo assim, uma pesquisa bastante original.

Palavras-chave: Digitalização industrial; Indústria 4.0; Quarta Revolução Industrial; Política industrial; Política de inovação.

Código JEL: O38, O25, O32

Área Temática: 6.2 Políticas de Ciência, Tecnologia e Inovação

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“Choked” spontaneous arrangements: strengths and weaknesses of the Brazilian industrial digitalisation policies

Abstract: This paper maps and analyses the recent Brazilian industrial digitalisation policies until 2022. More specifically, it analyses three federal government strategies – the Brazilian Digital Transformation Strategy, the National IoT Plan, and the Brazilian Strategy of Artificial Intelligence – and the industrial digitalisation policy programmes of five government organisations – the Brazilian Development Bank (BNDES), the Brazilian Innovation Agency (FINEP), the National Industrial Learning Service (SENAI), the Brazilian Company for Industrial Innovation (EMBRAPII), and the Brazilian Industrial Development Agency (ABDI). The research had two stages: the first stage consisted of a “desk-based” analysis of documents and data (some not publicly available) related to these policies; in the second stage, 12 semi-structured interviews were undertaken with high- and medium-level Brazilian government officials to validate the findings and obtain insider views of the policies. The federal government strategies are analysed in terms of their formulation, implementation, and (when applicable) evaluation processes. The programmes of government organisations are analysed using an original analytical framework with two dimensions: innovation system functions, and types of policy instruments. This allows for the identification of strengths, weaknesses, overlaps, and gaps in the Brazilian industrial digitalisation policy landscape. The main conclusion is that the federal strategies have not been effective in coordinating the efforts of public and private actors in Brazil, and thus the public organisations have been acting through “spontaneous arrangements” between them. These arrangements have given some rationality to the policy system, but gaps, overlaps, and problems with individual programmes remain. In addition, these arrangements have been “choked” by the lack of resources dedicated to science, technology, and innovation (STI) activities in the country in recent years, and by an adverse macroeconomic context. Although some studies of specific industrial digitalisation programmes exist, to the best of my knowledge, this is the first academic work that analyses the whole industrial digitalisation policy landscape of a country, and thus it is quite original research.

Keywords: Industrial digitalisation; Industry 4.0; 4th Industrial Revolution; Industrial policy; Innovation policy.

1. Introduction

In recent years, industrial digitalisation has received much attention from industrial and governmental actors as Digital Production Technologies (DPTs)[2] are seen as having the potential to transform production across sectors (ANDREONI; CHANG; LABRUNIE, 2021). However, many barriers have been identified to the process of technological catching-up in DPTs (LABRUNIE, 2024). Therefore, governments have been developing industrial policies to help mitigate these barriers (LABRUNIE; PENNA; KUPFER, 2021). Brazil is no exception to this trend and has also designed national strategies and policy programmes related to industrial digitalisation.

This paper has the goal of analysing the Brazilian policies towards industrial digitalisation and identify its strengths and weaknesses. It starts by presenting the research methods used for investigating the Brazilian DPT policy landscape: "desk-based" analysis of documents and databases, and semi-structured interviews with relevant government officials. Next, it analyses the recent context of Brazilian science and technology funding, and the recent trajectory of the government and quasi-government organisations under analysis – BNDES, FINEP, SENAI, EMBRAPII, and ABDI. Then, it critically evaluates recent federal government strategies towards DPTs, namely the Brazilian Strategy for Digital Transformation (E-Digital), the National IoT Plan, and the Brazilian Strategy for Artificial Intelligence. The subsequent section analyses the recent industrial digitalisation programmes using an original analytical framework. The final section summarises the strengths and weaknesses of the federal government strategies and the organisations' policy programmes, providing some policy recommendations based on the findings of the research.

It must be noted that while some existing works provide conceptual discussions about industrial digitalisation policies (see ANDREONI, CHANG; LABRUNIE, 2021; FOSTER; AZMEH, 2020; SINGH; SINGH, 2022), to the best of my knowledge, this is the first academic work that provides an in-depth analysis of the whole industrial digitalisation policy landscape of a country. OECD (2020a) provides lists of some of Brazil's policy programmes for industrial digitalisation but does not analyse them in detail. HÖLZL et al. (2019) provide a comprehensive report on Austria's digitalisation (including its policies), while BRATTA et al. (2020) analyse a specific Industry 4.0 policy programme in Italy. The analysis carried out in this paper, thus, is quite original.

The analysis conducted in this paper reveals that there are strong points in the Brazilian DPT policy landscape, such as the robust policy formulation processes of the federal plans, the diversity of organisations providing DPT-related programmes with few significant overlaps or gaps, and some well-designed programmes. Nevertheless, it also identifies some important remaining gaps, overlaps, bottlenecks, and policy design issues that have been restraining the impact of policies that otherwise could have strong transformative potential. The two main issues identified are the lack of an authoritative and adequately endowed national plan that goes beyond setting 'guidelines' for DPT policy programmes, on the one hand, and the lack of adequate funding and thus small-scale of many of the interventions, on the other hand. These two issues combined have created a policy system in which individual organisations operate through spontaneous arrangements between them, which are "choked" by a lack of resources and by an adverse macroeconomic context. This situation can, to a large extent, be attributed to the character of the Temer and Bolsonaro administrations, in which STI policies were not considered government priorities. It can also be attributed to the extremely restrictive fiscal regime adopted in December 2016 in Brazil, known as the "expenditure ceiling" ("*teto de gastos"*), which in practice prohibited any meaningful industrial policy actions. The last section will provide a summary and policy recommendations based on the findings of the paper.

2. Research methods and analytical frameworks

2.1 Document analysis and semi-structured interviews

This paper used a two-staged research method. The first stage consisted of a "desk-based" analysis of documents and databases available online on the Brazilian organisations' websites. The second stage consisted of semi-structured interviews with officials of the Brazilian government and quasi-government

[2] DPTs are defined here as four technology clusters: AI and data analytics; the Industrial Internet of Things (IIoT); 3D printing; and Smart robotics (for a discussion about this concept, see .

organisations.

The Brazilian organisations selected were: the Ministry of Science, Technology, and Innovation (MCTI), the Brazilian Development Bank (BNDES), the Brazilian Innovation Agency (FINEP), the National Industrial Learning Service (SENAI), the Brazilian Company for Industrial Innovation (EMBRAPII), and the Brazilian Industrial Development Agency (ABDI). These were chosen for their relevance to industrial digitalisation.

The first stage of the research entailed searching the relevant organisations' websites for documents, such as annual reports and policy programme guidelines, and databases, such as lists of policy beneficiaries. Media outlets were also searched for news related to these organisations. These were then used to provide an overview of the organisations' recent trajectory and their DPT-related initiatives. In addition, in the case of BNDES, a request for access to information (*pedido de Acesso à Informação*) was made with the institution, which resulted in access to unpublished information regarding some of its programmes.

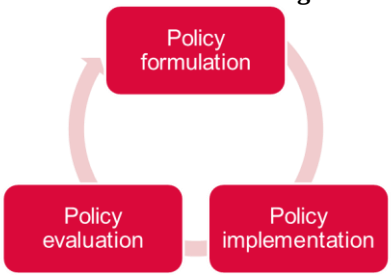
The second stage of the research was used to confirm the findings of the first stage, to make sure that no important programme or initiative was missing, and to deepen the analysis with insider views from the organisations under study. The contact with potential interviewees was established using the snowballing method: a set of initial relevant individuals was contacted and interviewed, who were asked to refer to other relevant individuals, who then indicated other relevant individuals, and so on. The interviews were semi-structured, that is, a set of questions was prepared beforehand, but follow-up questions were asked to explore relevant topics, and freedom was given to the interviewees to explore themes they thought were relevant. In total, 12 government officials were interviewed, including high-ranking individuals from the organisations. Anonymity of the interviewees was ensured, to allow them to speak more freely about potentially sensitive topics. The interviews were carried out mostly online, using Microsoft Teams or Zoom, except for the FINEP one, which was done in person.

A few limitations of this research method should be highlighted. First, due to the large number of policy programmes of the various Brazilian organisations studied, only the ones I consider the most relevant for industrial digitalisation are discussed in this paper. The interview stage, however, helped confirm that no major policy programme was missed in the research. Secondly, programmes purely directed at start-ups (i.e., incubators, accelerators, etc.) are not discussed, as these are large in number and usually small[3]. Also, organisations mainly focused on education and providing scholarships, e.g., CNPq and CAPES, were not included. Finally, given the large changes being made since the start of the new Lula administration on 1 January 2023, the policies discussed are the ones enacted until that date.

