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ICT Enterprises

SURVEY ON THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN BRAZILIAN ENTERPRISES

2025

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Brazilian Network Information Center

ICT Enterprises

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2025

Brazilian Internet Steering Committee
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(in August, 2026)

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The maintenance of this space for debate has been fundamental for identifying new areas of investigation, refining methodological procedures, and enabling the production of accurate and reliable data. It is worth emphasizing that the voluntary participation of these experts is motivated by the importance of new technologies for Brazilian society and the relevance of the indicators produced by the Brazilian Internet Steering Committee (CGI.br) for policymaking and academic research.

For the 17th edition of the ICT Enterprises survey, the Regional Center for Studies on the Development of the Information Society (Cetic.br) would like to specially thank the following experts:

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Foreword

The Internet is a network built over decades through collective effort. It has established itself as an essential infrastructure for contemporary society, enabling economic activities, public policies, fundamental services, and various forms of social interaction. More than just offering a set of applications and services visible to end users, the Internet operates on an open, neutral, interoperable, and distributed technical architecture, whose integrity is a prerequisite for innovation, inclusion, and the exercise of rights in the digital environment.

Following the guiding principles of the Internet and in constant interaction with the Brazilian Internet Steering Committee (CGI.br), the Brazilian Network Information Center (NIC.br) plays its role in coordinating and strengthening the Internet in Brazil. In 2025, 20 years after its reconfiguration as a legal entity, NIC.br reaffirmed its commitment to managing critical network resources, operating stable infrastructure, and promoting a secure, accessible, and high-quality digital environment for Brazilians. This institutional milestone occurred in an equally significant context, alongside the celebration of the 30th anniversary of CGI.br—internationally recognized as a successful experiment in multistakeholder Internet governance.

One of NIC.br's various areas of activity focused on digital security is the Brazilian National Computer Emergency Response Team (CERT.br), which has played a central role in coordinating incident responses, disseminating best practices, and strengthening technical capabilities for online security, contributing to the resilience of the country's Internet infrastructure. These actions are linked to the publication of extensive awareness-raising and training material, always reinforcing the importance of a preventive and collaborative approach to security in the digital environment.[1]

Promoting a more accessible and inclusive Internet is also part of NIC.br's agenda. The Web Technologies Study Center (Ceweb.br) plays a role in this area, developing initiatives focused on digital accessibility and the standardization of web technologies.[2]

[1] More information about these actions can be found at https://internetsegura.br/

[2] Among the initiatives related to technical standards, Ceweb.br|NIC.br was part of the committee that drafted the ABNT NBR 17225 standard, focused on accessibility requirements for web content and applications. More information at https://ceweb.br/projetos/norma-abnt/

In a more technical field, the Center of Study and Research in Network Technology and Operations (Ceptro.br) works to continuously improve Brazil's Internet infrastructure through initiatives to measure connection quality, disseminate best practices for network protocols, train professionals, and provide services essential to Internet operations.[3] It was also through the actions of Ceptro.br|NIC.br that the Brazil Internet Exchange (IX.br)[4] originated and operates. It currently reaches more than 40 Tbit/s of aggregate traffic in the 38 locations where it is present, being the largest set of Internet exchange points (IXPs) in the world, with approximately 3,900 participating Autonomous Systems (AS). It should be noted that the São Paulo point is currently the world's leading IXP.

Adding to NIC.br's efforts is the creation of the Brazilian Artificial Intelligence Observatory (OBIA). It provides data and indicators that broaden understanding of the impacts and challenges of Artificial Intelligence (AI) in the country, supporting public debate and the formulation of policies aimed at its responsible use.[5]

Throughout its activities, NIC.br maintains and supports initiatives to promote the Internet and its safe, responsible, and conscious use. Annual events such as Safe Internet Day,[6] the Seminar on Privacy and Personal Data Protection,[7] and the Symposium on Children and Youth on the Internet[8] represent the ongoing effort to coordinate technical, legal, and social debates on key issues on the digital agenda. These actions highlight the importance of protecting personal data, ensuring information integrity, and safeguarding rights in the digital environment, especially for children.

In this context, the Regional Center for Studies on the Development of the Information Society (Cetic.br) is the NIC.br department responsible for regularly producing indicators and analyses on access, use, and appropriation of information and communication technologies (ICT) in Brazil. Cetic.br|NIC.br has established itself as a national and international reference in the production of reliable, comparable data aligned with internationally recognized methodological standards, which support the formulation of public policies, academic research, and multisectoral debate on the development of digital technologies.

In 2025, Cetic.br|NIC.br expanded its participation in international forums and agendas, contributing empirical evidence and methodological expertise to debates within the scope of BRICS and the Southern Common Market (Mercosur) meetings,[9] as well as other multilateral spaces. In these instances, topics such as meaningful connectivity, AI adoption, and reducing inequalities in access to and use of digital technologies took center stage, underscoring the importance of comparable, context-specific indicators to guide both regional and international cooperation.

[3] The main projects and initiatives of Ceptro.br|NIC.br can be accessed at https://ceptro.br/#projetos

[4] More information at https://ix.br/

[5] More information at https://obia.nic.br/

[6] More information at https://www.diadainternetsegura.org.br/

[7] More information at https://seminarioprivacidade.cgi.br/

[8] More information at https://criancaseadolescentesnainternet.nic.br/

[9] Publications with BRICS and Mercosur, among other international organizations, can be accessed at https://cetic.br/en/publicacoes/indice/outros/

This year, Cetic.br|NIC.br began new studies focused on strategic topics for the development of the Brazilian digital ecosystem, such as the analysis of data center infrastructure, which is now essential for data processing, storage, and sharing, as well as for the expansion of applications based on cloud computing and AI. Another strategic topic concerns information integrity, which is central to analyzing information flows and trust in data sources, as well as to addressing challenges associated with misinformation in the digital environment.

By swiftly addressing emerging and relevant topics such as connectivity quality, digital competencies, privacy, AI use, critical infrastructure, and security, Cetic.br|NIC.br's surveys help understand the multiple factors that enable effective, meaningful connectivity. Measuring access remains essential, but it is increasingly necessary to understand the conditions of use, associated risks, and capabilities required for individuals and organizations to fully benefit from digital technologies.

The financial resources generated by .br domain registrations, managed by Registro.br|NIC.br, enable continuous investment in research, security, training, and technological development, sustaining a virtuous cycle that benefits the Internet in Brazil. In a scenario of rapid technological change and growing dependence on digital infrastructure, the governance model adopted by the country since 1995 remains current and fundamental, supporting an open, secure Internet guided by the public interest.

The purpose of this publication is to contribute to the quality of public debate and strengthen the formulation, monitoring, and evaluation of evidence-based public policies. By gathering reliable data and consistent analyses, NIC.br and CGI.br reaffirm their commitment to multistakeholder governance, the promotion of rights, the reduction of inequalities, and the construction of a more inclusive, accessible, and secure digital environment, capable of responding to contemporary challenges and expanding opportunities for Brazilian society.

Enjoy your reading!

Demi Getschko
Brazilian Network Information Center – NIC.br

Presentation

The intensification of digital transformation has significantly expanded the role of the Internet as an essential infrastructure for exercising rights and accessing information, education, social participation, and knowledge production. The Internet is also a strategic tool for formulating, implementing, and evaluating public policies aimed at innovation and economic and social development. In a context of rapid technological change, the expansion of digital platforms, and the growing use of automated data-based systems, there are increasing challenges associated with organizing the digital ecosystem. Ensuring that this ecosystem reduces inequalities, protects rights, and serves the public interest and national sovereignty is an urgent task that requires participatory institutional arrangements capable of guaranteeing democratic governance.

It is in this context that the Brazilian Internet Steering Committee (CGI.br) operates. In 2025, it celebrated 30 years of defending an open, secure, and inclusive Internet. The Brazilian multistakeholder model of Internet governance has established itself as a legitimate space for dialogue and collective construction, bringing together the government, the private sector, civil society organizations, and technical and academic communities in the formulation of principles, recommendations, and guidelines that steer the development of the Internet in the country. This approach becomes even more relevant in light of the growing complexity of challenges associated with the digital environment, such as personal data protection, transparency and accountability of digital platforms, tackling disinformation, and the impact of the use of automated systems and Artificial Intelligence (AI) on fundamental rights.

Throughout 2025, CGI.br actively participated in key debates on the future of Internet governance in Brazil and around the world, with an emphasis on discussions and public consultations[1] related to the regulation of digital platforms and the protection of rights in the online environment. The Committee contributed to the formulation of principles and recommendations aimed at balancing technological innovation, the protection of freedom of expression, and the need to safeguard users, particularly groups in situations of greater vulnerability, such as children.

[1] One of the results of this debate was the publication, in 2025, of the *Princípios do CGI.br para Regulação de Plataformas de Redes Sociais* (CGI.br Principles for the Regulation of Social Networks), available in Portuguese at https://cgi.br/pagina/principios-cgibr-regulacao-redes-sociais/

The contributions of CGI.br to the debate on the Brazilian Digital Statute of the Child and Adolescent (ECA Digital),[2] enacted in 2025, were based on the understanding that the comprehensive protection of children in the digital environment must be accompanied by measures that preserve the open architecture of the Internet and avoid solutions that compromise fundamental rights. The recommendations on age verification, the responsibility of application providers, and the promotion of safer digital environments reflect the pursuit of proportionate, evidence-based solutions aligned with the principles of multistakeholder Internet governance.[3]

Within the scope of this activity, the 15th edition of the Brazilian Internet Governance Forum (FIB, as per its acronym in Portuguese) in 2025 reinforced CGI.br's role as a facilitator of plural and qualified debates on the digital environment. The FIB brought together representatives from different sectors to discuss topics such as platform regulation, information integrity, digital sustainability, and meaningful connectivity. More than just a space for debate, the event has established itself as an environment for listening, building consensus, and formulating proposals aligned with both the national context and international Internet governance agendas.

The work of CGI.br is inseparable from the production of quality data and empirical evidence that inform public debate and decision-making. The Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br), plays a strategic role in providing fundamental data for the formulation, monitoring, and evaluation of public policies related to digital technologies. In 2025, upon completing 20 years of operation, Cetic.br|NIC.br reaffirmed its ability to respond quickly and competently to debates on the digital environment, systematically incorporating new topics and indicators into its research agenda.

An example of this responsiveness is the production of indicators and analyses widely used to monitor the implementation of public policies and regulatory frameworks, such as ECA Digital and Law No. 15.100/2025,[4] which provides for the use of personal devices by students in basic education facilities. Regular surveys by Cetic.br|NIC.br, such as ICT Kids Online Brazil and ICT in Education, produce data on the use of digital technologies by children and families, school mediation practices, and exposure to risks in the online environment. This data contributes to a deeper understanding of the challenges these young people face and is essential for evaluating the effectiveness of adopted policies and regulations, as well as guiding adjustments that protect rights without compromising access to or the positive use of digital technologies.

[2] Available at https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2025/lei/L15211.htm

[3] CGI.br's recommendations regarding the ECA Digital can be found at https://cgi.br/media/docs/publicacoes/4/pt/20251118175422/CGIbr_Contribuicoes_Consulta_MJ_Afericao_Idade.pdf and https://cgi.br/media/docs/publicacoes/4/pt-br/20251215152052/Contribuicoes_CGIbr_Tomada_Subsidios_ANPD_ECA_Digital.pdf

[4] Available at https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2025/lei/l15100.htm

By disseminating indicators and studies on meaningful connectivity, digital competencies, responsible use of technologies, information integrity, and protection of rights, among other topics, Cetic.br|NIC.br helps to provide a more comprehensive understanding of the effects of digital transformation on Brazilian society and to strengthen evidence-based public policies.

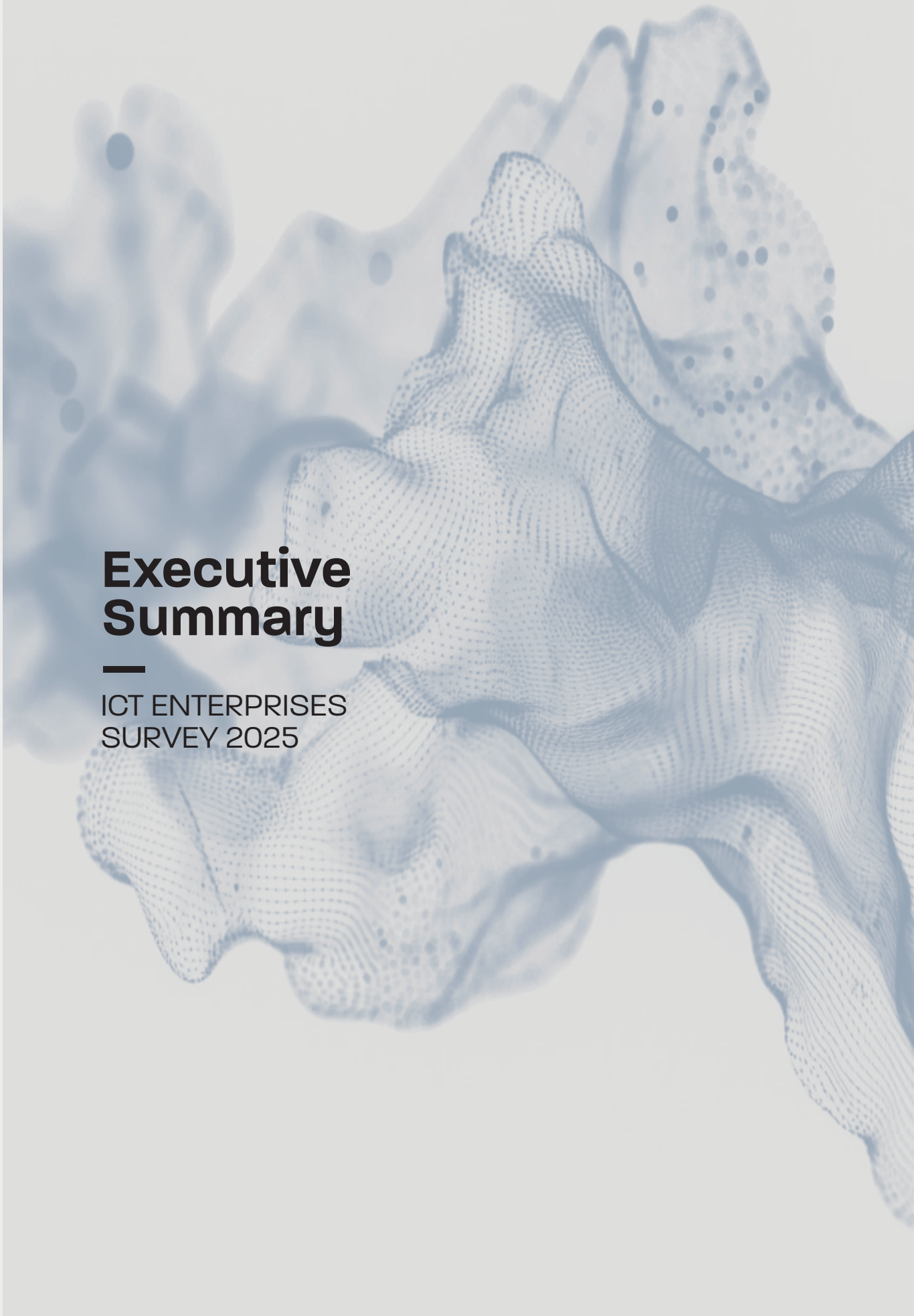
At the international level, in coordination with CGI.br and in cooperation with ministries, Cetic.br|NIC.br maintained active participation in multilateral and regional forums, such as the BRICS and the Southern Common Market (Mercosur) agendas, contributing to debates on digital governance, connectivity, inclusion, and sustainability. This action reinforces the importance of international collaboration and the production of comparable indicators to address common challenges, while respecting national and regional specificities. In the same vein, it is worth highlighting Brazil's commitment to multisectoral governance, evidenced by CGI.br's participation in the WSIS+20 renewal process.

In 2025, a sectoral study on data centers in Brazil was launched and conducted by Cetic.br|NIC.br with the support of a multisectoral group of experts and government agencies, including the Ministry of Science, Technology, and Innovation (MCTI), the Ministry of Development, Industry, Trade, and Services (MDIC), and the Ministry of Finance (MF). The study seeks to fill information gaps in a context where these infrastructures play an increasingly strategic role in the digital economy, development policies, technological sovereignty, and environmental challenges.[5]

Therefore, in a global environment marked by growing tensions, rapid technological advances, and disputes over regulatory models, CGI.br reaffirms the centrality of multistakeholder governance to strengthen a secure, open, and public-interest-oriented Internet. This publication showcases the efforts to gather reliable, robust public data produced within the scope of Cetic.br|NIC.br, which supports democratic debate, the formulation of public policies, and the construction of a more just, inclusive, and human-development-oriented digital environment.

Renata Vicentini Mielli
Brazilian Internet Steering Committee – CGI.br

[5] The initial results of this study can be accessed at https://cetic.br/en/publicacao/ano-xvii-n-4-data-centers-no-brasil/



Executive Summary

ICT ENTERPRISES
SURVEY 2025

Executive Summary ICT Enterprises 2025

In its 17th edition, ICT Enterprises 2025 provides an overview of the use of information and communication technologies (ICT) among Brazilian enterprises. The survey was conducted between February 2025 and January 2026 and collected data from Brazilian enterprises with more than ten employed persons. This edition expands the investigation into the state of the digital economy in Brazil, exploring aspects of enterprise connectivity, online presence, and electronic commerce. In addition, the survey presents indicators on the use of advanced technologies, such as the Internet of Things (IoT) and Artificial Intelligence (AI).

THE ESTIMATED TOTAL NUMBER OF ENTERPRISES THAT USED AI APPLICATIONS IN BRAZIL IS 93,475

Connectivity

In the 2025 edition, fiber-optic connections remained the most widely used type of connection among Brazilian enterprises, a trend observed since 2019. In 2025, 93% of enterprises were connected to the Internet via fiber optics, compared with 92% in 2024, indicating stability in this indicator. Regarding the distribution of enterprises by download speed range, 53% had connections of up to 500 Mbps in 2025, compared with 71% in 2023. The proportion of enterprises with connection speeds above 500 Mbps increased from 21% in 2023 to 35% in 2025, with growth observed across enterprises of all sizes (Chart 1).

Electronic commerce

The means used by Brazilian enterprises to sell online continued to follow the pattern observed in past survey editions. Most enterprises reported selling goods and services online via WhatsApp, Skype, or Facebook chat messages, while more automated forms of electronic commerce, such as Extranet, electronic data exchange, and their websites, accounted for smaller proportions. In 2025, the proportion of enterprises that sold online returned to the 2023 level, with 68% reporting sales through some online channel, compared with 61% in 2024 and 70% in 2023. Among enterprises that sold online, 79% used WhatsApp or Telegram. In contrast, channels specifically developed for online sales, such as websites, Extranet, and electronic data exchange, were used by fewer enterprises (Chart 2).

New technologies

In 2025, the ICT Enterprises survey showed an increase in the use of AI applications among Brazilian enterprises: 17% reported using them, compared with 13% in 2024. The estimated total number of enterprises that used AI applications in 2025 was 93,475. There was growth among small enterprises, from 10% in 2024 to 15% in 2025, and among large

CHART 1

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Enterprises, by range of maximum download speed and size (2023–2025)

Total number of enterprises with Internet access (%)

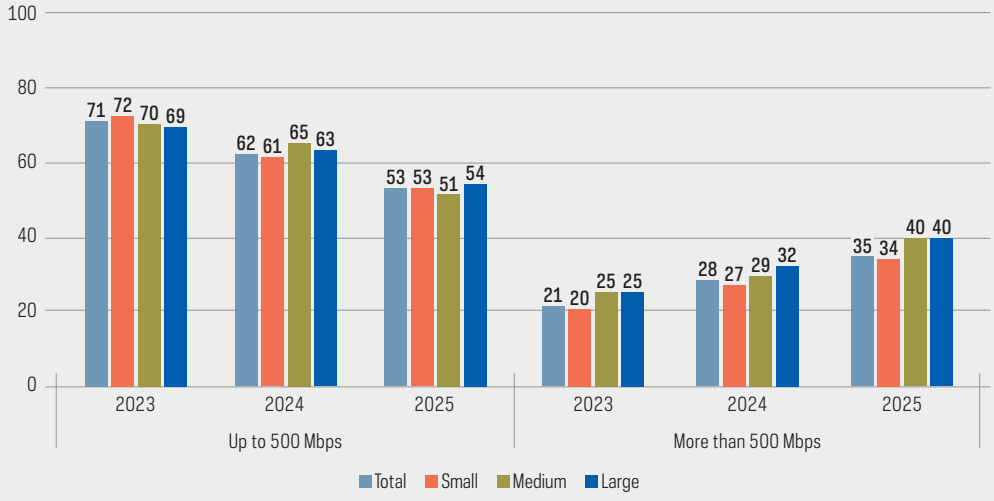

CHART 2

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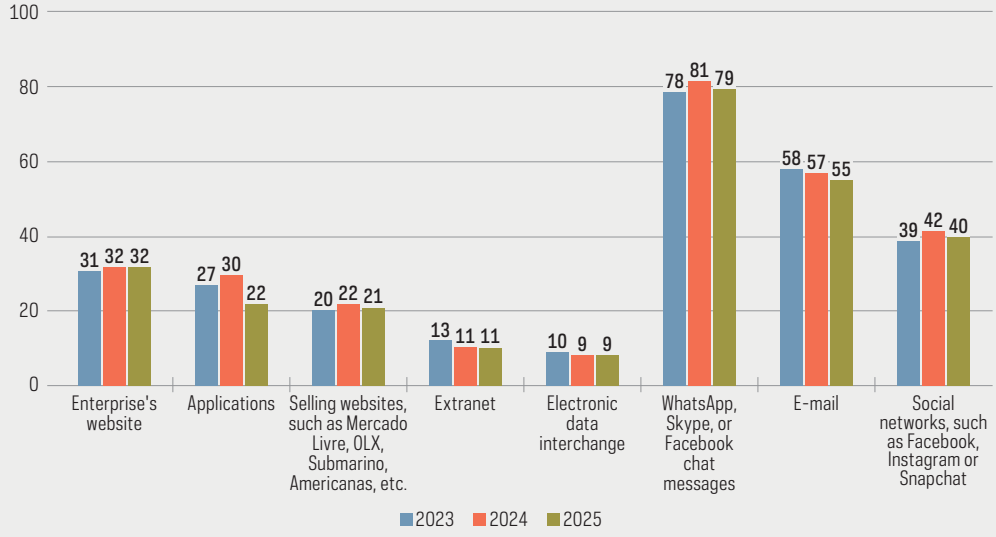
Enterprises, by online media used for transactions (2023–2025)

Total number of enterprises that sold on the Internet (%)



enterprises, which reached 50% in 2025, up from 38% in 2024 (Chart 3).

Among the types of AI applications used by Brazilian enterprises, the most frequently mentioned was workflow automation, reported by 68% of enterprises that used AI, a proportion that remained stable compared with previous years. On the other hand, this edition of the survey showed growth in two types of AI: text mining and written language analysis, and natural language generation (NLG) for written or spoken language. The first was used by 38% of enterprises that adopted AI, compared with 22% in 2024, while the second increased from 20% in 2024 to 30% in 2025 (Chart 4).

AMONG LARGE ENTERPRISES THAT USED AI, 37% REPORTED THAT THE SYSTEMS THEY USED HAD BEEN DEVELOPED IN-HOUSE, REPRESENTING AN INCREASE COMPARED WITH 2024

The ICT Enterprises survey also collects indicators on how Brazilian enterprises acquire or develop AI software and systems. In 2025, among enterprises that used AI, 80% chose ready-to-use solutions, up from 76% in 2024, indicating stability. Regarding development, 54% of enterprises hired external suppliers to develop or modify AI systems in 2025, a proportion that stood at 56% in 2024. Among large enterprises that used AI, 37% reported that the systems they used were developed in-house, up from 2024. According to the survey results, the pattern of AI use among Brazilian enterprises indicates a predominance of ready-to-use solutions, with limited in-house application development (Chart 5).

