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ICT Enterprises

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

2024

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Brazilian Network Information Center

ICT Enterprises

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

2024

Brazilian Internet Steering Committee
www.cgi.br

São Paulo
2025

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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 the Brazilian society and the relevance of the indicators produced by the Brazilian Internet Steering Committee (CGI.br) for policymaking and academic research.

For the 16th 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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Contents

List of charts

List of tables

List of figures

Foreword

A successor to Arpanet, the Internet was maintained in its first decades by research funds, such as the National Science Foundation (NSF) in the United States, and by the institutions connected to it. Throughout this period—which lasted until the mid-1990s—the Internet was used mainly for the communication of supercomputing centers and universities, without aiming for self-sustainability. With its widespread dissemination more than three decades later, we can say that the Internet has become mature, and is made up of a very complex ecosystem structured on layers of physical infrastructure, connection protocols, and a wide range of applications.

This maturation process, in addition to the search for Internet sustainability, has involved technical challenges of scalability and security, in addition to interaction with political and regulatory bodies. It has gone through many stages and an extensive multisectoral and international effort to define Internet governance arrangements that are capable of balancing diverse interests and guaranteeing stability, interoperability, and expansion. In the Brazilian case, the establishment of multisectoral, democratic, and collaborative governance was solidified with the creation of the Brazilian Internet Steering Committee (CGI.br) and the institutionalization of the Brazilian Network Information Center (NIC.br), which includes Registro.br, responsible since 1989 for registering domain names with the "last name" .br. In this way, it was possible to guarantee not only the Internet governance framework, already defined by Standard 4 of 1995, but also self-sufficiency in the technical management of names and numbers, making it possible to reinvest in the expansion and improvement of the Internet infrastructure in Brazil.

In addition to managing the registration and publication of .br domain names, and allocating autonomous system numbers (ASN) and Internet protocol (IP) addresses in versions 4 and 6, it carries out a number of other actions, all linked to the promotion of fundamental values for the Internet, such as integrity, interoperability, and accessibility.[1] These actions include supporting research centers with funds from Registro.br, holding national and international events, and promoting actions aimed at expanding the infrastructure and protecting users on the Internet, always with the goal of making the Internet increasingly accessible and safe. Another fundamental aspect is CGI.br's role in fostering constant and careful dialogue about the use of the Internet by individuals, enterprises, and the government.

[1] More information at https://principios.cgi.br/sobre

While technological advances bring countless possibilities, it is also true that new challenges need to be faced collectively if the Internet's guiding principles are to be preserved. In recent years, for example, the growing adoption of mobile devices and Artificial Intelligence (AI) technologies by individuals and organizations has brought to the fore issues such as privacy and data protection, the proliferation of false or misleading content, and the potentially harmful excessive use of digital devices by children. Several events promoted by NIC.br in 2024 addressed these issues, enabling multisectoral reflections anchored in data. Some examples are the 15th edition of the Seminar on Privacy and Personal Data Protection,[2] the 9th Symposium on Children and Adolescents on the Internet,[3] and the seminar launching the Brazilian Artificial Intelligence Observatory (OBIA),[4] which operates under NIC.br.[5]

It is also worth highlighting the participation of CGI.br and the collaboration of NIC.br in various G20 initiatives during Brazil's presidency in 2024. To contribute to the debate on the digital economy, the Regional Center for Studies on the Development of the Information Society (Cetic.br)—a department of NIC.br dedicated to the production of indicators and analyses—has been active in the production of three reports on topics considered to be priorities by the G20 that are fundamental to the dialogue on technology and society. These publications had important international organizations as partners: the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Telecommunication Union (ITU), and the Ministries of Science, Technology and Innovation (MCTI) and Communication (MCom). The first summarizes indicators on the state of AI development in the G20 countries,[6] while the second focuses on the adoption of AI in public services.[7] The third proposes a framework for the international measurement of meaningful connectivity.[8]

Cetic.br|NIC.br is also responsible for a series of other publications that provide a detailed overview of the use of information and communication technologies (ICT) by individuals and organizations in Brazil. In addition to publishing research on ICT adoption in different segments, such as households, enterprises, governments, education, and health, the Center conducts sectoral and cross-cutting studies with a national scope on topics such as meaningful connectivity, AI in health, privacy and data protection, and electronic waste.

In 2025, Cetic.br|NIC.br celebrates two decades of work dedicated to producing reliable indicators and analysis on the use of ICT in Brazil. Over these 20 years, it has established itself as a national and international benchmark in the generation of comparable data, which provides important input for policymaking, the development of academic research,

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

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

[4] More information at https://seminarioobia.nic.br/

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

[6] More information at https://cetic.br/pt/publicacao/toolkit-for-artificial-intelligence-readiness-and-capacity-assessment/

[7] More information at https://cetic.br/pt/publicacao/mapping-the-development-deployment-and-adoption-of-ai-for-enhanced-public-services-in-the-g20-members/

[8] More information at https://cetic.br/pt/publicacao/universal-and-meaningful-connectivity-a-framework-for-indicators-and-metrics/

and strengthening the multisector debate on digital transformation. Its commitment to methodological rigor and excellence in the production of knowledge has strengthened its position with international organizations, governments, and civil society, making it an important pillar in building a more inclusive and sustainable digital environment.

The publication you have before you is part of this trajectory and reflects the conceptual and methodological knowledge of Cetic.br|NIC.br. In it, you will find essential data and evidence to understand how Brazilian society has been appropriating these technologies over the last two decades, a period marked by significant advances and complex challenges emerging from the digital age. This celebration is not only an institutional milestone, but also an invitation to reflect together on the future of ICT research and the role of data in building policies and strategies for a connected and informed society.

Enjoy your reading!

Demi Getschko
Brazilian Network Information Center - NIC.br

Presentation

Throughout 2024, the Brazilian Internet Steering Committee (CGI.br), in conjunction with the Brazilian Network Information Center (NIC.br), actively participated in national and international debates on the challenges for the governance of the digital environment, reaffirming its commitment to an inclusive and sustainable future for Brazil and the world. In particular, it is worth highlighting the NetMundial+10 Conference,[1] held in April 2024 by CGI.br. The Conference has established itself as a multisectoral platform for dialog on the challenges of Internet governance in a scenario in which digital technologies profoundly transform social, economic, cultural, informational, and political relations. The meeting culminated in the document *NetMundial+10 Multistakeholder Statement: Strengthening Internet governance and digital policy processes*,[2] which has become a reference on global agendas.

Also in 2024, during its presidency of the G20, Brazil took on a leading role in promoting sustainable development, social inclusion, and the reform of global governance. With a focus on reducing inequalities and fighting hunger and poverty, the country promoted debates on the energy transition, climate change, and key issues related to the digital economy. Brazil's chosen priorities in the G20 Digital Economy Working Group (DEWG) also reflect its commitment to a more inclusive and sustainable digital economy, including topics such as meaningful universal connectivity, advancing digital government and digital public infrastructures, promoting information integrity and a more secure digital environment, and Artificial Intelligence (AI) for sustainable development and reducing inequalities.

With the prominent and collaborative work of the Ministries of Science, Technology and Innovation (MCTI), Communications (MCom), Management and Innovation in Public Services (MGI), and the Secretariat for Social Communication (Secom), these priorities were considered strategically, in line with the challenges of the digital economy. NIC.br and CGI.br played an important role in several of these activities, contributing their technical expertise and commitment to multisectoral Internet governance, such as the leadership of the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of NIC.br, in three publications related to the priority themes.[3]

[1] More information at https://netmundial.br/

[2] The Statement can be accessed at https://netmundial.br/pdf/NETmundial10-MultistakeholderStatement-2024.pdf

[3] Toolkit for Artificial Intelligence Readiness and Capacity Assessment; AI for enhanced public services in the G20 members: Artificial Intelligence for inclusive sustainable development and inequalities reduction; and Universal and meaningful connectivity: A framework for indicators and metrics.

At the same time as the international meetings, the 5th National Conference on Science, Technology and Innovation (CNCTI) was held in Brasilia. The meeting, which was open and participatory, was attended by more than 2,500 representatives from civil society, academia, the technical community, international organizations, and the Brazilian government, representing a space for social dialogue and proposing public policies. On that occasion, the Brazilian Artificial Intelligence Plan (PBIA) was launched,[4] which, under the coordination of the MCTI, aims to realize the Brazilian project of technological autonomy, increasing the competitiveness of the national economy, and stimulating the responsible use of AI. As one of their contributions to the issue, NIC.br and CGI.br organized the 1st Seminar of the Brazilian Artificial Intelligence Observatory (OBIA),[5] an integral part of the PBIA, which plays an essential role in producing and disseminating data and studies on the adoption and use of AI-based systems in the country.

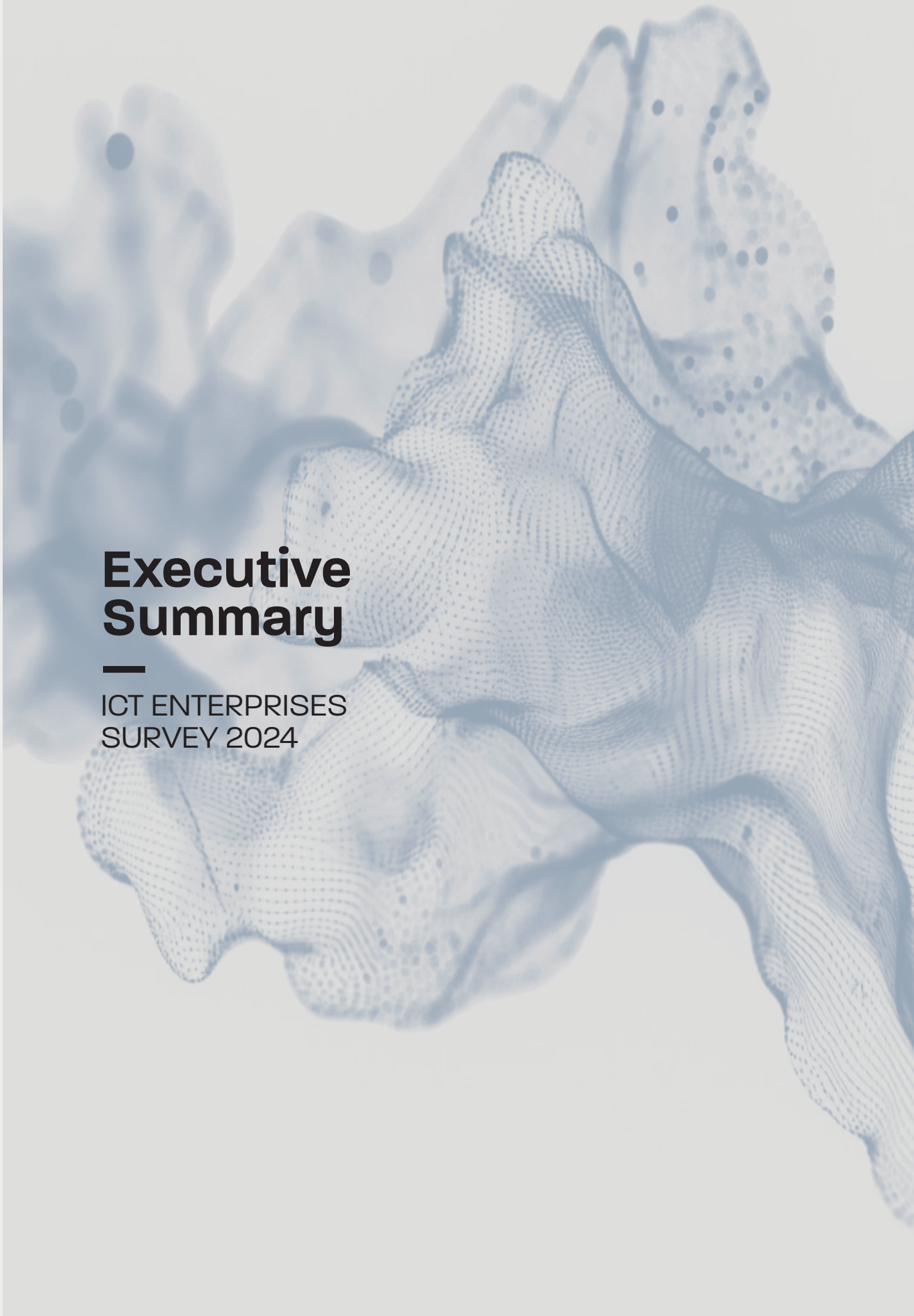
To support these debates and monitor the achievement of the commitments made, the availability of data and indicators is essential to map the socioeconomic implications of the adoption of digital technologies by different sectors of society. With two decades of regular production of reliable and internationally comparable statistical data, as well as dissemination of studies and analyses on the impacts of digital technologies on society, Cetic.br|NIC.br has many reasons to celebrate. Its commitment to excellence and methodological rigor in the production of quality data has ensured recognition and influence among public policymakers and international organizations linked to the ecosystem of indicators and statistics. In addition, Cetic.br|NIC.br maintains ongoing cooperation with civil society, the academic community, national statistical offices, and important international organizations such as the Organisation for Economic Co-operation and Development (OECD), the International Telecommunication Union (ITU), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Conference on Trade and Development (UNCTAD), the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and the United Nations Statistics Division (UNSD).

In this context, and in celebration of the 20th anniversary of Cetic.br|NIC.br, this publication offers valuable inputs for building accessible, relevant, and qualified knowledge, which is essential for informing debates and decisions on the country's digital transformation. Through the production of data and evidence as fundamental pillars, we seek not only to understand the challenges of the present, but also to pave the way for a more equitable and secure future for the next generations.

Renata Vicentini Mielli
Brazilian Internet Steering Committee – CGI.br

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

[5] OBIA can be accessed at https://obia.nic.br/



Executive Summary

ICT ENTERPRISES
SURVEY 2024

Executive Summary ICT Enterprises 2024

In its 16th edition, the ICT Enterprises 2024 survey provides an overview of the use of information and communication technologies (ICT) among Brazilian enterprises. The survey was carried out between March 2024 and November 2024, with data collected among Brazilian enterprises with more than ten employed persons. The recent version of the survey deepens the investigation into the state of the digital economy in Brazil, exploring aspects of enterprises' connectivity, their online operations, and electronic commerce. In addition, the survey provides indicators of the use of advanced technologies, such as the Internet of Things (IoT) and Artificial Intelligence (AI).

Connectivity

In 2024, the use of fiber optics among Brazilian enterprises continues to surpass other forms of connection, a trend observed since 2019. In 2024, 92% of enterprises were connected to the Internet via fiber optics, a proportion that was 87% in 2021, indicating a greater supply of this technology, and the capability of enterprises of all sizes to improve their connections over time. When looking at the download speeds available in enterprises, there was a decrease in the proportion of those that contracted speeds of up to 300 MBps, going from 54% to 43%, a trend identified in all sizes. On the other hand, there was a move toward higher speeds, with 28% of enterprises contracting speeds above 500 Mbps, a proportion that was 21% in 2023 (Chart 1).

IN 2024, 28% OF ENTERPRISES CONTRACTED CONNECTION SPEEDS ABOVE 500 MBPS

Electronic commerce

The means used by Brazilian enterprises to sell online continued to follow the pattern observed in past editions of the survey. Most enterprises reported that they sold goods and services online via WhatsApp or Skype messages or Facebook chat, while more automated forms of electronic commerce, such as Extranet, electronic data exchange, and the enterprises' websites, showed smaller proportions, with the first form being more prevalent among small enterprises and the second among large enterprises. However, there was a drop in the use of e-mail, with 40% of them using this sales channel in 2023, down to 34% in 2024. Another decrease was in the use of WhatsApp or Skype messages or Facebook chat, which was 55% in 2023, falling to 49% in 2024 (Chart 2).

New technologies

In 2024, the ICT Enterprises survey points to the stability of AI use in Brazilian enterprises: 13% said they used AI applications, the same proportion as in 2023. The distribution by size and market segment also remained the same between 2023 and 2024: AI was more concentrated in large enterprises and in the Information and communication market segment. Following the observed trend of maintaining the characteristics of the previous edition, in 2023 the type of application most used by enterprises was related to workflow automation (Chart 3).

CHART 1

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Enterprises with Internet access, by range of maximum download speed contractually offered by the Internet provider in the last 12 months and size (2023–2024)

Total number of enterprises with Internet access (%)

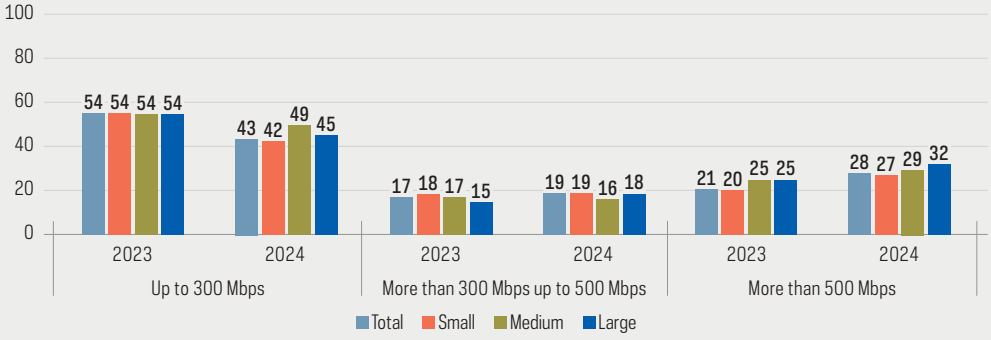

CHART 2

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Enterprises that sold on the Internet in the past 12 months, by type of online channel used for transactions (2023–2024)

Total number of enterprises (%)

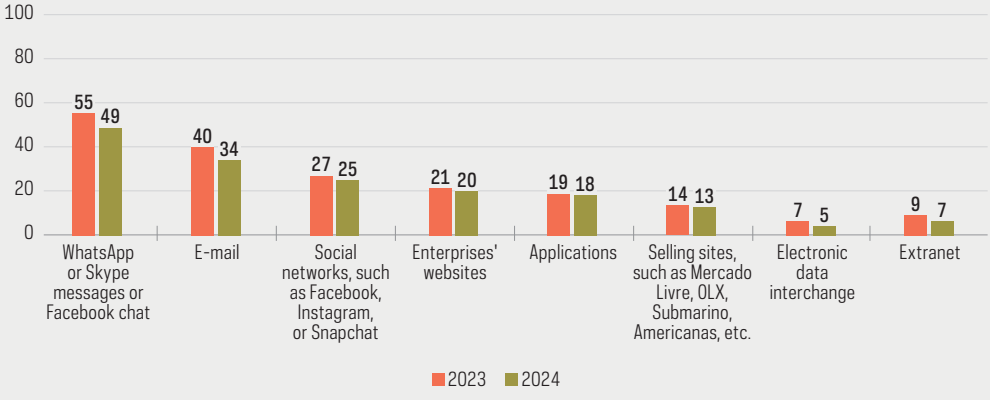

CHART 3

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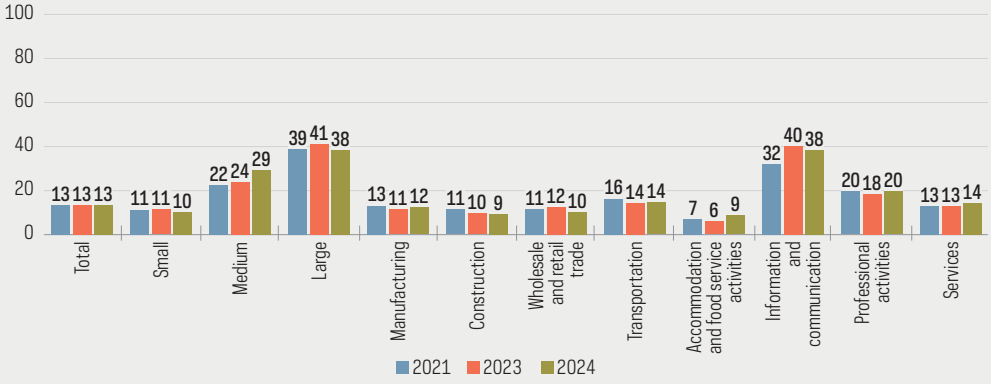
Enterprises that used AI technologies, by size and market segment (2021–2024)

Total number of enterprises (%)



In the 2024 edition, new indicators were collected on how Brazilian enterprises acquire or develop AI software and systems. Among enterprises using AI, 76% chose to acquire ready-to-use solutions, reflecting the adoption of technologies aimed at workflow automation. Regarding development, 56% of enterprises hired external suppliers to develop or modify AI software or systems, suggesting that in-house development by enterprises still occurs in a limited manner in the Brazilian market. This pattern was observed uniformly across different sizes and economic sectors (Chart 4).