2.2 Analytical frameworks

Regarding the federal government strategies, the framework that underpins our analysis is inspired by the "policy cycle" concept (KNOEPFEL et al., 2011) and focuses on three dimensions: policy formulation, policy implementation, and policy evaluation (Figure 1).

Figure 1 – Analytical framework for the federal government strategies



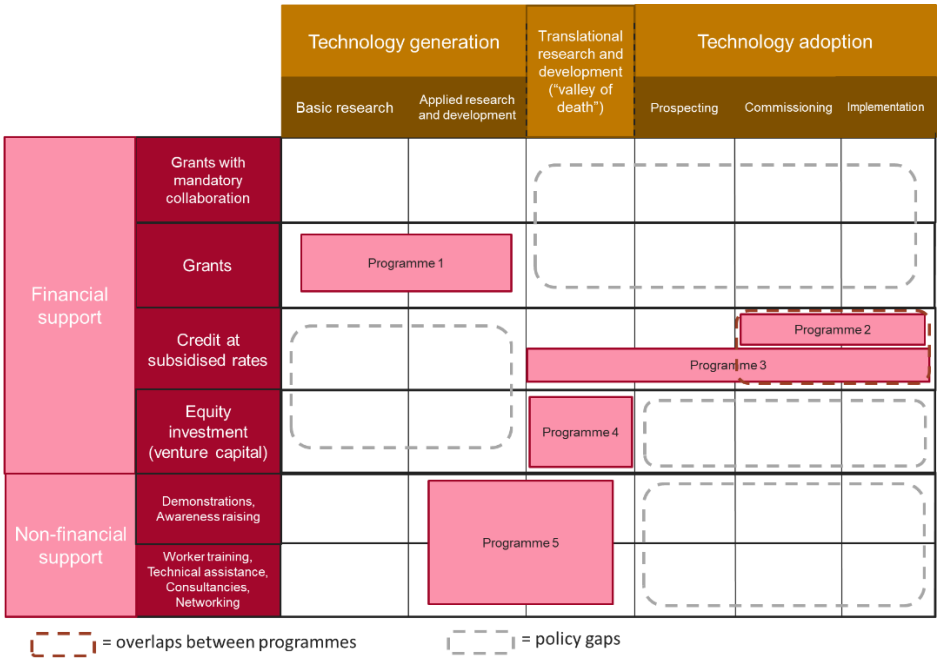
Source: Own elaboration, based on KNOEPFEL et al. (2011)

In respect to the policy programmes of governmental and quasi-governmental organisations, the policy framework used has two dimensions: the innovation system functions of the programmes, and the

[3] Programmes that will not be analysed include: Startup Brasil, Centelha, Finep Startups, IA2, BNDES Garagem, Mulheres Empreendedoras, and many others.

policy instruments used by the programmes (Figure 2 below). Inspired by references from the innovation literature, such as HUDSON; KHAZRAGUI (2013) and VOSS (1992), the innovation system functions are divided into technology generation, translational R&D, and technology adoption (and their sub-functions). Inspired by EDLER; GEORGHIOU (2007), the policy instruments are divided into a set of financial and non-financial instruments. This framework allows us to map the existing policy programmes in the country and visualise potential gaps and overlaps in the policy system.

Figure 2 - Analytical framework of policy programmes: hypothetical example of the analysis of 5 programmes



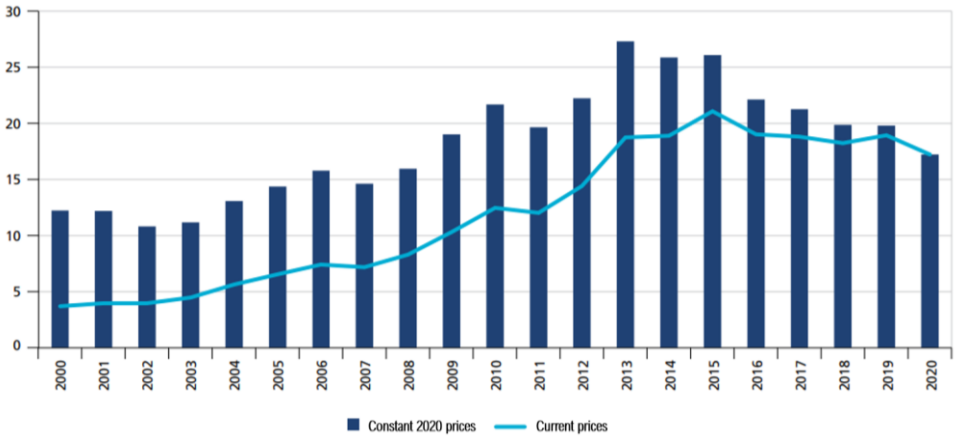
Source: Own elaboration.

3. Recent trajectories in the Brazilian National System of Innovation

3.1 Recent trajectory of public science and technology funding in Brazil

The Brazilian National System of Innovation (NSI) (LUNDVALL et al., 2002; FREEMAN, 2002; NELSON, 1993) has been transforming in recent years with the Temer (2016-2018) and the Bolsonaro (2019-2022) administrations. First, there has been a significant reduction in the overall spending on science and technology by the federal government. This can be seen in Figure 3 below, which shows that the real value of expenditure with R&D in 2020 was at a level below that of 2009.

Figure 3 - Federal government expenditure in science and technology (R$ billion)

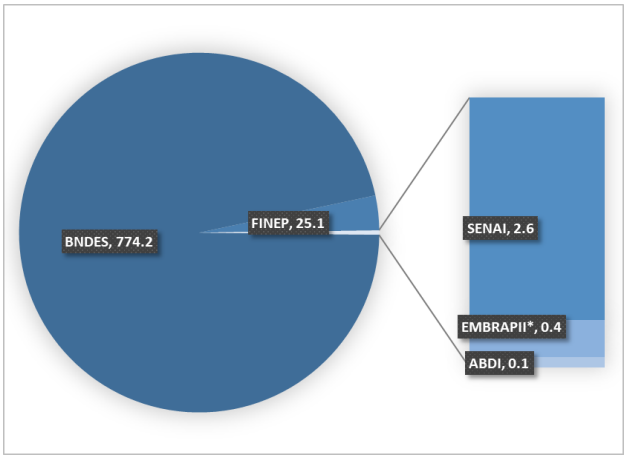


Source: DE NEGRI (2021)

3.2 Recent trajectories of key government and quasi-government organisations

Brazil has a diverse set of government and quasi-government organisations that provide a variety of policy instruments for innovation. In this paper, as discussed previously, five of them are analysed. It is important, however, to keep in mind the enormous size differences of the organisations we analyse in this paper. Figure 4 below shows the total asset values of each organisation, revealing that BNDES is incomparably larger than any other DPT-related organisation. FINEP is also large, although still less than 10% of the size of BNDES. SENAI is small in terms of assets, but its reach and local embeddedness in Brazilian industry and society are unrivalled, making it a fundamental piece of the Brazilian NSI. EMBRAPII is a small organisation in terms of assets, but its strength is in connecting and boosting the existing Brazilian R&D infrastructure, with 98 centres registered as EMBRAPII Units. ABDI is a tiny organisation, which is focusing on the role of information dissemination.

Figure 4 - Total asset value of DPT-related organisations in 2021, R$ billion



Source: Own elaboration based on the organisations' financial demonstrations.
*EMBRAPII works by registering existing research centres as EMBRAPII Units and thus its size is not adequately reflected in the organisation's assets.

During the Temer and Bolsonaro administrations, BNDES changed its focus from being a major funder of industrial projects to a "bank of services" dedicated to helping the government in its "denationalisation" efforts. BNDES disbursements decreased markedly between 2014 and 2019, going from R$187.8 billion to R$55.3 billion and remaining stable at around R$65 billion in 2020 and 2021.