Survey methodology and access to data

The ICT Enterprises 2025 survey maps the incorporation of ICT, especially new technologies such as AI, among Brazilian enterprises with more than 10 employed persons. The survey also investigates practices related to electronic commerce, digital security, connectivity, and online presence, examining the realities of Brazilian enterprises and comparing them with international indicators. Data collection for the 2025 edition, conducted by telephone, took place between February 2025 and January 2026. A total of 4,174 enterprises were interviewed, providing results by size, geographic region, and market segment. The results of the ICT Enterprises survey, including tables of proportions, total values, and margins of error, are available on the website of the Regional Center for Studies on the Development of the Information Society (Cetic.br): https://www.cetic.br. The "Methodological Report" and the "Data Collection Report" can be accessed in both the printed publication and on Cetic.br|NIC.br's website.

CHART 3

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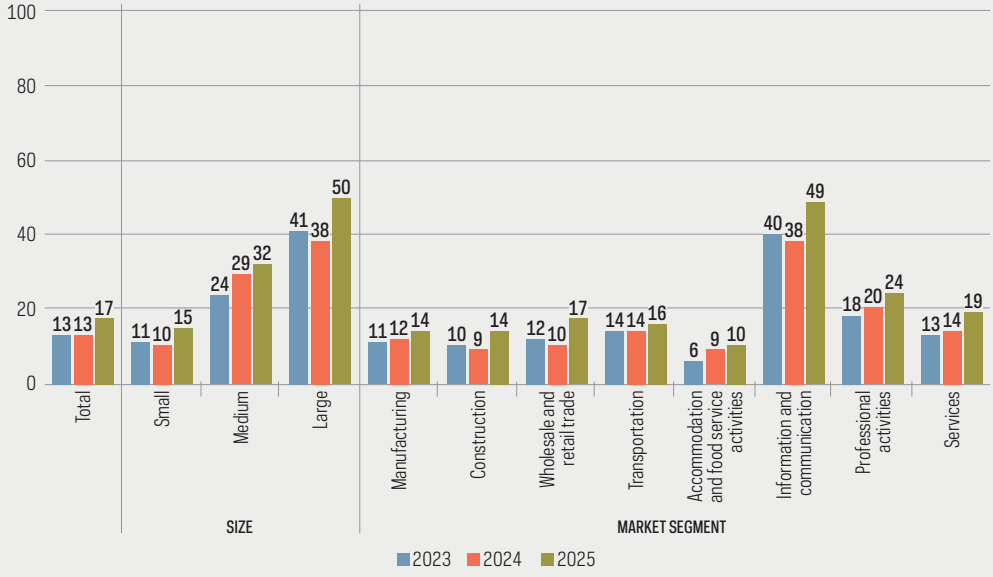
Enterprises that used AI, by size and market segment (2023–2025)

Total number of enterprises (%)



BOX

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ONLINE PRESENCE

Brazilian enterprises, especially small enterprises, continue to show a tendency to focus on a single digital communication channel, generally social media, interacting less frequently with customers and users through websites. In 2025, 53% of Brazilian enterprises had a website, compared with 54% in 2019, indicating stability over recent years.

Social media is the main form of online presence among Brazilian enterprises. There was significant growth in the proportion of enterprises with their own profile or account on social media: use of WhatsApp and Telegram increased from 74% in 2024 to 79% in 2025. Among large enterprises, LinkedIn use also increased, from 70% of enterprises in 2024 to 78% in 2025.

An estimated

77,316

enterprises in Brazil used smart or IoT devices

53%

of Brazilian enterprises had a digital security policy, with the indicator remaining stable compared with previous years

Among enterprises that used smart or IoT devices,

90%

reported that their use was related to facility security

20%

of enterprises collected data internally through processes and staff, while

16%

collected data from customers and users

CHART 4

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Enterprises that used some type of AI, by type (2023–2025)

Total number of enterprises that used AI (%)

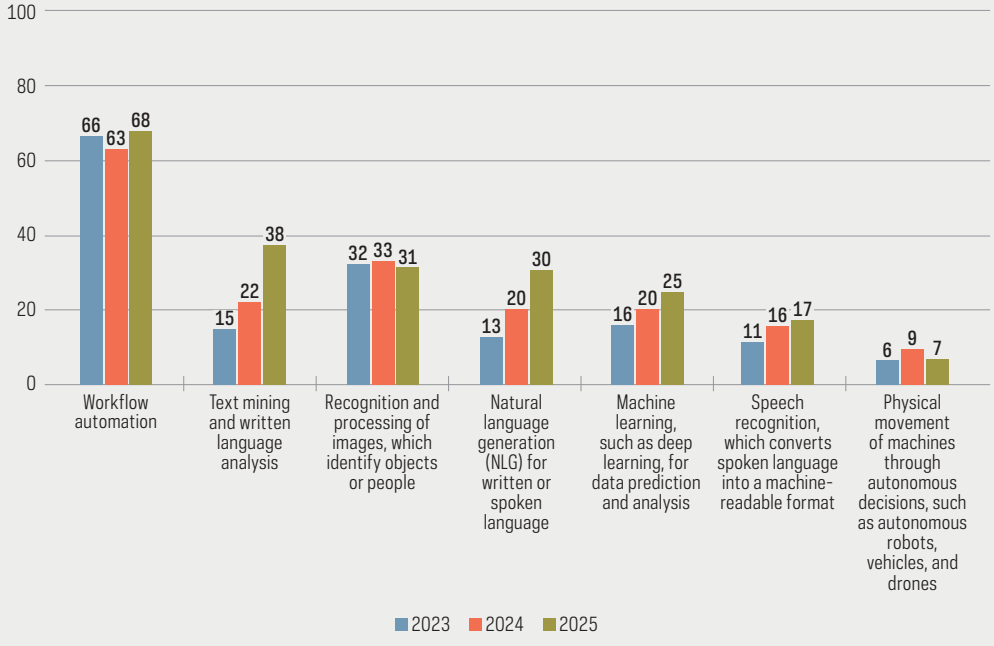

CHART 5

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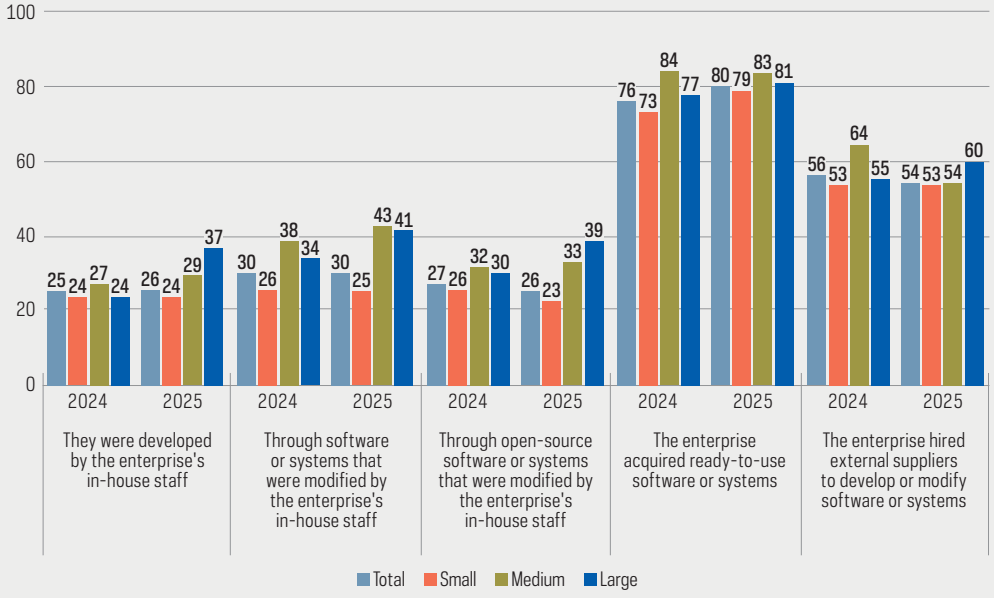
Enterprises that used AI, by how they acquired the AI software or systems they use and size (2024–2025)

Total number of enterprises that used AI (%)



Access the full survey data!

In addition to the results presented in this publication, tables of indicators, questionnaires, information on how to access the microdata, and the presentation of the results of the launch event are available on the Cetic.br|NIC.br website, as well as other publications on the topic of the survey.

The tables of results (https://cetic.br/en/pesquisa/empresas/indicadores/), available for download in Portuguese, English, and Spanish, present the statistics produced, including information on the data collected and cross-referencing for the variables investigated in the study. The information available in the tables follows the example below:

Code and indicator name

Population to which the results refer

B3 - ENTERPRISES WITH INTERNET ACCESS BY TYPE OF CONNECTION

Total number of enterprises with Internet access

PERCENTAGE (%)		DIAL-UP CONNECTION	CONNECTION VIA TELEPHONE LINE (DSL)	FIBER OPTIC CONNECTION	CABLE CONNECTION	RADIO CONNECTION
TOTAL		10	37	93	52	6
SIZE	10 to 49 employed persons	10	38	92	52	5
	50 to 249 employed persons	8	32	96	55	10
	250 or more employed persons	7	27	97	52	23
REGION	North	11	29	95	52	7
	Northeast	11	34	94	51	7
	Southeast	9	38	92	53	6
	South	11	36	94	52	5
	Center-West	12	41	91	49	5
MARKET SEGMENT	Manufacturing	9	34	94	49	7
	Construction	11	30	92	55	5
	Transportation and storage	10	32	92	48	9

Indicator responses

Results tabulation cut-outs: total (population as a whole) and characteristics of analysis (region, age group, etc.), different in each survey

Results: can be in % or totals

Source: Brazilian Network Information Center. (2026). *Survey on the use of information and communication technologies in Brazilian enterprises: ICT Enterprises 2025* [Tables].

How to reference the tables of indicators

This publication is also available in Portuguese on the Cetic.br|NIC.br website.

Methodological Report

ICT ENTERPRISES SURVEY 2025

Methodological Report
ICT Enterprises 2025

The Brazilian Internet Steering Committee (CGI.br), through the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br), presents the "Methodological Report" for the Survey on the use of information and communication technologies in Brazilian enterprises — ICT Enterprises survey. The survey was carried out across the entire country and addressed the following themes:

- **Module A:** General information on information and communication technology (ICT) systems;
- **Module B:** Internet use;
- **Module D:** Security;
- **Module E:** Electronic commerce;
- **Module F:** ICT skills;
- **Module G:** Software;
- **Module H:** New technologies;
- **Module X:** Privacy and personal data protection.

Survey objectives

The ICT Enterprises survey's primary objective is to measure ICT access and use in Brazilian enterprises with ten or more employed persons.

Concepts and definitions

The ICT Enterprises survey was developed to maintain international comparability. It used the methodological standards proposed in the manual from the UN Trade and Development (UNCTAD, 2020), prepared in partnership with the Organisation for

Economic Co-operation and Development (OECD), the Statistical Office of the European Union (Eurostat), and the Partnership on Measuring ICT for Development—a coalition formed by various international organizations that seeks to harmonize key indicators in ICT surveys.

MARKET SEGMENT

The target population of the survey was defined by using the National Classification of Economic Activities (*Classificação Nacional das Atividades Econômicas* — CNAE 2.0) and the 2009.1 Table of the Legal Nature of the National Classification Commission (Concla).

The Table identifies the legal-institutional constitution of private and public organizations in the country according to five broad categories: public administration; enterprises; nonprofit organizations; individuals and international organizations; and other extraterritorial institutions.

The CNAE is the basic framework used to categorize registered Brazilian enterprises according to their economic activities and has been officially adopted by the National Statistical System and by the federal agencies that manage administrative registries. The CNAE 2.0 is derived from the International Standard Industrial Classification of All Economic Activities (ISIC 4), which is administered by the United Nations Statistics Division (UNSD).

The CNAE 2.0 does not distinguish type of ownership, legal nature, size of business, mode of operation, or legality of activity. Its hierarchical structure has five levels of detail: sections, divisions, groups, classes, and sub-classes. For the ICT Enterprises survey, the section level was used to classify enterprises into their market segments. The sections for "Real Estate Activities" (Section L), "Professional, Scientific, and Technical Activities" (Section M), and "Administrative and Complementary Services" (Section N) were grouped into a single category (L+M+N). The sections "Arts, Culture, Sports, and Recreation" (Section R) and "Other Service Activities" (Section S) were likewise grouped into a single category (R+S).

SIZE

The ICT Enterprises survey considered small (10 to 49 employed persons), medium (50 to 249 employed persons), and large (250 or more employed persons) enterprises. Microenterprises, those with 1 to 9 employed persons, were not included in the scope of this survey.

EMPLOYED PERSONS

Employed persons are those with or without employment contracts who are remunerated directly by the enterprise. The number of employed persons included salaried employees, freelancers paid directly by the company, employees and associates, family members, and temporary workers. Third parties and consultants are not included.

Target population

The universe for the ICT Enterprises survey consisted of all active Brazilian enterprises with ten or more employed persons registered with the Central Register of Enterprises (*Cadastro Central de Empresas* [Cempre]) from the Brazilian Institute of Geography and Statistics (IBGE), that belong to the CNAE 2.0 market segments of interest to the ICT Enterprises survey and that met the definition of Legal Nature Type 2—business entities—except for public enterprises (Legal Nature 201-1) in order to ensure international comparability. The surveyed enterprises operated in the following segments:

C – Manufacturing;

F – Construction;

G – Wholesale and retail trade; repair of motor vehicles and motorcycles;

H – Transportation and storage;

I – Accommodation and food service activities;

J – Information and communication;

L – Real estate activities;

M – Professional, scientific and technical activities;

N – Administrative and support service activities;

R – Arts, entertainment and recreation;

S – Other service activities.

Reference and analysis unit

The unit of analysis is the enterprise, which IBGE defines as a legal entity characterized as a firm or company that includes a set of economic activities conducted in one or more local units (a physical space, usually a permanent location, where one or more economic activities are carried out, corresponding to one of the enterprise's addresses).

The Cempre registry includes establishments and local units, so the database had to be adapted in order to obtain a universe including only enterprises. This was achieved as follows:

- Enterprises were sorted by Company Registration Number (CNPJ).
- Local units were grouped by the first eight digits of the CNPJ, which identifies the company. In this process, the information from the CNAE section and the region where the enterprise was first registered was maintained. In addition, the number of employed persons for all units was summed.
- Enterprises with fewer than ten employed persons were excluded in the field created in the previous step.

- Enterprises belonging to sections A, B, D, E, K, O, P, Q, T and U were excluded because they were not included in the survey's target population.
- Enterprises not meeting the definition of Legal Nature Type 2, which covers business entities, were excluded. Public enterprises that met the criteria for Legal Nature 201-1 were also excluded.

Domains of interest for analysis and dissemination

For the units of analysis, the results are reported for areas defined based on the following variables and levels:

- **region:** corresponds to the regional division of Brazil, according to IBGE criteria, into the macro-regions Center-West, North, Northeast, Southeast, and South;
- **size:** corresponds to the division by number of employed persons into small (10 to 49 employed persons), medium (50 to 249 employed persons), and large (250 or more employed persons) enterprises. Furthermore, beginning with the 2017 survey, size has been based on the information available in the registry, and not that declared by respondents during the interviews, as occurred up to the 2015 edition;
- **market segments — CNAE 2.0:** corresponds to the classification of enterprises in the sections shown as: C, F, G, H, I, J, L+M+N, R+S.

Data collection instrument

INFORMATION ABOUT THE DATA COLLECTION INSTRUMENT

Data of interest for the survey was gathered using a structured questionnaire, with open- and closed-ended questions (when applicable). For more information on the questionnaire, see the section "Data collection instrument" in the "Data Collection Report."

Sampling plan

The sampling plan was stratified, and the enterprises were randomly selected within each stratum.

SURVEY FRAME AND SOURCES OF INFORMATION

The Cempre by IBGE provided consolidation and updating of enterprises and other formal organization information recorded in the Company Registration Number from the Brazilian Federal Revenue and its local units that responded to the IBGE economic surveys and/or submitted the Annual List of Social Information (*Relação Anual de Informações Sociais* [Rais]) declaration to the Brazilian Ministry of Labor and Employment (MTE).

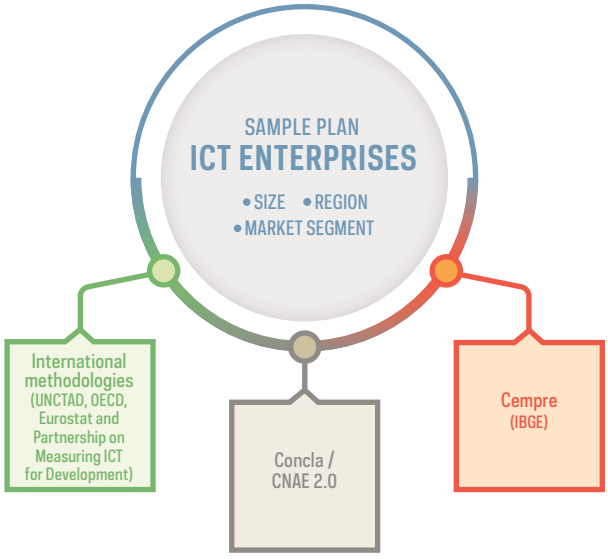
The IBGE annually provides a general picture of the active formal organizations in the country, highlighting information on legal nature, employed persons, and economic activities.

With the objective of producing a portrait of ICT use in Brazilian enterprises, and considering the differences between market, size (number of employed persons), and Brazilian region, ICT Enterprises used information from the Cempre, which served as the main survey frame for sample design. The choice of CNAE sections, as well as the sizes of the enterprises, followed the recommendations proposed in the UNCTAD statistics manual (2020).

FIGURE 1

–

Sample plan for the ICT Enterprises survey



CRITERIA FOR SAMPLE DESIGN

The survey sample was designed using the stratified sampling technique, which aims to improve estimate precision and guarantee the inclusion of subpopulations of interest. Stratification occurred in two steps.

The first step covered the definition of natural strata based on the correlation of the variables geographic region (Center-West, Northeast, North, Southeast and South) and CNAE 2.0 activity segment (C, F, G, H, I, J, L+M+N, R+S), as described in the section "Domains of interest for analysis and dissemination". Thus, 40 nonzero natural strata were formed. The final strata were defined by means of each natural stratum, which considered the division of natural strata by enterprise size. The size ranges considered were 10 to 19 employed persons, 20 to 49 employed persons, 50 to 249 employed persons, and 250 or more employed persons.

When no enterprises were registered in a stratum, this stratum was grouped with the previous size range, preserving the information on region and market segment.

With the stratification variables defined, the strata allowed all regions, markets, and sizes to be represented in the sample and permitted analyses for the areas defined by these three variables individually. However, with this design, it was not possible to draw conclusions for categories resulting from the intersection of variable pairs.

SAMPLE SIZE DETERMINATION

The planned sample size for the ICT Enterprises survey was approximately 4,500 enterprises.

SAMPLE ALLOCATION

The sample of enterprises was obtained by simple random sampling without replacement in each final stratum. The probabilities of selection were equal within each final stratum.

For the allocation of the enterprises sample, the marginal distributions of the "market segment," "region" and "size" were considered. In addition to the quantitative information per stratification breakdown, the response rate per stratum in previous surveys was considered for the distribution of the final sample. The final allocation is disproportionate, since the distribution by region, market segment, and size is not proportional in the survey universe. Thus, the final sample size was distributed by predefined strata, and more information can be found in the "Data Collection Report."

SAMPLE SELECTION

Within each stratum, the enterprises were selected by simple random sampling, as defined in Formula 1.

FORMULA 1

$$n_h = n \times \frac{N_h}{N}$$

N is the total enterprise population size

N_h is the enterprise population size of stratum h

n is the enterprise sample size

n_h is the enterprise sample size in stratum h

Hence, the inclusion probabilities (π) in sampling units i for each stratum h are given by Formula 2.

FORMULA 2

$$\pi_{ih} = \frac{n_h}{N_h}$$

The response rates of enterprises from the previous edition of the survey were considered to create a reserve sample, which was randomly selected from each sample stratum with the goal of approximating the final sample of the initially foreseen number of enterprises. The use of the reserve sample depended on the controls carried out to obtain interviews.[1]

Data collection

DATA COLLECTION METHOD

Enterprises were contacted for interviews using the computer-assisted telephone interview (CATI) technique. Data collection was carried out in three different periods during the reference year of the survey, taking place every four months (collection rounds). The samples of enterprises to be collected in each round were randomly selected from the strata so that a third of the sample could be contacted. Carrying out the survey in three rounds allowed a wider range of topics to be investigated, without increasing the length of the questionnaire or the interview duration. This strategy was established in order to collect more indicators without imposing a heavy burden on respondents during the questionnaire. As a result, some of the indicators were not collected in all the rounds and had a smaller sample size than the indicators collected in all the rounds, resulting in larger margins of error for these indicators.

The division of themes and rounds is shown in the following table.

TABLE 1

–

Modules applied in the three rounds of data collection

Module	Rounds in which they were applied		
	Round 1	Round 2	Round 3
A - General information on ICT systems	Applied	Applied	Applied
B - Internet use	Applied	Applied	Applied
D - Security	**Not applied**	Applied	Applied
E - Electronic commerce	Applied	Applied	**Not applied**
F – ICT skills	Applied	**Not applied**	Applied
G – Software	Applied	Applied	Applied
H – New technologies	Applied	Applied	Applied
X - Privacy and personal data protection	**Not applied**	Applied	Applied
Information on antecedents	Applied	Applied	Applied

[1] As described in the "Field procedures and control" item in "Data Collection Report".

In all enterprises, the survey sought to interview the persons in charge of information technology (IT), computer network management, or similar areas, which corresponded to positions such as:

- information and technology directors;
- business managers (senior vice presidents, business vice presidents, directors);
- technology managers or buyers;
- technology influencers (employed persons in commercial or IT operations departments who influenced decisions on technology issues);
- project or system coordinators;
- directors of other departments or divisions (excluding IT);
- system development managers;
- IT managers;
- project managers;
- enterprise owners or partners.

In large enterprises (250 or more employed persons), the strategy employed was to interview a second professional, preferably the accounting or finance manager. If one of these professionals was not available, the next option was the person in charge of the administrative, legal, or government relations area, who responded only to questions about e-commerce and activities carried out on the Internet.

Data processing

WEIGHTING PROCEDURES

The three rounds of the survey were grouped into four database files:

- database with indicators common to all three survey rounds;
- database with indicators common to rounds 1 and 2 of the survey data collection;
- database with indicators common to rounds 1 and 3 of the survey data collection; and
- database with indicators common to rounds 2 and 3 of the survey data collection.

A weight was created for each of these databases, in three stages:

STAGE 1

Each enterprise in the sample was assigned a basic sample weight that was obtained by dividing the population size of the stratum by the sample size within the corresponding final stratum, as shown in Formula 3.

FORMULA 3

$$w_{ih} = \frac{1}{\pi_{ih}} = \frac{N_h}{n_h}$$

w_{ih} is the basic weight, inverse of probabilities of selection, of enterprises i in stratum h

n_h is the enterprise sample size in stratum h

N_h is the total number of enterprises in stratum h

STAGE 2

In cases in which not all the enterprises completed the questionnaire, a nonresponse correction was made, within each stratum. In the strata where there were no respondents, they were grouped with the strata immediately above them in the hierarchy: region – market segment – size. The nonresponse correction was given by Formula 4.

FORMULA 4

$$w^*_{ih} = w_{ih} \times \frac{N_H}{\sum_I w_{ih}}$$

w^*_{ih} is the adjusted weight for nonresponse for enterprise i in stratum h

STAGE 3

Since the enterprises in the four databases have basic weights corrected for nonresponse, the survey respondents are calibrated according to the known marginal totals of the survey universe for the stratification variables (region, market segment, and size).