Following the same trend observed in the way the enterprises acquired or developed their AI software or systems, the ICT Enterprises 2024 survey sought to understand whether there had been any kinds of partnerships for the development of AI. Among those that used AI, 50% said they bought the AI software or systems from other enterprises, following the pattern discussed earlier, with no major differences by size and economic sector. This indicator helps us understand that the ecosystem for using AI in Brazil is still in its early stages, as there is little interaction between enterprises and universities, non-profit organizations, and government agencies. However, it is worth noting that 26% of enterprises used open AI systems and 20% developed AI internally, indicating an incipient creation of internal capacity, which was more present in the information and communication and services sectors, which are those in which applications can emerge for use by other enterprises (Chart 5).

THE ESTIMATED TOTAL NUMBER OF ENTERPRISES THAT USED AI APPLICATIONS IN BRAZIL IS 65,529

Survey methodology and access to data

The ICT Enterprises 2024 survey mapped the incorporation of ICT, especially new technologies such as AI, among Brazilian enterprises with more than ten employed persons. The survey also investigates practices related to electronic commerce, digital security, and aspects of connectivity and online presence, looking at the reality of Brazilian enterprises and comparing them to international indicators. Data collection for the 2024 edition, conducted by telephone, took place between March and November 2024. A total of 4,453 enterprises was interviewed, providing results by size, geographic region, and economic sector. 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.

Approximately

70,546

enterprises are estimated to have used smart or IoT devices in Brazil

Of the enterprises with IT departments or IT specialists that did not use AI,

19%

said it was due to incompatibility with existing equipment

Of the enterprises that used smart or IoT devices,

84%

said that the use was related to facility security

18%

of enterprises collected data internally from processes and staff and

16%

from customers and users

BOX 1

—

ONLINE PRESENCE

In 2024, Brazilian enterprises, especially small ones, followed a trend of focusing their digital communication on social networks, while maintaining a smaller presence of their own websites to interact with customers and users. In 2024, 53% of Brazilian enterprises had websites, a proportion that was 54% in 2019. It is important to mention that the boost caused by the pandemic, in terms of access to technologies by enterprises, has not necessarily been reflected in a greater online presence, with stability in the proportion of website ownership across all sizes. Social networks, therefore, are the main form of online presence among Brazilian enterprises. Throughout the survey's historical series, there has been a shift in emphasis toward different social networks. WhatsApp or Telegram, for example, were not adopted by even half of enterprises in 2017 (42%), but by 2024 they had been consolidated as the main platforms used, reaching 74%. The same movement occurred with Instagram, Snapchat, TikTok, and Flickr: from 22% in 2017 to 74% in 2024.

CHART 4

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Enterprises that used AI technologies, by how they acquired or developed the AI software or systems they used and market segment (2024)

Total number of enterprises that used AI technologies (%)

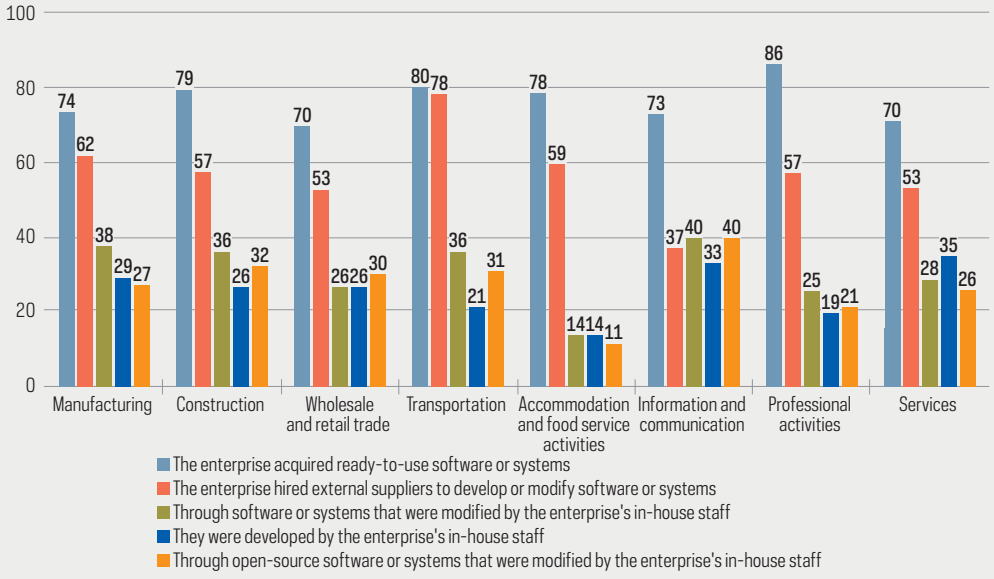
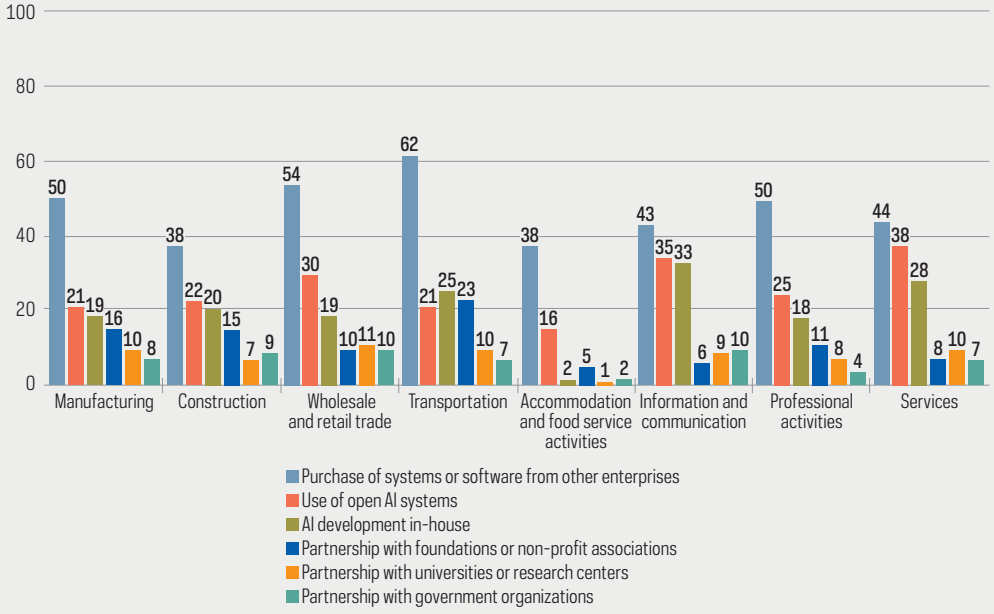


CHART 5

—

Enterprises that used AI technologies, by types of partnerships or actions for the development of AI and market segment (2024)

Total number of enterprises that used AI technologies (%)



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		9	36	91	54	8
SIZE	10 to 49 employed persons	9	36	90	54	6
	50 to 249 employed persons	8	32	96	51	16
REGION	North	14	31	93	49	9
	Northeast	9	32	95	53	11
	Southeast	9	36	89	55	7
	South	8	35	93	50	6
	Center-West	10	43	91	59	12
MARKET SEGMENT	Manufacturing	9	34	91	51	9
	Construction	8	37	91	50	7
	Transportation and storage	8	31	93	50	11

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. (2024). *Survey on the use of information and communication technologies in Brazilian enterprises: ICT Enterprises 2023* [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 2024

Methodological Report
ICT Enterprises 2024

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.

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). 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 instruments

INFORMATION ABOUT DATA COLLECTION INSTRUMENTS

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

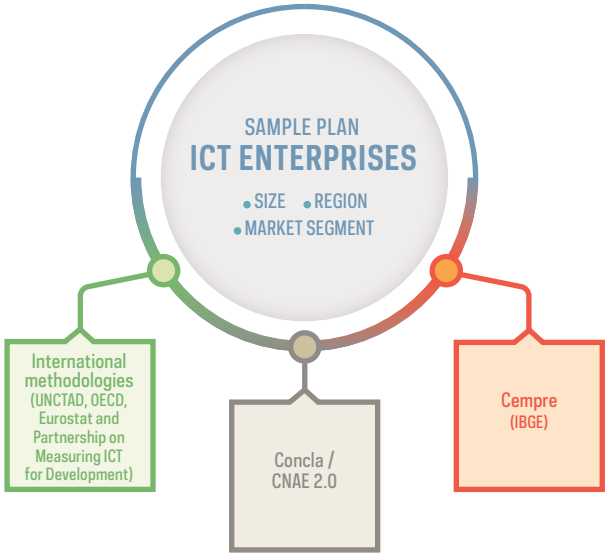
The sampling plan was stratified, and the enterprises were randomly selected within each stratum.

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. 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 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 margin 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 completed 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 waves allowed a wider range of topics to be investigated, without increasing the length of the questionnaire or the collection time. 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 waves 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
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, 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 2024

Data Collection Report
ICT Enterprises 2024

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 2024 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, are described in the "Methodological Report."

Sample allocation

The ICT Enterprises 2024 survey approached 50,807 enterprises and 4,453 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		**4 641**
Size	10 to 19 employed persons	1 786
	20 to 49 employed persons	1 387
	50 to 249 employed persons	552
	250 or more employed persons	916
Region	North	448
	Northeast	681
	Southeast	1 882
	South	994
	Center-West	636
Market segment (CNAE 2.0)	Manufacturing	891
	Construction	513
	Wholesale and retail trade; repair of motor vehicles and motorcycles	1 047
	Transportation and storage	540
	Accommodation and food service activities	354
	Information and communication	429
	Real estate activities; professional, scientific and technical activities; administrative and support service activities	523
	Arts, entertainment and recreation; other service activities	344

Data collection instruments

INFORMATION ABOUT THE DATA COLLECTION INSTRUMENTS

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 company-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.

Module F 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.

PRETESTS

The pretests for the ICT Enterprises 2024 survey were carried out at three different times in order to evaluate the flow of the questionnaire in each round of interviews. Twenty-one 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 22-26, 2024	May 27-29, 2024	August 20-21, 2024
Small (10 to 49 employed persons)	4	0	2
Medium (50 to 249 employed persons)	1	6	3
Large (250 or more employed persons)	2	1	2
Total	**7**	**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

The ICT Enterprises data collection instrument is revised for every edition of the survey to improve it and bring it up to date, without losing sight of its historical series and comparability with studies conducted by national and international institutions. These revisions can be based on both difficulties identified during the interviews and changes observed in the phenomena the survey is measuring.

The 2024 edition did not include Module C, on e-government, and Module X, on privacy and personal data protection. In addition, there were some specific changes to Module H, on new technologies, to further investigate the presence and use of AI in Brazilian enterprises.

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 2024 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 22 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 ecommerce and activities carried out on the Internet.

DATA COLLECTION PERIOD

Data for the ICT Enterprises 2024 survey was collected at three times:

- Round 1, between March and June 2024.
- Round 2, between June and August 2024.
- Round 3, between August and November 2024.

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

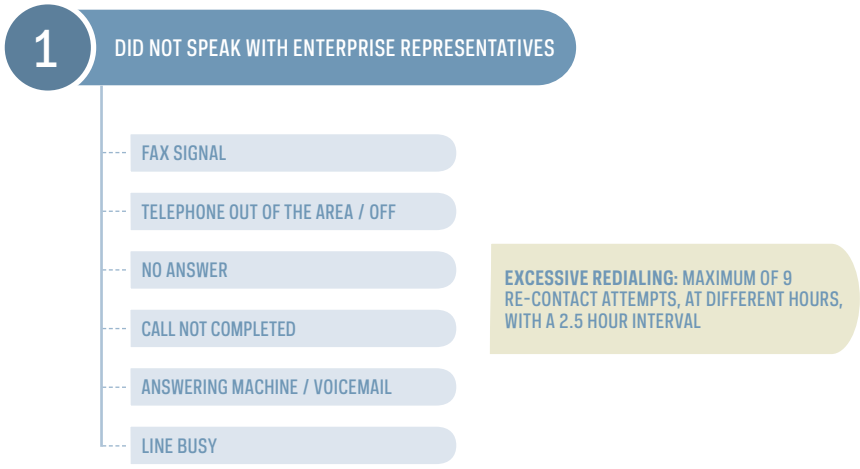


FIGURE 2

–

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

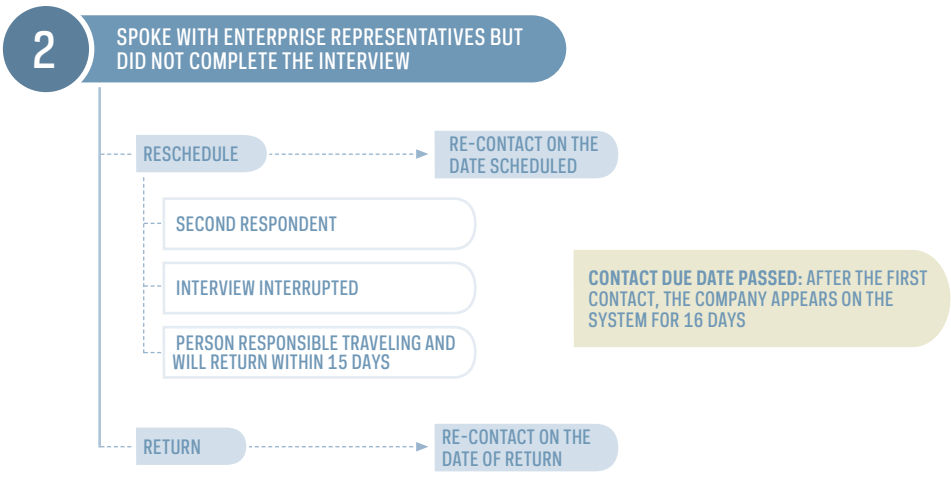


FIGURE 3

–

Situation 3 – Interview fully completed

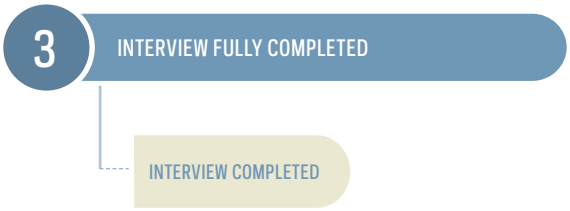
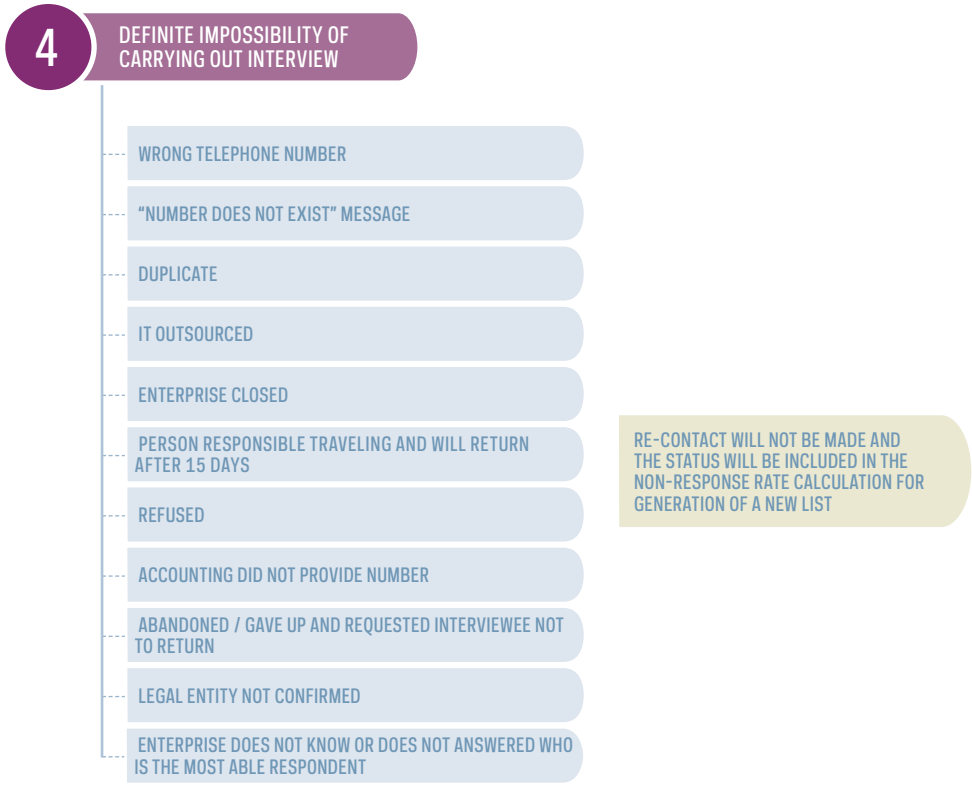


FIGURE 4

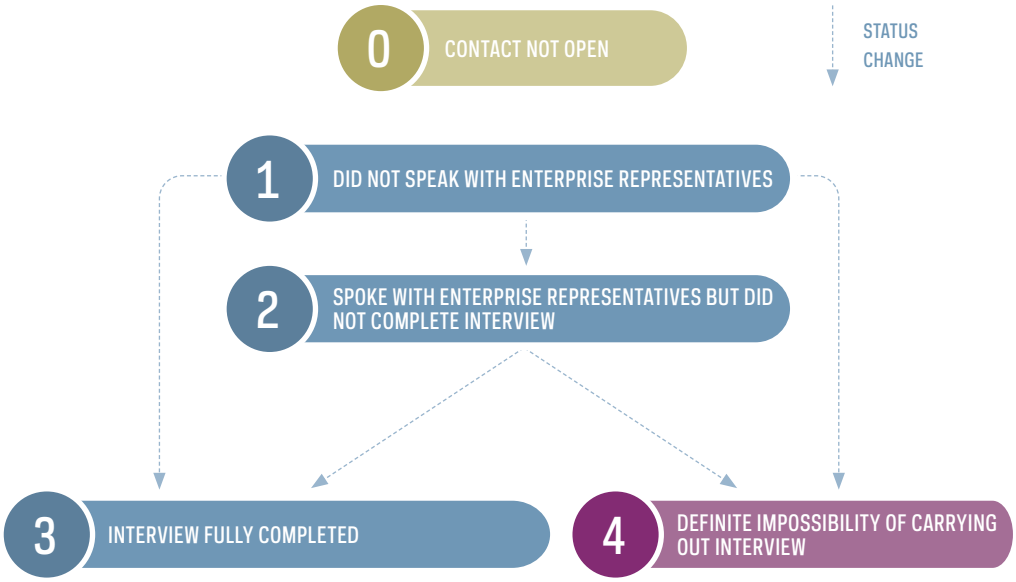
–

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," as illustrated in Figure 5.