FINEP, in turn, also faced a process of downsizing. Since 2014, FINEP has witnessed a big reduction in the Fund it uses for its operations (FNDCT). This – together with the economic crisis Brazil had been experiencing, the reduction in the commercial interest rates, and the pandemic – has led to a reduction in the number and value of the projects funded, especially grants, until 2021 (in 2022 there was an important rebound). FINEP's credit portfolio, thus came from R$12.8 billion in 2016 to R$8.4 billion in 2021. In terms of staff, there has also been a reduction, coming from 788 staff in 2013 to 549 in 2021.

EMBRAPII has a slightly different trajectory. Since its foundation, it has been operating in a lean and efficient way (it is a small organisation that had only 35 staff members in 2020), receiving positive reviews from the companies participating in the projects and from independent auditors. It has been consistently funding innovation projects, thus consolidating itself as an important organisation of the Brazilian NSI. EMBRAPII's small size reflects its operational model that seeks to leverage the existing research and innovation infrastructure in the country. The main issue with EMBRAPII is that the resources received by EMBRAPII from the Ministries every year have been much lower than originally predicted in EMBRAPII's management contract with them. Had they been respected, EMBRAPII could have been much bigger than it is now. According to the EMBRAPII official interviewed, the resources effectively transferred to EMBRAPII were only 35-40% of what had been originally planned. What has allowed EMBRAPII to perform well even in this circumstance is its three-party model of funding, which brings funding also from the companies and from the research centres, and the funds that come from the Informatics Law, which are, however, restricted to funding specific projects.

The recent trajectory of SENAI, in turn, is of moderate growth except for a slight fall in income in 2020, likely due to the reduced activity caused by the Covid-19 pandemic. Its funding model, based on a levy on private firms of a certain minimum size, instead of direct government transfers may have contributed to this stability. In the interview with a SENAI official, they mentioned that while SENAI is historically focused on providing worker training, it has recently been gradually shifting to giving more importance to its technical assistance role to SMEs through its technology institutes and local innovation agents.

In the case of ABDI, the organisation has had a relatively stable income in recent years, with a slight growth in 2021. Overall, however, it is a small organisation – even smaller than EMBRAPII in terms of budget, although with more staff – 79 vs. EMBRAPII's 35.

4. Industrial digitalisation policies of the federal government

4.1 Brazilian Digital Transformation Strategy (E-Digital)

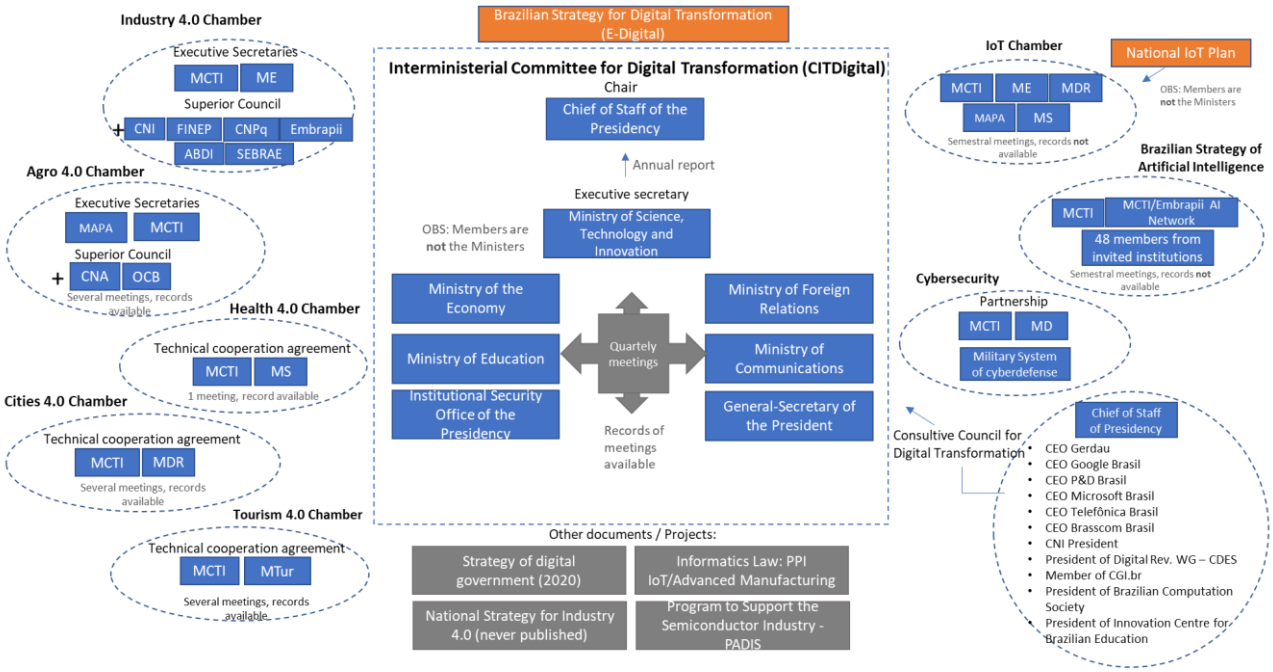
Enacted by Decree n. 9,319 of 21 March 2018, the National System for Digital Transformation was created, composed of the Brazilian Strategy for Digital Transformation (E-Digital), its thematic axes, and its governance structure. E-Digital was created aimed at the harmonisation of the initiatives of the federal government linked to digitalisation, including seizing the potential of digital technologies for inclusive and sustainable economic development (MCTI, 2022). A preliminary version was created by an inter-ministerial working group coordinated by MCTI, in collaboration with the scientific community, civil society, and industry[4]. This preliminary document was then opened for public consultation, to which more than 700 individuals and organisations contributed, including representatives of government (at federal, state, and municipal levels), industry (firms and associations), science and academia (institutes, universities, and schools) and civil society (associations, entities, NGOs, and citizens)[5].

The governance structure of E-Digital is characterised by a central Committee (the Interministerial Committee for Digital Transformation – CITDigital) which oversees several thematic "Chambers" composed of the relevant Ministries, agencies, and industry representatives (see Figure 5 below). These "Chambers", however, are mainly discussion forums while implementation is left to the relevant government agencies (e.g., MCTI, FINEP, EMBRAPII, BNDES, etc.). It is important to note that the Ministerial members of the "Chambers" are not the Ministers, nor there is any specified minimum ranking for the members, which already shows that this strategy is not a top priority of the Ministries, except, possibly, of MCTI.

[4] For the elaboration of E-Digital, 9 full meetings and 25 sub-group meetings were held for presentation and discussion of the themes to be addressed in the strategy. Simultaneously, a consultation with 130 specialists of government, academia, and private sector organisations was carried out, facilitated by CGEE. Finally, meetings were held with private sector representatives, non-government organisations, and government agencies associated to specific themes. These included four workshops on the themes: privacy and data protection; education in the digital era; ICT indicators; and cybersecurity.

[5] In 2022, an open consultation was conducted for the update of E-Digital in the face of new global events, such as the Covid-19 pandemic, and new technological developments. The updated document was published in November 2022. In this paper, only the first document is analysed.

Figure 5 - Governance structure of E-Digital



Source: Own elaboration based on MCTI (2022a).

The E-Digital white paper put forward 100 strategic actions divided into the following seven areas (number of actions in parenthesis):

A. Infrastructure and access to ICTs (9)
B. Research, Development, and Innovation (10)
C. Trust in the digital environment (15)
D. Education and training (9)
E. International dimension (10)
F. Digital transformation of the economy (26)
G. Digital transformation: citizenship and digital government (10)

These actions were monitored in three reports published in 2018, 2019, and 2020, respectively. There were no reports published in 2021 or 2022. In the latest available monitoring report (2020), it is stated that out of the 100 proposed actions, 5 were considered "short term", 15 "medium term", 56 "long term", and 24 "continuous" (meaning that they would require continuous monitoring). Also, out of the 100 actions, it was stated that 23 had been concluded, 59 were under implementation, and 18 were still "open" (meaning that they had not been started). For every action that was either under implementation or concluded, the monitoring report explained what the government "delivery" was, i.e., what it had done until then concerning that specific action. By analysing the "delivery" of the 100 actions, some observations can be made.

On the positive side, it can be noted that the Brazilian government has been active in implementing actions related to reforming or creating legal frameworks for the digital environment[6], and in digitalising the public administration (E-Government)[7]. It also has been making substantial advances in digital infrastructure, cybersecurity, and in participation in international forums regarding digital issues such as data protection, e-commerce, and cross-border cybersecurity.