Sampling error

The sampling error measurements or estimates for the ICT Enterprises survey indicators took into account in their calculations the sampling plan per strata employed in the survey.

Therefore, based on the estimated variances, the option was chosen to publish the sampling errors expressed by the margins of error, which were calculated for a confidence level of 95%. This means that if the survey were to be repeated many times, in 95%, the range could contain the actual population value. Other measures derived from this variability estimate are commonly presented, such as standard error, coefficient of variation, and confidence interval.

Calculations for the margins of error considered the product of the standard error (the square root of the variance) times 1.96 (the value of the sample distribution corresponding to the chosen significance level of 95%). These calculations were done for each variable in each of the tables, which means that all the indicator tables have margins of error related to each estimate presented in each table cell.

Data dissemination

The results of this survey are presented according to the following variables: enterprise size, market segment, and geographic region.

Rounding made it so that in some results, the sum of the partial categories differed from 100% for single-answer questions. The sum of frequencies on multiple-answer questions is usually different from 100%. It is worth noting that, in cases with no response to the item, a hyphen (-) was used. Since the results are presented without decimal places, a cell's content is zero whenever an answer was given to that item, but the result for this cell is greater than zero and smaller than one.

The survey results are published online and made available on the website (https://www.cetic.br) and on the data visualization portal of Cetic.br|NIC.br (https://data.cetic.br). The tables of proportions, estimates, and margins of error for each indicator are available for download in Portuguese, English, and Spanish. More information on the documentation, metadata, and microdata databases of the survey are available on the Cetic.br|NIC.br microdata webpage (https://cetic.br/microdados/).

References

UN Trade and Development. (2020). *Manual for the production of statistics on the digital economy 2020*. https://unctad.org/publication/manual-production-statistics-digital-economy-2020

Data Collection Report

ICT ENTERPRISES SURVEY 2025

Data Collection Report
ICT Enterprises 2025

The Brazilian Internet Steering Committee (CGI.br), through the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br), presents the "Data Collection Report" of the ICT Enterprises 2025 survey. The objective of this report is to provide information about the specific characteristics of this edition of the survey, including changes made to the data collection instruments, sample allocation, and response rates.

The complete survey methodology, including the objectives, main concepts, definitions, and characteristics of the sampling plan, is described in the "Methodological Report."

Sample allocation

The ICT Enterprises 2025 survey approached 49,331 enterprises and 4,174 interviews were conducted. The implementation of collection rounds allowed for an active search for contacts and fully met the collection objectives, given that the expected sample, considering previous surveys, was approximately 4,500 enterprises. Sample allocation by stratification is presented in Table 1.

TABLE 1
–
Sample allocation by size, region, and market segment

		Planned sample
Total		**4 492**
Size	10 to 19 employed persons	1 746
	20 to 49 employed persons	1 373
	50 to 249 employed persons	569
	250 or more employed persons	804
Region	North	466
	Northeast	671
	Southeast	1 866
	South	880
	Center-West	609
Market segment (CNAE 2.0)	Manufacturing	862
	Construction	564
	Wholesale and retail trade; repair of motor vehicles and motorcycles	952
	Transportation and storage	485
	Accommodation and food service activities	410
	Information and communication	406
	Real estate activities; professional, scientific and technical activities; administrative and support service activities	466
	Arts, entertainment and recreation; other service activities	347

Data collection instrument

INFORMATION ABOUT THE DATA COLLECTION INSTRUMENT

The first questions on the data collection instrument addressed aspects of enterprise profile. Module A elicited general information about information and communication technology (ICT) systems.

Module B addressed Internet use through questions on types of access technology and speed of purchased connections, online presence, among others. This module also collected indicators on social networks (the existence of enterprise-maintained profiles).

Module D investigated the digital security risk management of enterprises, including questions about the practices developed by them to mitigate their chances of suffering cyberattacks. The questions in this module were created with the support of the Organisation for Economic Co-operation and Development (OECD) and are part of a broader project about enterprise risk management.

Electronic commerce was addressed in Module E, which investigated information on online purchases and sales of goods and services. To obtain greater accuracy of results for enterprises with more than 250 employed persons, this module was directed to finance, accounting, or administration representatives. This module was applied in rounds 1 and 2.

Module F, applied in rounds 1 and 3, collected information on the needs and difficulties in recruiting information technology (IT) experts and the existence of outsourced services.

Module G, on software, was improved in partnership with the Association for the Promotion of Brazilian Software Excellence (Softex). The module investigated the use of enterprise resource planning (ERP) and customer relationship management (CRM) packages.

Module H consisted of questions developed for the Statistical Office of the European Union (Eurostat) survey on the use of digital technologies in enterprises, specifically robotic technologies, Big Data analysis, 3D printing, the Internet of Things (IoT), and Artificial Intelligence (AI). This edition of the survey includes questions related to the partnerships established by enterprises to implement AI solutions, as well as the skills and resources available internally for strategic use of data.

Implemented in rounds 2 and 3, Module X—on privacy and data protection—examines how enterprises are handling personal data in their day-to-day operations, investigating the measures they have put in place to ensure information security, as well as their efforts to comply with the Brazilian General Data Protection Law (LGPD).

PRETESTS

The pretests for the ICT Enterprises 2025 survey were carried out at three different times in order to evaluate the flow of the questionnaire in each round of interviews. Twenty-three telephone interviews were conducted with small, medium, and large enterprises, located in the five regions of the country, at three different times. The interviews were distributed as indicated in Table 2.

TABLE 2

—

Number of pretests conducted by size and region

	Round 1	Round 2	Round 3
	February 12-17, 2025	May 20-June 02, 2025	September 03-10, 2025
Small (10 to 49 employed persons)	2	1	2
Medium (50 to 249 employed persons)	4	4	3
Large (250 or more employed persons)	3	2	2
Total	**9**	**7**	**7**

The main purpose of the pretest was to assess the average time needed to complete the questionnaire, verify question flow, and observe respondents' difficulties in comprehension.

CHANGES TO THE DATA COLLECTION INSTRUMENTS

In order to maintain comparability with the indicators included in the module on new technologies in 2024, the data collection instrument did not undergo any changes for the present edition. The only difference from the previous questionnaire is the inclusion of Module X, on privacy and personal data protection, which was last conducted in the 2023 edition.

INTERVIEWER TRAINING

Interviews were conducted by a team of trained and supervised interviewers. They underwent basic research, organizational, ongoing, improvement, and refresher training. They also underwent specific training for the ICT Enterprises 2025 survey, which included how to approach respondents and information about the data collection instrument, procedures, and situations.

The data collection team also had access to the survey's instruction manual, which contains a description of all the necessary procedures to collect data and details about the survey objectives and methodology, ensuring the standardization and quality of the data collection. Data collection was carried out by 42 interviewers and two field supervisors.

Data collection procedures

DATA COLLECTION METHOD

Enterprises were contacted for interviews by means of the computer-assisted telephone interviewing (CATI) technique. The interviews lasted 25 minutes on average.

In all enterprises, the survey sought to interview the persons in charge of IT, computer network management, or similar areas, which corresponded to positions such as:

- information and technology directors;
- business managers (senior vice presidents, business vice presidents, directors);
- technology managers or buyers;
- technology influencers (employed persons in commercial or IT operations departments who influenced decisions on technology issues);
- project or system coordinators;
- directors of other departments or divisions (excluding IT);
- system development managers;
- IT managers;
- project managers;
- enterprise owners or partners.

In large enterprises (250 or more employed persons), a second professional was interviewed, preferably the accounting or finance manager. If one of these professionals was not available, the next option was the person in charge of the administrative, legal, or government relations area, who responded only to questions about e-commerce and activities carried out on the Internet.

DATA COLLECTION PERIOD

Data for the ICT Enterprises 2025 survey was collected at three times:

- Round 1, between February and June 2025.
- Round 2, between June and November 2025.
- Round 3, between September 2025 and January 2026.

FIELD PROCEDURES AND CONTROL

The focus of the survey was active Brazilian enterprises with 10 or more employed persons that are listed in the National Classification of Economic Activities (CNAE 2.0) activity segments covered in the definition of the target population. A system to control field situations was created to allow the identification and treatment of some data collection situations, in addition to controlling the effort expended to complete the interviews. It consisted of the differentiated treatment of situations that were identified during data collection.

The situations that took place during the fieldwork are described in Figures 1 to 4, as well as the procedure adopted for each.

FIGURE 1
–
Situation 1 – Did not speak with enterprise representatives

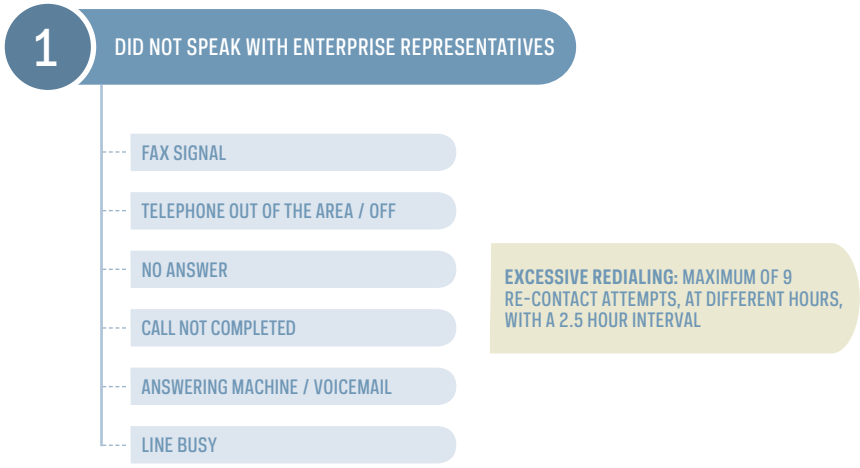


FIGURE 2

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Situation 2 – Spoke with enterprise representatives but did not complete the interview

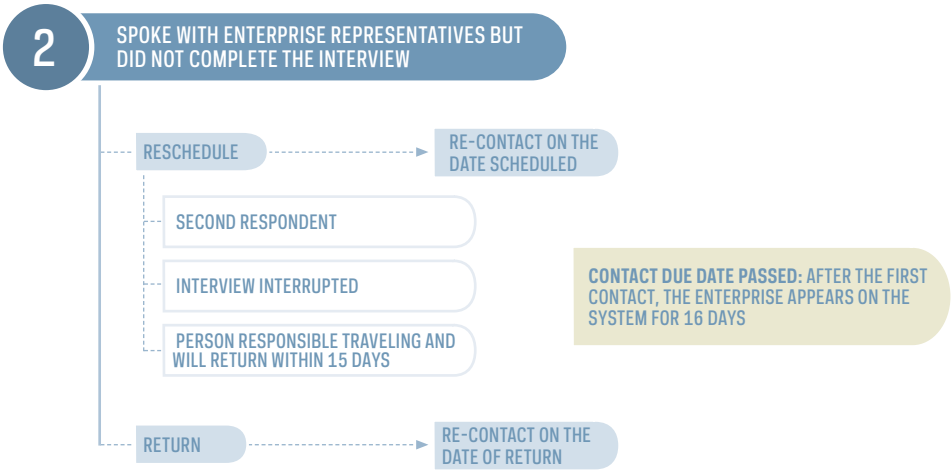

FIGURE 3

–

Situation 3 – Interview fully completed

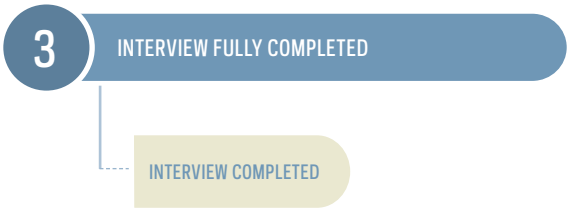

FIGURE 4

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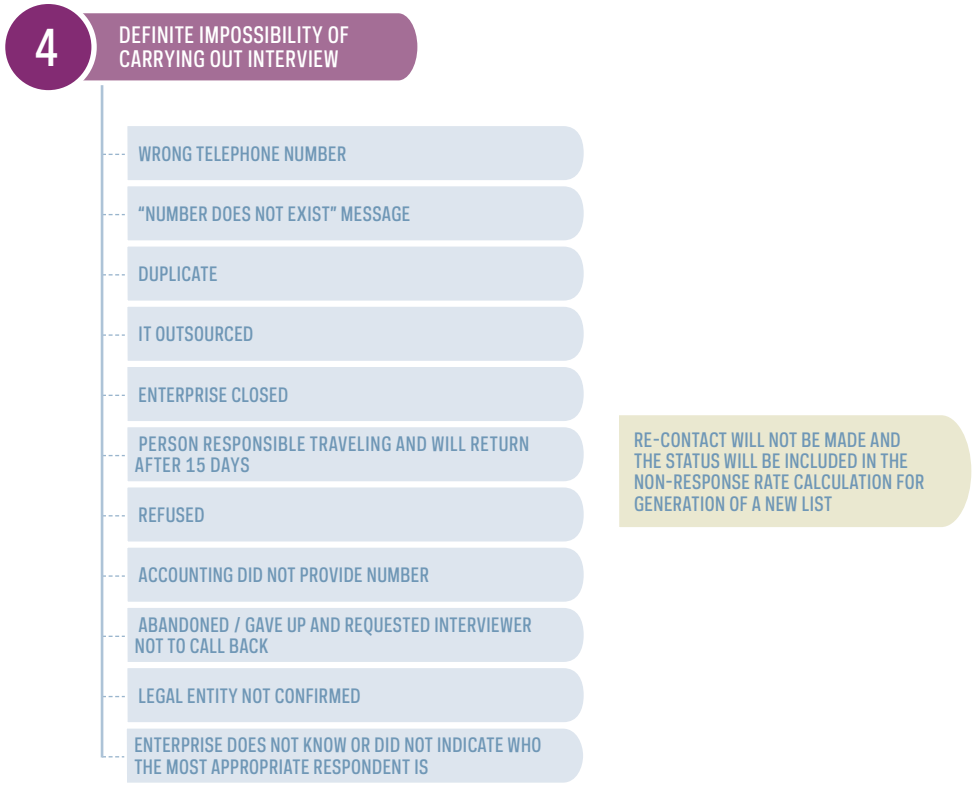
Situation 4 – Definite impossibility of carrying out the interview



As shown in Figures 1 to 4, the control of situations was grouped into four consolidated statuses: "Did not speak with enterprise representatives," "Spoke with enterprise representatives but did not complete the interview," "Interview fully completed," and "Definite impossibility of carrying out the interview."

In each round of the survey, enterprises were contacted and, when it was definitively impossible to carry out the interview, new enterprises were included in the sample for the respective round to achieve the goal of the initially foreseen sample. As presented in Table 3, 89% of the enterprises in this new list were contacted and, thus, had the final status and were considered in the weighting calculations.

TABLE 3

–

Final field situations by number of recorded cases

Situations	Number of cases	Rate
All missed calls	30 085	55%
Number does not exist	9 305	17%
Spoke with enterprise representatives, but did not complete the interview	7 683	14%
Interview completed	4 174	8%
Definite impossibility of carrying out the interview	3 123	6%
Pretest	363	1%
Total	**54 733**	**100%**

Data collection results

The ICT Enterprises 2025 survey attempted to contact a total of 49,331 enterprises, and the final sample was 4,174 enterprises. The response rate by stratification variable is presented in Table 4.

TABLE 4

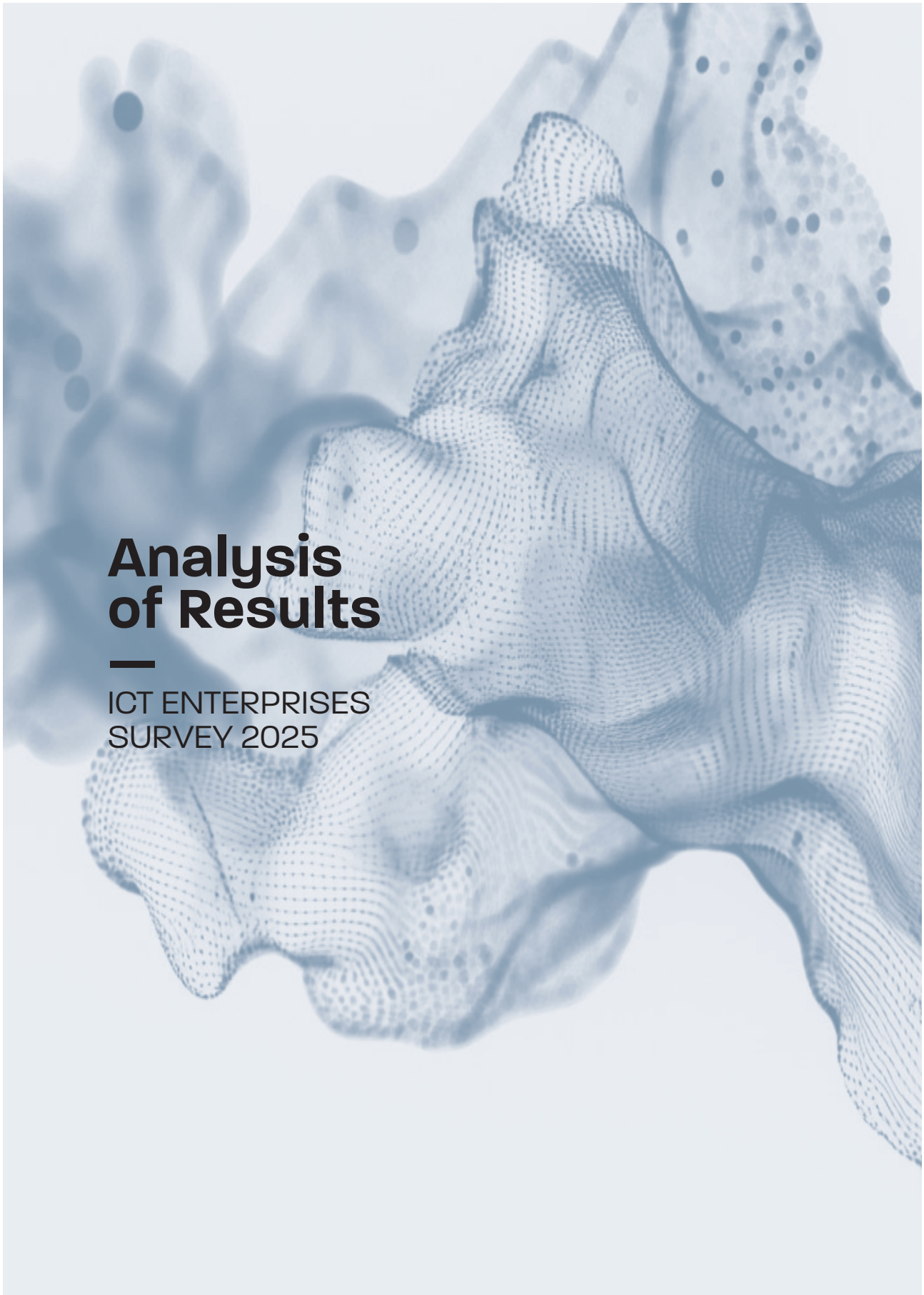
–

Response rates by size, region, and market segment

		Response rate (%)
Total		**8**
Size	10 to 19 employed persons	7
	20 to 49 employed persons	9
	50 to 249 employed persons	10
	250 or more employed persons	10

CONTINUES ▶

		Response rate (%)
Region	North	5
	Northeast	8
	Southeast	9
	South	12
	Center-West	9
Market segment (CNAE 2.0)	Manufacturing	10
	Construction	9
	Wholesale and retail trade; repair of motor vehicles and motorcycles	8
	Transportation and storage	8
	Accommodation and food service activities	6
	Information and communication	10
	Real estate activities; professional, scientific and technical activities; administrative and support service activities	10
	Arts, entertainment and recreation; other service activities	7



Analysis of Results

ICT ENTERPRISES SURVEY 2025

Analysis of Results
ICT Enterprises 2025

The new edition of the ICT Enterprises survey provides indicators on the presence of digital technologies in the daily operations of Brazilian enterprises, highlighting both the growth in the use of advanced applications and the existence of barriers to their wider dissemination. The survey also expands the investigation into how Artificial Intelligence (AI) is integrated into the daily operations of Brazilian enterprises of different sizes and market segments.

The advancement of AI in enterprises is accompanied by growth in the use of generative AI tools by the Internet user population, a phenomenon that has been verified by research conducted in several countries.[1] Therefore, it is already possible to observe the presence of AI in various segments of society, albeit in a non-uniform way, generating studies and analyses on how to expand its use equitably.

In this context, discussions and research are progressing on what the prerequisites would be for fostering the development of AI among countries. The most referenced documents include the *AI Index Report* from Stanford University, which deals with the most varied fields related to this type of technology, highlighting above all the leadership of the United States in the production of knowledge in the area, as well as the growing rise and consolidation of China, now the world's second-largest development center (Maslej et al., 2026). The analysis may also draw on indices developed by other international organizations, such as the Organisation for Economic Co-operation and Development (OECD, 2026a) and, more specifically for Latin America, the *Latin American Artificial Intelligence Index* (ILIA) (Soto et al., 2026): Both indices allow for ascertaining aspects of the use and production of AI knowledge and infrastructure, highlighting a series of indicators that address the skills needed for technology development. Furthermore, the indices suggest some key characteristics for the consolidation of these skills, especially among leading countries in technological production.

[1] The ICT Households 2025 survey provided new indicators on the use of generative AI among Internet users in Brazil. According to the results, around 32% of Internet users used this type of technology, with it being more frequent among users with Tertiary Education (59%) and from class A (69%). Among generative AI users, 84% reported that the purpose was personal use, 53% for school or college research/work, and 50% for professional or work use (CGI.br, 2026b). According to the Statistical Office of the European Union (Eurostat), 32.7% of the European Union population used generative AI tools in 2025, with personal use (25.1%) also being the most cited purpose among respondents. More information: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20251216-3

There are also more specific analytical approaches that seek to understand the more localized impact of the spread of AI. Several studies attempt to measure the exposure of occupations to AI, based on ideas about complementarity and substitution, but without statistical representativeness and focusing on certain occupations (Appel et al., 2026; Eloundou et al., 2023). Projections made by the US labor market statistics agency point to an increase in the hiring of people with skills related to software development and computing,[2] demonstrating that there is still no consensus on the implications of these technologies in the field of work.

AI also has the potential to affect qualification dynamics and job placement in the labor market. A study by the International Monetary Fund (IMF) analyzed the requirements for thousands of job postings published online and found that 1 in 10 occupations requires new skills, with more than half related to information technology (IT). Furthermore, among IT jobs, most of the skills demanded were related to AI (Jaumotte et al., 2026).

Other studies show an increase in investments related to the digital infrastructure necessary to support these applications. According to the UN Trade and Development (UNCTAD, 2026), from 2010 onwards, international trade in electronic components, such as chips, circuit boards, and sensors, began an upward trend that resulted in its leadership over the years, representing 12% of global exports.[3] Although it does not specifically address the topic, the UNCTAD report links this increase in investments to a greater demand for data centers.

Specifically for Brazil, there are also indications of increased investment activity driven by the demands and prospects related to the use of AI.[4] According to the study *Brazilian Software Market*, the amount of IT investment in Brazil was US$58.74 billion in 2024, rising to US$68 billion in 2025[5] (Brazilian Association of Software Companies [Abes], 2026). Similarly, the *Monthly Survey of Services* from the Brazilian Institute of Geography and Statistics (IBGE) showed a 0.3% increase in the volume of services compared to January 2025; the ICT market segment was the main driver of this growth, advancing 6.5% in January 2026 compared to December 2025[6] (IBGE, 2026b).

[2] The U.S. Bureau of Labor Statistics also indicates that some professions have been negatively impacted, such as credit analysts and insurance experts: https://www.bls.gov/opub/ted/2025/ai-impacts-in-bls-employment-projections.htm

[3] In the case of Latin America, data shows very modest participation in the export of information and communication technology (ICT) goods and services, highlighting the pattern of economic dependence on these types of goods and services already observed in other economic cycles.