FIGURE 5
–
Consolidation of situation control



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, 99% 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
Fully completed	4 453	8.66%
Scheduled	97	0.19%
Accounting office would not provide the phone number of the local unit	1 194	2.32%
Duplications	18	0.04%
Enterprise closed	326	0.63%
Excess dialing	18 126	35.27%

CONTINUES ▶

▸ CONCLUSION

Situations	Number of cases	Rate
Out of area/out of service	63	0.12%
Call could not be completed	1 031	2.01%
Requested never to be called	82	0.16%
Deadline for contact exceeded	9 983	19.43%
Refused	3 504	6.82%
Return	2 442	4.75%
Answering machine	436	0.85%
Wrong number	3 241	6.31%
Telephone provided by the accounting office	34	0.07%
No answer	3 355	6.53%
Phone number does not exist	2 224	4.33%
Line busy	197	0.38%
Fax signal	1	0.00%
Not contacted	585	1.14%
Total	**51 392**	**100%**

Data collection results

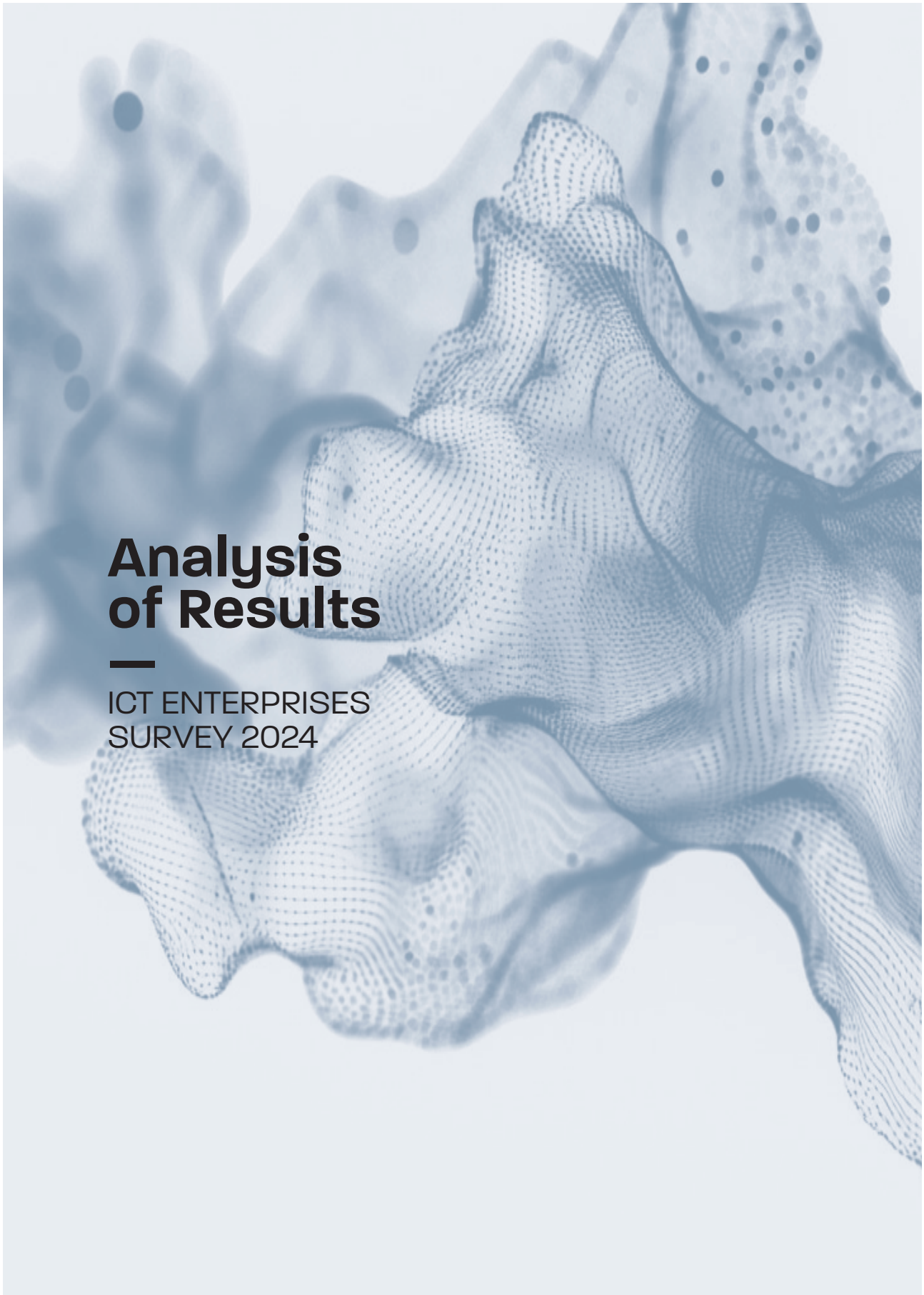
The ICT Enterprises 2024 survey attempted to contact a total of 50,807 enterprises, and the final sample was 4,453 enterprises. The response rate by stratification variable is presented in Table 4.

TABLE 4
–
Response rates by size, region and market segment

		Response rate (%)
Total		**9**
Size	10 to 19 employed persons	8
	20 to 49 employed persons	9
	50 to 249 employed persons	11
	250 or more employed persons	10

CONTINUES ▸

		Response rate (%)
Region	North	6
	Northeast	7
	Southeast	9
	South	11
	Center-West	10
Market segment (CNAE 2.0)	Manufacturing	10
	Construction	9
	Wholesale and retail trade; repair of motor vehicles and motorcycles	9
	Transportation and storage	9
	Accommodation and food service activities	6
	Information and communication	12
	Real estate activities; professional, scientific and technical activities; administrative and support service activities	8
	Arts, entertainment and recreation; other service activities	8



Analysis of Results

ICT ENTERPRISES SURVEY 2024

Analysis of Results
ICT Enterprises 2024

The latest edition of the ICT Enterprises survey presents crucial indicators to characterize the digital economy's advancement in Brazil, especially the adoption Artificial Intelligence (AI). Since the first data collection on the use of AI by the private sector in 2021, the public debate about its social and economic impacts has gained relevance, as have regulatory discussions aimed at addressing the potential consequences for the economy and the labor market.

In this context, studies published in 2024 by international organizations reveal a growing adoption of AI technologies, particularly among large enterprises. This expansion is most notable in the use of applications designed to automate routine processes, such as customer service operations and chatbot interactions (European Statistical Office [Eurostat], 2025). Most countries, however, still experience the traditional difficulties for small and medium enterprises in seeking greater digitization of their processes, especially at a time when advances in AI require more financial and technical resources. Thus, disparities persist between enterprises that are able to implement solutions and those that are at an earlier stage of digital maturity (Organisation for Economic Co-operation and Development [OECD], 2024; United Nations Industrial Development Organization [UNIDO], 2024).

From the point of view of the labor market, there are estimates showing that occupations with more routine tasks are at greater risk of being replaced by AI, althought recent evidence suggests a trend more toward complementarity rather than complete replacement (Cazzaniga et al., 2024; Handa et al., 2025). The available evidence indicates that AI tends to play a complementary role in occupations that require higher qualifications, generating greater productivity, which in turn can accentuate social and economic inequalities (Prates et al., 2024).[1] A report released at the beginning of 2025 by the World Economic Forum (WEF) points to the same trend, showing that occupations related to administrative services and customer service will see decreasing demand in coming years (WEF, 2025a).

[1] A study by the International Monetary Fund (IMF) points out that 40% of the world's occupations will be affected by AI (Cazzaniga et al., 2024). However, this will occur in different ways between occupations with "high exposure, high complementarity" and occupations with "high exposure, low complementarity." In occupations where AI has greater potential for complementarity, its adoption can result in increased productivity and, consequently, greater gains for enterprises. In occupations with low complementarity, AI can even lead to positions being replaced by technology, given their lower qualifications.

This becomes a point of attention as these are low-skilled occupations, making it difficult to relocate this workforce, although there is still no consensus on the extent of this impact (Acemoglu, 2024).

One example of countries' concern about AI is the development of industrial policies aimed at developing and promoting AI and other digital technologies and infrastructures, with a view to transforming their production structures. Industrial policy is defined as government action aimed at transforming the structure of economic activity, geared towards a given objective (Juhász et al., 2023), whether to overcome the primacy of the agricultural sector, as seen in the industrial policies of the 20th century, or to pursue an increase in technological intensity toward greater digital maturity, as observed today. Although the literature calls this set of policies "industrial," they are not restricted to the manufacturing sector but have broad links throughout a country's productive structure.

In the 2000s, the debate on industrial policy returned as a way of fostering economic growth after the 2008 crisis, with relevant discussions on the need to reverse the process of deindustrialization due to the growing industrial power of Asia, especially China (Pisano & Shih, 2012; Schwab, 2017).[2] During this period, initiatives were being developed mainly in the United States and in Latin American countries. In the case of Brazil, it should also be noted that the 2010s marked a continuous decline in both the participation of industry and the productivity of the economy, with the country being treated as a case of early deindustrialization (Rodrik, 2015).

Analyzing the actions of different countries regarding advances in AI and other emerging technologies, the United States has seen investments since 2022 aimed at maintaining its technological leadership. The main examples of this are the Chips and Science Act and the Create AI Act, which, while subsidizing the production of chips in United States territory, make this investment conditional on enterprises not expanding their operations in China, with the aim of guaranteeing United States leadership in the production of a crucial input for the development of technologies such as AI. In China, there is a continuous effort to invest in the entire technological development chain. An example is the growing number of researchers and scientific production, creating a huge critical mass for the development of an ecosystem conducive to innovation. Data from the OECD.AI portal show China's progress in training qualified AI staff: In 1999, China did not have a large share of AI publications, but it took the lead in 2018 and consolidated its position as a leader in both rankings analyzed (Open Alex and Scopus).[3] Continuing to direct the country's investments in technologies that it considers strategic for consolidating the country's leadership, the Chinese government has announced major investments in AI research and development, as well as in improving its infrastructure, at the same time as it directs local enterprises to make efforts in the proposed direction (Hiratuka & Diegues, 2025; Lundvall & Rikap, 2022).

[2] The term used was the need for "reshoring" industrial production, due to the loss of industrial capacities from traditional US regions to Asian countries with lower labor costs.

[3] For more information, visit: https://oecd.ai/en/data

In view of the advances and investments made by the United States and China, Europe is concerned about the continent's situation regarding the development of digital technologies. To this end, in September 2024, the Draghi report was launched, as the result of several debates held by major enterprises in the technology sector, governments, and universities. The report makes a number of recommendations about the future of the European economy, in view of the gap between it and the United States and China, as well as establishing sustainable technological development as the bloc's mission (European Commission, 2024). In February 2025, moving in the direction indicated by the Draghi report, the European Union announced investments of around 200 billion euros to boost the development of AI in the bloc.[4]

The scenario of huge investments in AI and other digital technologies in leading research and development countries is also driving countries looking to improve their enterprises' digital maturity to be more competitive internationally. In the case of Brazil, the need to update the industrial sector, given the constant loss of industry's share of the gross domestic product (GDP), also led to moves to draw up an industrial policy. Launched in the first half of 2024, the New Industry Brazil (NIB) program directed the action of the State to focus on six missions, including mission 4, which aims at the "digital transformation of industry to increase productivity."[5]

Also as part of the national actions to leverage AI research and development in the country, the Brazilian Artificial Intelligence Plan (PBIA) 2024-2028 was launched in 2024. The plan gathers various actions that aim to improve the country's role in AI and other digital technologies, providing support ranging from from workforce training to infrastructure financing, with an investment of BRL 23 billion. The plan seeks to coordinate investments in various sectors and foster coordination among academia, the public sector, and the private sector in order to accelerate the adoption of technologies and foster innovation in the national economy (Ministry of Science, Technology and Innovation [MCTI], 2024).

Therefore, the challenge facing Brazil and other developing countries is to seek to qualify their industrial sectors at a time of greater leverage of resources in the leading countries in technological development.[6] In this scenario, we can expect greater scarcity of foreign resources and greater restrictions on technology transfer.[7] In addition, there is a need to focus investments on future projects that seek to create an ecosystem for the

[4] More information at https://ec.europa.eu/commission/presscorner/detail/en/ip_25_467

[5] One of the goals of mission 4, to digitally transform 90% of Brazilian industrial enterprises, was developed based on the indicators of the ICT Enterprises survey.

[6] According to the most recent Technological Innovation Survey (Pintec), launched in 2022, industrial companies with 100 or more employed persons invested 36.9 billion reais in internal research and development (R&D) activities. Of this total, 16.5% came from the extractive industries, 13% from the manufacture of motor vehicles, trailers, and trucks, and 11.9% from the manufacture of coke, petroleum products, and biofuels. The majority of R&D expenditure did not come from traditional sectors of the national economy, which have important links in the Brazilian production structure. More information at https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/39503-empresas-industriais-de-medio-e-grande-porte-investiram-r-36-9-bilhoes-em-p-d-em-2022

[7] In 2010, Brazil received a total of 644 billion dollars in foreign investment, more than countries like Switzerland and close to Germany and France, representing a 20% increase on 2009. However, by 2023, Brazil was no longer among the ten countries that received the most foreign direct investment, showing that it was less attractive to multinational companies. More information at https://www.imf.org/en/Blogs/Articles/2025/02/20/foreign-direct-investment-increased-to-a-record-41-trillion

use and development of technologies and integrate the Brazilian economy in a qualified way into the world market. The results of the new edition of the ICT Enterprises survey showed possible scenarios for Brazil, presenting the level of use of the most advanced digital technologies among Brazilian enterprises with ten or more employed persons. The survey also highlighted some aspects of the presence of digital technologies in the production structure that can serve as guidelines for public policies aimed at fostering the digital transformation of the Brazilian economy.

In short, this analysis of the results addresses different characteristics of access to and use of information and communication technologies (ICT) among Brazilian enterprises. In order to point out the level of technology adoption in different dimensions of the companies' 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 in how enterprises are selling their products and services on the Internet;
- Digital security: presence of digital security policies and main practices;
- New technologies: indicators of the adoption and use of advanced technologies, such as cloud computing, the Internet of Things (IoT), and AI, as well as partnerships for the development and source of data used;
- Final considerations: agenda for public policies.

CONNECTIVITY AND ONLINE PRESENCE

In 2024, the use of fiber optics among Brazilian enterprises continues to surpass other forms of connection, a trend observed since 2019. In 2024, 92% of enterprises were connected to the Internet via fiber optics, a proportion that was 87% in 2021, indicating a greater supply of this technology,[8] in addition to the ability of enterprises of all sizes to improve their connections over time. It is important to note that small businesses are mainly responsible for this growth. As a result of the COVID-19 pandemic, the adoption of fiber optic connections has accelerated since 2020, with enterprises of all sizes reaching a majority in the use of this technology (Chart 1). Another important aspect was the homogenization of the use of fiber optics among Brazilian enterprises, regardless of size: In 2017, 46% of small, 67% of medium and 85% of large enterprises had connections via fiber optics, a proportion that reached near universalization by 2024.

[8] The ICT Providers 2022 survey showed that enterprises that offer last-mile access services have been offering more fiber optics since 2017, especially in locations far from major cities. According to the latest edition of the survey, in 2022, 95% of all provider enterprises offered access via fiber optics, which was the most common technology, regardless of the size and region in which these enterprises operated (Brazilian Internet Steering Committee [CGI.br], 2023).

CHART 1

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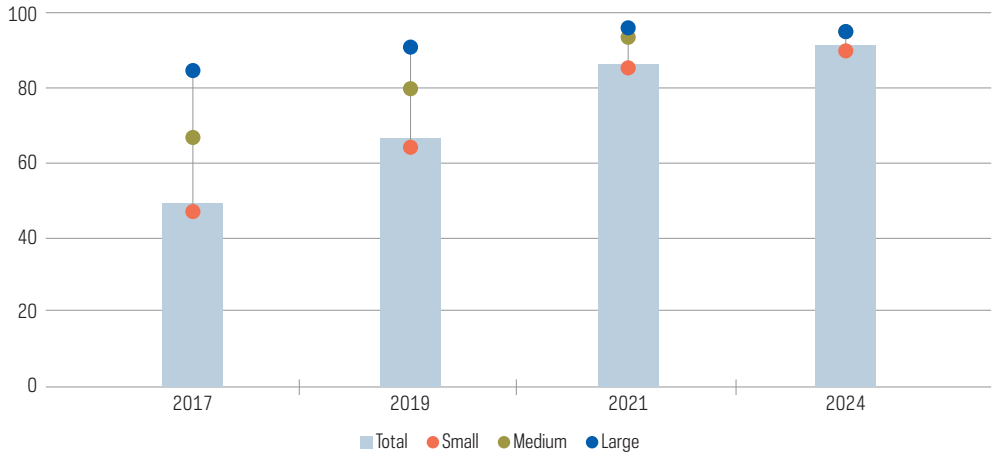
Enterprises by use of fiber optic connection and size (2017–2024)

Total number of enterprises that used fiber optics (%)



The greater presence of fiber optics is a crucial condition for better Internet quality, giving enterprises a greater chance to operate through digital means. However, it is essential to identify whether the increase in the use of optical fiber is also accompanied by an increase in contracted speeds, which may indicate greater opportunities for enterprises to use the Internet for various applications. When looking at the distribution of enterprises among the highest download speeds available, there was a decrease in the proportion of those that contracted speeds of up to 300 MBps, from 54% to 43%, a movement identified in all sizes of enterprises (Chart 2). In turn, there was a move towards higher speeds, with 28% of enterprises contracting speeds above 500 Mbps, a proportion that was 21% in 2023.[9]

[9] In the European Union, in 2024, 12.8% of enterprises had at least 1Gbps, with Denmark having the highest proportion of enterprises (29.1%) with this speed (Eurostat, 2025).

CHART 2

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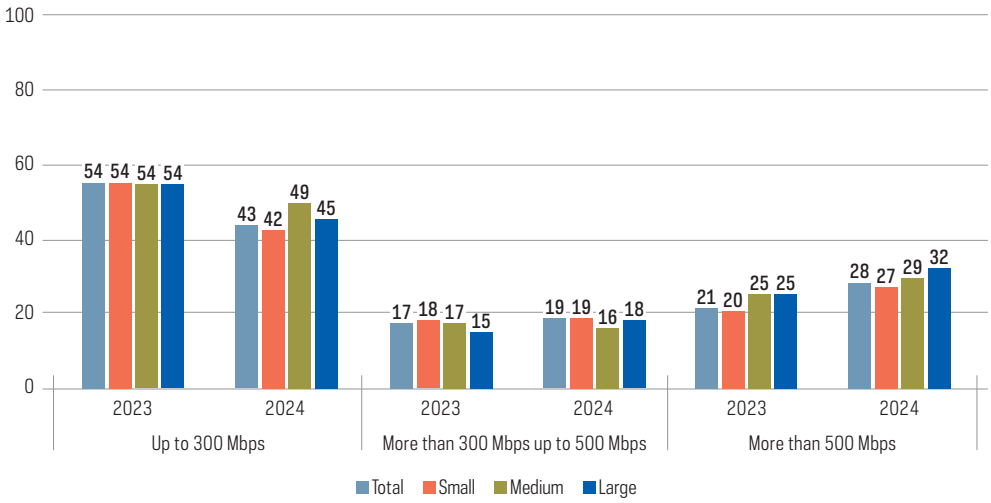
Enterprises with Internet access, by range of maximum download speed contractually offered by the Internet provider in the last 12 months and size (2023–2024)

Total number of enterprises with Internet access (%)



With the increase in contracted speeds, it is expected that enterprises will seek more intense digital activity. However, as far as digital presence is concerned, there was stability in the adoption of multiple online channels. In 2024, Brazilian enterprises, especially small ones, were following a trend of focusing on social networks, while maintaining a smaller presence on their own websites to interact with customers and users. It is important to mention that the boost caused by the pandemic, in terms of access to technologies by enterprises, has not necessarily been reflected in a greater online presence, with stability in the proportion of enterprises with websites across all sizes since 2019 (Chart 3). This type of online presence offers enterprises a digital environment customized to meet their needs and can provide greater security for customers and users in moments of interaction, such as in Internet sales.