Nevertheless, there are fundamental problems when it comes to the actions aimed at production (including STI promotion), and those aimed at education and the development of digital skills. This perception that the digitalisation of production did not advance as much as other areas was discussed with

[6] See section 2.1.4.3 above.
[7] Regarding E-Government, it has been making good progress in the digitalisation of public administration (E-government), through making public services available online, and consolidating the websites, databases, and individual platforms of public organisations under the "gov.br" platform.

a high-level official of MCTI, and they agreed with it. These problems become clear when analysing selected actions that were not delivered or the details of the "deliveries" of actions that were labelled as "concluded" (Table 1).

Table 1 – Selected "Open" and "Concluded" E-Digital actions

Action	Delivery	Problem
Action 13: Use the purchasing power of the state to stimulate the development of innovative solutions based on digital technologies.	Not delivered.	Not delivered.
Action 36: Formulate a new national policy of educational technology in substitution to Proinfo[8], articulating the strategic dimensions of infrastructure, competencies, content, and digital educational resources.	Not delivered.	Not delivered.
Action 59: Evaluate the social and economic potential impacts of disruptive digital technologies, such as Artificial Intelligence and Big Data, proposing policies that simultaneously mitigate their negative effects and maximize their positive effects.	Not delivered.	Not delivered.
Action 60: Approve the National IoT Plan, improve mechanisms of government procurement, and implement test platforms for IoT providers in supply chain links of each of the four priority sectors: Health, Farming, Industry, and Smart Cities.	Decree n. 9.854/2019 (National IoT Plan)	Out of the three measures appointed in the Action (approve the IoT Plan, improve government procurement, and implement IoT test platforms) only the first one was delivered. However, the National IoT Plan was approved but was never adequately implemented, as will be discussed in the next section.
Action 63: Implement actions aimed at the development of a dynamic and competitive environment in the segment of devices, sensors, and IoT machinery and equipment.	National IoT Plan, Informatics Law, Support Plan for Development of the Semiconductor Industry (PADIS)	The National IoT plan was approved but was never adequately implemented (see the section on this Plan below). The Informatics Law (1991) and PADIS (2007) were already in place when the strategy was formulated and thus cannot be considered a "delivery", since they were already part of the set of policies the strategy considered insufficient and meant to change. There were alterations to the Informatics Law and PADIS in 2019, but these were only minor and meant to make them more flexible and to conform them to WTO rules.
Action 64: Promote a normative and business environment that guarantees the attraction of new investments in connected devices, ensuring, at the same time, trust and preservation of users' rights.	National IoT Plan, Informatics Law and PADIS, General Law of Protection of Personal Data (LGPD), and Legal Framework of Science, Technology, and Innovation.	The National IoT plan was approved but was never implemented (see the section on this Plan below). The Informatics Law (1991), PADIS (2007), and the Legal Framework of Science, Technology, and Innovation (2016) were already in place when the strategy was formulated and thus cannot be considered a delivery action, since they were already part of the set of policies the strategy considered insufficient and meant to change.
Action 65: Incentivise the adoption of IoT solutions through technological procurement by the government.	Not delivered.	Not delivered.
Action 81: Stimulate the formation of human resources specialised in digital technologies, incrementing the workforce supply with the adequate competencies to act in a digital economy.	Initiative of qualification of human resources in cybersecurity by PPI RNP[9].	Action 81 speaks of the broad training and development of digital skills in Brazil, and the "delivery" mentions only a small and specific initiative of workforce qualification in cybersecurity. This cannot reasonably be considered as fulfilling what the action intended.

Source: Own elaboration based on CITDigital, 2020.

[8] National programme of educational technology, launched in 1997, aimed at promoting the use of ICTs in public middle- and high-schools.

[9] PPI RNP is one of the Priority Programmes of National Interest (PPIs) organised by the National Research Network (RNP), a social organisation responsible for developing digital infrastructure in Brazil.

It can be observed that many "bold" actions of E-Digital were not delivered. These included the proposal of formulating a national policy of educational technology (Action 36), the formulation of policies for disruptive digital technologies (Action 59) and using public procurement to promote technological development (Actions 13 and 65). Problems can also be observed in actions that were considered to have been "concluded". Initiatives that barely scratched the surface of what was intended by some of the strategy's proposed actions were presented as having been sufficient for their "conclusions".

This is perhaps clearest in the cases in which E-Digital actions were proposed to promote and support DPTs. In this case, the stated "deliverables" were R&D incentive policies that already had existed in the country for decades (e.g., Informatics Law, created in 1991, and PADIS, created in 2007). The publication of the National IoT Plan (2019) was also mentioned as a "delivery" of certain actions (actions 60, 63, and 64), even though it was never adequately implemented, as discussed in the next section.

These problems with the implementation of E-Digital seem to reflect at least four fundamental problems in the formulation and evaluation of the strategy. First, the actions were defined in excessively generic and vague ways. This makes it easy for one to claim that the action has been concluded based on very generic "deliveries". Second, there is a lack of prioritisation among the 100 actions. This puts very important measures that require enormous resources at the same priority level as those of relatively small importance or very specific actions. Third, and perhaps more importantly, there is no *independent evaluation mechanism*. Since the government is the one responsible for assessing its own actions, this opens space for a strong positive bias in the evaluation and indeed is what seems to have happened in the case of E-Digital. Fourth, as is common for long-term strategies, the government that formulated the strategy (Temer administration) was not the one implementing it (Bolsonaro administration), hence the possible reluctance of the later government to accept some of the objectives and/or recommended actions.

Furthermore, the identified problems also relate to the fact that CITDigital (the Committee responsible for monitoring E-Digital) and the "Chambers" have only the power to recommend a certain action and cannot issue legally binding directives. Thus, the overall tone of the monitoring reports is that the proposed actions were only guidelines, thereby implying that no consequences were to be expected from the non-fulfilment of some of them.

According to the interviewed high-level official of MCTI, the role of MCTI and of E-Digital was to serve as a "guideline" for coordination of government activities related to digital transformation in the country, especially those of organisations under direct administration of MCTI, such as FINEP, CNPq, EMBRAPII. Indeed, many DPT-related initiatives of these organisations were done in direct partnership with MCTI. Coordination with agencies that lie under another Ministry's jurisdiction was seen as more difficult, such as with BNDES and ABDI, which are under the Ministry of Economy.

Despite this alleged "guideline" role, a recurrent theme in the interviews with officials from the government and quasi-government agencies was the perception of a *lack of an overarching national policy* to help them coordinate their actions. When directly questioned if E-Digital would not provide exactly that, they claimed that the strategy was of little relevance, that it was "just a piece of paper", or that "a plan without a budget is not a plan". Hence, despite its importance as a guide for MCTI officials, it is not a plan that has the authority or budget necessary to drive the actions of government agencies, especially those not under MCTI's jurisdiction.

4.2 National IoT Plan

IoT technology started being discussed in Brazil in 2014 with the creation of the IoT Chamber – an organisation composed of more than 60 different organisations, bringing together representatives of the private sector, the government, and the academia. In 2017, a collaborative initiative between the MCTI (at the time, MCTIC), BNDES, business consulting firm McKinsey, the Research and Development Centre in Telecommunications (CPqD), and legal firm Pereira Neto/Macedo Advogados carried out an in-depth four-phase study of the topic, which culminated in a detailed Action Plan[10]. BNDES also carried out pilot projects related to IoT as a way of proving the potential of the technology (see BNDES section below).

The National IoT Plan (mentioned several times as a "deliverable" of some of E-Digital proposed

[10] For a detailed review of the process of the IoT study, Action Plan, and the National IoT Plan, see (BERNARDINI, 2021).

Actions) was the fruit of this study and its resulting Action Plan. The drafting of the plan was carried out close to the end of Temer's government, so the signing off on the plan was left to the following administration. Bolsonaro sanctioned the plan through Decree n. 9.854 on 25 June 2019.

The decree set the plan's objectives, appointed the IoT Chamber (significantly modified from its original composition to be composed only of Ministerial staff) as the body responsible for implementing and monitoring the plan, and set out three major projects: 1. Innovation Platforms in IoT; 2. Competence Centres for Enabling Technologies in IoT; and 3. The National Observatory for Monitoring Digital Transformation. These projects were deeply studied by BNDES, with comprehensive reports detailing their operational models, funding sources, and governance structures – all detailed in BNDES' IoT Action Plan (BNDES, 2018).