[4] According to UNCTAD data, there was 14% growth compared to 2024, accumulating a total of 270 billion dollars, with Brazil having received around 10 billion dollars in investments in data centers, ranking behind only France, the United States and Korea (UNCTAD, 2026).

[5] In this study, whose first edition was in 2010, Brazil ranked tenth internationally in terms of the amount of IT investment. Although this is a prominent position for a developing country, it is important to note that these values are significantly lower than those for the countries that are leaders in technological development.

[6] The survey also shows which ICT services contributed most to the segment's growth: "information technology consulting; portals, content providers and other information services on the Internet; data processing, application service providers and Internet hosting services; software development and licensing; integrated book publishing; and custom software development" (IBGE, 2026b).

When compared to the countries that are leaders in AI research and development, Brazil occupies an intermediate position, while exercising leadership in Latin America in many areas (Soto et al., 2026). In general, the country is currently identifying opportunities and overcoming bottlenecks, seeking to orchestrate efforts to accelerate research and development of emerging technologies within the national territory. Initiatives such as the Brazilian Artificial Intelligence Plan (PBIA)[7] (Brazilian Ministry of Science, Technology and Innovation [MCTI], 2024) and the Special Taxation Regime for Data Center Services (Redata)[8] (Brazilian Ministry of Development, Industry, Trade and Services [MDIC], 2025) seek to leverage advantages identified in the country, such as clean energy and a large market of Internet users, while expanding ways for the country to integrate into global value chains.

Following the global trend, another aspect that should guide the actions of Brazilian enterprises is their adaptation to a series of laws and regulations that seek to organize the digital environment, with significant impacts on their online presence. Both the Brazilian General Data Protection Law (LGPD, Law No. 13.709/2018) and the Brazilian Digital Statute of the Child and Adolescent (ECA Digital, Law No. 15.211/2025) confer regulatory powers on the National Data Protection Agency (ANPD) with respect to enterprises' data-processing activities.

In this sense, it can be said that Brazil follows a trend observed in other countries, with a scenario of expanding investments in connectivity infrastructure and computing capacity, the presence of larger-scale digital technologies, and expansion of regulation of the digital environment. While this is a time for defining how enterprises will operate in the coming years, this scenario also brings challenges related to the allocation of financial and human resources.

In this context, this analysis of results addresses different aspects of access to and use of ICT among Brazilian enterprises. To highlight the level of technology adoption in different dimensions of business operations, this section is organized as follows:

- **Connectivity and online presence:** analysis of indicators of how enterprises access the Internet and the characteristics of their online presence.
- **Electronic commerce:** presentation of the main trends of enterprises in selling goods and services on the Internet.
- **New technologies:** presentation of indicators on the adoption and use of advanced technologies—such as cloud computing, the Internet of Things (IoT), and AI—as well as partnerships for development and data sources used.
- **Final considerations:** agenda for public policies.

[7] More information about the PBIA is available at https://www.gov.br/lncc/pt-br/assuntos/noticias/ultimas-noticias-1/plano-brasileiro-de-inteligencia-artificial-pbia-2024-2028

[8] More information about Redata is available at https://www.gov.br/mdic/pt-br/assuntos/noticias/2025/setembro/mp-cria-o-redata-que-estimula-datacenters-e-impulsiona-economia-digital-no-brasil

Connectivity and online presence

This first section discusses the elementary aspects of the digital economy: how enterprises connect to the Internet and how they present themselves in the digital environment. In 2025, what stood out was a pattern already observed in previous years: While most enterprises were connected to high-quality Internet, the complexity of their Internet use did not increase, highlighting limitations that could impact the implementation of more elaborate digital transformation strategies. In 2025, 93% of Brazilian enterprises, regardless of their size, had fiber-optic connections, a basic requirement for better quality access (Chart 1).[9]

CHART 1

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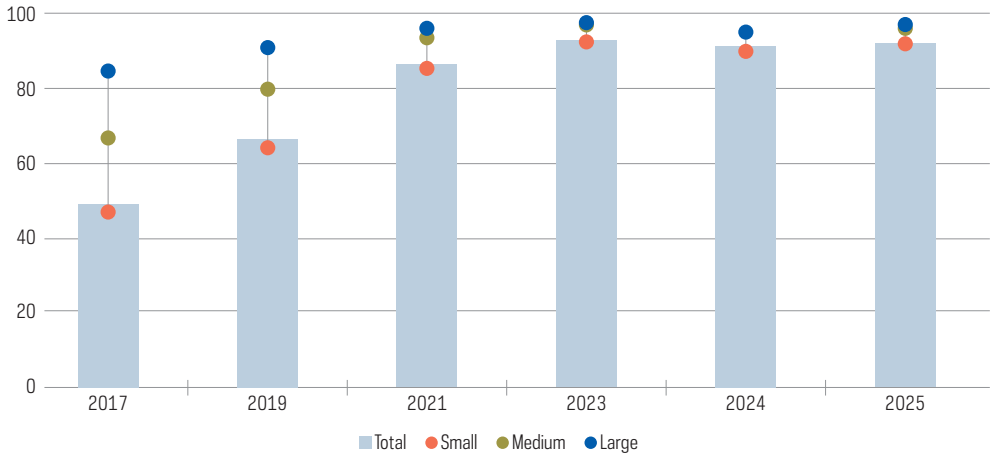
Enterprises by ownership of fiber optics and size (2017–2025)

Total number of enterprises with Internet access (%)



[9] In December 2025, the Regional Center for Studies on the Development of the Information Society (Cetic.br) launched the new version of the ICT Providers survey, which maps enterprises that provide Internet access in Brazil. One of the indicators of this survey shows that, since 2017, Internet access providers have been expanding the availability of fiber optics throughout the country (Brazilian Internet Steering Committee [CGI.br], 2025a).

Greater availability of fiber optics is a factor that enables advances in connection quality, which is evidenced by the increased proportion of enterprises in higher speed ranges. Although several factors should be considered when evaluating Internet quality, download speed is a key factor, providing a useful parameter for evaluating the connectivity of enterprises.[10] On the lower end of connection speed, in 2023, 71% of enterprises had connections of up to 500 Mbps, a proportion that was 62% in 2024 and 53% in 2025. Regarding the higher end, in 2023, 21% of enterprises had connections of more than 500 Mbps, rising to 28% in 2024, and reaching 35% in 2025.[11] It is important to highlight that this trend toward higher Internet speeds occurred among enterprises of all sizes (Chart 2).

CHART 2

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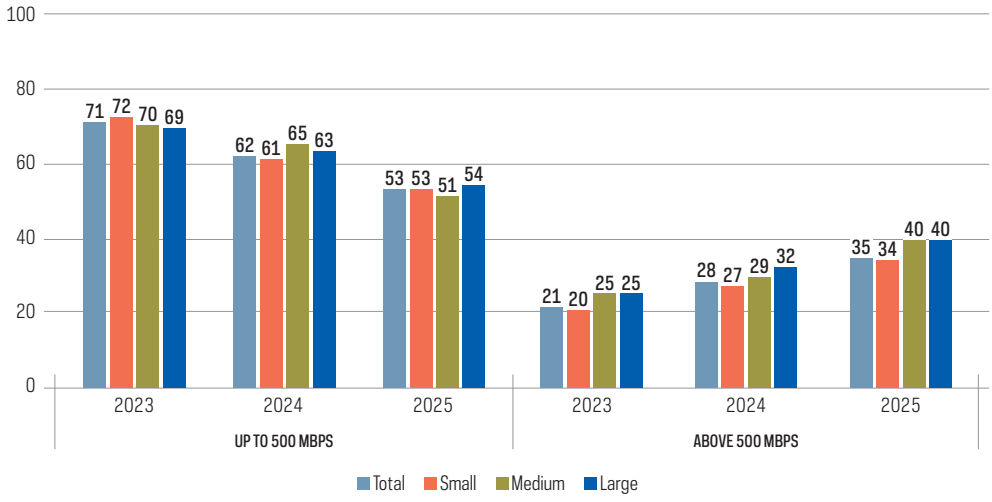
Enterprises by maximum download speed range and size (2023–2025)

Total number of enterprises with Internet access (%)



[10] The Brazilian Network Information Center (NIC.br) has developed a tool for evaluating Internet connection quality parameters, available free of charge. More information is available at https://simet.nic.br/

[11] Comparing global Internet quality is a complex task, as it must take into account local infrastructure factors. One of the most widely used indices was developed by Ookla, and Brazil ranks 27th in terms of median download speed. The country with the highest median download speed was Singapore, reaching 430.31 Mbps. More information is available at https://www.speedtest.net/global-index

The analysis of connectivity indicators shows expansion of the use of fiber optics and an increase in access speeds, revealing a scenario of universal broadband access among Brazilian enterprises. However, while small enterprises have stood out in recent years in terms of connectivity, their online presence via websites has not followed the same trend. The proportion of small enterprises with websites has remained constant since 2017, staying around 50%. Among medium and large enterprises, although the proportions are higher, there are still difficulties in achieving universal website adoption (Chart 3).[12]

CHART 3

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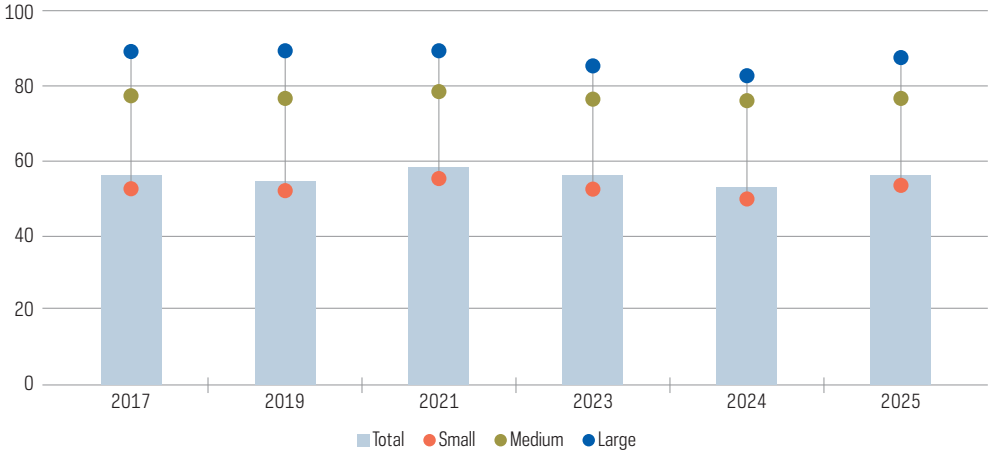
Enterprises with websites, by size (2017–2025)

Total number of enterprises with Internet access (%)



[12] In addition to serving as an institutional and commercial medium for enterprises, websites are increasingly central to complying with regulatory aspects of the digital environment. Two recent laws include legal requirements that websites must comply with. In the LGPD, paragraph 1 of Article 41 states: "The identity and contact information of the data protection officer shall be publicly disclosed, in a clear and objective manner, preferably on the controller's website." (Law No. 13.709/2018). The ECA Digital, in its Article 31, also specifies that information must be provided on the websites of enterprises that have specific Internet applications for children or that have probable access (Law No. 15.211/2025).

BOX

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TEST THE STANDARDS (TOP)

Since 2021, NIC.br has offered the Test the Standards (*Teste os Padrões* [TOP]) tool, which evaluates the adoption of international technical standards related to the security and resilience of Brazilian websites, such as IPv6, DNSSEC, HTTPS, and RPKI.

Cetic.br|NIC.br used this tool to collect information on the technical security of .br websites of enterprises in the ICT Enterprises survey. In the 2025 edition of the survey, among the approximately 55,000 enterprises selected for telephone data collection, those with domains registered in .br were identified. The information obtained for these domains through TOP allowed for the production of representative estimates for Brazilian enterprises.

The results indicate low adoption of digital security best practices. It is estimated that 34% of enterprises had domains registered in .br and 81% of them were associated with active websites. Among the indicators analyzed, RPKI showed the highest adoption rate (74.54%), while IPv6 was used by only 15.41% of domains. Overall (Table 1), the results show that a significant portion of corporate websites still do not adopt recommended practices for Internet security and infrastructure modernization, increasing their exposure to vulnerabilities and potential financial and reputational losses.

To learn more about TOP and check the adoption of technical standards and security best practices for free, visit https://top.nic.br.

TABLE 1

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Proportion of active URL in .br linked to the Company Registration Number (CNPJ) of Brazilian enterprises, by adherence to TOP standards (2025)

Total number of active URL (%)

IPv6	15.41
HTTPS	3.01
DNSSEC	9.45
RPKI	74.54

From the point of view of online presence, social networks are the tools most used by enterprises. Monitoring their presence across various platforms allows for capturing changes over the years. In 2017, 59% of enterprises were on Facebook, a proportion that increased over the years but then returned to the same level in 2025. In 2017, 22% of enterprises were on Instagram, Snapchat, TikTok, or Flickr, a proportion that reached 76% in 2025. The same growth trend was identified for WhatsApp or Telegram, which was the most-mentioned category in 2025, present in 79% of enterprises (Chart 4).[13]

[13] It is important to note that this migration between social networks is observed in other Cetic.br|NIC.br surveys, such as the ICT in Government survey. In 2023, 89% of state and federal government organizations and 83% of local governments had their own accounts on Instagram or Flickr. In both cases, an increase in the proportion of Instagram profiles over time is observed, along with a decrease in the use of Facebook (CGI.br, 2024).

CHART 4

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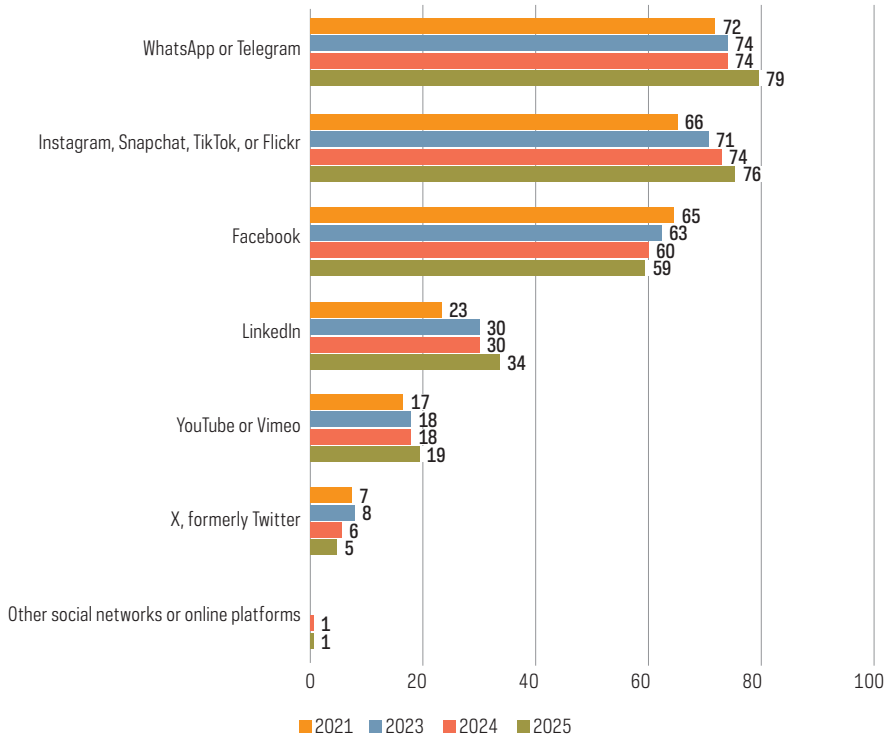
Enterprises with a social network account or profile, by type of social network (2021–2025)

Total number of enterprises with Internet access (%)



The use of social networks is shown to be the main form of online presence for Brazilian enterprises, especially small ones. In 2017, 30% of small enterprises did not have accounts on social networks, a proportion that fell to 10% in 2025, behavior similar to that observed in medium and large enterprises. The same trend was observed among enterprises that used only one social network, indicating the need for diversification of online presence: In 2017, 13% of small enterprises used 3 of the social networks investigated by the survey, a proportion that reached 30% in 2025. The presence of large enterprises on 4 social networks has expanded, going from 11% in 2017 to 27% in 2025. The 2025 results seem to indicate a trend toward diversification of enterprises' presence on different platforms, probably responding to the need to monitor customer movement on them (Chart 5).

CHART 5

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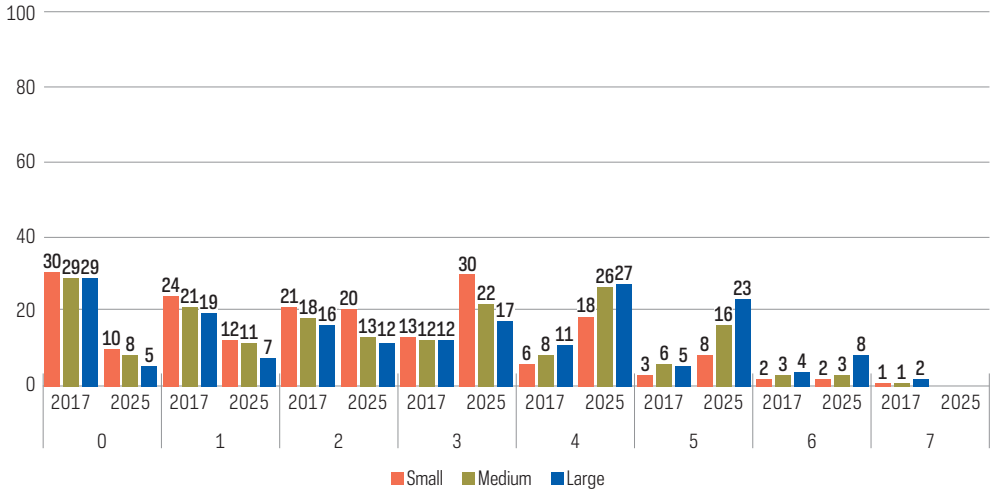
Enterprises with a social network account or profile, by number of social networks and size (2017–2025)

Total number of enterprises with Internet access (%)



The trends observed for the connectivity and online presence of Brazilian enterprises show a scenario of increased access, with stable website ownership and a focus on the use of social networks, especially among small enterprises. While the use of social networks gives enterprises direct access to customers and ways to showcase goods and services—generally in a simpler and freer manner—it is important to note that the full use of these platforms' tools involves investment, and there is little room for customization. Websites can offer greater autonomy to enterprises, as they provide total control over appearance and the content to be published. Furthermore, as a vehicle for transparency, websites are an important part of the legal and regulatory compliance process for enterprises, which are subject to sanctions if they fail to comply with regulations. Therefore, the digital presence of enterprises should be understood institutionally, including an obligation to present updated information and demonstrate transparency in their business model.

Electronic commerce

One of the most important aspects of an enterprise's online presence is electronic commerce (e-commerce), especially given the diversification of sales channels and customer contact methods available to enterprises.[14] In 2025, 68% of enterprises sold goods and services online, of which 79% stated they used WhatsApp, Skype, or Facebook chat messaging, a practice quite common for small enterprises.

The indicator allows for a distinction between sales channels that are more related to direct contact with customers—which are the most cited by small enterprises—and more automated relationship methods—more common among large enterprises.[15] The results point to a division between enterprises that use digital tools not intended for e-commerce to sell services and goods to customers and those that have a structure designed to operate exclusively with orders on the Internet, generally the larger ones (Chart 6).[16]

[14] According to the ICT Households 2025 survey, 52% of Internet users purchased goods and services online, which represents approximately 82,340,909 people (CGI.br, 2026b).

[15] Analysis of e-commerce indicators from the ICT Households 2024 survey shows a consumption pattern more closely linked to channels specifically created for e-commerce: Among Internet users who made online purchases, 90% did so on buying or selling websites and 65% through mobile phone store apps. The use of messaging apps, the sales channel most cited by enterprises, was mentioned by 30% of Internet users who purchased online (CGI.br, 2025b).

[16] The definition of e-commerce is under discussion in several international organizations that debate standards on economic statistics, especially the OECD and UNCTAD. According to a recent OECD report, the original 2009 concept has been reformulated to better define the ways in which enterprises sell goods and services online. The most recent definition is: "An e-commerce transaction is the sale or purchase of goods or services, conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders. The goods or services are ordered by those methods, but the payment and the ultimate delivery of the goods or services do not have to be conducted online." (OECD, 2025, p. 9). Some methods offered as response options in the ICT Enterprises survey did not qualify, according to this definition, as e-commerce, as they did not constitute an automated method, such as the use of WhatsApp. However, it is worth reiterating that the methods foreseen by the OECD definition are taken into account in the ICT Enterprises survey, allowing for comparison with countries that use the same definition.

CHART 6

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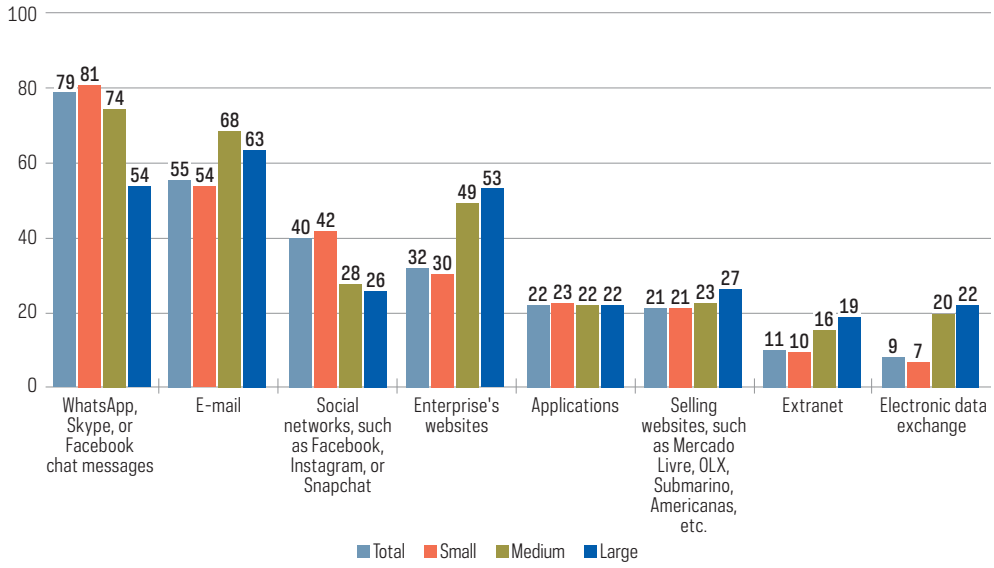
Enterprises by online media used for transactions and size (2025)

Total number of enterprises that sold on the Internet (%)



The most commonly used payment methods also varied by enterprise size. Most used Pix, or wire or online banking transfers as their main means of receiving payment. Methods exclusively used in a digital environment appeared less frequently: 42% of enterprises that sold online used credit cards required on the website at the time of purchase, and 22% resorted to online payment services, such as PagSeguro, PayPal, or Google Checkout.[17] However, the payment methods indicator shows that methods that depend on enterprises' online presence, such as online payment services, are underutilized, even among large enterprises, highlighting limited adoption of methods specifically designed for e-commerce (Chart 7).[18]

[17] According to the ICT Households 2024 survey, among individuals who bought online, 84% used Pix as a form of payment, a proportion that was 66% in 2022. In addition, there was a decrease in the use of bank slips, from 43% in 2022 to 24% in 2024 (CGI.br, 2025b).