CHART 3

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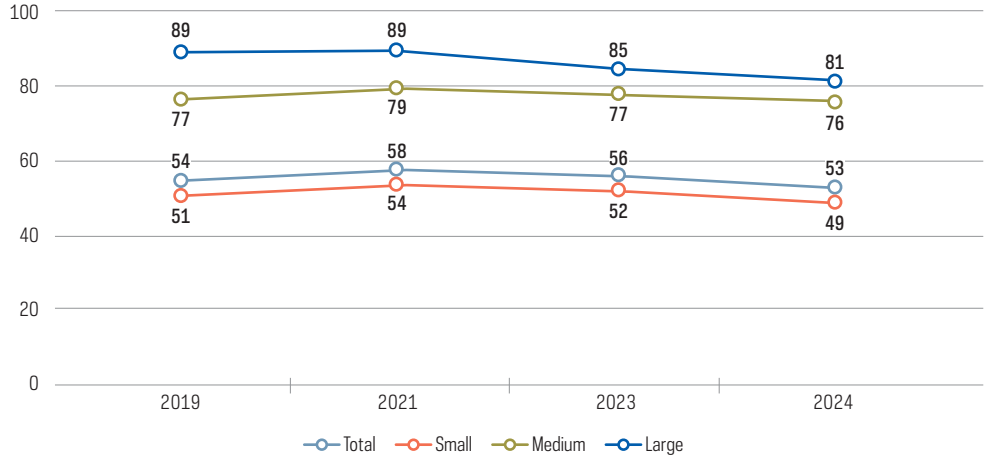
Enterprises with websites, by size (2019–2024)

Total number of enterprises with Internet access (%)



Social networks were, therefore, the main form of online presence among Brazilian enterprises (Chart 4). Throughout the historical series, there has been a shift in emphasis towards different social networks. WhatsApp and Telegram, for example, had not been adopted by even half of enterprises in 2017 (42%), but by 2024, they were consolidated as the main platforms used, reaching 74% of them. The same movement occurred with Instagram, Snapchat, TikTok, and Flickr: from 22% in 2017 to 74% in 2024.[10] To a large extent, this trend can be linked to the changing popularity of social networks, as companies seek these platforms to showcase their products and services, as well as to engage directly with customers.

[10] In the context of the distribution of the adoption of platforms and social networks, it is worth noting that, according to the report *Mobile network usage in Latin America: Current data trac and forecasts to 2030*, produced by the Global System for Mobile Communications Association (GSMA), 70% of the download traffic running on Latin American mobile networks is concentrated on Meta, Alphabet, and TikTok. In addition, using social networks is the most frequent activity, followed by web browsing and streaming. The report stated that between 2016 and 2023, total traffic from Latin America will grow by 46% per year, at higher rates than North America and Europe. More information at https://www.gsma.com/about-us/regions/latin-america/wp-content/uploads/2024/10/Uso-de-redes-moviles-en-America-Latina-ENG_-octubre-2.pdf

CHART 4

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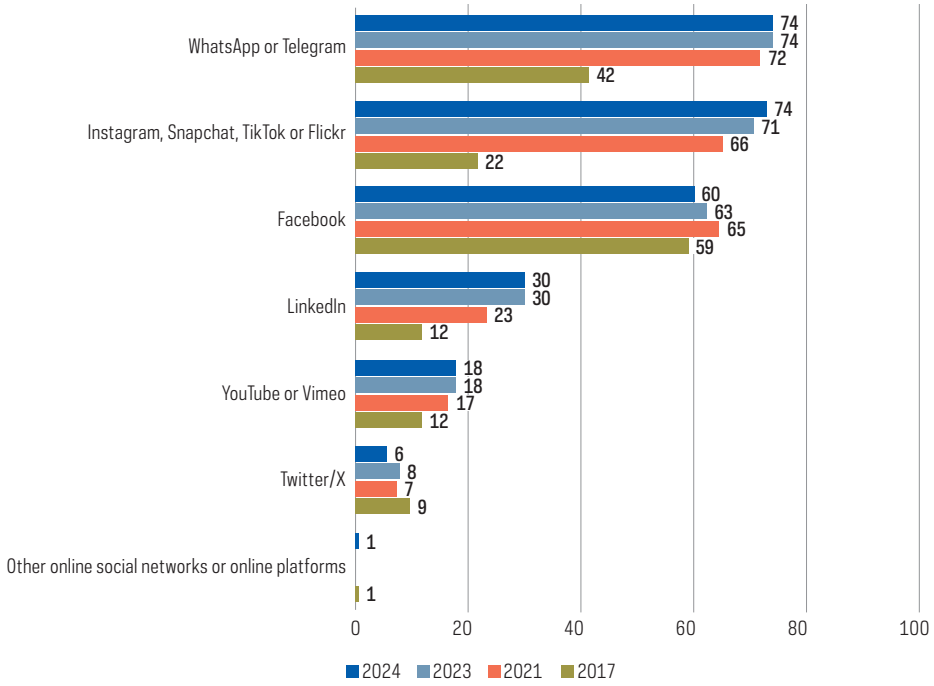
Enterprises with social network profiles or accounts (2017–2024)

Total number of enterprises with Internet access (%)



Therefore, the observed movement to improve enterprises' connectivity is not necessarily followed by greater diversification of their digital presence. There has been a tendency for enterprises, especially small ones, to adopt social networks as their main way of being online. Although it is possible to act strategically on all social networks, to the extent that customers and users are present on these platforms, it is important to mention that they do not offer enterprises full control of applications, and they seek to adapt to the rules of each medium.[11]

A website can be an outlet for more control and customization, as well as being a way to provide more credibility to customers and users, with information and centralized means of contact, generating greater trust for carrying out transactions and providing personal data.[12]

[11] According to ICT Households 2024, 81% of Internet users accessed social networks, an indicator with little variation by region and social class. However, it is interesting to note that the proportion of use decreased among the older age groups, with 74% among Internet users 45 to 59 years old and 50% among those 60 years old or older (Brazilian Network Information Center [NIC.br], 2024).

[12] According to ICT Households 2024, 48% of individuals who did not purchase things online reported having concerns about providing personal information, and 48% mentioned a lack of trust in the products they would receive. This indicates the need for greater transparency in digital media, such as efficient customer service and reliable product displays (NIC.br, 2024).

ELECTRONIC COMMERCE

A detailed classification of the means used for online sales is a central element in the e-commerce definitions adopted by international references followed by the ICT Enterprises survey, such as OECD (OECD, 2019) and the UN Trade and Development (UNCTAD, 2020). The definition adopted by international organizations considers e-commerce only as the sales made through means developed to receive orders, such as enterprises' websites, apps, Extranet, and electronic data interchange.[13] However, the use of messages and social networks for online sales is a common practice among Brazilian enterprises, especially small businesses. Therefore, the ICT Enterprise survey also incorporates these channels in the analysis of the topic, in order to reflect local nuances, without excluding the possibility of comparison with the indicators developed according to the international definition. In 2024, there was stability in e-commerce in Brazil, when considering the criteria adopted by international references, including enterprises' websites, apps, Extranet, and electronic data interchange (Chart 5). However, when channels like email, messages, and social media are included in the calculation (expanded indicator), a significant drop is observed in the proportion of enterprises selling online.

When comparing by enterprise size, it is observed that, to a large extent, the decline in the proportion of the expanded indicator is a result of changes among small enterprises: in 2024, 61% of small businesses sold online, compared to 71% in 2023.

CHART 5

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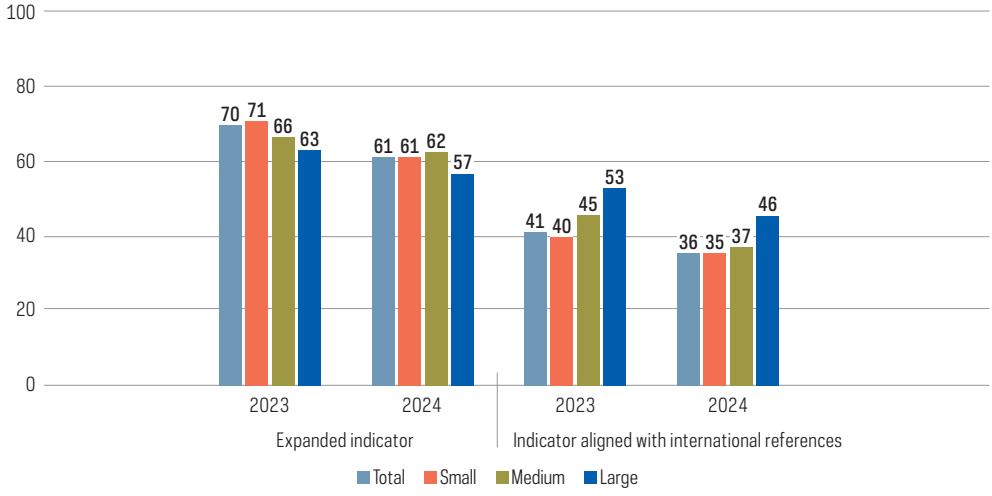
Enterprises that sold on the Internet, by size (2023–2024)

Total number of enterprises with Internet access (%)



[13] The e-commerce module of the Eurostat questionnaire has the following definition "In e-commerce sales of goods or services, the order is placed via websites, apps, or EDI-type messages (EDI: Electronic Data Interchange), by methods specifically designed for the purpose of receiving orders. Payment can be made online or offline. E-commerce does not include orders placed by e-mail."

As discussed above, the e-commerce indicator is constructed by aggregating the channels used to sell goods or services over the Internet. Therefore, an enterprise is considered to have sold on the Internet if there was at least one positive response to any of the eight sales methods measured by ICT Enterprises. In addition to analyzing the aggregated e-commerce indicator, it is also essential to understand the changes that have taken place in the different platforms and applications used for online sales. When looking at the supply side, there was a drop in the use of email, with 40% using this channel for sales in 2023, down to 34% in 2024. Another decrease was in the use of WhatsApp or Skype messages or Facebook chat, which was 55% in 2023, falling to 49% in 2024. After a continuous increase in the proportion of enterprises selling on the Internet, the sales indicator in the ICT Enterprises survey (expanded indicator) fell in the 2024 edition.[14] Although there has been a decline in the proportion of enterprises selling goods and services over the Internet, there is evidence that the volume of sales in global e-commerce is growing. According to the Digital Economy Report 2024, produced by UNCTAD, in 2016 Internet sales in the world's main economies generated 17 trillion dollars, reaching 27 trillion dollars in 2023, with most of these transactions being generated within countries (UNCTAD, 2024). However, in view of the representation in the total number of enterprises that sold on the Internet, it is possible to point out that the changes observed were mainly due to the decrease in the proportion of small enterprises that reported selling via WhatsApp or Skype messages or Facebook chat (Chart 6).[15]

[14] Surveys with individuals in Brazil show that e-commerce purchases is increasing. According to ICT Households 2024, 46% of Internet users bought things on the Internet, which represents around 74 million people, while in 2022 the estimated figure was around 67 million (NIC.br, 2024).

[15] The drop in the indicator for sales via WhatsApp messages directly influences the total, since this is the most common form of online sales mentioned by small enterprises. In terms of totals, it is possible to assess the impact of this fall: In 2023, it was estimated that 294,196 small enterprises said they sold online, falling to 263,697 in 2024.

CHART 6

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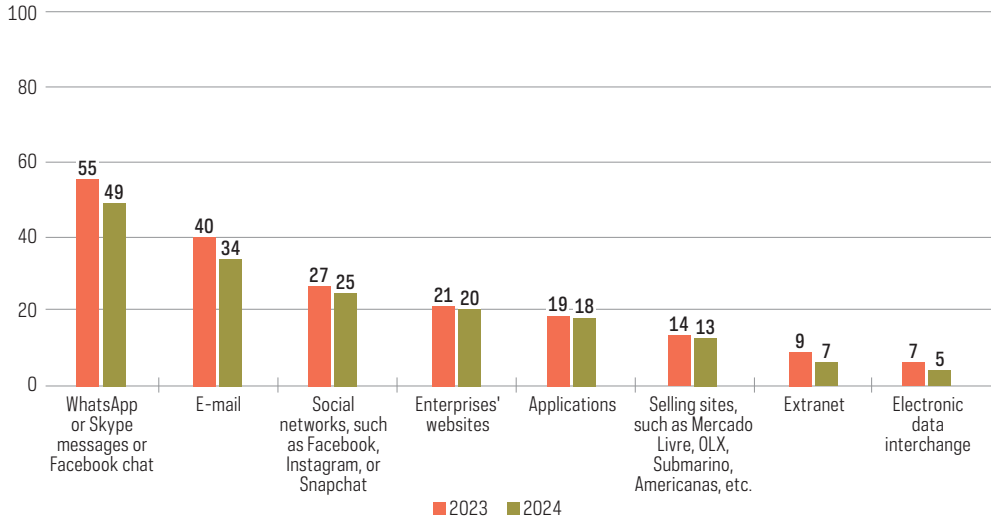
Enterprises that sold on the Internet in the past 12 months, by type of online channel used for transactions (2023–2024)

Total number of enterprises (%)



When considering the share of companies selling online, the means used by Brazilian enterprises online continue to follow the pattern observed in past editions of the survey. Most enterprises reported selling products and services over the Internet via WhatsApp or Skype messages or Facebook chat. In contrast, more automated forms of e-commerce, such as Extranet, electronic data interchange, and the enterprises' websites, showed lower proportions, with the first being more prevalent among small enterprises and the second among large enterprises (Chart 7).

CHART 7

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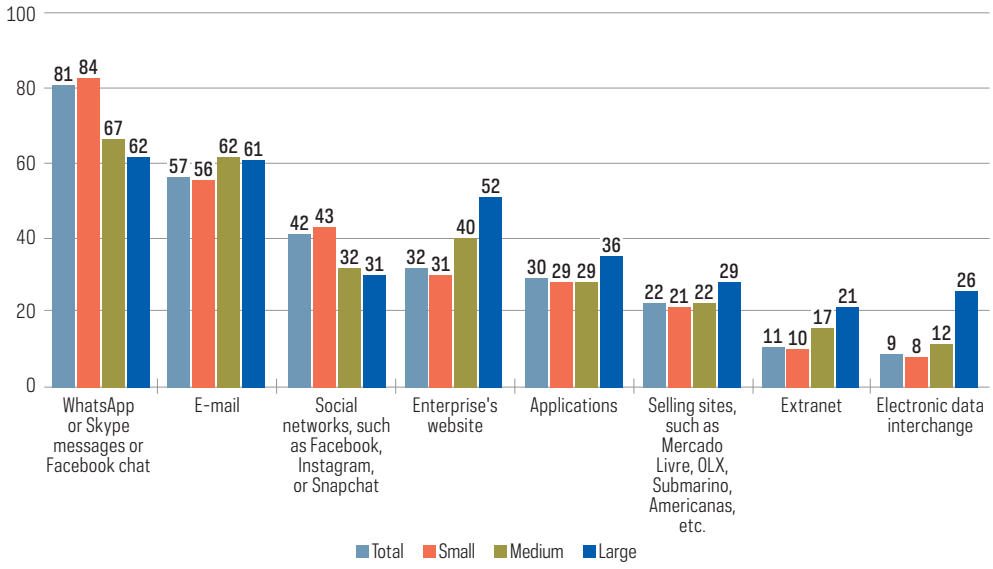
Enterprises that sold on the Internet in the past 12 months, by type of online channel used for transactions and size (2024)

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



Regarding payment methods, the most used among enterprises for online sales, regardless of size, was Pix, maintaining the pattern observed in 2023. This result was in line with the behavior of Internet users when they made payments for the purchase of products and services online (according to the ICT Households survey, in 2022 the proportion was 66%, compared to 84% in 2024). Data from the Central Bank of Brazil (BC) corroborates this result, with Pix being the most used means of payment in all transactions in the country. According to the report *O brasileiro e sua relação com o dinheiro* [*Brazilians and their relationship with money*], in 2021, shortly after its launch, Pix was used by 46.1% of the population, reaching 76.4% in 2024. On the other hand, the use of cash has been falling: In 2021, 83.6% of the population used this means of payment, falling to 68.9% in 2024 (BC, 2024). Among large enterprises, bank payment slips were used more (72%), while payment on delivery was more common among small and medium-sized enterprises, reported by 55% (Chart 8).

CHART 8

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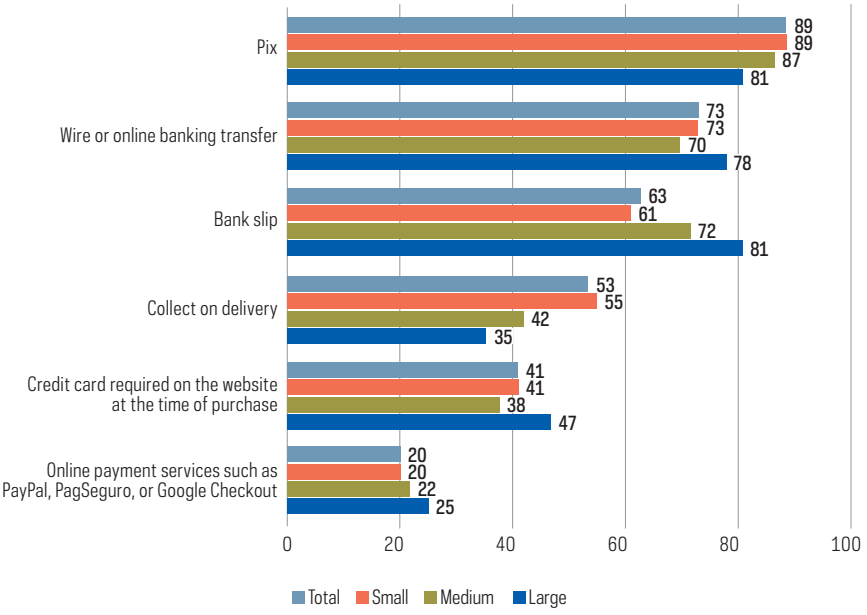
Enterprises that sold on the Internet, by type of payment and size (2024)

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



DIGITAL SECURITY

At the beginning of 2025, WEF warned of the low presence of more robust digital security practices in enterprises, with a greater frequency of training and awareness-raising actions, but few more specific actions such as allocating personnel dedicated exclusively to digital security or developing whistleblowing channels (WEF, 2025b). The Forum also highlights that in 35% of the enterprises interviewed, there were no programs to encourage the reporting of incidents and risks, revealing a scenario of little or no concern about the digital exposure of organizations, as well as a lack of awareness about the risks related to digital security incidents.

In Brazil, concern about digital security has remained stable in recent editions of the survey: In 2021, 50% of enterprises had digital security policies, reaching 53% in 2023 and 51% in 2024. Among large enterprises, there was a higher proportion with digital security policies, as well as a greater prominence of actions in this area in the information and communication and professional activities sectors (Chart 9).

CHART 9

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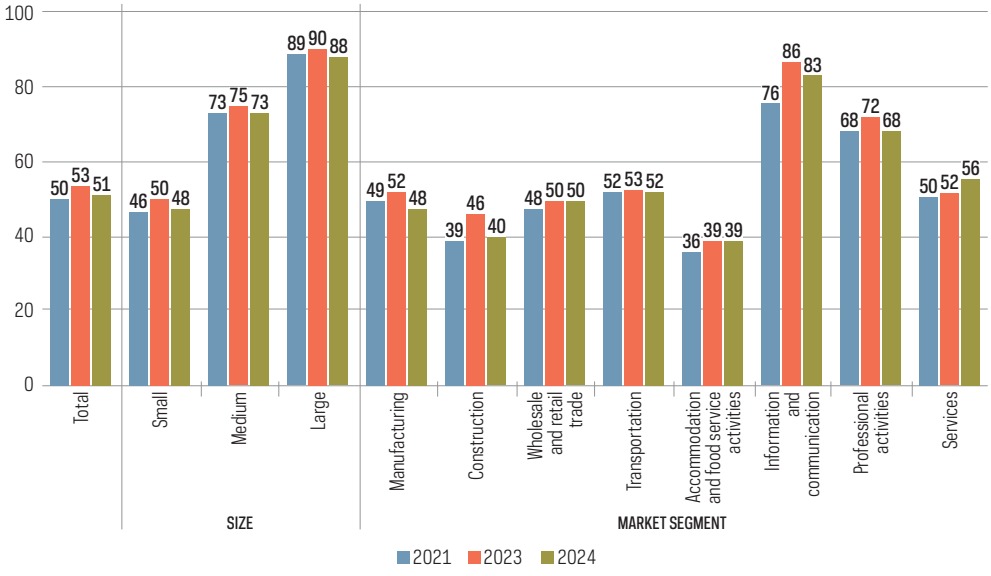
Enterprises with digital security policies, by size and market segment (2021–2024)

Total number of enterprises with Internet access (%)



With regard to the practices carried out to guarantee enterprises' digital resilience, the scenario of Brazilian enterprises is a prevalence of simpler and more informative practices and a lower presence of more advanced digital security practices (Chart 10). Since 2021, the practice most mentioned by enterprises has been the discussion of digital security risks, mentioned by four out of ten enterprises in 2024. More structured actions, such as offering training about digital security risk management and providing performance incentives for employees who reduce digital security risks, were present in 30% and 25% of enterprises, respectively, maintaining the proportions observed since 2021.