However, after its publication, the plan has not advanced much in any of the three projects. This is surprising, given that BNDES alone spent R$10 million (US$1.9 million) on the research, and R$30 million (US$3.7 million) on pilot projects to prove the viability of IoT concepts (SOPRANA, 2019). The few relevant governmental actions related to IoT in the country were the adoption of Law n. 14.108 authored by federal deputy Vitor Lippi which made Machine-to-Machine communication (M2M) projects exempt from paying some fees (AGÊNCIA SENADO, 2020) and the inauguration of the Centre of Excellence in 4.0 Technology (CET 4.0). CET 4.0 is a pilot centre in the technological park of the city of Sorocaba, focusing on IoT and robotics, created in the context of the National IoT Plan and E-Digital. The centre, however, is physically small (see Figure 6 below), while its finance is meagre. The centre was created with R$500,000 (US$100,000) funding from MCTI, R$500,000 (US$100,000) from parliamentary funding through federal deputy Vitor Lippi, and administrative support from the mayor of Sorocaba. The idea was to replicate this project in the rest of the country but, so far, this is the only one[11]. These initiatives fall significantly short of what was envisaged by the IoT Action Plan.

Figure 6 - CET 4.0 - A pilot Centre of Excellence in 4.0 technologies

Source: CET 4.0, 2022

The interviewed official from the MCTI confirmed that not much had been done in terms of the National IoT Plan and that, in their opinion, the plan had been "run over" (i.e., overshadowed) by the creation of other strategies and fora, such as E-Digital, the 4.0 Chambers, the Brazilian Strategy for Artificial Intelligence, and other related policies. According to the interviewee, however, the BNDES IoT study was the basis for all these policies. Indeed, this can be seen by the fact that the framework developed in the study – separating IoT applications into four areas: Agro, Industry, Healthcare, and Cities – permeates the Brazilian DPT policies – this framework is found in E-Digital, the 4.0 Chambers, in FINEP's programmes, in BNDES programmes, and others. Despite this conceptual influence, once the other policies were enacted, the National IoT Plan was largely forgotten, and few actions came directly from it.

[11] Also in Sorocaba, there is a Centre of Reference IoT and 4.0 Technologies, which has support from MCTI, but it is not a standalone institute, but is housed within Facens (Engineering University of Sorocaba).

4.3 Brazilian Strategy for Artificial Intelligence (EBIA)

A more recent strategy that is important for our study is the Brazilian Strategy for Artificial Intelligence (EBIA), launched in 2021. Similar in style to E-Digital, the strategy was created through a 3-staged process involving the hiring of a specialised consulting company, national and international benchmarking exercises, and running a public consultation process. This led to a document that established 73 strategic actions divided into six vertical axes and three transversal axes.

The main action associated with the strategy so far has been the collaboration between MCTI, FAPESP, and the Management Committee of the Internet in Brazil (CGI) for the creation of up to eight Centres of Applied Research (CPA) in Artificial Intelligence. So far six centres have been established, each of which focuses on specific areas of application. Each centre will receive up to R$1 million (US$190,000) per year for five years, renewable for another five years. This is a tiny amount if compared with countries such as the US and China, whose governments have been investing a few billion dollars a year in AI research and development (CSET, 2019).

In the interview with a high-level official of MCTI, it was highlighted that the funding for these centres was obtained from an unusual source: a public account that had been idle for decades, which gathered money from the set-up of online domains (basically, to set up certain domains in Brazil, a fee must be paid to a public account associated with the São Paulo Research Foundation - FAPESP, whose resources had never been used). Given its recent launch, not much can yet be analysed in terms of outcomes of these initiatives or in terms of policy evaluation.

5. Industrial digitalisation programmes of government and quasi-government organisations

Figure 7 below maps the industrial digitalisation programmes of the Brazilian government and quasi-government organisations using the analytical framework described in Section 2.1. A detailed description of each programme is provided in the Appendix.

Overlaps were detected between BNDES and FINEP, on one hand, and between EMBRAPII, SENAI, ABDI, and FINEP, on the other. BNDES and FINEP both have funding for buyers of 4.0 machines or solutions (BNDES Máquinas 4.0 and FINEP Inovacred 4.0). While they vary in terms of the criteria they use (e.g., BNDES has a local content requirement much stricter than FINEP's), they both have registers of firms eligible to receive their funding – which often contain the same firms. These two programmes could potentially be unified so that DPT providers would not have to do a separate process of registration for each funding body. BNDES and FINEP also have credit and grants for DPT innovators. Synergies between their programmes could be explored and a rationalisation of tasks could be made – e.g., making BNDES responsible for large-scale projects, and FINEP for small-scale ones.

EMBRAPII, SENAI, ABDI, and FINEP all have grants for innovators. However, on a closer look, there is a division of labour between these organisations. EMBRAPII is focused on providing funding through a very specific mechanism: automatic funding to projects contracted between EMBRAPII Units and companies. SENAI is focused on providing worker training and has been moving towards supporting innovation and providing technical assistance to firms through its locally embedded innovation centres (SENAI Innovation and Technology Institutes) and local innovation agents. Its focus, however, is SMEs. ABDI is a smaller organisation, and as a result is more focused on providing demonstration projects that can be scaled up by other organisations (e.g., companies, municipalities, etc.). FINEP, in turn, has been providing innovation grants but these have been made available mainly through public calls for projects (Tecnologias 4.0 and Startups IA), which are more targeted in their objectives and have specific eligibility criteria. Thus, at a greater level of detail, there is not so much overlap between these organisations, although their distinctions could be made clearer for firms seeking support for DPT-related projects.

Furthermore, the framework highlighted two main gaps in the Brazilian industrial digitalisation policy landscape. First, none of these organisations provides grants for the adoption of DPTs (except for some very small ABDI programmes). DPT-related grants in Brazil are mainly for the creation of new technologies and often with mandatory collaboration with the firms demanding those technologies. However, technology adoption grants could provide more direct funding for the acquisition of off-the-shelf DPT solutions, or hiring specialised technology services, especially for SMEs. In Japan, for example, the Organization for Small & Medium Enterprises and Regional Innovation (OSMERI) provides US$1.3

billion annually in match-funding grants for SMEs to use in acquiring new machines, hiring technology services, training workers, and other services (METI, 2020, p. 18). Some interviewed firm managers from the Brazilian machinery and equipment sector noticed that accessing subsidised credit for DPT adoption was somewhat difficult and required having a dedicated organisational capacity – something most SMEs cannot afford (LABRUNIE, 2024). Technology adoption grants would exactly address this gap, facilitating the access of SMEs to DPTs.

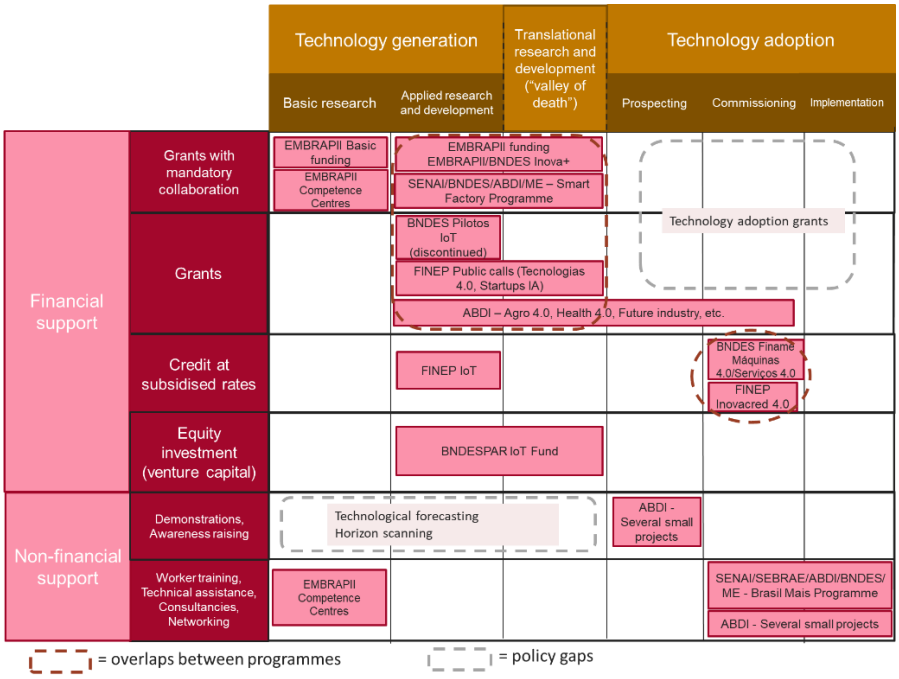
Secondly, the organisations analysed are not providing technological forecasting or "horizon scanning" services in Brazilian government agencies. These activities would seek to identify potential threats, risks, emerging issues, and opportunities in new technologies and to drive the Brazilian NSI towards activities that may be beneficial for the country in the future.