[18] Pix is the most used means of payment, regardless of enterprise size, and is widely accepted among Internet users who buy online. This payment method has rapidly established itself as the main form of financial transaction in Brazil. According to data from the Central Bank, Pix reaches 80% of the Brazilian population and moved R$3 trillion in October 2025. More information is available at https://www.bcb.gov.br/estabilidadefinanceira/pix-em-numeros-estatisticas

CHART 7

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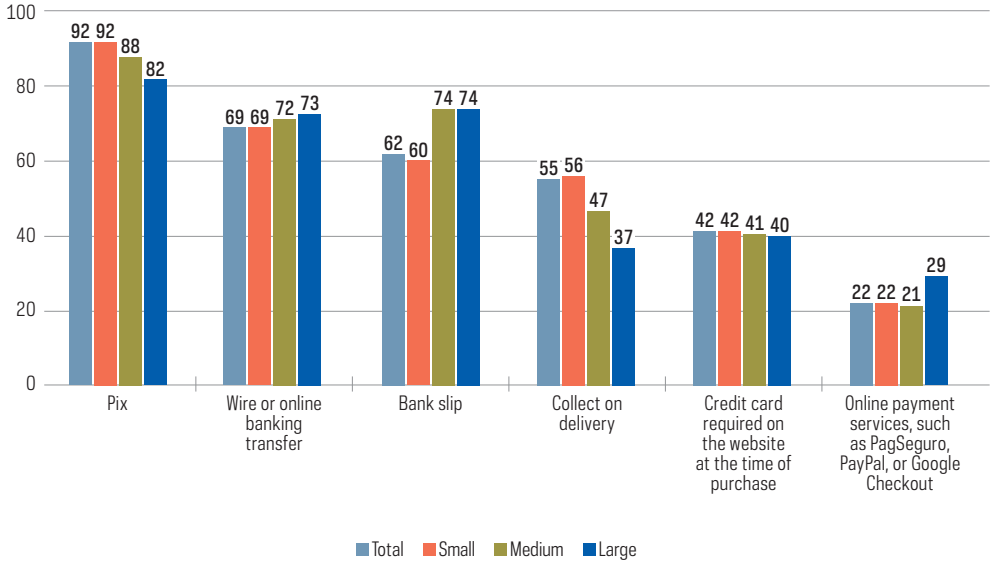
Enterprises that sold on the Internet, by type of payment and size (2025)

Total number of enterprises that sold on the Internet (%)



Analysis of the number of e-commerce methods used by enterprises over time reveals concentration in a few sales channels. Most enterprises used one or two online sales channels. In 2025, among enterprises that sold online, 18% used only one channel, the same proportion as those that used two. The proportion of enterprises that did not sell online increased between 2023 and 2024, as indicated by the zero number of channels used during that period (Chart 8), and returned to the previous level in 2025—that is, indicating that more enterprises are engaging in electronic commerce in the current version of the survey. Therefore, when it comes to e-commerce, enterprises tend to concentrate on a small number of channels. This pattern reflects two factors: the greater opportunity for customer contact offered by some channels, such as social networks, and the possibility of automating transactions (Chart 8).

CHART 8

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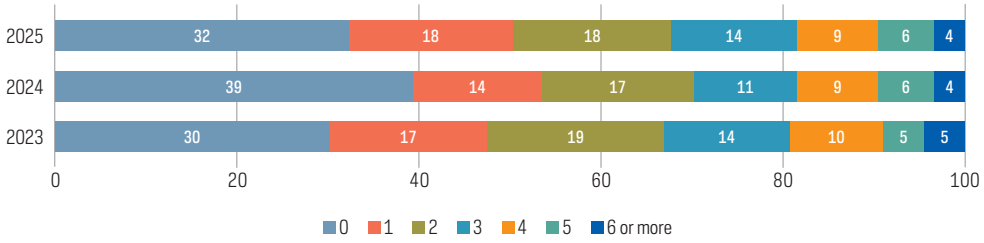
Enterprises by number of channels used to sell goods and services on the Internet (2023–2025)

Total number of enterprises that sold on the Internet (%)



The diversification of channels used for online sales highlights the need for enterprises to increase their exposure to more sales methods. One way to accomplish this is by purchasing online advertising, which increases the possibility of market segmentation and boosts advertising campaigns. Social networks play a decisive role in capturing the attention of potential customers and offer customer segmentation as one of their main benefits for enterprises. According to the ICT Households 2024 survey, which addresses forms of e-commerce more broadly, 46% of Internet users purchased goods or services online, with 49% of them having watched videos and 41% having seen posts on social media (CGI.br, 2025b).

The ICT Enterprises 2025 survey found that 41% of enterprises paid for online advertising, an indicator that has remained stable since 2023. No significant differences were noted when considering enterprise size, indicating that specific groups of enterprises make more strategic use of their online presence. For example, in the professional activities segment, 55% paid for online advertising, while in the information and communication segment the proportion was 53% (Chart 9).[19]

[19] An aspect that has currently increased in importance is the need for greater protection against the exposure of children to online advertising. According to the ICT Kids Online Brazil 2025 survey, 84% of children who used the Internet reported seeing advertisements for products or brands online, while 44% searched for information about a brand or product (CGI.br, 2026a). It is important that enterprises offering goods and services that are more likely to be misused by children seek to expose them only to appropriate audiences, implementing age verification mechanisms established by legislation, particularly Article 12 of the ECA Digital (Law No. 15.211/2025).

CHART 9

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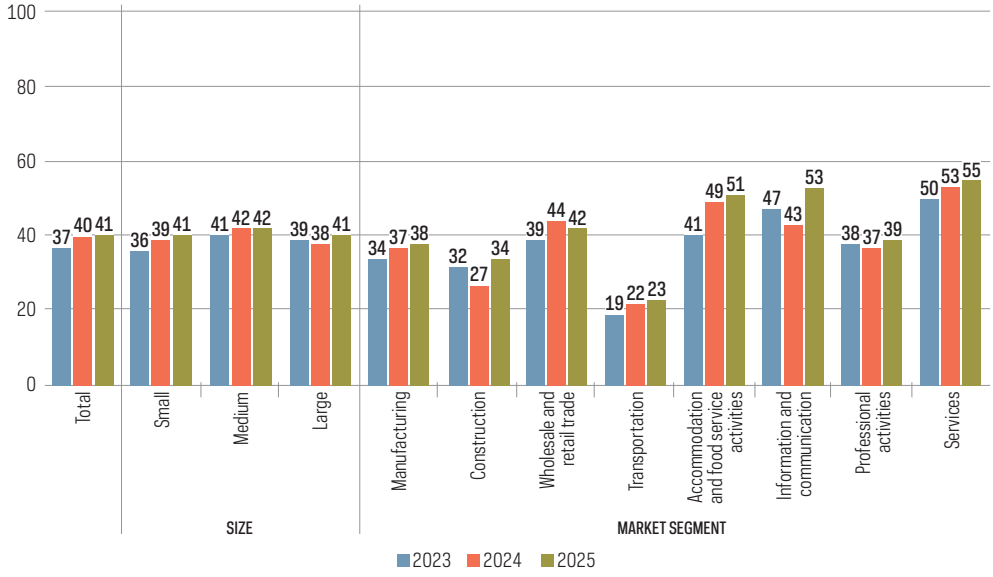
Enterprises that paid for Internet advertising, by size and market segment (2023–2025)

Total number of enterprises with Internet access (%)



The proportion of enterprises that sold goods and services on the Internet showed recovery, settling at the levels observed in 2023. There were differences in the way e-commerce was conducted depending on size, with small enterprises relying more on direct contact with customers, while medium and large enterprises made more use of specific and automated means for their sales.

Furthermore, it is important to highlight that, regardless of enterprise size, new rules for conducting e-commerce are beginning to be defined, especially regarding the consumption habits of children, which obliges them to adapt their online channels. Previous sections addressed more basic aspects of connectivity, such as online presence and e-commerce. The next section focuses on more advanced digital technologies, whose adoption is associated with the automation, integration, and transformation of enterprise processes.

New technologies

Recent studies have shown that the use of digital technologies by enterprises is steadily increasing, although this adoption is neither happening at an accelerated pace nor crucially altering the way enterprises operate, focusing mainly on secondary tasks unrelated to the enterprise's core business (Lins, 2025; OECD et al., 2025).[20] What these studies have depicted is a period of experimentation in which enterprises seek to adapt some work processes to the use of new technologies and introduce new equipment into auxiliary routines, but still with little effect on their main operations. It is important to highlight that this scenario is observed even in developed countries, indicating that the difficulties in adopting technology are much more closely related to organizational aspects related to process changes—such as regulatory uncertainties and high costs—than to complications arising from unfamiliarity with the technology's functionality (OECD, 2026b).

An example of this technological adoption process is the use of cloud computing by Brazilian enterprises. Services already offered predominantly through the cloud are more prevalent than those for which the cloud serves as a development platform for goods and services. In 2025, 56% of enterprises paid for cloud-based email services; 54% for file storage or databases; and 51% for finance or accounting software. On the other hand, in terms of what can be considered a prerequisite for enabling enterprises to use new technologies, 36% of them used cloud processing capacity in 2025, highlighting the stability of the indicator and the widespread use of on-premises infrastructure among Brazilian enterprises (Chart 10).

[20] Cetic.br|NIC.br participated in the design and testing of a specific questionnaire for enterprises using AI, which was applied by the Seade Foundation among industrial and ICT segment enterprises in the state of São Paulo (OECD et al., 2025). In general, in common with studies covering more market segments, the results pointed to uses more focused on auxiliary processes, with little or no influence on the enterprises' final products or services.

CHART 10

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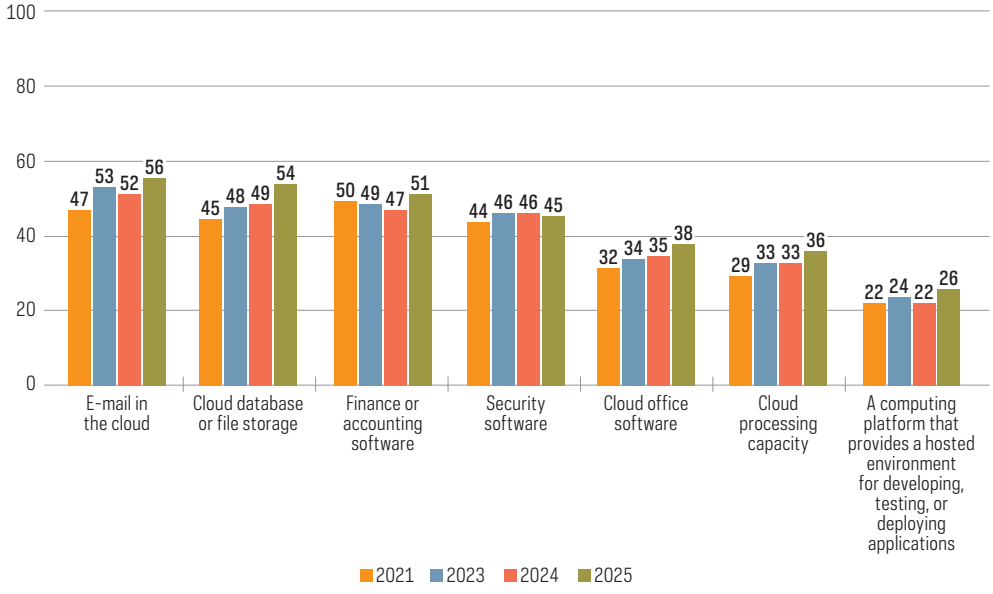
Enterprises that purchased cloud services, by type (2021–2025)

Total number of enterprises with Internet access (%)



Two examples of the challenges to increasing the presence of digital technologies in enterprises are the use of enterprise resource planning (ERP) and customer relationship management (CRM). Even though these tools have been on the market for a long time and are distributed by traditional IT enterprises, the historical series of the ICT Enterprises survey has shown stability in the indicator for their use. However, the most recent survey showed that the use of CRM by enterprises had increased, going from 25% in 2024 to 31% in 2025. This growth occurred mainly among small enterprises (23% in 2024 to 29% in 2025) and in the Southeast region (24% in 2024 to 32% in 2025), in a trend that aligns with the increasing adoption of these technologies by less complex organizations (Chart 11).

CHART 11

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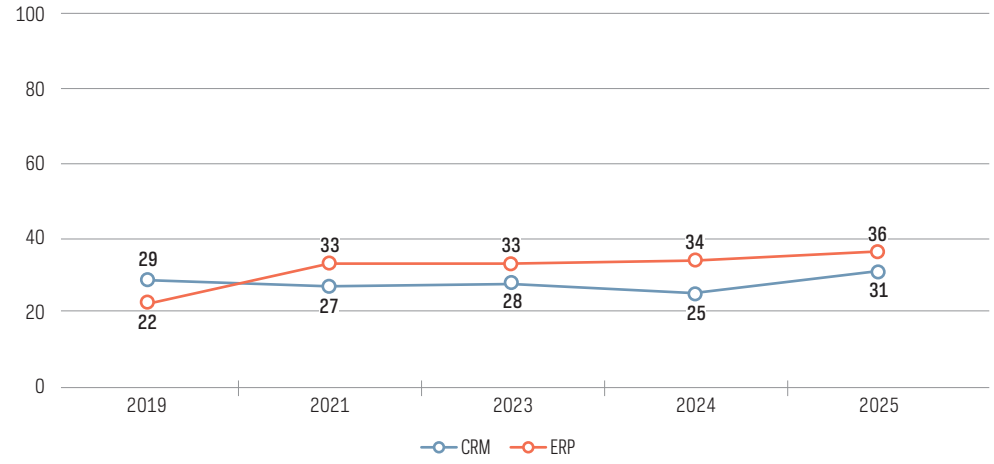
Enterprises that use CRM and ERP (2019–2025)

Total number of enterprises (%)



Analyzing the use of more specialized technologies shows that some solutions have not yet been adopted on a large scale among enterprises. This is the case for Big Data, 3D printing, and robotics,[21] for which the survey shows localized use that is generally more frequent in large enterprises and has remained stable since the beginning of the historical series in 2019 (Table 1).

TABLE 1

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Enterprises by use of new technologies (2023–2025)

	2023		2024		2025	
	Total number of enterprises (%)	Estimated total	Total number of enterprises (%)	Estimated total	Total number of enterprises (%)	Estimated total
Big Data	7	32 181	6	30 969	6	32 778
3D printing	3	15 748	3	14 154	4	22 186
Industrial robots	2	10 257	2	10 782	3	13 409
Service robots	1	5 845	1	6 087	1	5 104

[21] The International Federation of Robotics (IFR) conducts a survey on the number of industrial robots in operation around the world. The latest version, with data collected in 2024, showed that there were approximately 500,000 units in operation, with China leading in the installation of new robots, followed by Europe and the Americas. In terms of sectoral presence, most robots were in the electronics and automotive industries (IFR, 2025).

Another technology encountering obstacles to wider adoption among Brazilian enterprises is the Internet of Things (IoT). In 2025, 14% of Brazilian enterprises had used some type of smart device, the same proportion as in 2023. Although this usage among large enterprises reached 40%, sectorally, there was greater concentration in the information and communication segment (Chart 12).[22] Notably, the most commonly used devices related to facility security (90% of enterprises that used IoT), such as alarm systems, smoke detectors, door locks, and smart security cameras, followed by energy consumption management (48% of those that used IoT), such as smart meters, thermostats, or light bulbs.

CHART 12

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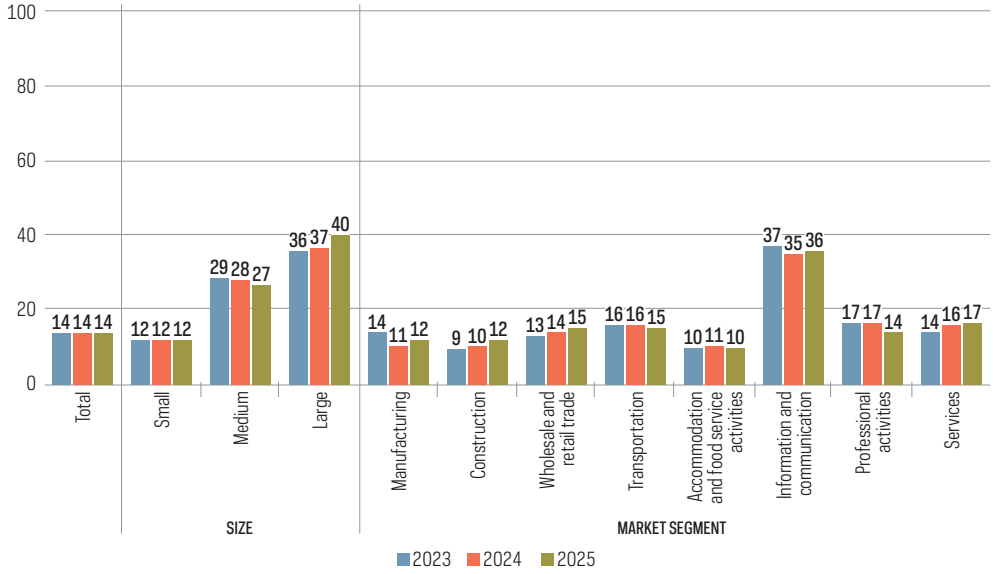
Enterprises that used smart devices or IoT, by size and market segment (2023–2025)

Total number of enterprises (%)



AI is the technology that is currently generating the most debate, whether seen in discussions about how to foster its development through public policies or in initiatives to mitigate its consequences, especially its impact on the labor market (OECD, 2026a). The assessment of the topic by ICT Enterprises, which had its first edition in 2021, shows that the adoption of AI has grown among Brazilian enterprises, going from 13% in 2024 to 17% in 2025.

[22] The most recent Global System for Mobile Communications Association (GSMA) report on the mobile economy indicates that, in 2025, there were approximately 8.8 billion mobile connections worldwide, with growth driven by the increased use of IoT devices. According to the report, mobile connections account for 6.4% of the world's gross domestic product (GDP) (GSMA, 2026).

The results for 2025 represent 93,475 enterprises, with significant growth in the Southeast and North regions. It is important to highlight the increase in AI use by enterprise size. In 2024, 10% of small enterprises used AI, a proportion that rose to 15% in 2025; in large enterprises, 38% employed AI in 2024, reaching 50% in 2025 (Chart 13).

CHART 13

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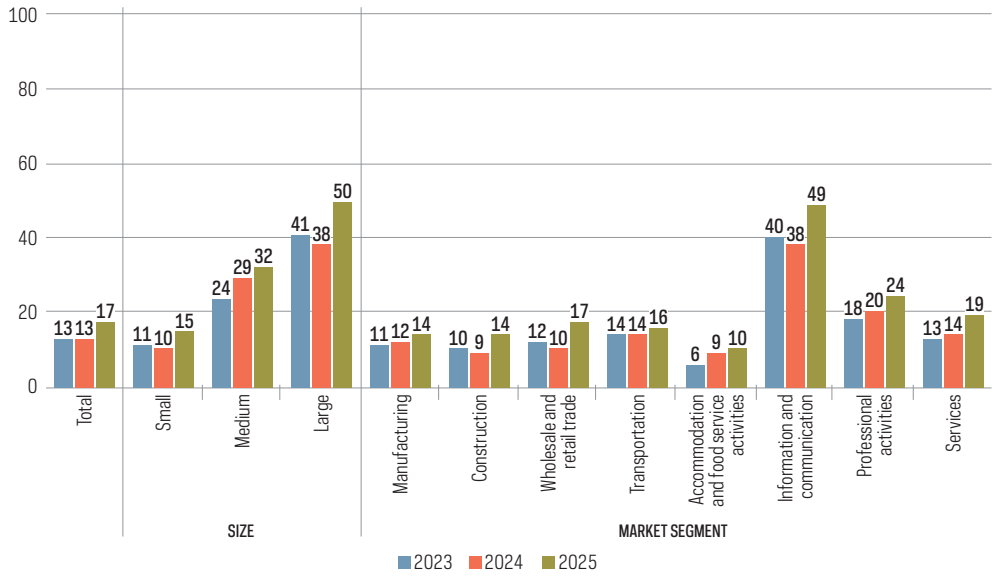
Enterprises that used some type of AI, by size and market segment (2023–2025)

Total number of enterprises (%)



This increased presence was influenced by growth in two types of AI measured by the survey. Among enterprises that used AI, 22% used text mining and written language analysis in 2024, rising to 38% in 2025, while natural language generation (NLG) for written or spoken language increased from 20% to 30%.[23] It is noteworthy that both items refer to functionality associated with generative AI, which could explain why the respondents said they had applied digital technology to a greater extent than in previous editions. However, the use most commonly reported by enterprises continued to be the automation of work processes, present in 68% of enterprises that used AI (Chart 14).

[23] Specifically for Brazil, while limited to large enterprises in the industrial sector, data from the Semiannual Survey of Innovation (Pintec Semestral) show an increase in the use of AI, rising from 16.9% in 2022 to 41.9% in 2024. The highest proportion of use is found among industries with more than 500 employees, and it is most concentrated in areas of the enterprise related to administration, sales, and project development (IBGE, 2026a). These results are consistent with those of other studies, indicating that AI is being adopted by enterprises to automate routine secondary processes—particularly administrative ones—and thus has a limited presence in the organizations' core activities (Lins, 2025).

CHART 14

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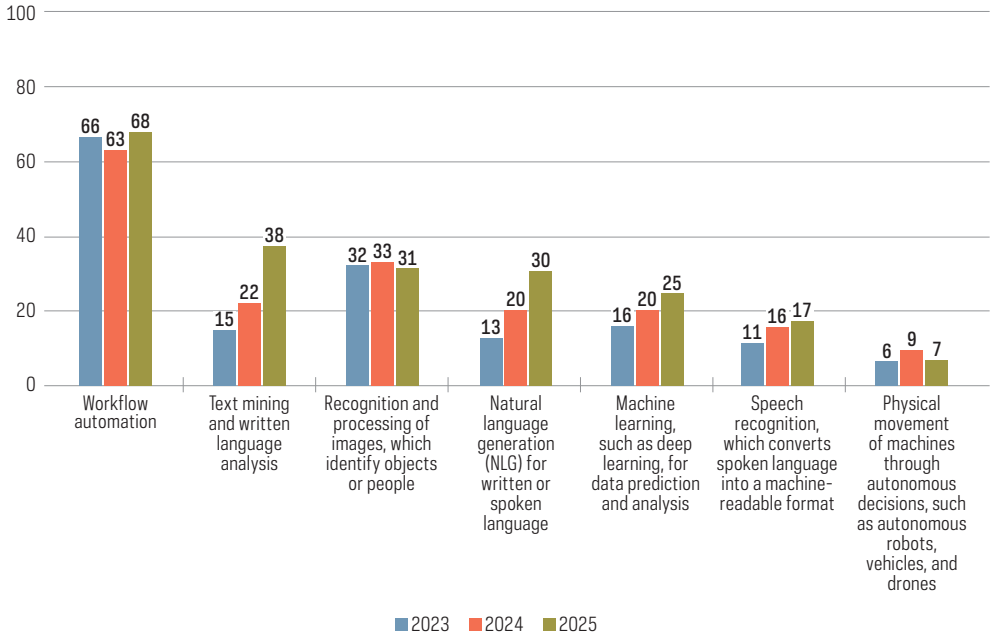
Enterprises that used some type of AI, by type (2023–2025)

Total number of enterprises that used AI (%)



The indicator on AI use in ICT Enterprises was constructed by adapting Eurostat's questionnaire, which allows for comparison of data between Brazil and the EU member states. The latest version of the Eurostat survey found that 20% of European enterprises used some type of AI, with the Nordic countries standing out: 42% of enterprises in Denmark, followed by 37% in Finland and 35% in Sweden.[24] With 17% of its enterprises applying AI, Brazil is approaching the average of countries like the Czech Republic and Italy. It is worth noting that in all countries considered in the survey, the same pattern of more frequent use in large enterprises was observed (Chart 15).[25]

[24] The AI usage indicator is calculated from at least one positive response in the types of AI measured by the survey, which are the same in both the European study and the ICT Enterprises survey. However, in 2025, Eurostat added another item to the types of AI (AI Technologies generating pictures, videos, sound/audio), which is not yet available in the ICT Enterprises 2025 survey, but will be included in the 2026 version. The Eurostat survey reported that 9.05% of European enterprises used this type of AI.