CHART 10

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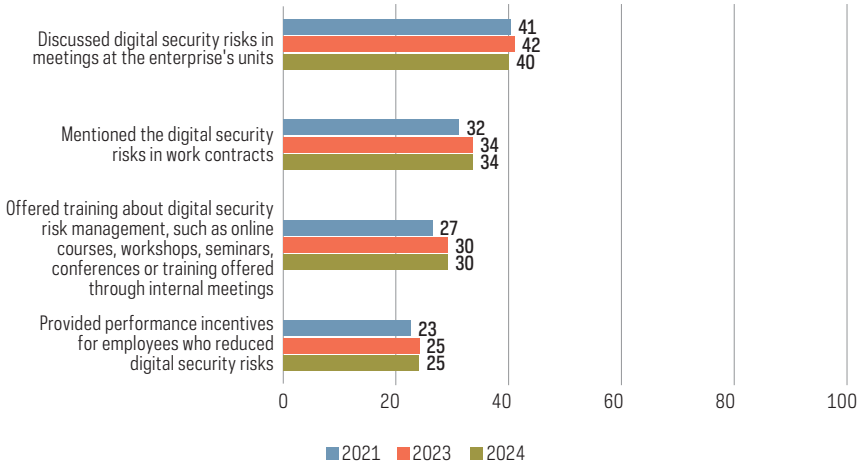
Enterprises by digital security practices (2021–2024)

Total number of enterprises with Internet access (%)



Therefore, the increase in enterprises' online exposure is not necessarily accompanied by greater awareness of digital security risks, since the practices most mentioned by enterprises do not target specific actions to strengthen digital resilience. In this regard, it is important to establish more concrete actions to protect enterprises from attacks and risks, including those arising from more intensive use of data-based technologies such as AI, which can lead to irreversible financial and reputational damage.

NEW TECHNOLOGIES

The advance of AI is redefining public and private investment, mainly to strengthen the connectivity infrastructure needed to support the adoption of this type of technology, as well as to build a research and development ecosystem, seeking to accelerate the adoption of solutions by enterprises and individuals. 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. The challenges of intensifying the use of technology in enterprises are not an obstacle only in the Brazilian context but are also shared by many different countries.[16]

[16] The Regional Center for Studies on the Development of the Information Society (Cetic.br) has contributed to the development of a report based on the methodology of the United Nations Educational, Scientific and Cultural Organization (UNESCO), aimed at understanding the capabilities of the G20 countries for AI research and development, as well as the infrastructure needed for its adoption (G20 Digital Economy Working Group, 2024).

In this context, one of the requirements to support the most advanced applications in the digital economy is the use of cloud services. Enterprises with higher digital maturity are increasingly transferring their operations to the cloud and relying less on on-premises infrastructure, which gives their operations greater speed and security. With regard to connectivity, given the greater use of fiber optics and the contracting of higher speeds, Brazilian enterprises have the capacity to contract cloud services, but as observed with their online presence, the necessary steps toward greater digitization encounter obstacles. ICT Enterprises shows stability in the use of cloud services between 2021 and 2024, especially for more advanced applications, such as processing capacity or computing platforms that provide hosted environments for developing, testing, or deploying applications (Chart 11).

CHART 11

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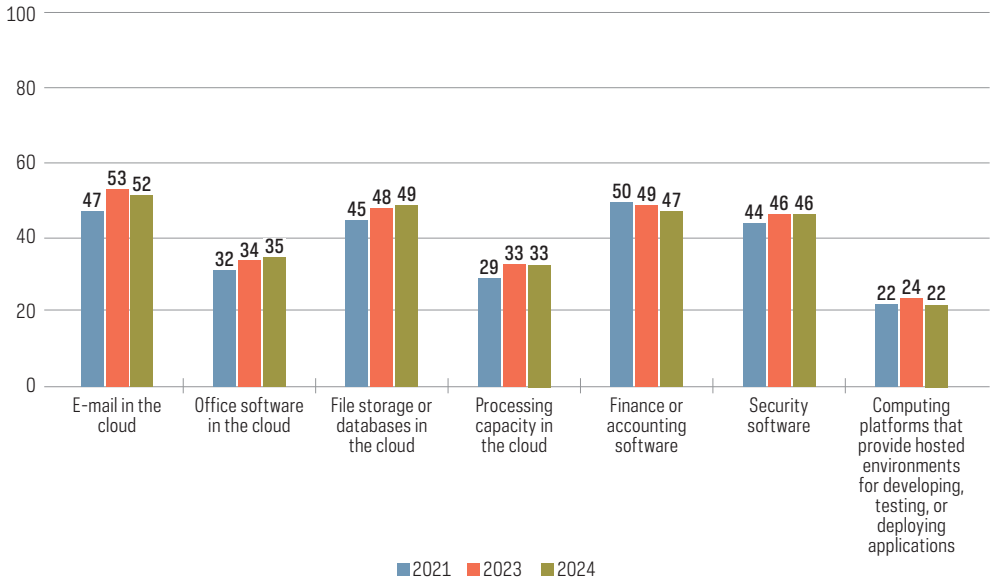
Enterprises that purchased cloud services, by type (2021–2023)

Total number of enterprises with Internet access (%)



Because the use of the cloud is intended to support organizations in transferring their most diverse operations to the digital environment, cloud processing is characterized as one of the main requirements for achieving greater digital maturity. There was an increase in the adoption of this type of cloud service between 2017 and 2023, but it stagnated in 2024. When detailing the use of cloud processing services by company size, it is noted that there was no change in usage among small businesses, while there was growth among medium and large companies over the historical series. Among medium enterprises, 29% used cloud processing services in 2019, rising to 39% in 2021, 49% in 2023, and 46% in 2024. As far as large enterprises are concerned, there was significant growth in the use of cloud processing capacity between 2019 and 2021, with a small increase in the years 2023 and 2024 (Chart 12).

CHART 12

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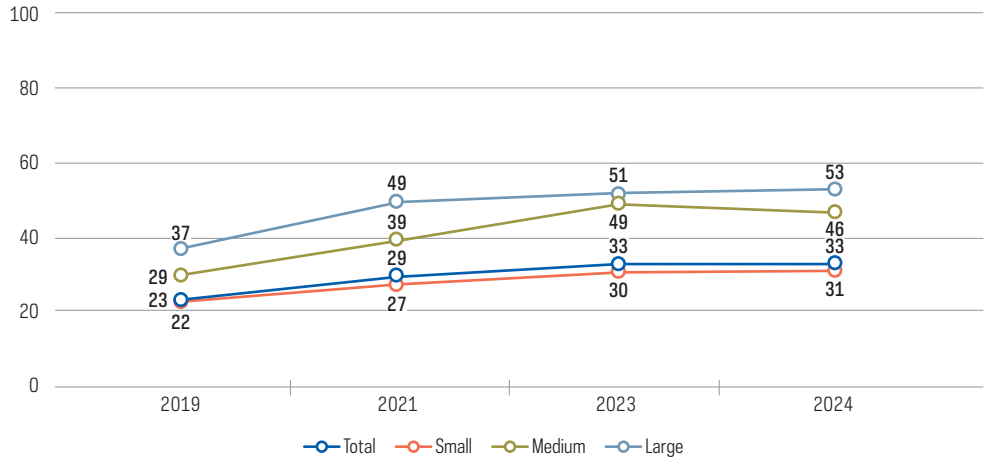
Enterprises that purchased cloud processing capacity, by size (2019–2024)

Total number of enterprises with Internet access (%)



Another technology whose use characterizes the advance of the digitization of internal processes is IoT. In the context of the industrial sector, this adoption becomes even more important, as the use of sensors characterizes applications in industry, with a view to better resource management and predictive maintenance. In this regard, a study by Cetic.br|NIC.br with the OECD, released in 2023, highlighted several challenges for small enterprises in the industrial sector to implement IoT devices, including the need for overcoming organizational cultures that are averse to changing routines, which is one of the factors that most hinder greater digitization (OECD, 2024).

As noted above, basic aspects of connectivity are already in place among Brazilian enterprises. There is a need for greater concern about training specialized manpower to support technology implementation projects, especially among small enterprises. In this regard, the results point to the stable use of IoT devices among all enterprises. There was growth among medium companies, from 21% in 2021 to 29% in 2023, with stability in 2024. The use of IoT devices was higher among large enterprises, although there were no significant changes between 2021, 2023, and 2024.[17] In the industrial sector, there was an increase between 2021 and 2023, from 11% to 14%, but returning to the 11% level in 2024 (Chart 13).

[17] It is important to relate the data on IoT use by enterprises to the results on the use of personal data presented in the ICT Enterprises 2023 survey. In 2021, 24% of enterprises kept biometric data, rising to 30% in 2023. According to ICT Enterprises 2024, among the enterprises that used smart devices or IoT, 84% said that this was related to facility security, such as alarm systems, smoke detectors, door locks, and smart security cameras. It is therefore important for enterprises to seek more information about how to handle personal data resulting from these uses, especially sensitive data, avoiding possible consequences in the event of leaks and, above all, guaranteeing the privacy of employees and customers (CGI.br, 2024).

CHART 13

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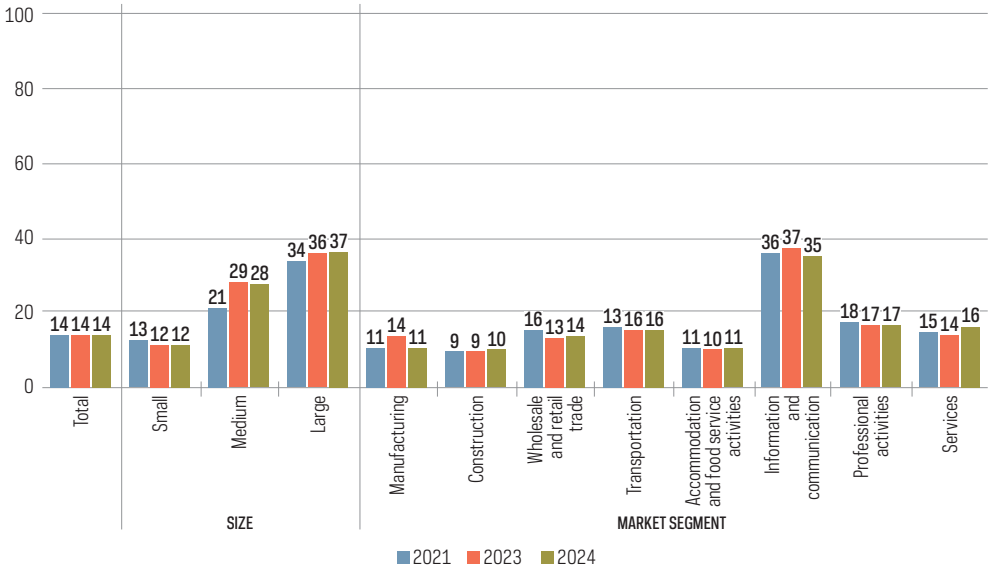
Enterprisers that used smart devices or IoT, by size and sector (2021–2024)

Total number of enterprises (%)



Given the moves toward strengthening the use of AI in various countries, the 2024 edition of ICT Enterprises added indicators to characterize Brazil's AI research and development ecosystem. AI-related technologies are general-purpose in nature, with numerous possible applications within the business context. In many cases, they are also still experimental in nature, which allows the creation of demonstration environments that can accelerate their use (Handa et al., 2025).

In terms of use characteristics, there was stability in the presence of AI among Brazilian enterprises, with no significant increase between 2021 and 2024. The pattern observed is the same as that outlined by the ICT Enterprises in previous editions, with a greater presence among large enterprises and in the information and communication sector (Chart 14).[18]

[18] An example of this incipient moment in technological adoption was the results presented in joint research by the Cetic.br|NIC.br, the State Data Analysis System Foundation (Seade Foundation), and the OECD. This study investigated the use of AI in industrial enterprises and the ICT sector of the state of São Paulo and found that only 7% used some kind of AI (Freire et al., 2024).

CHART 14

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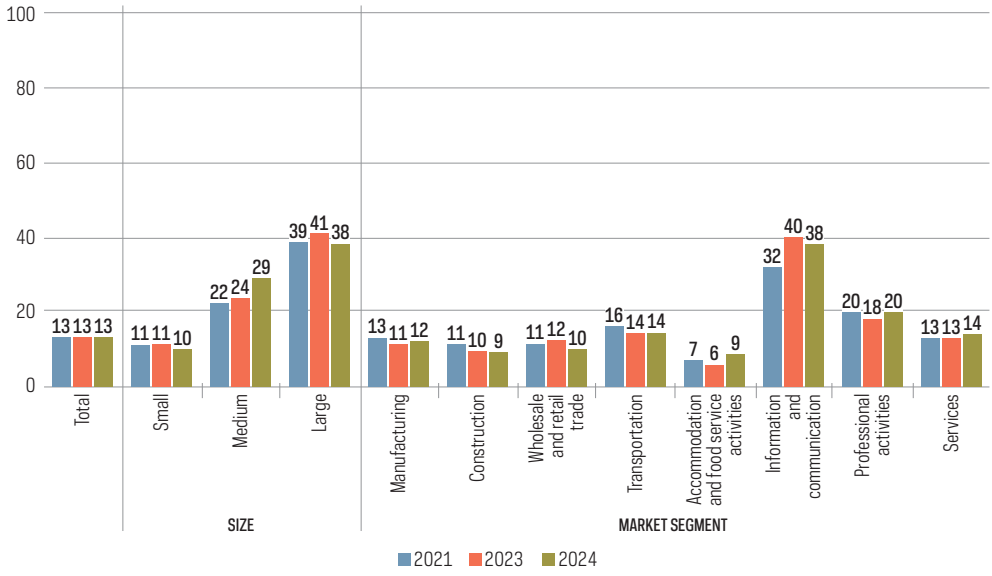
Enterprises that used AI technologies, by size and market segment (2021–2024)

Total number of enterprises (%)



The AI use module of ICT Enterprises is based on the survey on ICT use in European companies conducted by Eurostat,[19] making the Brazilian results internationally comparable (Chart 15). According to the latest version of the European survey, 13.48% of enterprises in the bloc used some form of AI, with Denmark, Sweden, and Belgium in the top three, with 27.58%, 25.09%, and 24.71%, respectively, of their enterprises using AI. Therefore, in comparison with countries from the European Union, it is observed that some of the more digitalized countries are moving toward a higher proportion of AI use (Chart 15), with Brazil at a level similar to the European average.

[19] More information on the European survey at https://ec.europa.eu/eurostat/cache/metadata/en/isoc_e_esms.htm

CHART 15

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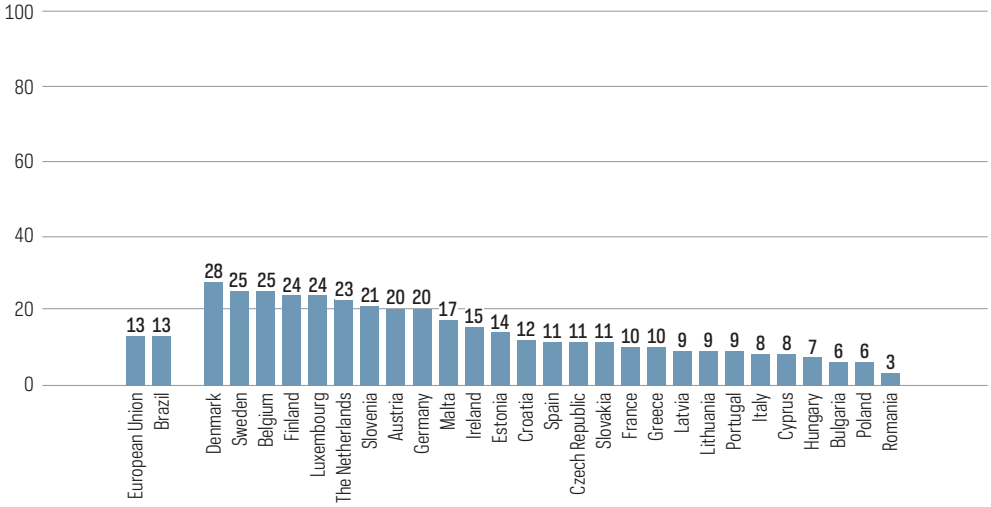
Enterprises that used AI technologies in Brazil and the European Union (2024)

Total number of enterprises (%)



When analyzing the use of AI by enterprise size in Brazil and the European Union, the pattern that has been established over the years remained the same: Large enterprises presented the highest proportion of AI use (Chart 16). Since these enterprises have more capacity to invest and experiment with technologies, and given the incipient nature of AI, it is to be expected that they will have a greater capacity to adopt this type of technology. When comparing Brazil and Europe, however, the indicators show an acceleration in the use of AI among large European enterprises, while in the Brazilian case, the percentages remained stable: In 2023, 30% of large enterprises in the European bloc used some form of AI, rising to 41% in 2024, while in Brazil these proportions were 41% in 2023 and 38% in 2024 (Chart 16).

CHART 16

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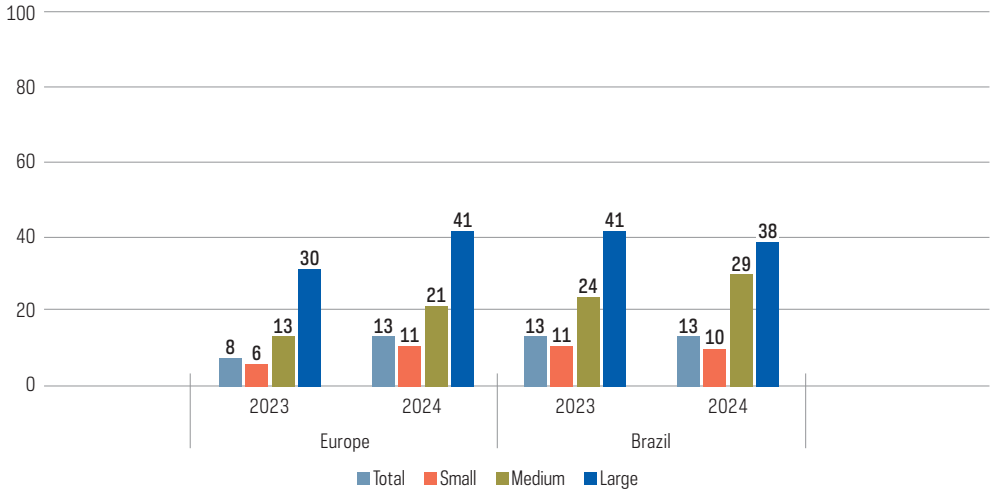
Enterprises that used AI technologies in Brazil and the European Union, by size (2024)

Total number of enterprises (%)



Among the Brazilian enterprises that had employed some kind of AI, most reported uses related to automating processes and workflows. Although there were no changes outside the margin of error in the proportion of enterprises using the various types of AI, it is worth noting that, in 2024, the total number of enterprises that cited some of the most advanced uses was higher than the previous year. These included text mining (15% in 2023 to 22% in 2024), machine learning (16% in 2023 to 20% in 2024), and speech recognition (11% in 2023 to 16% in 2024) as shown in Chart 17.[20]

[20] The results of the European survey for the year 2024 follow a pattern different from that observed in Brazil. The AI application most mentioned by enterprises was text mining, mentioned by 7.88%, followed by natural language generation, representing 5.41% of European enterprises (Eurostat, 2025).