The issue of policy coordination between different agencies was also explored in the interviews. What became clear is that there is an important effort of collaboration between them, which is often carried out in the MCTI-run "4.0 Chambers". As a result, there are many DPT-related partnerships between different agencies (e.g., Brasil Mais programme, BNDES-Embrapii Inova+ programme, etc.), not to speak of informal communications and relationships between the officials that compose these organisations. However, the existing strategy does not seem to have a sufficient budget or authority to provide effective coordination of the individual efforts of government agencies and the private sector. In the absence of a coherent national policy framework, Brazil is left with spontaneous arrangements between the different organisations. This leads to some, although not major, overlap between the different agencies and some important policy gaps.

Some potential programme-specific design issues were also perceived. This was the case of BNDES Máquinas 4.0 and Crédito Serviços 4.0. The issue found with BNDES Máquinas 4.0 is that it works by incentivizing the acquisition of individual machines. However, as pointed out by interviewed machinery firms in LABRUNIE (2024), the benefits of DPT solutions are only achieved when the whole production line, the whole factory, or the whole company are connected. The issue with Crédito Serviços 4.0 is that it was not attractive to firms, having carried out zero operations until 2022.

Another issue worth mentioning is the approach of these policy programmes to the conditionalities required from the companies receiving the benefits. Overall, the programmes analysed do not have *ex post* conditionalities (e.g., related to performance), but rather establish *ex-ante* conditions for the eligibility of companies or some of its products and services. If companies can prove that they fulfil the criteria established by the policies, it is assumed that the activities are worth supporting with public money. The criteria used include company size, level of innovativeness of products or services, and degree of local content used in the production of products and services. For example, for a product to be eligible for acquisition via BNDES subsidised loans for machinery and equipment (FINAME) the company must prove that the product is produced with at least 50% local content. This percentage can go down to 30% if the company proves that the product or the company has some other characteristics such as: uses sophisticated technology, carries out innovation activities, exports significantly, and employs a significant amount of technical workforce.

Figure 7 - Map of main policy instruments used by each DPT-related government or quasi-government organisation



Source: Own elaboration.

6. Summary and discussion

From the analysis carried out, it can be observed that the Brazilian DPT policy landscape is varied, reflecting its well-established NSI. However, there are several shortcomings and inconsistencies both in national policies and in the organisations that are related to DPTs. A summary of our findings and some policy recommendations are presented next.

6.1 Federal government policies

6.1.1 Strengths and main issues of individual policies

Based on the analysis carried out in this paper, Table 2 below summarises the strengths and main problems of the federal policies studied.

Table 2 – Federal DPT policies strengths and main problems

	Strengths	**Main problems**
E-Digital	Robust formulation process.	Only a "guideline", lacking in budget and authority. Flawed implementation, especially regarding issues related to the digitalisation of productive activities. Flawed evaluation process with no external input from independent sources.
National IoT Plan	Robust underlying "IoT study" that informed the policy.	Not implemented significantly. Overshadowed by other industrial digitalisation policies.
Brazilian Strategy for Artificial Intelligence	Robust formulation process. Creation of Applied Research Centres.	Implementation relied on the creativity of policymakers in finding an unconventional source of funding.

Source: Own elaboration

Overall, it appears Brazil is good at making plans, but less so at implementing them, and even worse at evaluating them and learning from them. A recurrent issue in almost all interviews is that Brazil lacks an authoritative national plan that would guide the individual efforts of the different government agencies and the private sector. The existing plans were not seen as having the strength or the authority to serve as such a guide.

6.2 DPT-related government and quasi-government organisations

6.2.1 Strengths and main issues of individual organisations

Based on the above analysis, the strengths and main problems of the DPT initiatives of the analysed organisations are presented in Table 3 below.

Table 3 – Government and quasi-government DPT policies' strengths and main problems

	Strengths	**Main problems**
BNDES	A range of programmes that address DPTs directly (BNDES Pilotos IoT, Finame Máquinas 4.0/Crédito Serviços 4.0, and BNDESPAR IoT Fund) - Collaboration with other organisations (SENAI, ABDI, EMBRAPII)	- Shrinking disbursements in recent years. Potentially ineffective support as BNDES interest rates are close to market rates - Recent changes have dropped innovation as one of the bank's priorities. - Potential policy design issue in the Finame Máquinas 4.0 programme.
FINEP	A range of programmes that address DPTs directly (Finep Inovacred 4.0, Finep IoT, public call for projects on 4.0 technologies and AI start-ups)	- Shrinking disbursements, credit portfolio, and staff in recent years, although with an important reversal in 2022.
SENAI	- Local embeddedness of SENAI Innovation Institutes and training courses - Brasil Mais programme, which has achieved very positive results - Relevant regional programmes, e.g., SENAI/SP's Digital Transformation Journey	- No major problems were found with SENAI, as it is the only organisation that is of adequate size for Brazil's needs, has been having consistent funding, and has been providing effective industrial digitalisation programmes.
EMBRAPII	- Lean and efficient operations - Mandatory collaboration and financial contribution between research and technology organisations and firms - Digital transformation network of firms and research centres - Channelling of Informatics Law funds through PPIs - Competence centres	- Small size, and government transfers that are much smaller than what had been established in the management contract of the organisation, stifling its growth.
ABDI	- Lean and efficient operations - Focus on demonstration projects which can be scaled up by clients	- Small size.

Source: Own elaboration

In addition to what is summarised in the above Table, the interviewees commonly highlighted that one of the main problems faced was the lack of demand by the private sector for the existing programmes. In the case of BNDES and FINEP, it was highlighted that the organisations have the capacity to provide credit to many more companies than the current level but that the demand was simply not there[12]. This lack of demand for credit was attributed to a lack of knowledge in the Brazilian industry about the public support available to them. They also mentioned the lower interest rates available in the market in the 2019-2021 period as a potential cause (i.e., with low interest rates in the market, firms would prefer to take private credit rather than public) as well as the economic recession context, which makes firms reluctant to take loans and make investments – regardless of how subsidised they are.

6.3 Concluding remarks

To sum up, the Brazilian government has formulated national plans for DPTs but with clear shortcomings in their implementation and evaluation. Nonetheless, the country has a diversified set of organisations that

[12] Please note that this only applies to credit. For grants, the demand is usually large as was seen in the case of FINEP's "4.0 technologies" call for applications (see Appendix).

have been implementing different types of DPT-related policies. The main issue observed is that the large-scale funding organisations (BNDES and FINEP) have seen their budget reduced and a smaller one has been unable to scale up its activities as originally planned (EMBRAPII). SENAI's funding is not dependent on government transfers, so the organisation has been able to increase its revenue and spending capacity.

There are four overall recommendations of this paper:

1. Create an authoritative national plan that goes beyond just making recommendations and actively guides and coordinates the efforts of individual government agencies and the private sector.
2. Fix the possible policy design issues with some programmes, such as the BNDES Máquinas 4.0 and Crédito Serviços 4.0.
3. Create technology adoption grants of easy access for SMEs, possibly attaching them to the Brasil Mais Produtivo programme.
4. Overall, scale-up the funding to the relevant agencies for industrial digitalisation programmes.

Another important point raised by this research (although not highlighted in this paper, but which can be found in LABRUNIE (2024)) is the important role of *integrators* in the diffusion of DPTs. Brazil has many integrator firms that work at the global technological frontier. These firms could be leveraged and incentivised to help diffuse DPTs in the Brazilian industry and become internationally competitive players.

Finally, an important point raised in this research, but which needs further studies to confirm it, is the importance of a *complete policy system*, that is, a policy system that can address all barriers to DPT adoption and development simultaneously. There are many conditions for successful technological catching-up, and many of them are *necessary conditions*, thus meaning that even the non-fulfilment of one of them can bring the whole process to a halt. This entails that it may be better to support a limited number of firms to address *all barriers*, rather than to support a large number of firms to address a few barriers.