[25] An OECD study found that 20.2% of enterprises in the EU countries used some type of AI in 2025, a proportion that was 8.7% in 2023, with higher prevalence in large enterprises (OECD, 2026c).

CHART 15

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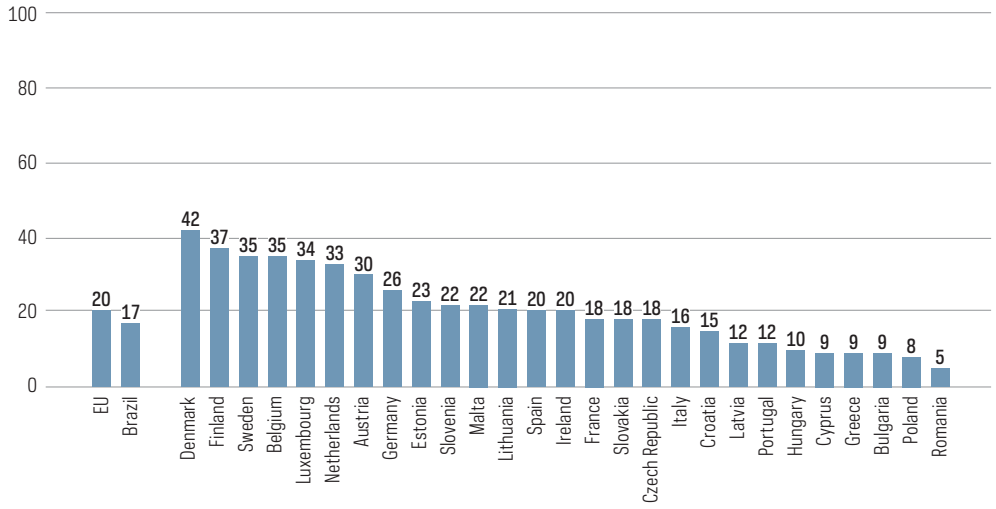
Enterprises that used some type of AI in Brazil and in EU member states (2025)

Total number of enterprises (%)



The ICT Enterprises survey also investigates how AI is being implemented in enterprises, in an attempt to determine the extent to which solutions are developed internally. According to the latest version, among the enterprises that used AI, 80% acquired ready-to-use software or systems, followed by 54% that hired external suppliers to develop or modify them, showing stability compared to 2024. Therefore, the prevalent pattern is purchasing solutions that are available on the market. However, there was an increase in "development by the enterprise's in-house staff" among large enterprises, which grew from 24% in 2024 to 37% in 2025.[26] These results suggest that there is an incipient research and development ecosystem, while the use of off-the-shelf solutions continues to be the main way to implement AI in enterprises (Chart 16).[27]

[26] This indicator from ICT Enterprises does not specify the type of technology involved in this in-house AI development. However, the index developed by Stanford University indicates the areas in which countries excel in the research and development of AI technologies. The index is based on the analysis of the technical and scientific output of approximately 658,000 influential researchers in the field, considering aspects such as participation in research, creation of new models, and data repositories. This indicator shows that Brazil has just over 11,000 authors and inventors: 18% are in the area of software engineering and networks, 10% in machine learning, and 10% in computer vision and image processing—areas that can be considered fields of expertise for the country globally (Maslej et al., 2026).

[27] A survey by the Center for Strategic Management and Studies (CGEE) showed that there were 121 AI research centers in Brazil. However, the report indicated that there is some redundancy of efforts and fragmentation of distributed resources, with little communication between initiatives, suggesting the need to create a coordination mechanism (CGEE, 2026).

CHART 16

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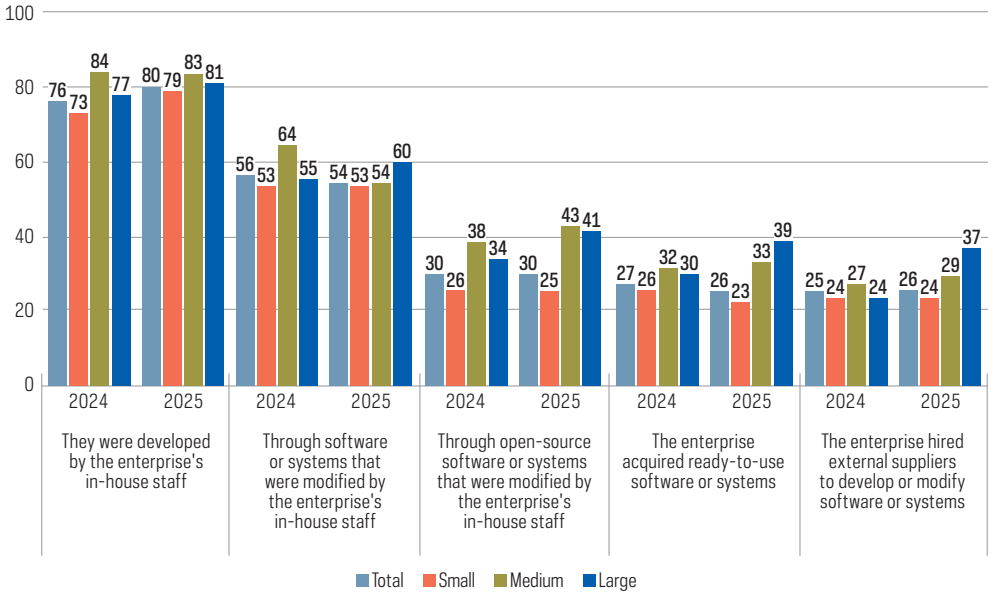
Enterprises that used AI, by how they acquired or developed the AI software or systems they use and size (2024–2025)

Total number of enterprises that used AI (%)



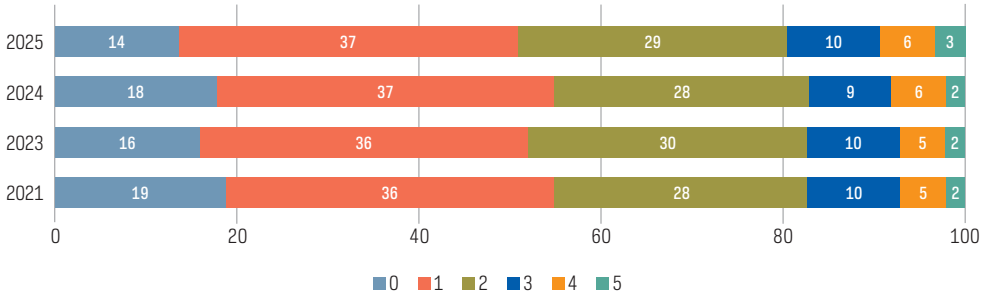
So far, this section has analyzed the one-off use of various advanced technologies. However, it is also important to assess the interactions between technologies. An enterprise's digital maturity is related to the number of technologies employed simultaneously, not just in a one-off manner. In this sense, an indicator can be constructed based on the results of the ICT Enterprises 2025 survey to capture the use of at least one of the following technologies: cloud computing, CRM/ERP, Big Data, robotics, IoT, and AI.[28] The results can range from the use of no technologies to a maximum of six simultaneously, on a continuum that shows the extent to which enterprises have adopted technologies that are interdependent. The use of one technology is prevalent, mentioned by 37% of enterprises in 2025, followed by the use of two, at 29%. During the historical series of the survey, no enterprises have used all six technologies (Chart 17).

[28] It is important to mention that these indicators are used to monitor goal 4 of the New Industry Brazil (NIB) policy, launched in 2024. This goal aims for the digitalization of 90% of national industry, understood as the use of three or more of the highlighted technologies. More information is available at https://www.gov.br/fazenda/pt-br/acesso-a-informacao/acoes-e-programas/transformacao-ecologica/programas-em-destaque/nova-industria-brasil

CHART 17

Enterprises by number of advanced technologies used (2021–2025)

Total number of enterprises (%)



This section has provided an overview of the increased adoption of AI among Brazilian enterprises, suggesting greater scalability of the technology. However, the analysis of application types indicates that AI has been predominantly employed in support processes, not in activities directly related to the core business of enterprises—a pattern also observed for the use of IoT. However, the use of AI has also increased among small enterprises, which may indicate digital technology is entering a phase of broader adoption, initially focused on optimizing auxiliary processes, with the potential to expand to other areas in the coming years.

Final considerations: Agenda for public policies

The results of the new edition of ICT Enterprises show progress in the adoption of AI among Brazilian enterprises, a trend also observed in other countries. Its use in Brazil has grown among both small and large enterprises, and the results suggest that there are two ways in which AI technology is being implemented in these organizations. Growth among small enterprises may indicate that AI technologies are already gaining in scale and being used in processes that support the business. Large enterprises show a scenario of incipient exploration of the potential of AI, as evidenced by an increase in in-house development of AI in these enterprises.

However, increased use of AI was not accompanied by more use of other digital technologies investigated by the survey, such as the use of cloud and IoT services. Cloud computing can be considered a prerequisite for more complex use of AI. It comes after digital maturity, and is more frequently achieved by large enterprises because of their greater financial and human resources.

The results reinforce the importance of considering the digital maturity of enterprises in the formulation of public policies aimed at the development of digital technologies, since organizational learning tends to be gradual and heterogeneous. Furthermore, studies and research report several setbacks in the processes of technology implementation, which often fail to achieve the expected results or lead to unanticipated or unsatisfactory solutions (Bailey et al., 2019; Faraj & Leonardi, 2022; Shrestha et al., 2019).

Several public policies focused on AI have prioritized strategies for strengthening innovation ecosystems: Their focus is not on specific enterprises, but on a pool of advanced technologies (OECD, 2026b). The strategy is to develop continuous learning, bringing together research centers, universities, and small enterprises in the search for solutions to technological challenges. The ICT Enterprises 2025 survey showed that, in the adoption of AI, there was little interaction between universities and research centers with enterprises, which signals the importance of fostering development and technology transfer relationships between these organizations. Even if classic public policy instruments are used, such as tax exemptions and incentives, the focus should be more on coordinating the efforts of various actors and sharing uncertainties than on just guiding financial and human investments (OECD, 2026b).

However, despite growing activity in other countries, the United States and China still lead in AI research and development, driving the consolidation of enterprises, goods, and services that dominate the market. It is essential that other countries seek a qualified way to enter the supply chain for this market (Brandão & Lins, 2025). The strategies currently under discussion in Brazil include the creation of a regulatory and fiscal environment aimed at attracting investments in data centers, with Redata, and investments directed toward AI research and development for both academia and specific economic sectors, based on PBIA.[29] Data centers are a crucial component of the infrastructure needed to sustain the digital economy. Brazil could work to establish itself as a hub for data centers, which would improve the country's position in value chains related to digital infrastructure, but this must be accompanied by environmental safeguards and financial returns for the country (Brazilian Association of Information and Communication Technology Companies [Brasscom], 2025; Laboratory of Public Policies and Internet [Lapin], 2025).

From a legal and regulatory standpoint, we are currently experiencing a period of discussion about the applicability of regulations in the digital environment, including a certain amount of flexibility. This is particularly true in Europe, which is dealing with the repercussions of the debates surrounding the conclusions of the Draghi Report[30] (Draghi, 2024). In practical terms, the European digital omnibus package proposes important changes to the laws on the protection of personal data and intellectual property[31] (European Commission, 2025). The changes under discussion in Europe may lead to significant effects for countries whose regulations or proposals for regulations have been influenced by the European model, such as Brazil.

In this context, the results of this version of the ICT Enterprises survey point to a period of expanded adoption of advanced digital technologies in enterprises of all sizes, which may lead to a period of greater experimentation and, at the same time, greater challenges in enforcing the regulations and laws currently in effect in the country.

[29] The MCTI provides a dashboard for monitoring the actions of the PBIA. More information is available at https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/plano-brasileiro-de-inteligencia-artificial

[30] *The Draghi Report: A competitiveness strategy for Europe*, released by the European Commission, argues for the need to reassess some regulations in order to reposition the bloc in the face of competition with the United States and China.

[31] Although it does not aim to repeal laws, the proposal seeks to facilitate needed adaptations, providing regulatory flexibility depending on the size of enterprises, and streamlining bureaucratic processes, for example, in providing information to authorities responsible for the protection of personal data.

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Articles

Pathways to AI adoption in enterprises: From experimentation to institutionalization

Natália Marroni Borges[1]

The adoption of Artificial Intelligence (AI) in enterprises is still maturing and, for this reason, is following different and still experimental trajectories. Some organizations start with specific, low-risk use cases; others begin with initiatives, actions, or processes structured on platforms and guided by governance; and still others accelerate development through partnerships with suppliers and startups. In this article, internalizing refers to incorporating AI into work routines and practices, while institutionalizing involves formalizing capabilities, responsibilities, controls, and support mechanisms over time. This distinction helps avoid confusion between recurring use and consolidated organizational capacity.

The main dilemma in corporate adoption of AI is not purely technical, but rather organizational. The same AI that generates quick gains when used individually, whether by individuals, teams, or departments, can lead to fragmentation, risk, and increased total cost when scaled without proper coordination. This discrepancy also appears in international surveys: One study found that 88% reported making regular use of AI in at least one role, but nearly two-thirds indicated that they have not yet begun to scale AI within their organization (McKinsey & Company, 2025). The traditional path of technology adoption driven by information technology (IT) has, in a sense, been diverted by solutions that directly engage business teams in a simplified way, adding new dimensions to the challenges of the informal, non-institutionalized use of IT tools in organizations.

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This article presents excerpts from postdoctoral research conducted in the Department of Administrative Sciences at the Federal University of Rio Grande do Sul (UFRGS). Based on this, the way the topic has been approached in the consulting/corporate context is analyzed, and a practical roadmap for AI adoption is proposed, arguing that there is no single model to be considered "correct". Different types of AI fit into organizational processes, products, and routines in distinct ways. Throughout the text: (i) the main categories of AI relevant to the adoption decision are distinguished; (ii) existing incorporation pathways for each category are discussed; and (iii) a synthesis is presented of how to internalize and institutionalize AI in a complementary way, in a rapidly transforming technological scenario. The operational thesis is that it is worthwhile to differentiate when to experiment with, standardize, and institutionalize AI, depending on the type in question and its typical mode of failure at scale.

Three practical categories of AI

When the term "Artificial Intelligence" was coined in the mid-1950s, it broadly referred to the ambition of building systems capable of performing tasks associated with human intelligence. Over the decades, however, the field has expanded considerably, and today AI serves as an umbrella term for a heterogeneous set of concepts, techniques, approaches, and tools that are often treated as equivalent, even when they entail very different requirements, risks, and forms of integration.

For management and strategic purposes, it is useful to categorize AI. The reason for this decision is purely operational, since each tends to require different inputs, controls, and integration mechanisms. It is worth noting that the categories outlined in this article are not the only possible ones, as there are several ways to classify types of AI depending on the objective. In this article, we deliberately simplify, highlighting approaches that are more commonly adopted in organizations and sufficiently distinct in functionality and requirements to be treated differently.

- **Generative AI:** models capable of producing text, images, code, and other content, supporting the creation, communication, design, and development of digital products, services, and solutions. The value generated by AI typically comes from gains in productivity, quality, and speed, but risks include hallucinations, information leaks, and copyright infringement (Bommasani et al., 2021).
- **Agentic AI:** systems that not only generate outputs, but also execute sequences of goal-oriented actions — such as querying systems, filling out forms, opening tickets, triggering flows, and negotiating constraints — with different levels of autonomy and supervision. In this sense, permissions, audit trails, testing, containment, and accountability become important, as they represent control over the executed flows (Russell & Norvig, 2020; Yao et al., 2022).
- **Predictive or analytical AI:** models that estimate probabilities and classify, rank, or predict values (e.g., churn, fraud, demand, default), generally based on structured data and statistical and machine learning techniques. The value usually comes from making better decisions, automating triage processes, and optimization. Risks include bias, drift, and data governance (Hastie et al., 2009).

The categorization above, while not encompassing all the techniques associated with the term "AI," helps to avoid the common mistake of treating it as a homogeneous package. In practice, what works in predictive AI initiatives may not be sufficient for generative AI, and even less so for agentic AI. The differences expressed in these categories highlight the need for further study of the adoption of each type of AI. The following sections address these issues.

ADOPTION PATHWAYS FOR GENERATIVE AI

In general, generative AI refers to models capable of producing new artifacts from patterns learned from large volumes of data. In business practice, the main point is that this technology operates as a flexible layer for generating and transforming content, whose value and risk depend on the context, the sources used, data policies, and the degree of integration into the work (Bommasani et al., 2021).

From a corporate perspective, a recurring path for the adoption of generative AI in enterprises begins with the pursuit of individual and team gains (support for writing, summarization, internal customer service, and engineering support, among others), evolves into departmental use cases, and finally reaches end-to-end products and processes.

This initial and typically individual stage is accelerated by the popularization of ready-made tools and relatively low barriers to entry. In many enterprises, this manifests as shadow AI—the informal, often undocumented use of AI tools to speed up day-to-day operations. While this movement is understandable and generally generates real productivity gains, it differs from an institutional approach and tends to be poorly standardized, difficult to audit, and subject to some risks, such as privacy, compliance, and quality issues, in addition to all the issues related to (lack of) knowledge management.

A second stage emerges when specific areas begin to organize the use of this type of AI—for example, a marketing team creating prompt routines and libraries, a legal department standardizing templates, or an HR department structuring screening processes. Agility tends to increase, but the attention points arising from these practices cannot be ignored. Without cross-functional coordination, it is common to have overlapping necessary activities—content curation, review, access management, and documentation, among others. Furthermore, it is common to observe a certain duplication of efforts, as well as of contracting between departments, especially with multiple tools, distinct contracts, and parallel integrations, which can compromise efficiency and governance.

The third stage—the end-to-end stage—is when generative AI is actually institutionalized within the organization. This involves more than just operational efficiency gains, since achieving it requires defining model performance criteria, establishing an integration architecture with corporate systems, and addressing ethical and legal aspects—such as intellectual property, privacy, transparency, and accountability. It is also important to conduct risk analysis and implement controls proportionate to the impact obtained. It is at this moment that the organization effectively takes ownership of the process and, for this reason, positions itself as the "owner" of the decisions. This involves accepting full formal responsibility for the defined processes, their operating criteria, controls, and results.

Furthermore, a "shortcut" is emerging where a significant portion of suppliers—especially those in core technology—are incorporating generative AI into their own platforms. In this context, resources such as pilot programs for tools from major vendors (such as Microsoft and SAP) can accelerate institutional adoption of AI by leveraging existing integrations, permissions, and workflows. Conversely, these shortcuts do not eliminate the need for planning, as it remains important to assess scope, security, governance, costs, and dependence on specific suppliers. In this transition from pilot programs to scaling up—or from more individual use to institutional use—the following points are usually important.

- **Defining usage boundaries:** what can or cannot be sent to external models, what sensitive data requires masking or anonymization, and what outputs need human review.
- **Prioritizing the integration of AI into the workflow:** value appears when content generation is in the place where the work happens, with context and reliable sources.
- **Building a knowledge layer:** curating documents, taxonomies, permissions, and retrieval mechanisms to reduce hallucinations and increase traceability.
- **Defining priorities regarding the results to be achieved in the face of organizational challenges:** some enterprises seek greater accuracy in the responses of generative AI, while others prioritize efficiency in the use of infrastructure. When these points are clearly understood, they contribute to a more informed decision-making process for selecting suppliers for this type of solution.

Naturally, the points listed above are not sufficient to address the entire topic of generative AI adoption, but they provide an initial overview of the first steps necessary to enable its use from an institutional perspective.

ADOPTION PATHWAYS FOR AGENTIC AI

In short, the expression "agentic AI" refers to goal-oriented systems that can plan and execute actions sequentially, using tools and interacting with systems to achieve a result—an idea present in the classic literature on agents in AI, such as in Stuart Russell and Peter Norvig (2020). What changes in the recent cycle is not the conceptual existence of "agents," but their practical viability on a larger scale, since the popularization of generative AI has brought linguistic interfaces and context interpretation capabilities that have made it simpler and more "producible" to delegate the coordination of multiple steps to a system, including in situations with exceptions and ambiguity.

From this perspective, agentic AI can be understood as an evolution of traditional automation (such as robotic process automation [RPA]), now combined with models capable of interpreting instructions, deciding on next steps, and dealing with real-world variations. Instead of relying exclusively on rigid workflows, the agent begins to operate as an action coordinator, capable of recognizing the state of the work, selecting available tools, executing operations, verifying intermediate results, and adjusting plans

based on context. This shifts the focus from "task automation" to "work orchestration," broadening the range of processes that can be automated and reducing the need to code all exceptions in advance. At the same time, this shift introduces an important asymmetry, because the more capacity an agent has to act, the greater the operational risk associated with permissions, scope, and impact. That is why, in this category, the most important challenge goes beyond model performance and becomes organizational control and responsibility for execution (Wang et al., 2024).

In practice, the adoption of agentic AI tends to gain more traction when the enterprise already has digitized processes and mature integrations. This dependency is not a technical detail, as it defines how well an agent can operate "within" the actual work, without resorting to shortcuts that may be fragile. When this infrastructure exists, a prudent approach to incorporating it is usually organized by levels of autonomy, not as a formality, but as a mechanism for learning and risk reduction. The initiatives often begin in an assisted mode, where the agent proposes plans and recommends actions, but execution remains with the user. Next, the process enters a supervised stage, in which the agent can perform delimited actions under human supervision, with a restricted scope and explicit containment rules. Only after that does it make sense to consider higher levels of autonomy, and even then, under clear safeguards such as impact and budget limits, allowlists, environment segregation, audit logs, and routines for interruption and rollback when necessary.

This progression also reorganizes the division of labor between IT and business areas. Today, solutions allow you to configure agents and automations in low-code/no-code paradigms (Binzer et al., 2024), which tends to encourage the appropriation of agentic AI by non-technical areas. However, apparent simplicity does not eliminate structural requirements. Integration, testing, observability, access control, and security remain crucial for reliability. Therefore, a hybrid arrangement is frequently observed, in which IT acts as a platform and guardian of standards, while business areas consume and adjust automations as internal products, closely aligned with the routines they wish to transform. This organizational architecture is particularly relevant because agentic AI amplifies systemic effects—a well-integrated agent can reduce friction at multiple points in the flow; a poorly contained agent can escalate failures with the same speed.

From this perspective, differentiating experiments from reliable implementations depends less on "having a working agent" and more on creating the institutional conditions that make execution predictable, auditable, and secure. Governance of actions—including role-based permissions, environment segregation, and audit trails—becomes the backbone of the design. Similarly, testing and observation practices need to capture representative scenarios, likely failures, and rollback procedures, since errors here are not just "bad outputs," but rather improper actions. Finally, security takes on an expanded role of protecting against prompt injection, tool abuse, improper privilege escalation, and unauthorized access. With this change, it ceases to be a "peripheral" concern and becomes an operational requirement. In summary, the adoption of agentic AI, when well-managed, tends to usher in a leap in productivity and work coordination. However, when this does not happen, it tends to usher in a new type of operational instability that is faster, harder to track, and costly to correct.

ADOPTION PATHWAYS FOR PREDICTIVE OR ANALYTICAL AI

Before discussing adoption pathways, it is important to clarify what is meant by predictive or analytical AI in this article. The terminology can be limiting, as it is not just about "predicting" future values, but about offering a set of machine learning-based solutions—often anchored in statistical modeling applied to structured data—that allow organizations to estimate probabilities, and classify, rank, segment, and identify patterns relevant to decision-making and diagnostics. In practical terms, this category ranges from risk and propensity models (default, churn, fraud) to decision support and optimization applications (demand, capacity forecasting, queue prioritization), as well as clustering and anomaly detection tasks (Chandola et al., 2009; Hastie et al., 2009; MacQueen, 1967).