CHART 17

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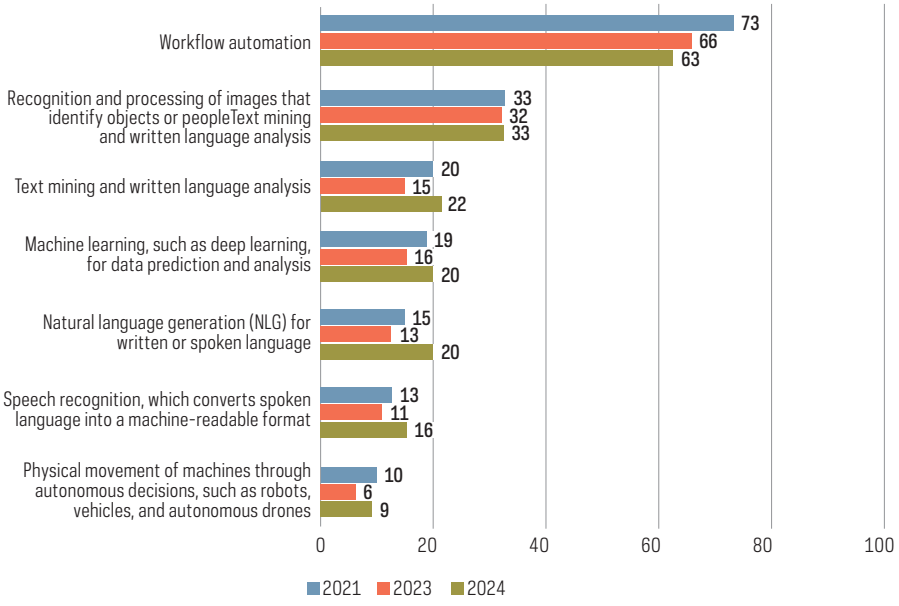
Enterprises that used AI technologies, by type (2021–2024)

Total number of enterprises that used AI technologies (%)



A new feature of ICT Enterprises 2024 is the indicator of how enterprises acquired or developed the AI software or systems they use (Chart 18). The purpose of the indicator is to ascertain the presence of possible AI research and development ecosystems, which are of crucial importance for technologies to enter the market, accelerating use and exploration. Among the enterprises that used AI in 2024, 76% said they had acquired ready-to-use AI software or systems. This result is related to the most-used type of AI, analyzed above, for automating processes and workflows, indicating that these are largely off-the-shelf solutions. Moving in the direction of joint development in AI, 56% of enterprises said they had contracted external suppliers to develop or modify AI software and systems. Therefore, although little mention was made of self-development, it is important to note that the technology enters enterprises through partnerships with other enterprises, in a pattern that is indifferent to size or economic sector, indicating some characteristics of the AI adoption in the country[21] (Chart 18).

[21] The results from Europe follow the same pattern of AI adoption as that observed in Brazil; 7.35% of the enterprises in the bloc reported using ready-made AI software or systems. Of the three countries with the highest use of AI among enterprises in the European Union, the proportions were 14.85% in Denmark, 13.70% in Sweden, and 13.99% in Belgium (Eurostat, 2025).

CHART 18

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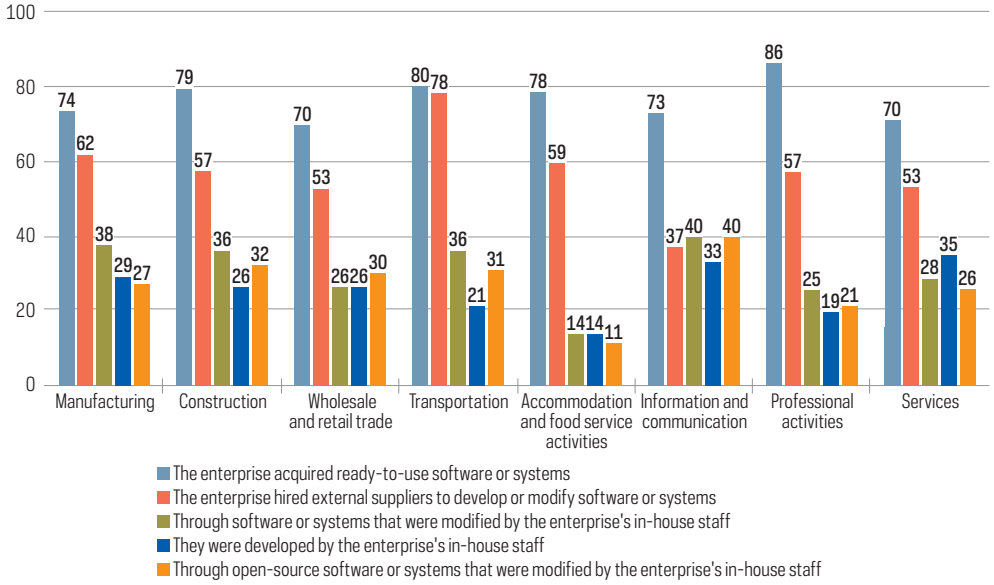
Enterprises that used AI technologies, by how they acquired or developed the AI software or systems they use and market segment (2024)

Total number of enterprises that used AI technologies (%)



Following the same trend observed in the ways that the enterprises acquired or developed their AI software or systems, ICT Enterprises 2024 sought to understand whether there had been any type of partnership for the development of AI (Chart 19). Among those that used AI, half said they bought the AI software or systems in use from other enterprises, following the pattern discussed earlier, with no major differences by size and economic sector. This indicator helps us understand that the ecosystem for using AI in Brazil is still in its infancy, as there is little interaction between enterprises, universities, non-profit organizations, and government organizations.

However, it is worth noting that 26% of the enterprises used open AI systems and 20% developed AI in-house, indicating an incipient creation of in-house capacity-building, which was more present in the information and communication and services sectors, which are those in which applications can emerge for use by other enterprises (Chart 19).

CHART 19

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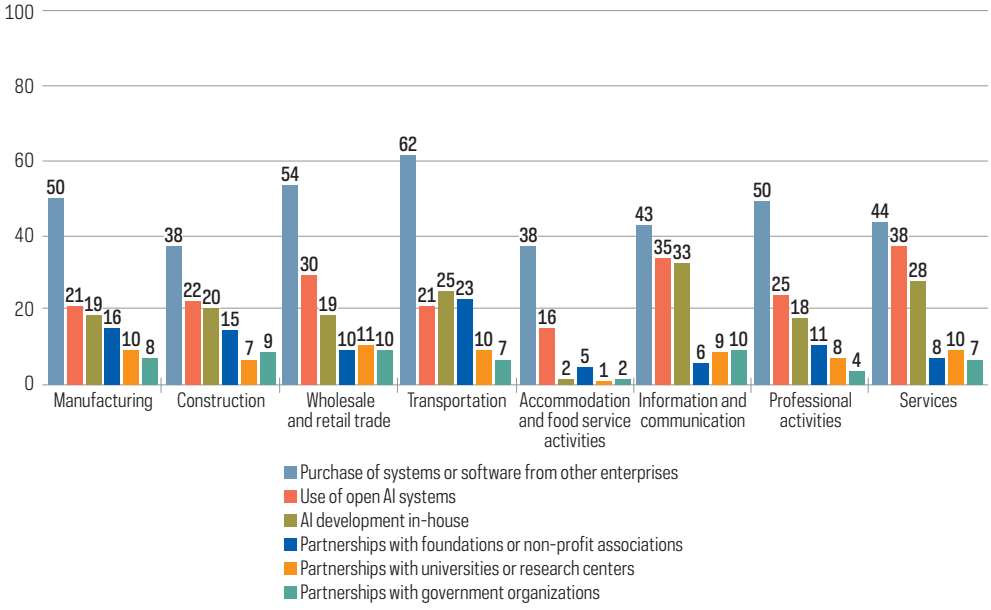
Enterprises that used AI technologies, by type of partnerships or actions for the development of AI and market segment (2024)

Total number of enterprises that used AI technologies (%)



Another new indicator in ICT Enterprises concerns the sources of the data collected by enterprises, which is the basis for training the AI models they use. As discussed above, the most frequent use of AI among Brazilian enterprises was to automate workflows, i.e., to optimize internal processes and external aspects that can be routinized (e.g., customer service). In this sense, it is worth noting that 18% of the enterprises collected data internally from processes and staff and 16% collected it from customers and users, with such practices being very specific to large enterprises and the information and communication sector (Chart 20).

Therefore, the indicator for the sources of data used by enterprises highlighted the trend toward the use of AI, which was still very much geared toward automating internal processes. However, in view of the internal origin of the data sources most used by the enterprises, a discussion arises about the use of personal data in the training processes of the models being applied, giving rise to the need to follow security and privacy standards to avoid leaks or abuse (Chart 20).

The latest edition of the survey *Privacy and personal data protection: Perspectives of individuals, enterprises and public organizations in Brazil,* launched in 2024, showed that there was an increase in the preparation of compliance or adequacy plans for the protection of personal data among Brazilian enterprises, rising from 24% in 2021 to 32% in 2023, showing that this type of initiative has a smaller presence despite the importance of best practices to ensure security and privacy in the handling of personal data, especially data of a sensitive nature (CGI.br, 2024).

CHART 20

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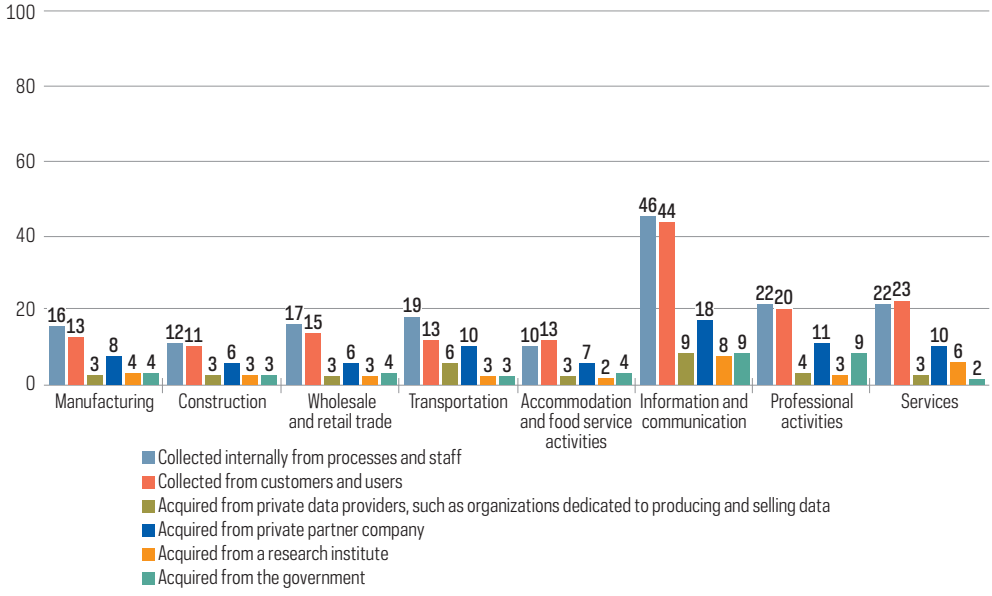
Enterprises that collected data, by types of sources and market segment (2024)

Total number of enterprises (%)



Finally, it is important to discuss the obstacles reported by enterprises that did not use any kind of AI. Compared to the results of the ICT Enterprises 2023 survey, there were aspects that seemed to point to a greater understanding on the part of enterprises of the prerequisites for adopting AI, as well as a decrease in concern about the consequences of using these technologies (Chart 21). In 2023, 19% of enterprises that did not use AI said they did not do so due to incompatibility with existing equipment, software, or systems in the enterprise, a proportion that was 14% in 2024. Similarly, in 2023, 16% of these enterprises reported difficulties in the availability or quality of the data necessary to use these technologies, a proportion that rose to 11% in 2024. Finally, 9% of enterprises that did not use AI in 2023 pointed to ethical reasons, a proportion that was 6% in 2024. However, these decreases need to be better evaluated in future editions because they are outside the margin of error. In any case, they may be related to what has already been discussed, in the sense of an incipient but already functioning AI solutions market, in which one enterprise seeks to automate some processes with the help of another, using its own processes, customers, and employees as a source of data (Chart 21).

CHART 21

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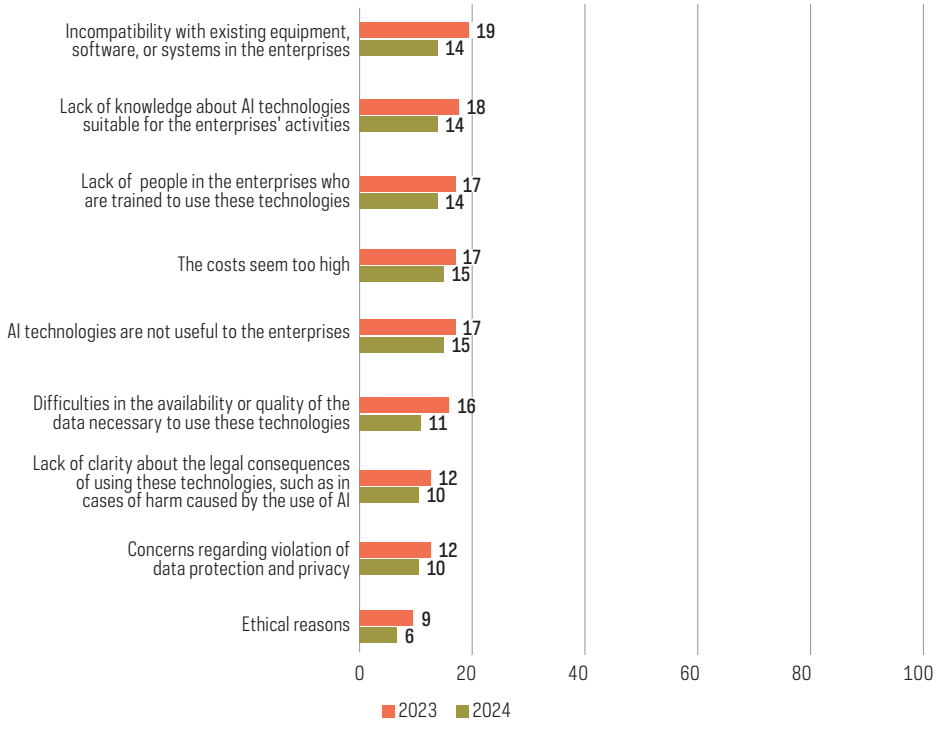
Enterprises that did not use AI, by type of barrier (2023–2024)

Total number of enterprises that did not use AI technologies (%)



Final considerations: Agenda for public policies

The results of the new edition of the ICT Enterprises survey show that Brazilian enterprises are struggling to diversify their online presence and make progress in adopting more advanced technologies. If, on the one hand, the issue of connectivity has made concrete progress, with faster fiber optic connections becoming more common, on the other hand, the establishment of a digital presence among small enterprises is very dependent on social media. From the point of view of digital security, more elaborate practices for digital resilience are barely present.

Regarding e-commerce, the means used by enterprises to sell their products and services have maintained the pattern observed since 2019. Small enterprises tend to use more messaging, using applications that were not necessarily developed for sales, while larger companies use more automated means developed exclusively for sales. In a way, this difference concerns the type of e-commerce, with the former being more related to retail trade (B2B), while the latter to transactions between enterprises (B2C).

From the perspective of advanced technology adoption, the ICT Enterprises Survey highlights significant challenges that Brazilian enterprises encounter in enhancing their performance. One of the most important characteristics of industrial policies aimed at leveraging AI research and development is the sectoral diversity of investments. Although there is an obvious strict technological aspect, the policies that have been developed have sought to achieve a diverse impact in sectoral terms. Due to its nature as a general-purpose technology, AI has the capacity to impact the most diverse sectors of the economy and has broad applications in the public sector and academia, creating regulatory and implementation challenges that must be taken into account when formulating public policies.

In Brazil, the NIB program and PBIA seek to bring together efforts in various sectors, supporting aspects such as the training of qualified personnel and research and development for the national production of technologies. Moreover, one aspect that must be taken into account when designing policies to support AI is the creation of ecosystems of use that foster the implementation of solutions in enterprises. As shown by the results of the ICT Enterprises survey, the use of AI among enterprises prevails among large ones and those in the information and communication sector, and the spread of these solutions to small enterprises and other sectors is a challenge that involves cost and qualification aspects, impacting their technological maturity.

The available evidence indicates that the capacity for AI use among enterprises is also the result of knowledge built through the use of related technologies, which contribute to the creation of tacit knowledge among employees and support the process of exploring innovations (Kubota & Rosa, 2025; Lins, 2022). Moreover, the process of implementing technologies is facilitated by cooperation among companies, both in the sale of solutions and in the follow-up of their use, resulting in an ecosystem of adoption that can be accelerated by policies supporting testbeds (Arbix et al., 2017).

Therefore, the scenario for the implementation of technologies in enterprises is more complex than at other times of productive transformation, considering the broad applications that technologies such as AI or IoT make possible for the most diverse organizations, creating greater implementation challenges. Thus, seeking to coordinate efforts between different stakeholders, with a view to creating ecosystems for the use of technologies, can be a strategy that brings benefits for both their implementation and their research and development.

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Articles

International benchmarking of practices for the digitalization of small industrial enterprises[1]

Néstor Fabián Ayala,[2] Jéssica de Assis Dornelles,[3] Joyce Danielle de Araújo,[4] and Alejandro Germán Frank[5]

Small enterprises play a vital role in the Brazilian economy, accounting for a significant share of employment generation, innovation, and local development. However, in order to be competitive in an increasingly dynamic market, these enterprises need to digitize their processes and appropriate Artificial Intelligence (AI) tools. Digitalization and the use of AI make it possible to increase operational efficiency, improve strategic decision-making, and expand into new markets, in addition to promoting innovation and adaptation to rapid changes in the business environment. These technologies are therefore key to ensuring the sustainability and growth of small enterprises in Brazil.

This article presents global practices and initiatives aimed at digitization and the use of AI by small enterprises, offering a comprehensive overview of the strategies adopted in various countries to encourage the adoption and integration of these technologies. The study, developed by NEO at UFRGS, in partnership with UNIDO and Sebrae, was inspired by the Brazilian context, but its results have global relevance for policymakers. The aim is to share insights and recommendations with decision-makers in different countries, promoting effective strategies for the digital transformation of small enterprises on an international scale. The benchmarking study covered governments and organizations in the BRICS member countries (Brazil, Russia, India, China, and South Africa), as well as Tunisia, Germany, the European Union, Argentina, Mexico, and Colombia, and was

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based on desk research, interviews with representatives of various organizations, and workshops with experts.

The results, summarized in this article, identify the main initiatives that encourage the adoption of digital technologies and AI by small enterprises, provide an overview of the best practices implemented globally, and analyze these practices based on the theory of diffusion of innovation (Rogers et al., 2019). This classification focuses on three fundamental elements of innovation diffusion: awareness, implementation, and maintenance. Awareness refers to the process by which small enterprises become aware of the existence and potential benefits of digital technologies. Implementation refers to the way in which these enterprises adopt new technologies. Maintenance concerns the continued use and integration of these technologies over time. The classification model used provided a structured approach to analyzing and interpreting the initiatives, offering a broad understanding of how digital innovations spread among small enterprises.

The following sections present highlights of policies and initiatives in the different countries analyzed, with a view to each of the stages in the diffusion of innovation. The full list and detailed description of each country's initiatives can be found in the document published on the UNIDO website.[6]

Analysis of awareness-raising initiatives

Raising awareness is a critical factor in the spread of digitization among small businesses. It involves the degree to which potential adopters are informed about the existence of digital technologies and their potential benefits. Within the theoretical model of innovation diffusion, raising awareness represents the initial phase of the adoption process. Before individuals or organizations can adopt digital technologies, they need to be aware of their existence, and understand their nature and functionalities.