In sum, so far, the Brazilian DPT policy landscape has developed through spontaneous arrangements between individual agencies. This has worked to a certain extent, for example, in avoiding too much overlap between the initiatives and gaps in the policy system. However, the government officials were almost unanimous in arguing that a stronger national strategy is needed to help policy coordination and stimulate private sector efforts. The main problem, however, is that these spontaneous arrangements have been "choked" by the lack of resources, attention, and effort dedicated to STI activities in the country and by a macroeconomic environment of stagnation and instability, which stifles the private investments needed for DPT development and adoption. Recent changes are being made since the new Lula government took power in 2023, addressing some of the issues raised in this paper. The analysis of these changes, however, goes beyond the scope of this research, and further work is necessary to understand which weaknesses may still remain.

Appendix – Industrial digitalisation programmes of selected government and quasi-government organisations

Table A1 – Brazilian programmes for industrial digitalisation

Organisation	Programmes	Description
BNDES	BNDES Funtec – IoT Pilots	Programme designed in the context of the IoT study and Action Plan. Selected 15 pilot projects in 3 areas (Health, Rural, and Cities) as a proof-of-concept of IoT applications. It provided at least R$1 million (US$ 200 thousand) in match grants to each project.
	BNDES FINAME Máquinas 4.0 and Crédito Serviços 4.0	Special instrument of BNDES's credit line for machinery and equipment acquisition (FINAME), focused on 4.0 Machinery and 4.0 services. In 2022 there were 187 machines or equipment and 106 services registered as 4.0. An information access request revealed that by the end of 2022, 150 operations had been done in the 4.0 Machines line, with an average of R$1.1 million (US$220 thousand) and no operations had been done in the 4.0 Services line.
	Partnership BNDES Funtec/EMBRAPII – Inova+	Partnership between BNDES Funtec and EMBRAPII devoting R$50 million (US$10 million) for digital transformation projects. In practice, BNDES provides the funding and EMBRAPII delivers the programme through its system of support of EMBRAPII Units.
	Partnership BNDES Funtec/SENAI/ABDI/ME – Brasil Mais ("Brazil Plus")	BNDES has provided R$20 million (US$4 million) for the Brasil Mais programme, which corresponds to 50% of the programme's total budget. The programme develops and diffuses digital solutions to SMEs through SENAI's technology institutes and local innovation agents. See the SENAI section below.
	Partnership BNDESPAR/Qualcomm – IoT Fund	In December 2019, BNDESPAR (the part of BNDES that makes equity investments) committed to investing up to R$40 million (US$8 million), with a limit of up to 25% of the total capital, to a venture capital fund focused on IoT technology firms. Technology firm Qualcomm matched this amount and the fund has been operational since early 2020.
	BNDES Finem – Direct Innovation Credit	Although not specific to DPTs, BNDES has a credit line for innovation projects at subsidised rates that can be used for large DPT-related projects. The minimum scale of projects is R$20 million (US$4 million).
FINEP	FINEP Inovacred 4.0	Similar to BNDES Finame 4.0, this instrument provides funding for the acquisition of 4.0 solutions. The 4.0 solution must be developed by a registered integrator. This instrument provides funding of up to R$15 million (US$3 million) for 8 years. Until the end of 2022, 49 projects had been commissioned using this instrument, with an average of R$1.1 million per project (US$220 thousand).
	FINEP IoT	Finep IoT is focused on the development and diffusion of new products, processes, and services based on digital technologies for IoT and Advanced Manufacturing. It can be used to fund the development of new IoT solutions, the development of digitalisation plans, and the implementation of digitalisation plans in production processes.
	FINEP Public Selection – 4.0 Technologies	In June 2020, FINEP and MCTI opened a public call for projects related to 4.0 Technologies in four themes: Agriculture 4.0, Smart Cities, Industry 4.0, and Health 4.0. Originally, the call for applications had a total grant budget of R$50 million (US$10 million). However, the sum of applications received demanded R$2.5 billion (US$500 million), or 50 times more than the budget allocated. In total, 1,190 proposals were submitted, of which 698 were considered for selection and 310 were approved, but only 26 (or 8.3% of the approved projects) were funded, due to the limited resources. When a supplementary budget became available in December 2021, FINEP raised the amount of resources allocated to the public call. After the increase, the number of projects funded was raised to 166 and the budget allocated totalled R$267 million (US$50.5 million). After the revision, in each area, at least 50% of the approved projects were funded.
	FINEP Public Selection – Startups IA	In March 2022, FINEP launched the public call for projects "Startups IA" meant to provide grants for Artificial Intelligence projects developed by micro- and small enterprises (start-ups). The total budget allocated to the call for projects is R$80 million (US$16 million), which is to be applied to the themes: Agriculture 4.0, Health 4.0, Industry 4.0, Smart Cities, and Tourism 4.0. In each project proposal, a "co-financer intervenor" has to be appointed. This "intervenor" is a medium-sized or large enterprise that is interested in the solution developed by the start-up and thus will join the project as a co-financer. In this public call, 47 projects have been approved, reaching the limit of the resources (R$79.7 million).
SENAI	SENAI 4.0	SENAI 4.0 is a set of programmes designed to help SMEs prepare for the so-called Fourth Industrial Revolution. Three types of services are offered: 1. Worker training and post-graduate courses in Industry 4.0 technologies; 2. Consultancies, applied research, and innovation through SENAI's 26 Institutes of Innovation (focused on carrying out applied research and developing new products, processes, and customised industrial solutions) and 58 Institutes of Technology (focused on providing technical metrology services and business consultancy to Brazilian firms); 3. Industry 4.0 Maturity Evaluation - based on the methodology developed by the German Academy of Sciences and Engineering (Acatech), this service helps firms determine their degree of maturity in terms of implementation of Industry 4.0 concepts and technologies.
	SENAI/BNDES/ABDI/ME – Smart Factory programme	The Smart Factory programme aims to stimulate the development of new products that accelerate the adoption of Industry 4.0 technologies (TRLs 6 to 9) by SMEs in various industrial sectors by providing funding to a consortium of actors. The duration of the projects is 12 months (extendible for another six) and for each project, a maximum of R$800,000 (US$160,000) grant is given, the exact amount depending on how many SMEs the technological solution will be applied to. A minimum investment of 30% from the technology provider is also required. In total, the project