While in previous sections the adoption of generative and agentic AI appears strongly associated with the reorganization of work and interaction with knowledge and processes, in predictive AI the central point lies in the relationship between data, decision-making, and the lifecycle. This is a form of AI whose usefulness depends on how the model's output concretely alters organizational behavior. This dependence makes predictive AI both more "industrializable" and more demanding. It is more industrializable because, when data and processes are well defined, it is possible to stabilize pipelines, validate performance, and operate with repetition. This is more demanding because, without consistent data, historical background, and causal clarity regarding the use of the prediction, the model tends to become a technically sophisticated but organizationally irrelevant artifact.

Therefore, a recurring path to adoption begins with decision-making where estimation truly changes the game—decisions in which gains in accuracy, speed, or consistency directly impact cost, risk, revenue, or service quality. From that point on, the question ceases to be one of "training a model" and becomes one of "putting a model into production without losing control." This is where operationalizing the lifecycle (machine learning operations [MLOps]) becomes a structuring element, not a later refinement. MLOps practices and tools enable data and model versioning, validation and testing, controlled deployment, continuous monitoring, retraining routines, and ensuring governance and traceability—that is, it is a set of mechanisms that sustains reliability over time and allows explaining what was decided, based on which version, under which data and limits.

However, the sustainability of this layer depends on a prior foundation, which is data quality and governance. Since predictive AI is based on structured data, the maturity of definitions, lineage, access controls, compliance, and remediation processes is not merely a "data" concern; it is, in fact, an essential condition for the modeling itself. Without consistency, the model learns noise; without stable access, the model is unsustainable; without governance, the organization cannot respond over time to adverse effects, biases, or variations. Furthermore, as models begin to guide decisions, an inevitable layer of organizational management emerges, which involves ensuring that the automated decision remains aligned with the business objective, that the model's metrics do not replace the outcome's metrics, and that containment mechanisms are in place when the context changes.

It is therefore common for organizations to combine predictive AI with complementary layers of control and interpretation. Rules can be used to define the decision-making space, making behavior more predictable in critical situations. Some strategies allow for

continuous comparison between approaches and prevent the crystallization of obsolete models, while business metrics monitor the stability of the impact, even when technical accuracy seems adequate. Nevertheless, the most important distinction regarding content generation-focused initiatives remains: in predictive AI, without structured data and a minimum lifecycle architecture, there is no sustainable scale. In other words, the challenge is not simply about "finding a good use case". It expands to the construction of a reliability regime that endures over time, which involves changes in data, processes, customer behavior, and the external conditions the model seeks to capture.

From internalization to institutionalization: How the approaches complement each other

The institutionalization of AI depends, first and foremost, on a clear distinction between the different types of AI and the deliverables each enables. The following is a summary of the three categories discussed earlier.

TABLE 1

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Summary of functionalities and deliverables by AI type

Type of AI	Key features and deliverables	References
Generative AI	Generation and transformation of content (text, code, and other artifacts), support for creation and communication, as well as conversational interfaces, with relevant implications for evaluation, risk, and governance in organizational contexts.	Autio et al., 2024; Bommasani et al., 2021.
Agentic AI	Goal-oriented execution through planning and the use of tools, enabling the automation of tasks and the coordination of steps in workflows with different levels of autonomy and supervision.	Russell & Norvig, 2020; Yao et al., 2022; Wang et al., 2024.
Predictive AI (analytics)	Estimation, classification, ranking, and segmentation from structured data; decision support and detection of patterns and anomalies, typically through statistical modeling and machine learning techniques.	Hastie et al., 2009; Chandola et al., 2009; MacQueen, 1967.

Source: prepared by the author.

Understanding these functionalities serves as a starting point for selecting the type or combination of AI best suited to the problem. In many cases, the pressure to "have AI," coupled with a lack of understanding of the differences between approaches, leads to technology, architecture, and governance choices that do not maximize value and may increase risks.

In addition to functionality, the requirements for implementation and scalability vary substantially across categories. The following table summarizes typical requirements, in line with the discussion in the previous sections.

TABLE 2

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Summary of typical implementation and scaling requirements by AI type

Type of AI	Typical requirements	References
Generative AI	Usage and privacy policies; knowledge curation and access control; workflow integration; quality/security assessment; governance and risk management.	Autio et al., 2024; Tabassi, 2023.
Agentic AI	Integrations and permissions; observability and auditing; autonomy limits and safeguards; testing and security against tool abuse and attacks such as prompt injection; execution governance.	Tabassi, 2023; Wang et al., 2024.
Predictive AI (analytics)	Availability and quality of structured data; definition of labels and metrics; versioning and traceability; training and validation pipelines; drift monitoring; MLOps and lifecycle governance.	Kazmierczak et al., 2024; Sculley et al., 2015; Zarour et al., 2025.

Source: prepared by the author.

Based on these distinctions, the challenge takes on an organizational character and involves creating conditions for AI initiatives to reinforce one another rather than compete for attention and resources. In this context, four fronts frequently emerge:

1. **Strategy and portfolio:** Structuring a portfolio of initiatives by AI type (generative, agentic, and predictive), by time horizon (quick gains vs. transformation), and by criticality, with explicit prioritization criteria (expected value, feasibility, data dependency and integrations, risk, and compliance). In practice, this typically involves an intake and screening process for use cases and decision steps, along with a minimum set of comparable metrics aligned with a risk management approach throughout the lifecycle (National Institute of Standards and Technology [NIST], 2023; Tabassi, 2023).

2. **Platform and architecture:** Creating reusable capabilities that reduce rework and increase security. Typical examples include: identity and access, logs and auditing, connectors/APIs, observability, data catalog, integration layer for large language models (LLM), and MLOps components. In many organizations, this is operationalized as an internal platform with recommended standards and components, reducing the incentive for parallel solutions (International Organization for Standardization [ISO] & International Electrotechnical Commission [IEC], 2023; NIST, 2023).

3. **People and capabilities:** Defining roles and routines to bridge the business and technology boundary (e.g., process/product owners, engineering, data, security, legal/compliance, and audit), as well as developing AI literacy and continuous training mechanisms. A recurring arrangement is the combination of a core (e.g., center of excellence or platform team) with execution close to the domains (federated model), to ensure scale without losing relevance (European Union, 2024; ISO & IEC, 2023).

4. **Governance and risk:** Implementation of policies and processes that make decisions traceable and auditable: risk classification by use case, minimum documentation (data, model, purpose, limits), assessment and monitoring (including drift, incidents, and changes), privacy and security controls, as well as accountability mechanisms. Guidelines and frameworks such as the NIST AI Risk Management Framework (AI RMF) explicitly state practices and expected outcomes for governing, mapping, measuring, and managing risks, and can serve as a reference for structuring controls proportionate to the organization's risk and maturity.

This summary makes it clear that "AI adoption" is neither a one-time decision nor a uniform technological package. Each category shifts the organizational center of gravity to a distinct infrastructure: in generative AI, the challenge lies in knowledge, privacy, evaluation, and governance of use; in agentic AI, in execution control, permissions, auditability, and operational security; and in predictive AI, in structured data, lifecycle, and statistical reliability in production. The practical effect is that institutionalization depends not only on "choosing the right technology," but also on building organizational capabilities that align with the typical failure mode of each approach—whether through hallucination and opacity in content, improper actions in flows, or drift and silent degradation in analytical models.

Final considerations: A world in transformation

The AI landscape is changing rapidly—models, tools, costs, regulations, and integration standards are evolving in short cycles. Even model and infrastructure vendors are still testing different ways of "packaging" products (e.g., combining models, tools, connectors, observation, and security). In this context, more than seeking a definitive design, it is important to build continuous learning capabilities that involve monitoring trends, experimenting with clear criteria, documenting lessons learned, and updating governance. In other words, competitive advantage tends not only to come from adopting AI, but also from staying attentive and up to date to incorporate it safely, with value and organizational coherence.

A relevant organizational development stemming from this scenario is the gradual movement toward reducing the dependence of traditional IT areas on innovation. The classic dynamic of translating business needs into IT demands has been under strain since the spread of agile approaches and the formation of cross-functional squads that bring together different specialties and accelerate delivery. Nevertheless, in many enterprises, the dependency persists, resulting in long development and adjustment cycles for solutions.

The spread of low-code/no-code tools and the incorporation of AI capabilities into widely used platforms have helped to overcome some of this bottleneck, allowing non-technical professionals to use the technology with less need for programming or developing systems from scratch. At the same time, this shifts the focus of the work: more than writing code, it becomes necessary to design processes and safeguards, measure effects, and govern risks.

Furthermore, the understanding of the nature of AI is still maturing. After several years in which different solutions were treated indiscriminately, there is a growing need to differentiate approaches (generative, agentic, and predictive) and to clarify their requirements, limitations, and impacts. It is possible that, in the coming cycles, additional layers, beyond the technical aspects, will gain prominence in AI projects (for example, legal, compliance, audit, risk management, and areas responsible for ethics and impact), given that the relevant results are not limited to operational performance, but include regulatory, reputational, and social implications.

In future cycles, the advantage will not be "using AI," but rather governing it at scale. This tends to require three strategic moves: (1) reducing shadow AI without killing productivity, creating a paved road with well-defined exceptions; (2) treating data, identity, audit, and risk as business infrastructure, not as an exclusively IT matter; and (3) instituting explicit executive accountability for algorithmic decisions and incidents. Organizations that fail to do so may achieve rapid adoption, but at the cost of chronic instability.

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ICT and the development of professional skills in contemporary enterprises

Rodrigo Müller[1]

Technological advances have intensified rapidly in contemporary society, producing direct impacts on people's daily lives and the organizational environment (Weiss, 2019). From the popularization of computers in the mid-1980s to the rise of Artificial Intelligence (AI)-based tools, people's behavior has changed to make room for new forms and means of relationships, shopping, access to information, consumption of culture and art, and professional activities, among others, as indicated by reports from the Organisation for Economic Co-operation and Development (OECD, 2023) and the World Economic Forum (WEF, 2025).

In the world of work, these impacts are manifested in transformations in the technical basis of various professions, the automation of processes, the use of information systems to support decision-making, and the adoption of AI applications for the execution of routine tasks and chatbots for customer service, among other examples (Filgueiras, 2021; Schunk, 2020). These changes are not limited to the incorporation of new technologies, but also affect the organization of work, production flows, and the skills required of workers.

In the Brazilian context, data from the ICT Enterprises and ICT Households surveys, conducted by the Brazilian Internet Steering Committee (CGI.br), demonstrate the widespread use of the Internet and digital technologies. According to the ICT Households survey, in 2024, "84% of the population 10 years old or older, or 159 million individuals," used the Internet every day or almost every day (CGI.br, 2025a, p. 21). These findings indicate that a significant proportion of the population has regular access to digital tools, which expands the potential for using these technologies in professional activities.

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In the organizational field, according to data from the ICT Enterprises 2024 survey, the adoption of digital tools for activities such as selling products and services online, as well as the use of AI and automation, is growing nationwide (CGI.br, 2025b). In terms of online sales, between 2019 and 2025, the number of enterprises selling products and services through this medium increased in at least one communication channel, as shown in Chart 1 below. Messaging channels such as WhatsApp, Skype, and Facebook chat were the most used.

CHART 1
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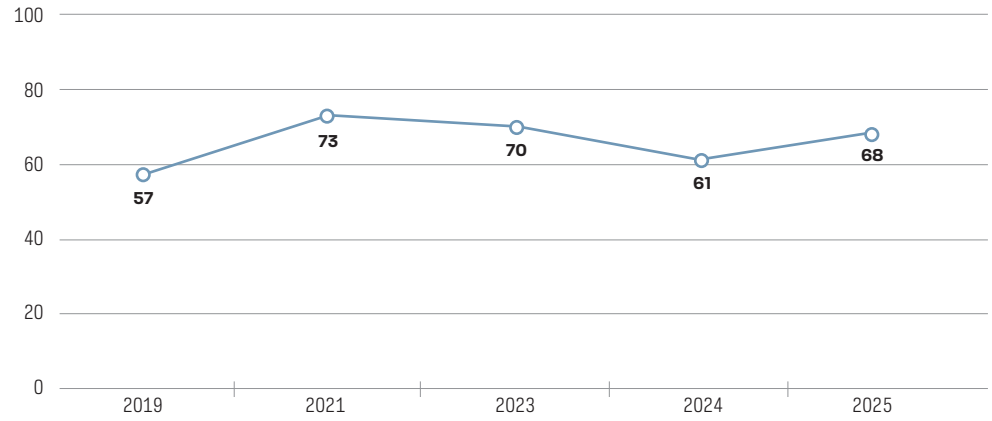
Internet sales in Brazilian enterprises (2019–2025)
Total number of enterprises with Internet access (%)



Source: prepared by the author based on ICT Enterprises surveys (CGI.br, 2020, 2022, 2024, 2025b, Brazilian Network Information Center [NIC.br], 2026).

This data is consistent with the results of the ICT Households 2024 survey, which found that 92% of Internet users in Brazil used instant messaging services, a figure that has remained stable in recent years (CGI.br, 2025a). This scenario reinforces the idea that the challenge for enterprises and workers is not limited to access to technologies, but also includes the ability to use them productively and strategically.

Another relevant finding from the ICT Enterprises 2024 survey concerns the use of AI-based applications: 13% of participating enterprises reported using this technology, particularly large organizations in the information and communication sector, focusing on process and workflow automation (CGI.br, 2025b).

These technological and digital transformations, including the growth in the use of AI applications, combined with other changes in the economic, cultural, political, and social landscapes, lead to alterations in the patterns of production and performance of activities, the ways work is carried out (Grohmann, 2021), the marketing of products and services, the access to and use of data and information, and contact with customers and other stakeholders of enterprises (Rogers, 2023). In this context, workers in virtually all fields face the challenge of updating their skills and developing competencies compatible with an increasingly digital organizational environment.

Recent studies reinforce this trend. Cazzaniga et al. (2024) indicated that around 40% of global jobs are exposed to AI, with potential impacts on both advanced economies and developing countries. Converging on this point, *The Future of Jobs Report 2025*[2] indicated that technological transformations can affect established professions, promoting organizational restructuring processes and redefining the skills required for work (WEF, 2025).

Therefore, this article discusses recent digital transformations and their impacts on the world of work, based on data from national and international reports, and analyzes the technical and socio-emotional skills required for enterprises and workers to adapt to the contemporary technological landscape.

Skills for a constantly changing world of work

Manuel Castells, a sociologist who has conducted extensive studies on technology, already noted that "technology is society, and society cannot be understood or represented without its technological tools" (1999, p. 43). This suggests that a society's development potential is linked to its ability to develop and master the strategic technologies of each historical period. In the organizational field, this relationship is expressed in the growing adoption of information and communication technologies (ICT), management information systems, and AI applications, driven by increasing data volume and the need for computational support for processing.

The acceleration of digital transformations in enterprises has been occurring at an fast pace, expanding the use of digital platforms for communication, team management, information sharing, and the execution of productive activities. This process was significantly accelerated from 2020 onwards, when the global COVID-19 health crisis demanded the rapid adoption of remote work modalities and the intensive use of digital tools, highlighting technical limitations and skills gaps in different professional groups (Backes et al., 2020).

This rapid change has challenged traditional work patterns, boosting the use of ICT and virtual platforms for carrying out work activities. The processes of incorporating technologies into enterprises, which were already underway, were accelerated by the pandemic scenario, and this demanded, in addition to the change and digital transformation of processes, products, and services, the development of new skills for the effective use of these tools.

In this scenario, technical skills, or hard skills, take on a central role. They are defined as those that can be learned and that qualify an individual to perform a function, being the set of specific knowledge necessary to carry out particular jobs, especially those related to the use of digital technologies (Fleury & Fleury, 2001; Kovaleski & Picinin, 2020). Behavioral or socio-emotional skills, known as soft skills, can be seen as those linked

[2] *The Future of Jobs Report 2025*, conducted with over 1,000 employers representing more than 14 million workers across approximately 22 sectors of the economy, analyzes the global labor market, considering technological, geographic, political, and environmental factors. The report can be accessed at: https://www.weforum.org/publications/the-future-of-jobs-report-2025/

to ways of thinking and feeling, forms of behavior and relationships with oneself and others, and communication and problem-solving. Soft skills are intangible, while hard skills can be measured (Cruz & Moraes, 2013; Fleury & Fleury, 2001).

Professional skills play a strategic role in both organizations and workers' career paths. For enterprises, they form the basis for delivering quality products and services. For professionals, these skills directly influence their opportunities to enter, remain in, and move within the job market. In a context of rapid technological transformations, analyzing the skills required becomes fundamental for organizational and professional planning.

Between the digital and the human: The search for balance between soft skills and hard skills

In work environments marked by the growing presence of ICT and AI applications, enterprises and workers face the challenge of developing skills that simultaneously meet both the technical and human demands of their jobs. In a study by the International Monetary Fund (IMF) on the impacts of AI on the labor market, Cazzaniga et al. (2024) indicated that, in developing economies, AI tends to act in a complementary way to human work, increasing its complexity and requiring both digital skills and advanced cognitive and socio-emotional abilities.

The study also indicated that workers with higher education are better prepared to transition to highly complementary jobs with the help of AI. Older workers and people without higher education are more vulnerable, as they tend to occupy more routine roles that are potentially automatable (Cazzaniga et al., 2024).

Complementing this discussion, data from the WEF (2025) shows that occupations with a high proportion of routine tasks are at risk of job loss due to automation. These professions include postal service workers, data entry operators, cashiers, administrative professionals, and assistants and secretaries, for example.

These findings suggest that digital transformation processes in organizations can significantly impact the lives of many workers. While younger populations tend to be more familiar with digital tools and have broader access to training and qualification processes related to technologies, older workers require greater effort to update professional skills and develop new abilities.

Among the main skills required, those related to the use of digital technologies stand out, due to their increasing adoption in organizations and their relative ease of acquisition. Behavioral skills—such as empathy, communication, interpersonal relationships, teamwork, creativity, and resilience—have been increasingly valued in organizations due to their greater complexity in development and the positive impacts they can have on productivity and competitiveness. Furthermore, analytical thinking, flexibility, agility, leadership, and social influence are core soft skills (WEF, 2025).

In the field of technical skills, understanding algorithms and the use of AI, data security, digital culture, design and user experience (UX), and mastery of technological tools, among others, have become skills required by enterprises in various sectors of economic activity, due to the intensification of the use of technologies in work processes (WEF, 2025).

TABLE 1
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Hard and soft skills demanded in the job market

Hard skills	Soft skills
Digital literacy	Analytical thinking
Information processing	Empathy and active listening
Big Data	Communication
Cloud computing	Resilience and flexibility
Networks and cybersecurity or information security	Creativity
	Interpersonal relationships
	Lifelong learning

Source: prepared by the author based on WEF (2025) and OECD (2025).

Table 1 summarizes the competencies that can serve as a reference for conducting organizational diagnoses and planning professional training and retraining actions. For the Brazilian scenario, considering that the country is in the midst of a digital transformation process,

> while AI and big data, creative thinking, and technological literacy are anticipated to be the fastest-growing skills in the country, companies also expect a greater focus on empathy and active listening (...) as well as resilience, flexibility, agility, and curiosity and lifelong learning. (WEF, 2025, p. 75)

As the OECD report noted (2025), global population aging is one of the factors that simultaneously raise concerns and create opportunities. This issue is concerning, since older workers have historically had fewer opportunities to access work and income, and, given technological advances in society and organizations, they may be disadvantaged in developing the skills and abilities required by the contemporary labor market. However, the increase in the proportion of elderly people in the population also represents an opportunity for the retraining of these workers, whether among those already employed, who can undergo upskilling processes to update existing professional skills or acquire new skills for different roles (reskilling), or among those outside the labor market, who can be trained to work in constantly changing technological scenarios.

Another relevant aspect refers to the process of acquiring technological and digital literacy. According to the WEF (2025), this concept refers to the workforce's ability to understand, use, and adapt to new technologies effectively. This concept is closely related to meaningful connectivity, understood as that which goes beyond simple Internet

access, ensuring that users can have a safe, satisfactory, enriching, and productive online experience at an affordable cost (NIC.br, 2024). Meaningful connectivity also considers users' ability to effectively leverage the potential of the Internet, from searching for information and job offers to performing tasks through the Internet.

Data from the ICT Households 2024 survey indicated that the Brazilian population still had low levels of meaningful connectivity: 34% were at the lowest level (0 to 2 points), while only 22% reached the highest level (7 to 9 points). The data also revealed striking inequalities in meaningful connectivity, such as between geographic regions (the South and Southeast regions had the highest rates) and level of education (higher proportions for users with higher education). These results show that the development of digital skills is strongly associated with access and training conditions and may exacerbate inequalities by age, race, gender, and social class.

Conclusions

To a greater or lesser degree, all organizations, from the smallest to the largest, will feel the impact of technological development and the digital transformation in the coming years. Small and medium-sized enterprises can benefit from digital communication processes, the use of online social media, cloud data storage, and e-commerce to boost sales and speed up internal processes. Large enterprises, with greater structural and financial potential to acquire and/or develop AI and management tools, can evaluate current results and implement digital transformation processes in workflows, production processes, and customer service, optimizing time and maximizing resource utilization. In both cases, the success of these processes depends on analyzing organizational contexts and aligning technologies, organizational strategies, and worker skills.

It is worth noting that barriers to implementing digital tools, and even to professional training and retraining, can slow the digital transformation. Factors such as technical complexity, high financial costs of investing in technological infrastructure, and cultural issues within organizations can act as obstacles. However, by recognizing the strategic potential of technologies and investing in training and professional retraining, enterprises can overcome these obstacles and adapt more effectively to the contemporary landscape.

Based on the data presented here, it is clear that digital transformation is an ongoing process and that its effectiveness depends on organizations' and workers' ability to adapt processes, strategies, and professional skills.

The ideal scenario for organizations and professionals is one in which there is a balance between the development of socio-emotional skills—which allow for greater integration, acceptance, and connection with people—and digital skills that enable effective use of technological resources. However, despite being constantly surrounded by tools and innovations, it is essential to remember that these elements serve only to support human interaction.

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Use of AI in decision-making in small and medium-sized enterprises and the importance of digital maturity

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A survey on the use of information and communication technologies (ICT) in Brazilian enterprises, carried out in 2024 by the Regional Center for Studies on the Development of the Information Society (Cetic.br), highlighted that "if, on the one hand, there has been progress in the basic connectivity of Brazilian enterprises, on the other hand, digital maturity is not necessarily a subsequent step" (Brazilian Internet Steering Committee [CGI.br], 2025, p. 71).

Digital maturity represents the presence of strategic planning related to the use and incorporation of information technologies in businesses. This maturity necessarily implies the definition of strategic objectives, the commitment of leadership to the adoption of technology, the implementation of organizational cultures that prioritize and encourage a positive attitude towards change, among other aspects (Rossmann, 2018). Given the presence of Artificial Intelligence (AI) and its complexity, potential, and inherent risks, this article argues that the successful use of these technologies in business management demonstrates digital maturity. It is argued that adopting AI goes beyond mere market enthusiasm over its benefits.

Considered one of the most advanced technologies today, capable of learning over time how to perform information-based operations efficiently and effectively (Manis & Madhavaram, 2023), AI is seen as a disruptive force that has revolutionized the market and altered organizational practice (Kumar et al., 2024).

Amidst the "technological storms," an expression presented in a recent article in *IT Forum* magazine (Oliveira, 2026), the objective of this article is to discuss the space and use of AI, seen as an emerging technology and one of the causes of technological storms in small and medium-sized enterprises. Attention is primarily paid to the importance of strategically considering the use and applications of AI and agentic systems in managerial decision-making, given that the digital maturity of Brazilian enterprises is still in its early stages.

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Technological storms can be understood as "moments in which multiple trends meet and produce profound changes in economy, business and society" (Oliveira, 2026, para. 5). The definition of the expression "technological storm" is similar to the concept of disruptive market changes, which are conceptualized as "drastic changes in the norms, practices, and routines in organizations and in the market environment in which they are embedded" (Olabode et al., 2023, p. 5). Based on evidence from scientific studies, Olabode et al. (2023, p. 3) highlight that the timing and sequence of organizational responses to disruptive events are critical to "eliminating inefficiencies, recalibrating resources, and carefully planning appropriate actions," thereby enabling organizations to appropriately address the new reality.