In the study, 32 of the 39 global initiatives examined were identified as efforts to increase small businesses' awareness of the adoption of digital technologies. These initiatives aim to ensure that small businesses are well-informed and prepared to adopt digitization effectively. They include a variety of activities, such as:

- offering training programs to improve digital skills and knowledge;
- providing workforce training programs for the use of new technologies;
- providing consulting services;
- organizing events to facilitate the sharing of knowledge and the development of business skills;

[6] More information available at: https://www.unido.org/news/unido-report-sheds-light-importance-digitalization-smes-achieve-sustainable-development-goals

- establishing dialog platforms that connect small and medium enterprises (SME) with digital service providers;
- providing access to relevant information related to Industry 4.0.

Small businesses often face greater challenges in becoming aware of digitization compared to larger enterprises—unlike them, which often have departments or teams dedicated to technological innovation, small enterprises generally have limited resources, with all employees involved in administrative and operational tasks. Consequently, they may have little time and capacity to keep up-to-date with emerging technologies and their potential benefits. In recognizing these challenges, governments and policymakers around the world have made significant efforts to raise awareness among decision-makers in small enterprises. Policies and initiatives aim to fill the information gap by offering targeted support, training programs, and access to resources that help them understand the importance of digitization and its potential impact on their performance and competitiveness. By increasing awareness and knowledge about digitization, policymakers work towards empowering small enterprises to make informed decisions and adopt digital technologies that will boost their growth and success.

However, the results of the study reveal that most of the initiatives identified focused mainly on raising awareness among small enterprises, highlighting an imbalance in the distribution of efforts aimed at promoting digital transformation. This observation is in line with the argument raised by Dedehayir et al. (2017), which suggests that awareness-building activities tend to be more prevalent among innovators and early adopters, such as small enterprises. While investing in the dissemination of knowledge about digitization and AI is essential to supporting the development of SME, it is equally important to ensure a comprehensive diffusion of innovation. This requires planning initiatives with a long-term perspective that includes all three elements of innovation diffusion (Rogers et al., 2019). By considering the entire diffusion process, initiatives can more effectively drive the digital transformation of small enterprises and maximize its benefits.

Analysis of implementation initiatives

Implementation is a critical phase in the digitization process for small enterprises, as it involves the adoption and effective use of digital technologies. This stage marks the transition from theoretical concepts to practical applications, with a focus on integrating these technologies into enterprises' existing systems and workflows. During this phase, small enterprises need to learn how to effectively and efficiently use the digital technologies they have adopted, which requires acquiring the knowledge and skills necessary to take advantage of all their functionalities and benefits. Successful implementation also depends on seamlessly integrating these technologies into enterprises' daily routines, ensuring that they become an essential part of regular operations.

Again, small enterprises face different challenges compared to medium and large businesses—different from them, which often have dedicated IT or digitization departments staffed by technical experts, small enterprises often have limited resources, with only one or no people responsible for technology implementation tasks.

This difference requires a unique approach to digital technologies for small enterprises, as it is essential for them that technologies are designed to be simple and easy to use. Ideally, these technologies should be plug-and-play solutions, meaning that they can be easily integrated into existing equipment without the need for extensive installations or complex configurations. Small enterprises often cannot afford expensive installations or invest in highly specialized technical expertise. Therefore, usability is crucial: New software or tools should not require excessive training, significant changes in working habits, or major adjustments to communication methods. Complex and difficult-to-use technologies can lead to errors or even abandonment, especially when the workforce lacks digital proficiency. Therefore, digital technologies aimed at small enterprises should prioritize simplicity and ease of use.

The study identified 17 initiatives in the 11 countries analyzed that were specifically designed to support small entrepreneurs in adopting and using digital technologies. These initiatives are essential for offering valuable support to small enterprises through various mechanisms, including:

- providing subsidies to help small enterprises acquire and implement technologies without the need for reimbursement;
- offering access to financing options with subsidized rates, making it more affordable to invest in digital technologies;
- providing free or low-cost consulting and training services, usually facilitated by science and technology institutes or related institutions;
- offering promotional and discount prices to encourage small enterprises to invest in technology.

It is important to note that most of the initiatives identified in this study are mainly focused on investment, financing, and subsidies. These programs aim to facilitate the acquisition and implementation of digital technologies, enabling small enterprises to improve their operational processes, enhance the quality of their products or services, and ultimately increase their overall competitiveness.

By providing financial support and resources, these initiatives help to reduce the financial barriers that often prevent small enterprises from fully embracing digital transformation. In addition, the inclusion of training programs helps to fill the knowledge and skill gaps within the workforce, ensuring that employees are qualified to effectively use and take advantage of digital technologies. These initiatives also recognize the importance of providing access to essential infrastructure, such as high-speed Internet connectivity and digital platforms, which are crucial for small enterprises to effectively adopt and integrate digital technologies into their daily operations.

The existence of these implementation initiatives is an encouraging sign that small enterprises are beginning to recognize the benefits of digital technologies and are taking proactive steps to acquire the necessary digital skills and resources. Participating in training programs, accessing grants and financing options, and receiving support in acquiring and implementing digital solutions can help small enterprises overcome barriers and begin their digital transformation journey. However, to further advance and increase their digital maturity, SME should also focus on sharing information about

these technologies with their partners, exploring new digital opportunities and trends, and continuously monitoring and evaluating the results of their digital initiatives (Müller et al., 2021; Ricci et al., 2021).

Analysis of maintenance initiatives

Maintenance is a vital component in the diffusion of digital technologies after their implementation. It involves the continued use and support of innovations by individuals or organizations, which is essential to ensure the long-term success and sustainability of these digital technologies. During the maintenance phase, users continue to use the technologies and can provide valuable feedback on their performance, suggesting improvements or adjustments to better meet their specific needs.

Initiatives of this kind are especially critical for technologies that require ongoing support or have a long lifespan. For example, software may need regular updates and maintenance to deal with security vulnerabilities or maintain compatibility with new hardware or operating systems. Technology providers therefore play a key role in ensuring the continued functionality and relevance of their products, which can involve delivering regular updates, resolving technical problems, and offering ongoing technical support to users. Consequently, digital technologies offered as a service may be more suitable for small enterprises. By subscribing to these services, small enterprises receive assurances from technology providers that their digital tools will remain effective, up-to-date, and in line with constantly evolving business requirements (Marcon et al., 2022).

Maintenance is, in fact, a crucial aspect of the innovation diffusion process, as it ensures that the impact and success of the innovation is sustained over time. However, in the context of the countries analyzed in this study, there is a significant lack of specific initiatives focused on maintenance in the innovation diffusion process for small enterprises. This gap can be attributed to two main reasons. First, the level of maturity of small enterprises in adopting digital technologies plays an important role. Many small enterprises worldwide are still in the early stages of integrating digital technologies into their operations, and policymakers tend to focus more on initial implementation and adoption, rather than paying attention to long-term maintenance and support. Second, there is often insufficient follow-up on implementation initiatives. While there are efforts to support the adoption and initial implementation of digital technologies, the focus can drift once the initial phase is complete. The absence of dedicated maintenance initiatives suggests a gap in the provision of ongoing support and optimization of these technologies within small enterprises.

Studies by Li (2022), Borštna and Pucihar (2021), and Costa et al. (2018) highlight that many small enterprises are still in the early stages of digital transformation and would benefit from support and resources to advance their digital maturity. This low level of maturity poses challenges, as small enterprises may stop using the technologies they have adopted and fail to grasp their benefits. Public policies can play a crucial role in supporting the digital transformation of small enterprises, offering financial, technical, and regulatory assistance to help them overcome barriers and to grow, as discussed in studies by Chen et al. (2021) and Rupeika-Apoga et al. (2022).

Based on our findings, we propose that implementation initiatives be complemented by maintenance efforts to ensure the effective and sustained use of the technologies adopted by small enterprises. Although two Brazilian initiatives address the maintenance phase, they are still in their early stages, and the results are not clearly perceived. Therefore, while implementation initiatives support the initial adoption and integration of digital technologies, maintenance initiatives would ensure ongoing support, updates, and optimization of these technologies. By creating a comprehensive support ecosystem that includes both implementation and maintenance initiatives, small enterprises can overcome challenges related to their digital maturity, sustain the use of adopted technologies, and fully enjoy the benefits of digital transformation. This integrated approach would contribute to the long-term success and competitiveness of small enterprises in the digital age.

Conclusions

This article summarizes the results of the benchmarking study, highlighting digitization initiatives implemented in small enterprises in various regions, including the BRICS countries, Tunisia, Germany, the European Union, Argentina, Mexico, and Colombia. The results indicate that most digitization initiatives for small enterprises are still in the early stages of the innovation diffusion process, with the main focus on the awareness phase. This phase includes training in digital skills and knowledge, qualification of the workforce, consulting services, organization of events, and dialogue platforms. In addition, initiatives that have reached the implementation phase tend to focus on investments, funding, and subsidies to support the acquisition and use of technologies. With the exception of two initiatives in Brazil, there is a notable scarcity of initiatives focused on maintaining digital technologies within small enterprises.

These results can be attributed to the current level of maturity of small enterprises in their digital transformation journey. Many of these enterprises are still familiarizing themselves with the technologies and their benefits, which explains why most initiatives focus on raising awareness. Implementation-oriented initiatives often rely on financial support to help decision-makers in small enterprises overcome barriers, and while digital technologies are not always inherently expensive, subsidies and funding play a crucial role in facilitating initial implementation. Such initiatives aim to create a critical mass of early adopters, who can then inspire other enterprises to follow suit without the need for ongoing government funding. By demonstrating the benefits and success of digital technologies, they seek to create a self-sustaining momentum that fosters a broader adoption among small enterprises.

Germany stands out among the countries that have successfully digitized their small enterprises, with well-structured initiatives for awareness and implementation that are making significant progress. Notable practices in Germany include Mittelstand-Digital 4.0, which supports small enterprises through centers of excellence that offer information, guidance, and funding to foster digital transformation. Another example is the Digital Jetzt program, which offers funding and consulting services to help small enterprises develop their digitization plans and make new investments in technology. While these

initiatives are well-structured and offer substantial support to small enterprises, they still do not fully address the three stages of innovation diffusion. To comprehensively support the innovation diffusion process, these initiatives must also be aligned with the maintenance phase, ensuring that small enterprises that adopt technology receive ongoing support and monitoring to optimize their results.

Initiatives aimed at fostering small enterprises in their digitization process must support them from start to finish, from awareness to maintenance. To this end, the same initiatives can be divided into three phases, with each phase focusing on a specific part of the innovation diffusion process. This strategy allows small enterprises to develop toward digitization and allows enterprises at different levels of maturity to benefit from the initiatives. In addition, it is essential to have reference sites for initiatives that cover all three stages, such as centers of excellence or hubs. Partnerships with universities, consulting businesses, and technology providers are also key to building a comprehensive initiative that includes all stages.

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Technology adoption and professional qualification: An analysis of the progress of digital transformation in Brazil

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The labor market undergoes constant transformations, driven by numerous exogenous influences, including technological changes. This dynamism also has an impact on the productive and organizational structures of enterprises, requiring rapid adaptation so that they are in line with new market practices and have professionals who comply with new needs. Consequently, this requires a qualified workforce to work in the new configurations of the labor market.

In this respect, the aim of this study is to identify the technologies in use by enterprises in the goods and services sectors, relating the results of a study carried out on the impact of automation on educational courses related to these economic sectors. To achieve this, the authors used two main sources of information: the ICT Enterprises survey database (Brazilian Network Information Center [NIC.br], 2024) and the results of the automation impact study developed by Lima and Pereira (2024) for the technical courses provided by Senac.

The first step of this study involved a descriptive analysis of the use of technology by enterprises with Social Security and Assistance Fund (FPAS, as per its acronym in Portuguese) 515, based on data from the ICT Enterprises survey for 2019, 2021, and 2023. These enterprises were identified based on the National Classification of Economic Activities (CNAE). The interest in this group of enterprises lies in the fact that they

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operate in the same economic activities, according to the CNAE, as Senac contributors (Senac, 2017). It is worth noting that this is an approximate identification, given that some enterprises may not be taxpayers even though they operate in an activity in the aforementioned sectors, as is the case with micro-enterprises or small enterprises that have opted for the Special Unified Regime for the Collection of Taxes and Contributions. Thus, the enterprises of interest analyzed here are identified as "FPAS-515 enterprises."

The descriptive analysis focuses mainly on questions related to the use and adoption of new technologies by enterprises (Module H), such as cloud storage software and Big Data, service robots, and Artificial Intelligence (AI). The description provides a historical comparison (considering the availability of data) of this adoption, taking into consideration the size, region, and market in which each enterprise operates, where applicable.

Analysis of the relationship between Senac's educational offer and the adoption of technologies in Brazilian enterprises is guided by the study that maps the impact of automation on Senac's educational offer. This study makes it possible to establish a direct relationship between the courses offered by the institution and automation, in order to connect automation, education, and work (Lima & Pereira, 2024). The study identified six main automation technologies: i) Data analysis; ii) Applied AI; iii) 3D/4D printing and modeling; iv) the Internet of Things (IoT) and connected devices; v) Digital platforms and applications; and vi) Extended reality. These technologies, similar to those investigated in the ICT Enterprises survey, will be related to the adoption of technologies in order to observe how enterprises are prepared for potential technological advances, while assessing how the institution's educational offer is aligned with the real productive changes in enterprises.

The authors hope to contribute evidence to the debate on the mismatch between demand for labor and professional qualifications. The results will make it possible to qualify the speed and level of the adoption of technologies in sectors that employ approximately 43% of the formal workforce in the country, according to data from the 2022 Annual List of Social Information (Rais) (Ministry of Labor and Employment, 2024), in addition to contributing a significant portion of Brazil's gross value added (IBGE, 2024). At the same time, the aim of the study is to suggest ways to help educational institutions plan learning opportunities that is more in line with the real skills demanded by employers.

This article is divided into five sections, including this introduction. The second section characterizes the sample and includes methodological considerations. The third section presents the status of the adoption of technologies by enterprises, while the fourth section reflects on automation and educational provision. Lastly, a conclusion is presented.

Characteristics of FPAS-515 enterprises

Charts 1 and 2 show the proportion of FPAS-515 enterprises based on their geographical and sectoral distribution, respectively, throughout the 2019, 2021, and 2023 editions of the ICT Enterprises survey. Overall, 49.6% of the 2023 sample was FPAS-515. Although the Southeast region had a higher proportion of these enterprises (approximately 51% of the total), in the Center-West and North regions, FPAS-515 enterprises represented a larger share of the market (69% in 2023).

CHART 1
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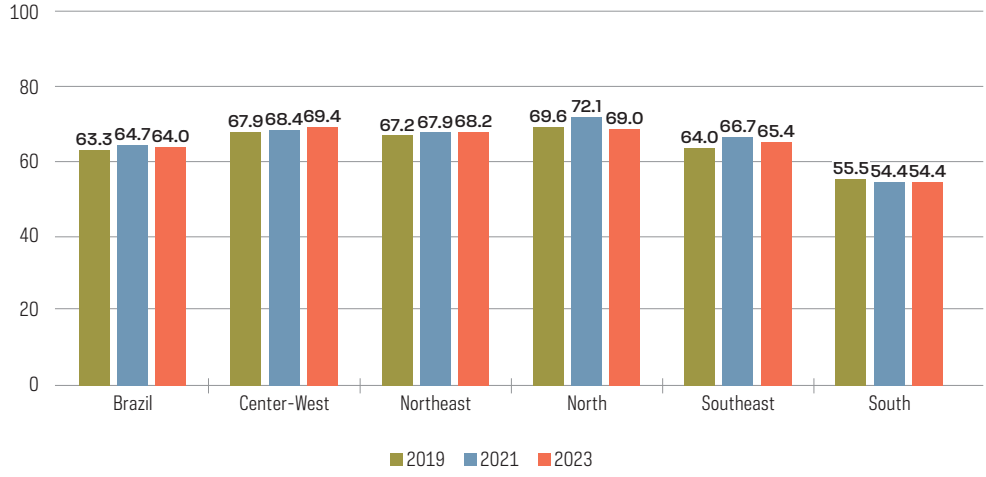
Proportion of FPAS-515 enterprises by region (%)



Source: NIC.br (2024).

In sectoral terms, as expected given their economic nature, in 2023 almost all enterprises in the accommodation and food services sector (99.2%) are listed as FPAS-515. The presence of enterprises in the sectors of wholesale and retail trade, repair of motor vehicles and personal and household goods (95.7%), and real estate activities, professional, scientific and technical activities, administrative and support service activities (89.9%) is also representative, while enterprises in the manufacturing and construction sectors have lower percentages of FPAS-515 enterprises.

CHART 2

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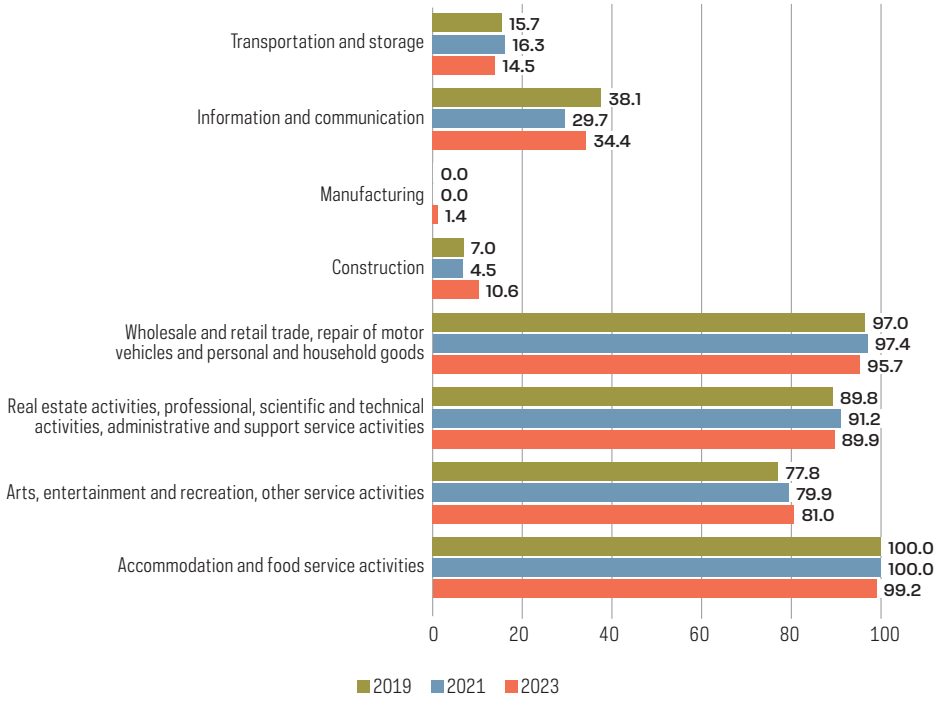
Proportion of FPAS-515 enterprises by sector of economic activity (%)



Source: NIC.br (2024).

Technology adoption

This section presents the adoption of technologies by Senac's potential contributing enterprises, based on the results of Module H (New technologies) of the 2019, 2021, and 2023 ICT Enterprises surveys. Chart 3 shows the proportion of enterprises in our analysis group that used cloud services. It can be seen that all services, except finance or accounting software, have grown over the editions of the survey. The biggest increase was seen in the use of cloud email, which rose from 38.4% in 2019 to 52.3% in 2023 (13.9 percentage points [p.p.]). The use of environments for developing, testing, or deploying applications is still low.