		plans to provide R$28 million (US$5.5 million) in several cycles.
	ME/ABDI/SENAI/SEBRAE/BNDES – Brasil Mais ("Brazil Plus")	This programme seeks to increase the productivity and competitiveness of SMEs through the provision of consultancy and technical assistance services. It is divided into two tracks: the "Productivity" track helps them implement better business management practices, such as establishing a business plan and applying lean production concepts to the firm's organisation; the "Digital Transformation" track helps them adopt digital solutions that have a high impact and can be implemented quickly and at a low cost. Since 2020, more than 90,000 SMEs in different sectors across the country have been served by the programme, with impressive results.
	SENAI/SP (São Paulo) - Digital Transformation Journey	In addition to national-level policies, some of SENAI's regional directorates have policies of their own. An important and recent one is SENAI/SP's Digital Transformation Journey programme. Similar to Brasil Mais, it works through technical visits to companies, providing an 8-stage "journey" that goes from diagnostic of the firms' needs to implementing automation, digitalisation, integration, and smart-industry solutions. The programme aims to support 40,000 firms (roughly 10,000 firms per year) and is collaborating with funding bodies to seek dedicated credit lines for the registered DPT solutions they implement (this credit line is currently in a pilot stage).
EMBRAPII	MCTI/EMBRAPII Innovation Networks	EMBRAPII coordinates the Digital Technologies and Innovation Network (started in June 2022), involving several research centres across the country on specific technology areas. Previously, this was split into two networks: the Digital Transformation Innovation Network (started in March 2021 connecting 22 EMBRAPII Units), and the Artificial Intelligence Innovation Network (started in December 2020, connecting 19 EMBRAPII Units).
	PPI in IoT/4.0 Manufacturing [13]	EMBRAPII is also responsible for carrying out the IoT/4.0 Manufacturing PPI funded by the resources from the Informatics Law. These resources can be used for projects to be carried out with EMBRAPII Units that are part of the EMBRAPII network of IoT and 4.0 Manufacturing, and follow the usual division of investments: 1/3 EMBRAPII and 2/3 private companies and EMBRAPII Units; or ½ EMBRAPII and ½ private companies and EMBRAPII Units, if the private company is medium-sized or smaller (turnover lower than R$90 million).
	MEC/EMBRAPII/SENAI - 4.0 Capability Building programme (Programa Capacitação 4.0)	Launched in October 2020, this programme seeks to train 10,000 students in 5 years on new industrial technologies through exposure to real industrial experiences and advice from a tutor. The programme involves students from federal schools, federal universities, and SENAI Innovation Institutes associated with EMBRAPII. The programme is funded by MEC and operated by EMBRAPII, in collaboration with SENAI.
	Basic funding EMBRAPII	This programme seeks to help the development of technology areas that are not yet internalised in the EMBRAPII Units and that are not yet part of the investment portfolio of the participating companies. It focuses on high-risk technologies of Technology Readiness Levels 2-4 (the early stages of technology development). Funding for this programme comes both from the PPI in IoT/4.0 Manufacturing, and from a programme for the automotive sector (the Rota 2030 Programme). The first cycle focused on three Artificial Intelligence areas, three digital transformation areas, and three areas related to autonomous vehicles and mobility. For each of these areas, R$1 million (US$200 thousand) was provided to a consortium of at least two EMBRAPII Units, two firms, and one start-up. The consortium had to contribute at least 10% of the value of the project.
	Competence Centres (CCs)	Using resources from the PPIs (Informatics Law), EMBRAPII opened in August 2022 a public call for registering five research groups of existing research and technology centres as Competence Centres (CCs). The eligible technology areas are 5G/6G communication networks, open Radio Access Networks, quantum technologies, cybersecurity, and immersive technologies for virtual reality. EMBRAPII will provide up to R$60 million (US$15 million) for a 3.5-year contract with the consortium of CCs and firms, and firms associated with the CCs will also have to contribute financially. At least one of the CCs has to be headquartered in the North, Northeast, or Centre-West region of Brazil.
ABDI	Many small projects	ABDI's projects are usually small. Many do not reach R$1 million (US$200,000), and only a few surpass R$10 million (US$2 million). Many ABDI programmes focus on the demonstration of digital technologies.

Source: Own elaboration.

References

AGÊNCIA SENADO. **Sancionada lei de incentivo à "internet das coisas"**. Disponível em: <https://www12.senado.leg.br/noticias/materias/2020/12/17/sancionada-lei-de-incentivo-a-internet-das-coisas>. Acesso em: 7 out. 2022.

[13] Not a lot of information was found on the second PPI managed by EMBRAPII – HardwareBR. EMBRAPII's interviewee clarified that this is due to the more specific character of the HardwareBR programme, which involves only a few organisations.

ANDREONI, A.; CHANG, H.-J.; LABRUNIE, M. Natura non facit saltus: Challenges and opportunities for digital industrialisation across developing countries. **The European Journal of Development Research**, v. 33, n. 2, p. 330–370, 2021.

BERNARDINI, G. **Internet das Coisas no Brasil: a comunicação nos processos interativos das Cidades Inteligentes**. São Paulo: UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO" – UNESP FACULDADE DE ARQUITETURA, ARTES E COMUNICAÇÃO – FAAC PROGRAMA DE PÓS-GRADUAÇÃO EM MÍDIA E TECNOLOGIA – PPGMIT, 2021.

BNDES. **Internet das Coisas: um plano de ação para o Brasil - Desenho de alto nível das Plataformas de Inovação e dos Centros de Competência.** Disponível em: <https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinternetdascoisas/fase4_11_desenho-de-plataformas-de-inovacao-e-centros-de-competencia.pdf>. Acesso em: 7 out. 2022.

BRATTA, B. et al. The Impact of Digitalization Policies. Evidence from Italyï¿½s Hyper-depreciation of Industry 4.0 Investments. **Working Papers**, Working Papers. jun. 2020.

CET 4.0. **CET 4.0**. Disponível em: <https://www.cet40.org/>. Acesso em: 7 out. 2022.

CITDIGITAL. **Relatório de acompanhamento E-Digital**. Brasília: Comitê interministerial para a transformação digital, MCTI, 2020. Disponível em: <https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosestrategiadigital/citdigital_relatorio-de-acompanhamento-2020-rev-12-2020.pdf>. Acesso em: 10 out. 2022.

CSET. **Chinese Public AI R&D Spending: Provisional Findings**. **Center for Security and Emerging Technology**, 2019. Disponível em: <https://cset.georgetown.edu/publication/chinese-public-ai-rd-spending-provisional-findings/>. Acesso em: 10 mar. 2023

DE NEGRI, F. **Políticas públicas para ciência e tecnologia no Brasil: cenário e evolução recente**. [s.l.] Instituto de Pesquisa Econômica Aplicada, Diretoria de Estudos e Políticas Setoriais de Inovação e Infraestrutura, 2021. Disponível em: <http://repositorio.ipea.gov.br/bitstream/11058/10879/2/NT_92_Diset_Politicas_Publicas_Para_Ciencia.pdf>. Acesso em: 29 set. 2022.

EDLER, J.; GEORGHIOU, L. Public procurement and innovation—Resurrecting the demand side. **Research Policy**, v. 36, n. 7, p. 949–963, 1 set. 2007.

FOSTER, C.; AZMEH, S. Latecomer Economies and National Digital Policy: An Industrial Policy Perspective. **The Journal of Development Studies**, v. 56, n. 7, p. 1247–1262, 2 jul. 2020.

FREEMAN, C. Continental, national and sub-national innovation systems—complementarity and economic growth. **Research policy**, v. 31, n. 2, p. 191–211, 2002.

HÖLZL, W. et al. Digitalisation in Austria. State of Play and Reform Needs. **WIFO Studies**, 2019.

HUDSON, J.; KHAZRAGUI, H. F. Into the valley of death: research to innovation. **Drug Discovery Today**, v. 18, n. 13, p. 610–613, 1 jul. 2013.

KNOEPFEL, P. et al. **Public Policy Analysis**. [s.l.] Policy Press, 2011.

LABRUNIE, M. **Economic development and industrial policy in the age of digitalisation: global mapping and the case of Brazil**. PhD Thesis—Cambridge, United Kingdom: University of Cambridge, Centre of Development Studies, 2024.

LABRUNIE, M. L. **Economic development and industrial policy in the age of digitalisation: global mapping and the case of Brazil**. Cambridge, UK: Centre of Development Studies, University of Cambridge, forthcoming.

LABRUNIE, M. L.; PENNA, C. C.; KUPFER, D. The resurgence of industrial policies in the age of advanced

manufacturing: an international comparison of industrial policy documents. **Revista Brasileira de Inovação**, v. 19, 2021.

LUNDVALL, B.-Å. et al. National systems of production, innovation and competence building. **Research policy**, v. 31, n. 2, p. 213–231, 2002.

MCTI. **Estratégia Brasileira para a Transformação Digital**. Disponível em: <https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/estrategia-digital>. Acesso em: 5 out. 2022.

METI. 令和４年度補正予算の事業概要. Disponível em: <https://www.meti.go.jp/main/yosan/yosan_fy2022/hosei/pdf/pr_hosei_221202.pdf>. Acesso em: 27 mar. 2023.

NELSON, R. R. **National innovation systems: a comparative analysis**. [s.l.] Oxford University Press, USA, 1993.

OECD. **Going Digital in Brazil**: OECD Reviews of Digital Transformation. Paris: OECD Publishing, 2020. Disponível em: <https://doi.org/10.1787/e9bf7f8a-en>. Acesso em: 27 mar. 2023.

SINGH, S.; SINGH, R. Economic Imperatives of Evolving National Digital Policy: A Call for a Modern Industrial Policy Framework in India. **The International Trade Journal**, v. 36, n. 6, p. 572–593, 2022.

SOPRANA. **Plano de incentivo à conectividade no país está na geladeira**. Disponível em: <https://www1.folha.uol.com.br/seminariosfolha/2019/02/plano-de-incentivo-a-conectividade-no-pais-esta-na-geladeira.shtml>. Acesso em: 6 out. 2022.

VOSS, C. Successful innovation and implementation of new processes. **Business strategy review**, v. 3, n. 1, p. 29–44, 1992.