In disruptive market contexts, managers of small and medium-sized enterprises face intense pressure to adopt "plug-and-play technology" (Su et al., 2023). Compatibility, readiness, time savings, and improved efficiency are seen as motivators for the adoption of AI technologies in small and medium-sized enterprises (Schwaeke et al., 2025), where technological development plays a crucial role in the competitiveness and sustainable growth of the businesses (Das et al., 2020). With frequent resource limitations and insufficient capacity to handle digital transformation (Baah et al., 2026; Schwaeke et al., 2025), small and medium-sized enterprises face the challenge of planning for the strategic use of new technologies in the enterprises, such as AI, and reaping the positive results stemming from the necessary digital transformation in this process. Digital transformation can bring advantages to small and medium-sized enterprises, such as knowledge generation in interactions between enterprises and the development of collaborative innovations (Baah et al., 2026). However, not everything is seen as positive in digital transformation scenarios. Although the growth of digital technologies presents opportunities, threats in the business environment expose small and medium-sized enterprises to cybersecurity risks and the exposure of confidential data (Baah et al., 2026).

The initial conceptions of AI tools were geared toward solving logical problems and, over time, evolved to include learning components (Madhavaram & Appan, 2024). In this context, the reality of agentic systems—which are capable of performing complex tasks without human intervention, including code generation, content production, and conducting interactions with consumers (Oliveira, 2026)—led to reflection on the participation of non-human actors in decision-making, and on the crucial assessment and subjective perceptions of managers in the process (Murtinu & Massis, 2025).

It is the task of the people and managers involved in decision-making to immediately recognize the limitations of AI tools, which often lack originality and sometimes yield ambiguous or inaccurate results (Dwivedi et al., 2023). Based on contributions from 43 experts from diverse fields of knowledge, such as computer science, information systems, marketing, and public policy, Dwivedi et al. emphasized that AI users "need to reflect deeply on the capabilities and reliability of generative AI tools" (2023, p. 57). This is because, as the authors highlight, biases can arise from the functioning of systems, as these tools depend on various components—data, training models, and human input, among others—that need to work together (Dwivedi et al., 2023).

Madhavaram and Appan (2024) warned that AI can reduce the effectiveness and efficiency of decision-making due to biases, errors, or inherent knowledge gaps. Although these authors acknowledged the role of AI in facilitating and improving managers' skills and in eliciting voluntary behaviors and contributions from customers, employees, and other stakeholders beyond basic, self-directed interactions, they warned that AI is inherently inferior to human knowledge (Madhavaram & Appan, 2024). The risks associated with persistent and systematic errors in AI systems include inconsistent results that can bias decision-making, potentially favoring certain customer groups over others and causing social or racial discrimination (Kumar et al., 2024).

In addition to the issues of reliability and capacity of AI technologies in organizational contexts, another aspect to consider is investment in this and other information technologies for the sustainable development of small and medium-sized enterprises. While some scientific studies on the subject suggest a positive relationship between investment in information technologies and the performance of small and medium-sized businesses (Baah et al., 2026; Karhade & Dong, 2021; Schenkel et al., 2025), some studies report null results—see, for example, Haug et al. (2023)—and emphasize that the adoption of information technologies, by itself, may not be sufficient to guarantee the resilience of small and medium-sized enterprises (Tantawy et al., 2026). Furthermore, researchers highlight the managerial challenge of fostering a learning culture, engaging in transparent communication, and exercising more flexible leadership to achieve success in adopting advanced information technologies, as is the case with AI (Gyamerah et al., 2025; Schwaeke et al., 2025). Schenkel et al. (2025) warned that organizational focus and technology fit within the context of small and medium-sized enterprises are crucial to achieving positive business performance results. The entrepreneurial orientation of businesses, characterized by leaders with risk-taking profiles, is a relevant factor in mitigating the negative relationship between investments in information technology and organizational performance (Schenkel et al., 2025).

In the Brazilian context, the results of the survey carried out by Cetic.br|NIC.br in 2024 on the use of ICT in enterprises indicated that "among the Brazilian enterprises that had employed some kind of AI, most reported uses related to automating processes and workflows" (CGI.br, 2025, p. 77). Beyond these uses, the survey highlights the incipient context of digital maturity in Brazilian organizations, as noted at the beginning of this article.

Digital maturity, according to Rossmann (2018), involves the development of digital capabilities such as technological expertise, experience, and interactions with consumers, and organizational restructuring that implies the creation of new business models. This author also highlighted two essential capabilities in the context of leadership, namely, the ability to manage change and the ability to promote governance and a culture conducive to transformation. As this author suggested, the development of these capabilities indicates the level of digital maturity of organizations, and is essential for successfully managing the transformation process for the adoption and use of information technologies (Rossmann, 2018). Westerman et al. (2014) argued for the importance of developing organizational capabilities in the context of digital transformation, drawing on the experiences of enterprises in traditional sectors of the US economy as they transitioned to the digital age during the first decade of the 2000s. According to these authors, enterprises with mature digital capabilities but underdeveloped leadership skills are characterized as fashionistas, whereas when the opposite occurs, they are considered conservative (Westerman et al., 2014).

Alongside the joint development of digital and leadership capabilities, which are key aspects of digital maturity (Rossmann, 2018; Westerman et al., 2014), attention should be paid to the role and use of AI in small and medium-sized enterprises regarding the level of dependence on this tool for decision-making. As Madhavaram and Appan (2024) pointed out, unless knowledge can be completely codified and there is a finite number of choices for each problem, AI will continue to require the capabilities, discernment, and oversight of people to be effective. According to Kumar et al. (2024), when not properly checked, algorithms can imperceptibly perpetuate biases and lead to unfair and discriminatory decisions, harming certain groups of individuals. On the other hand, the implementation of AI technologies can be promising for guiding innovations and strategies, enhancing customer experiences, and generating growth opportunities in digital transformation contexts (Kumar et al., 2024).

Returning to the context of small and medium-sized enterprises, recent studies on digital transformation indicate that the benefits of AI remain uncertain—see, for example, Schenkel et al. (2025) and Tantawy et al. (2026). These benefits depend on enterprises' focus and organizations' technological adaptation (Schenkel et al., 2025) and are also conditioned by entrepreneurs' and managers' motivation to ensure business sustainability in challenging market contexts (Tantawy et al., 2026). In Brazil, considering the incipient digital maturity of enterprises (CGI.br, 2025) and reiterating its importance for the adoption and successful use of digital technologies by small and medium-sized enterprises, it is worth highlighting that the use of AI technologies can positively impact organizational performance when aligned with existing management practices. As highlighted by Schwaeke et al., "decision-makers [in small and medium-sized enterprises] must foster a learning culture, invest in employees, engage in transparent communication, and practice flexible leadership" (2025, p. 1316) for the successful implementation of AI technologies. It is also important to understand that AI can be an excellent tool to support decision-making. Considering this, it needs to be trained and configured by people to generate input for strategic business decisions, which must ultimately remain in the hands of the individuals responsible for determining the direction of the enterprise. In this context, analysis, strategic planning, and managers' intuition are crucial regarding the role that AI can or should play in the development and sustainability of businesses. Finally, it is necessary to develop digital and leadership skills to achieve digital maturity and ensure the successful adoption and use of AI technologies.

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Algorithmic discrimination: A step backward into old digital prejudices

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In recent years, advances in Artificial Intelligence (AI) and automation, and the advent of phenomena such as Big Data, have radically transformed various aspects of our society. It can be said that the current era is governed by data and controlled by algorithms. However, as this technology becomes more prevalent, concerns arise about the social and ethical impacts associated with these innovations. One of these significant challenges is algorithmic discrimination.

Inadequate programming and/or failure in algorithm training can result in the reproduction of past stereotypes and social injustices. For example, an algorithm used in a hiring process tends to inadvertently favor candidates of certain ethnic backgrounds or gender, while facial recognition systems are capable of exhibiting high error rates when identifying Black or Brown people — nomenclature consistent with the color or race standards of the Brazilian Institute of Geography and Statistics (IBGE, 2022). This practice not only violates the principles of equality and non-discrimination enshrined in articles 3, item IV, and 5 of the Constitution of the Federative Republic of Brazil, but also perpetuates historical inequalities.

Given this situation, the main mechanisms currently available to combat algorithmic discrimination have been the regulation of the collection and processing of personal and sensitive personal data, as well as the privacy governance tools provided for in the Brazilian General Data Protection Law (LGPD). Mitigation measures related to privacy governance include: transparency management for data subjects, audits and reviews of automated decisions; data protection impact assessments; and the existence of a dedicated regulatory and supervisory body for the processing of personal data (the National Data Protection Agency [ANPD]). However, as demonstrated in this article, all these mechanisms require significant development to achieve their full effectiveness.

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Legal guarantees and discrimination in algorithmic decisions

The Universal Declaration of Human Rights (UDHR) provides for the right to equality and non-discrimination (United Nations [UN], 1948). These rights are the result of a historical process stemming from a long journey, which has often been marked by struggles, suffering, and violations of dignity (Barretto, 2019).

Algorithmic bias reinforces the idea that the obvious needs to be stated, even after a long struggle to secure legal guarantees, so that old social prejudices are not renewed through new technologies. An example is an AI system being developed by Amazon for candidate selection purposes that exhibited sexist and discriminatory behaviors. The AI gave lower scores to resumes that contained the word "woman"—in one case, the tool judged the fact that a candidate had been captain of a women's chess club as something negative (Tecmundo, 2018).

This occurred because the machine used hiring data from the last ten years as a basis for learning patterns that could indicate who might be the best employee, which led the AI to reproduce the same sexist pattern that Amazon intended to avoid by transferring the activity to a program (Tecmundo, 2018). Amazon even tried to correct the AI's behavior with filters intended to teach it that the word "woman" is not a negative term, but it failed to guarantee the method's effectiveness (Tecmundo, 2018).

To understand the origin of failures such as the Amazon case, it is imperative to define the nature of algorithms and AI. Algorithms are sets of instructions organized sequentially that determine how a task should be performed to achieve a specific goal (Mendes & Mattiuzzo, 2019). This sequential logic fails to comprehend words that imply a subjective definition of the world around us, such as "almost," "easy," "fun," and others. Unlike human beings, they lack the ability to make sense of these definitions and to understand tasks described in an imprecise manner (Mendes & Mattiuzzo, 2019).

AI stems from an area of computer science that aims to study aspects of human intelligence, especially learning and problem-solving, with the goal of improving machines to the point where they can simulate these characteristics (Duarte & Negócio, 2021). According to the authors, AI can be defined as a "set of techniques, methods and systems that aim to make a computer exhibit intelligent behavior, especially learning, based on the collection and interpretation of external data" (p. 10). Requião and Costa (2022) explain that the use of machine learning algorithms and deep learning techniques has given AI the astonishing ability to evolve through experience and to make decisions autonomously, without the need for human intervention.

Machine learning consists of algorithms that learn from experience and improve over time. Initially structured based on equations and rules defined by experts, these algorithms can detect patterns in datasets, enabling decision-making and supporting speculation and interpretation based on the processed data, and learning and improving continuously (Damaceno, 2018; Surden et al., 2023). For this process to be possible, machine learning programs need to analyze large amounts of data, since they are designed to improve over time. Initially, machine learning algorithms may perform poorly, as they require time and data volume to develop their internal rules (Surden et al., 2023).

Deep learning, in turn, is a type of machine learning that uses multilayer neural networks to enable machines to perform more complex processes, such as speech recognition, image identification, and prediction based on pattern recognition (Damaceno, 2018).

Algorithmic bias can occur in two ways: when algorithms reflect discriminatory patterns built into the programming, or through the databases to which the learning algorithms had access (Requião, 2022). In this context, when developers create algorithms, they bring with them their own perspectives and biases, which can be reflected in the calculations and data used, as well as in the decisions made. This occurs because algorithms, however advanced they may be, lack the ability to interpret context or understand social and cultural nuances, limiting themselves to executing the instructions and patterns contained in the commands; therefore, they may replicate and reinforce pre-existing social biases (Requião, 2022).

Considering that discriminatory treatment is the act of segregating/excluding someone, treating an individual unequally and unfairly based on prejudice, the absence of digital inclusion mechanisms on websites can be an example of this digital barrier, reflecting developers' and even investors' trends and biases. This form of segregation by omission often goes unnoticed because it is treated as something that is "normal".

According to IBGE (2023), it is estimated that there are 18.6 million people with disabilities in Brazil. Despite this high number, a study conducted by BigDataCorp in partnership with the Web for All Movement found that, among 21 million active websites, only 0.46% passed all accessibility tests (Web for All, 2022).

Another example of algorithmic discrimination resulting from a programming flaw was the operation of facial analysis software that failed to recognize the face of scientist Joy Buolamwini because it had not been trained to identify a wide variety of skin tones and facial structures (Requião, 2022).

As mentioned earlier, such discrimination can also occur during the learning process of machine learning programs due to the nature of the data they interact with. This involves the indirect infusion of social biases, as the information is collected from society itself, leading machine learning to reinforce and replicate possible discriminatory patterns in databases (Requião, 2022).

A clear example of algorithmic bias arising from the learning process was the case of the Tay chatbot, an AI developed to entertain people through informal conversations (Veja, 2016). It mimicked the behavior of a 19-year-old American girl on social media, starting with "Hello, world," followed by Earth emojis. However, in less than a day, Tay learned and began to reproduce hate speech and racism that it picked up from Twitter users. Microsoft acknowledged the failure and took the chatbot offline.

It is also important to highlight the lack of transparency in machine learning algorithms, which develop their own code without explaining their development process, often leaving developers unable to understand how they work, explain their decision-making, or correct trends that are inconsistent with social principles (Requião, 2022). This process makes the workings of AI inaccessible to everyone, except perhaps for some mathematicians and computer scientists (Requião, 2022). Furthermore, even when these trends are identified, AI makes its judgments immune to challenge and correction, thereby further reinforcing social inequality and discrimination (Requião, 2022).

It is against this complex backdrop that algorithmic discrimination reveals the urgent need to correct flaws in the programming and training of automated systems that may inadvertently perpetuate historical inequalities and injustices. It is crucial to explore the mechanisms and regulations that aim to mitigate discriminatory treatment via algorithms. The next topic will address available strategies and tools, such as privacy governance practices.

Mechanisms and strategies for mitigating algorithmic discrimination

AI has a major transparency deficiency in its decision-making and is even resistant to corrections applied to its verdicts. This was evidenced in the aforementioned cases. A large proportion of discriminatory algorithmic decisions involves the processing of personal data available in databases used in the learning process. Therefore, the solutions to issues in computer science, including those of an ethical and legal nature, must follow the norms set by the principles governing their processing, including the principle of good faith.

Article 20 of the LGPD is an important remedy against the lack of transparency of algorithms created by AI itself to improve, as well as against immutable decisions made by it, since it guarantees the right to review when the decisions affect the interests of data subjects. This article also mandates that controllers ensure transparency regarding the automation process, establishing mechanisms to identify and understand the criteria and procedures the AI uses to make automated decisions. The article states that the information needs to be "clear and adequate," meaning that it is not enough for only a few mathematicians and computer scientists to understand the AI's decision-making process; it is necessary to ensure that the rules developed by algorithms are understandable to a wider group of professionals.

Another point raised by Article 20 is the possibility that enterprises may not provide clear explanations of their decision-making processes due to commercial and industrial secrets; in this case, it provides for an audit by the ANPD to verify any discriminatory aspects of the processing. According to Requião (2022), this auditing process meets a long-standing demand from legal scholars, who advocate constant oversight of algorithmic processes, particularly those capable of causing discriminatory impacts.

Furthermore, the principles set forth in Article 6 of the LGPD are highly important for combating algorithmic discrimination. This includes: transparency, which ensures clear, accurate, and easily accessible information about the processing of data; non-discrimination, which prevents the processing of data for discriminatory, illicit, and abusive purposes; security, which affirms the need to adopt technical and administrative protection measures; and prevention, which is the adoption of mechanisms to prevent harm resulting from the processing.

It should be noted that the Privacy Notice is also an essential tool for ensuring transparency, since it is the instrument through which the agents responsible for processing inform the data subjects, clearly and immediately, about how their personal data is processed. However, this document has proven ineffective in a scenario where 80% of enterprises have not yet adhered to the LGPD, as shown in a 2022-2023 study by the Daryus Group (2023), which evaluated 200 enterprises across all 27 states.

Training and awareness campaigns are also excellent ways to enable professionals to develop a deeper understanding of the biases that can arise during the development and application of automated systems.

Returning to the principles of safety and prevention, Mendes et al. (2021) clarify that the Data Protection Impact Assessment (DPIA) is an essential instrumental element for its implementation and emphasizes that, in the context of emerging new technologies that make data processing increasingly complex, those responsible must address the risks associated with their use of impact analysis, considered a basic best practice.

Although the standardization of the DPIA is foreseen in the ANPD's 2023/2024 Regulatory Agenda, to date, no specific regulation has been issued for the issuance of impact reports, despite the need for further development of this important tool.

Finally, Bill No. 2.338/2023, which addresses the use of AI and includes the ANPD's direct participation in the regulatory process, could become the main regulatory tool against algorithmic discrimination.

In light of all the above, it has become evident that the LGPD provides mechanisms to combat discriminatory treatment by algorithms; however, these instruments have not yet been fully implemented due to a lack of maturity, whether due to the absence of regulation or the lack of audits/oversight carried out by the ANPD. In this regard, the next topic addresses the main challenges faced by the ANPD, which may constitute the rationale and the solution to these two highlighted obstacles.

Challenges faced by the ANPD

The ANPD was created as a body of the federal public administration, becoming an autonomous public administrative entity in 2022 through Provisional Measure No. 1.124/2022, and converted into Law No. 14.460/2022 (ANPD, 2023). It is important to note that the first version of Bill No. 5.276/2016 did not include the entity, which was only included after the preparation of a technical report by the special committee of the Chamber of Deputies, which provided for it as a federal autonomous entity under a special regime, integrating the indirect public administration (Sarlet & Rodriguez, 2022).

However, the proposed wording was vetoed by the president due to increased expenses. Seeking to proceed with the project and still maintain the creation of the entity—which was considered essential for compliance with the legislation—the approved text now provides for its establishment, without "increasing expenses," as a direct administration body, subordinate to the Presidency of the Republic—a link that has fostered doubts regarding the independence necessary to guarantee the full performance of its functions (Sarlet & Rodriguez, 2022).

In October 2020, the Organisation for Economic Co-operation and Development (OECD) presented a report to the Brazilian government, recommending "reassessing and amending the conditions that establish the National Data Protection Authority [...] to ensure that the Authority operates with complete independence" (Sarlet & Rodriguez, 2022, p. 12).

Finally, in June 2022, Provisional Measure No. 1.124/2022, later converted into Law No. 14.460/2022, changed the legal nature of the ANPD, transforming it into a federal autonomous agency with its own regime, assets, headquarters, and jurisdiction in the Federal District.

In a new stage of this maturation, Provisional Measure No. 1.317/2025 was converted into Law No. 15.352, of February 25, 2026, establishing the ANPD as a regulatory agency. This change strengthened the institution and ensured the fulfillment of its responsibilities by creating regulatory and oversight career paths, which will favorably impact the agency's control and standardization activities. Despite this promising outlook, the agency has faced obstacles since its creation, most notably staff shortages and its initial reliance on personnel seconded from other agencies.

It formally began its activities in November 2020 with the appointment of its first director-president (ANPD, 2023). Only in 2025, almost 5 years later, was the first selection process held for the temporary hiring of 213 professionals, aiming to establish its own technical staff (ANPD, 2025). However, the number of positions at 213 raises questions about its proportionality, given the scope of the authority's supervisory and regulatory responsibilities at the national level.

A robust theoretical framework is insufficient if its implementation is hampered by a lack of institutional and operational support. Algorithmic discrimination has its roots in personal and non-personal data, in aggregated data, and in inferences. The ANPD has the means to ensure compliance with the law, transforming abstract protection into a real mechanism to combat discriminatory treatment.

The effectiveness of new regulations is nil if the main agency responsible for enforcement lacks the necessary resources. It will simply be another theoretical procedure, not a practical one. Thus, despite the importance of the ANPD and its structural transformations, the entity still faces major operational and personnel challenges, which compromise its effectiveness in overseeing data protection in Brazil.

Final considerations

In light of the information presented in this article—based on doctrine and current legislation—regarding algorithmic discrimination, it is concluded that algorithmic bias underscores the urgent need to address and correct flaws in the programming and training of automated systems, which can inadvertently perpetuate historical inequalities and injustices.

Furthermore, as we move to discuss solutions to these issues, it is crucial to explore the mechanisms and regulations that aim to mitigate automated bias.

Although the LGPD provides the necessary framework, its effectiveness is hampered by the ANPD's current institutional and operational immaturity, which acutely impacts the regulatory process and audits/oversight.

This article has demonstrated the urgent need to recognize and promote the ANPD for the effective application of all controls, regulations, and standards necessary to combat discrimination via algorithms.

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List of Abbreviations

Abes – Brazilian Association of Software Companies

AI – Artificial Intelligence

ANPD – National Data Protection Agency

Brasscom – Brazilian Association of Information and Communication Technology Companies

CATI – computer-assisted telephone interviewing

Ceptro.br – Center of Study and Research in Network Technology and Operations

CERT.br – Brazilian National Computer Emergency Response Team

Cetic.br – Regional Center for Studies on the Development of the Information Society

Ceweb.br – Web Technologies Study Center

CGEE – Center for Strategic Management and Studies

CGI.br – Brazilian Internet Steering Committee

CNAE – National Classification of Economic Activities

CNPJ – Company Registration Number

Concla – National Classification Commission

CRM – Customer Relationship Management

DPIA – Data Protection Impact Assessment

ECA Digital – Brazilian Digital Statute of the Child and Adolescent

ERP – Enterprise Resource Planning

Eurostat – Statistical Office of the European Union

FIB – Brazilian Internet Governance Forum

GSMA – Global System for Mobile Communications Association

IBGE – Brazilian Institute of Geography and Statistics

ICT – information and communication technologies

IEC – International Electrotechnical Commission

IFR – International Federation of Robotics

ILIA – Latin American Artificial Intelligence Index

IMF – International Monetary Fund

IoT – Internet of Things

IPv6 – Internet Protocol version 6

ISIC – International Standard Industrial Classification of All Economic Activities

ISO – International Organization for Standardization

IT – information technology

IX.br – Brazil Internet Exchange

IXP – Internet Exchange Point

Lapin – Laboratory of Public Policies and Internet

LGPD – Brazilian General Data Protection Law

LLM – large language model

MCTI – Brazilian Ministry of Science, Technology and Innovation

MDIC – Brazilian Ministry of Development, Industry, Trade and Services

Mercosur – Southern Common Market

MF – Brazilian Ministry of Finance

MLOps – machine learning operations

MTE – Brazilian Ministry of Labor and Employment

NIB – New Industry Brazil

NIC.br – Brazilian Network Information Center

NIST – National Institute of Standards and Technology

NLG – natural language generation

OBIA – Brazilian Artificial Intelligence Observatory

OECD – Organisation for Economic Co-operation and Development

PBIA – Brazilian Artificial Intelligence Plan

Pintec – Survey of Innovation

Rais – Annual List of Social Information

Redata – Special Taxation Regime for Data Center Services

RPA – robotic process automation

UDHR – Universal Declaration of Human Rights

UFRGS – Federal University of Rio Grande do Sul

UN – United Nations

UNCTAD – UN Trade and Development

UNSD – United Nations Statistics Division

UX – user experience

WEF – World Economic Forum

unesco
Centre
under the auspices
of UNESCO

cetic.br
Regional Center for
Studies on the
Development of the
Information Society

nic.br
Brazilian Network
Information Center

cgi.br
Brazilian Internet
Steering Committee