CHART 3

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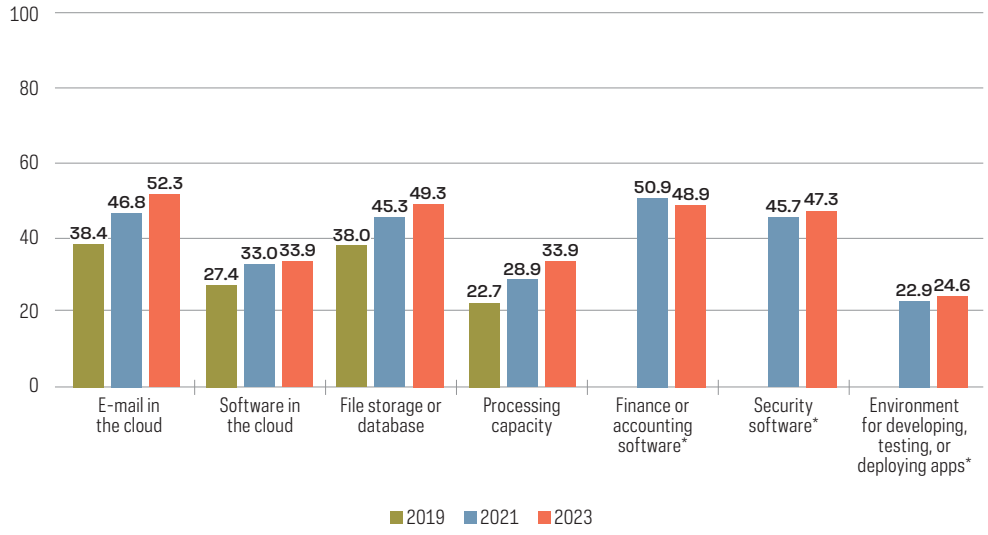
Proportion of FPAS-515 enterprises that used cloud services (%)



Note: *Technologies that were not investigated in 2019.

Source: NIC.br (2024).

Chart 4 shows that IoT was the most widely used technology (31.1%), while the second was Big Data, which had less than half as many enterprise users (14.5%) as IoT. There was also less use in 2023, compared to 2021, of IoT technologies and robots—either service or industrial. The use of Big Data and 3D printing, on the other hand, presented an increase in enterprises over the period analyzed.

CHART 4

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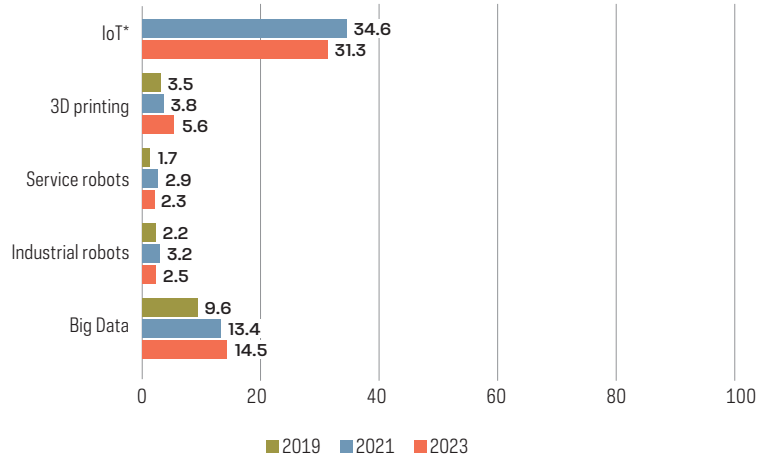
Proportion of FPAS-515 enterprises that used various technologies (%)



Note: *Technologies that were not investigated in 2019.
Source: NIC.br (2024).

Regarding the use of AI by enterprises, there was a reduction in use between 2021 and 2023 for all types of technology applications (Table 1). These inferences should be analyzed cautiously, considering the high coefficient of variation in the data. Regarding the use of AI software or systems applied in business areas, there was also a decrease between 2021 and 2023 for enterprises that used at least one type of AI application. The exceptions were the use of AI for marketing or sales (an increase of 6.2 p.p.), production processes (0.9 p.p.), and human resources management (0.8 p.p.). On the other hand, there was a considerable drop in the use of AI in the areas of digital security (-9.7 p.p.) and business management (-5.5 p.p.) among FPAS-515 enterprises.

Comparing FPAS-515 and non-FPAS-515 enterprises in terms of AI use in 2023, it was observed that FPAS-515 enterprises used AI more in human resource management (35.7% compared to 32.0% of non-FPAS-515 enterprises) and marketing and sales (47.4% compared to 46.5%). In the other types of application and business areas, FPAS-515 enterprises made less use of AI.

TABLE 1

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Proportion of enterprises that used AI technologies, by type of application and business area

Type of application and business area	FPAS-515			Non-FPAS 515	
	2021 (%)	2023 (%)	△ 2023-2021 (p.p.)	2023 (%)	△ 2023 FPAS 515 and Non-FPAS 515 (p.p.)
Type of application					
Workflow automation	72.8	64.7	-8.2	68.5	-3.8
Recognition and processing of images that identify objects or people	34.9	32.3	-2.6	32.5	-0.3
Machine learning for data prediction and analysis*	21.8	13.7	-8.1	19.4	-5.7
Text mining and written language analysis*	23.8	13.6	-10.2	16.9	-3.3
Natural language generation (NLG) for written or spoken language*	17.9	11.8	-6.2	15.5	-3.7
Speech recognition (converts spoken language into a machine-readable format)*	14.0	11.1	-2.9	11.4	-0.3
Physical movement of machines through autonomous decisions, such as autonomous robots, vehicles, and drones*	10.6	5.4	-5.1	7.8	-2.4
Business area					
Marketing or sales	41.2	47.4	6.2	46.5	0.8
Digital security	51.5	41.8	-9.7	45.9	-4.1
Business management	43.3	37.8	-5.5	40.1	-2.3
Human resource management or recruitment	34.9	35.7	0.8	32.0	3.7
Organization of business administration processes	39.7	34.7	-5.0	40.5	-5.9
Logistics	34.6	31.7	-2.8	33.5	-1.8
Production processes	27.3	28.2	0.9	38.4	-10.2

Note: Estimates with low statistical precision (coefficient of variation [CV] > 15%).
Source: NIC.br (2024).

In addition to the use of technologies per se, it is important to understand the reasons why enterprises are not using AI tools as much. Between 2021 and 2023, the justifications for enterprises not adopting these technologies also showed some variations, reflecting changes in the perceptions and challenges faced by organizations. The high cost remains one of the main obstacles, suggesting that the investment needed to implement these tools is still limited. In addition, the lack of people trained to operate AI technologies has increased markedly (40.5% in 2021 to 46.5% in 2023), which highlights a need for skilled labor to deal with these issues.

Incompatibility with existing systems and equipment and the perception that these technologies are not useful for the enterprise are still relevant barriers, suggesting that the adoption of AI may be gradually adjusting to the reality of enterprises. Ethical and legal issues, however, gained greater prominence in 2023, which may be linked to discussions about digital relationships, as well as regulations on the use of AI tools.

TABLE 2

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Proportion of enterprises that did not use any AI technology, by reason

Reasons for not using AI	FPAS-515			Non-FPAS-515	
	2021 (%)	2023 (%)	△ 2023-2021 (p.p.)	2023 (%)	△ FPAS-515 and Non-FPAS 2023 (p.p.)
Incompatibility with existing equipment, software, or systems in the enterprise	53.3	52	-1.3	61.7	-9.6
Lack of knowledge about AI technologies suitable for the enterprise's activities	43	49.8	6.8	51.2	-1.4
AI technologies are not useful to the enterprise	52.7	49.2	-3.5	44.4	4.7
Lack of people trained, in the enterprise, to use these technologies	40.6	46.5	6	52.3	-5.7
The costs seem too high	43.8	45	1.2	53.5	-8.5
Difficulties in the availability or quality of the data necessary to use these technologies	43	43.4	0.4	47.4	-4
Lack of clarity about the legal consequences of using these technologies, such as in cases of harm caused by the use of AI	27.4	36.4	8.9	32.8	3.5
Concerns regarding violation of data protection and privacy	33	35.7	2.7	33.3	2.4
Ethical reasons	20.7	27.9	7.1	24.0	3.8

Source: NIC.br (2024).

However, ethical and legal issues, high costs, and a lack of knowledge about the most suitable technologies mainly affected smaller enterprises (10 to 49 employed persons) which, between 2021 and 2023, pointed out these issues as reasons for not adopting AI technologies. For larger enterprises (250 employed persons or more), these issues have become less frequent and, for more than half of large enterprises, one of the reasons for not adopting AI technologies was the lack of skilled people or incompatibility with equipment, software, or systems that already exist in the enterprise. In the case of medium-sized enterprises (50 to 249 employed persons), the reasons that most affected them were the lack of knowledge about suitable technologies combined with the incompatibility of equipment.

Automation and workforce training

The ICT Enterprises survey provides information on the adoption of technology by enterprises, revealing an important part of the dynamics of technological change in Brazil. To understand another fundamental aspect of this change, it is necessary to analyze the impact of technologies on vocational education, which is responsible for preparing a significant part of the workers who will be employed by enterprises and can be a catalyst in this process. Lima and Pereira (2024) therefore proposed a study to assess the impact of automation on vocational education, in which they presented Senac's technical courses as a case. To do this, they used generative AI to support the evaluation of 2,100 competence indicators (CI) of the National Course Plans of 35 technical courses offered by Senac. Each CI could be impacted by up to three technologies, with five possible levels of automation (none, low, medium, high, or total). The authors analyzed seven different technology categories: 3D/4D printing and modeling (PRT); Extended reality (XR); Robotics (RBT); Internet of Things (IoT); Data analysis (DA); Applied AI (AAI); and Digital platforms and applications (APP).

Given the similarity between the technologies mentioned in the questions in Module H of the ICT Enterprises survey and those used in the study by Lima and Pereira (2024), it is interesting to note how much each of them appeared in the assessment of the impact of automation on CI. The APP category was mentioned in 1,141 cases, approximately three times more than the following categories: AAI was cited in 401 cases and DA in 400. Among the least mentioned were PRT and XR (25 and 40 mentions, respectively).

CHART 5

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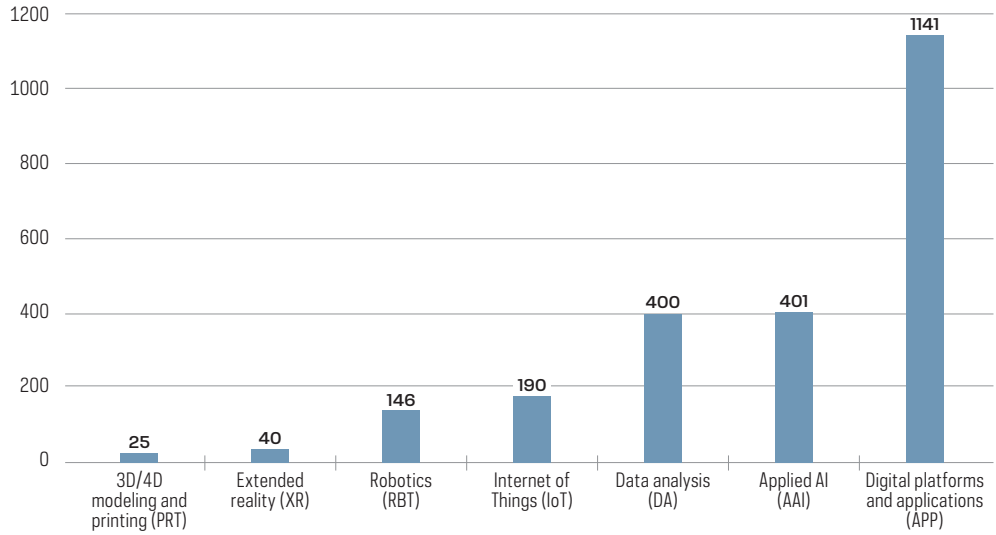
Total number of mentions by technology category



Source: Lima & Pereira (2024).

The results also show that approximately 70% of the CI of the courses analyzed had low (31%) or medium (39%) levels of automation impact. Only 0.7% of the CI were assessed as having a full level, 16% as high, and 13% as none. The technological axis of "Educational and social development" courses, whose only course was School Secretary Technician, had the highest impact forecast – 40% of its CI were likely to receive a high automation impact. On the other hand, the CI of the "Environment and health," "Tourism, hospitality and leisure," "Security" and "Cultural production and design" axes had a lower probability of automation, with between 10% and 20% of their CI in the highest range. The "Management and business" and "Information and communication" axes, which concentrate most of the courses offered by the institution, had mixed results (between 22% and 25%).

Final considerations

This study was dedicated to understanding the relationship between the adoption of technologies by enterprises and the qualification of their workforce. For this purpose, it considered the enterprises identified as FPAS-515, which are potentially contributors to Senac, and the technical courses offered at this institution.

The analysis of the adoption of technologies shown by the ICT Enterprises survey revealed that taxpaying enterprises have increased their use of cloud software (except finance and accounting software), while the impact of automation on technical courses also highlights digital platforms and applications as the technology that was most cited.

Another similarity between the studies was the low occurrence of robotics and 3D printing, both in terms of adoption by enterprises (below 5% for both technologies) and in relation to courses (146 and 25 mentions, respectively). IoT is a technology that, despite being one of the most used by contributing enterprises (31.3% in 2023), did not feature as prominently in the study on the impact of automation.

Finally, AI deserves a separate analysis, given the importance of this technology, especially since the end of 2022, when ChatGPT was launched. Despite this moment of prominence for AI between the 2021 and 2023 editions of ICT Enterprises, the results show that the use of AI in FPAS-515 enterprises fell in the vast majority of application types and business areas. This is not an isolated result for contributing enterprises, as there has been stability in the use of AI in general, as pointed out by ICT Enterprises (NIC.br, 2024).

Given this reduction or stagnation in the use of AI, it is essential to understand the reasons why FPAS-515 enterprises do not adopt AI in their operations. Incompatibility with equipment or software (52.0%), the uselessness of AI technologies for the enterprise (49.2%), lack of knowledge about suitable AI technologies (49.8%), lack of trained people (46.5%), and high costs (45.0%) were the reasons most commonly mentioned. The increased presence of all these factors between 2021 and 2023, except the uselessness of the technologies, shows the challenge for enterprises in adopting AI.

Some of these reasons are directly related to professional qualifications, such as the lack of trained people and the lack of knowledge about suitable technologies, while other obstacles could be more easily overcome if the AI workforce were more qualified, such as the high costs that can be reduced if professionals know AI solutions well and can suggest better options in financial terms. In this sense, the study on the impact of automation highlights Applied AI as the second most mentioned technology (401 times).

It is therefore essential to include Applied AI in the national curricula of the courses in which this technology is considered most relevant, so that the professional performance of graduates can act as a catalyst for the adoption of AI in FPAS-515 enterprises. At the same time, enterprises need to invest in qualified professionals to map out the possible solutions and/or improvements that these technologies can offer and thus become more competitive, ensuring an effective digital transformation in Brazil.

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Social networks, training, and strategies for adopting digital technologies[1]

Emerson Gomes dos Santos[2] *and Márcia Siqueira Rapini*[3]

The growing importance of digital technologies in enterprises requires an adequate assessment of their adoption, a challenge that is intensifying due to the pervasiveness, intangibility, and speed of progress of these technologies (Ferraz et al., 2019; Gambardella & Torrisi, 1998). Thus, characteristics that determine the adoption of these technologies have been analyzed in the reference literature.

A study by Rosa and Kubota (2024) is among the most recent studies identifying difficulties for and obstacles to enterprises adopting digital technologies. The authors state that digital transformation is still a process limited to large enterprises, which can access the necessary technical knowledge and adequate funding and have qualified workforce. They also highlight the importance of having a digital security policy when adopting digital technologies. Other studies have identified that the extent of the adoption of digital technologies and their speed of incorporation vary according to the size of the enterprise and the technological intensity of the sector (Ruiz et al., 2023; Torracca et al., 2023).

Regarding human resources, which are fundamental for incorporating new technologies into organizational practices, according to the National Confederation of Industry (CNI, 2016), the structure and culture of enterprises, as well as their lack of technical knowledge, are some of the main internal obstacles to implementation. Among the external barriers, the lack of qualified workers was pointed out as a relevant factor, as well as the unpreparedness of customers and suppliers.

[1] Special thanks to the National Council for Scientific and Technological Development (CNPq) for project 311722/2023-7.

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In this context, the present article assesses whether training activities, engagement (or cooperation) with customers, and collaboration with partners in social networks increase the adoption of digital technologies. In addition, it analyzes how the fact that enterprises have a strategy influences the incorporation of digital technology, understanding that the success of a strategy depends on the existence of an appropriate organizational structure and the organizational capabilities supporting it (Dosi, 1982; Nelson & Winter, 1982).

The following hypotheses were tested: (a) training actions increase the adoption of digital technologies; (b) digital policies and strategies that consider training increase the adoption of digital technologies; and (c) customer and employee engagement with partners through social networks increases the adoption of digital technologies.

Methodological approach and analysis

To test the hypotheses, the researchers used microdata from the ICT Enterprises 2021 survey, which were made available to one of them through a cooperation agreement signed with Unifesp in 2023 (Brazilian Network Information Center [NIC.br], 2022). As dependent variables (Y), the authors considered the adoption of the following technologies, according to the questionnaire: cloud storage (B18_1_3), cloud processing (B18_1_4), Big Data (H1), the Internet of Things (IoT) (H7), and Artificial Intelligence (AI) (H9_AGREG). As independent variables, the following were defined: training, digital security/strategy, and social networks, from: B7B_1, F7A, D16_D, D12_I, B16_9_1 and B16_12_1 (Table 1). Finally, enterprise size, region, and market were considered as controls.

TABLE 1

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Definition of the variables selected for the study

Variable	Variable description	Response categories
Training	Characterization of the enterprise according to three variables: B7B_1, F7A, and D16_D	0 = "If no training was taken" (0 in all three variables); 1 = "If the Internet was used for training" (1 in B7B_1); 2 = "If ICT training was provided" (1 in F7A); 3 = "If risk management training was promoted" (1 in D16_D); 4 = "If two of the three training programs were offered"; 5 = "If all three training programs were offered" (1 in all three variables).
Digital security/ Strategy	Characterization of the enterprise based on the variable: D12_I	0 = "Does not have a digital security policy/strategy" (99 in D12_I); 1 = "The strategy does not cover awareness-raising and training activities" (0 in D12_I); 2 = "The strategy covers awareness-raising and training activities" (1 in D12_I).

CONTINUES ►

► CONCLUSION

Variable	Variable description	Response categories
Social networks	Characterization of the enterprise based on the variables: B16_9_1 and B16_12_1	0 = "Does not have a profile or account on social networks or has not involved customers in development or has not collaborated with partners" (If 99 or 0 in B16_9_1 and B16_12_1); 1 = "Did not involve customers in development, but collaborated with partners" (If 0 in B16_9_1 and 1 in B16_12_1); 2 = "Involved customers in development, but did not collaborate with partners" (If 1 in B16_9_1 and 0 in B16_12_1); 3 = "Involved customers in development and collaborated with partners" (If 1 in both B16_9_1 and B16_12_1).

Source: prepared by the authors.

Of the total of 4,064 enterprises in the sample, 61 were excluded because they declared that they did not use the Internet (question B1 = 0) and another 224 enterprises because the respondents did not answer or answered "don't know" to the questions: P3 (not having an IT department), B7B_1, F7A, D16_D, D12_I, B18_1_3, B18_1_4, H7, B16_9_1, and B16_12_1. At the end of this process, the final base contained 3,779 enterprises (93% of the initial gross base) for use in logistic regression models, considering the sample design (Heeringa et al., 2017).

Results

Table 2 shows the results for the logistic regression models, with each technology as the dependent variable in two views (Model 1 and Model 2), to test whether there is a difference in the adoption of each technology for training actions, in relation to the enterprise having a digital policy/strategy and the use of social networks (to involve customers in developing innovation and collaborate with partners).

The model known as "Model 1" was first estimated using only the control variables (size, region, and market). The results show that no differences were found in terms of technology adoption between regions.

In terms of size, there is a significant difference in adoption between medium-sized (50 to 249 employed persons) and large enterprises (250 or more employed persons) when compared to small ones (20 to 49 employed persons), except in the case of IoT in medium-sized enterprises. Regarding Big Data, medium-sized enterprises had a 1,468-fold higher chance of adoption, while large enterprises had a chance 2,067 times higher. For AI, the chance of adoption is 2,143 times greater for medium-sized enterprises and 4,554 times greater for large enterprises.

Regarding their market segment, taking the manufacturing market as a reference, the knowledge-intensive services (KIS) sector is around twice as likely to adopt cloud storage and processing and AI, and approximately 1.6 times more likely to adopt IoT. However, it was not possible to detect differences between the sectors for IoT. It should be noted that as for the sector, in addition to manufacturing and construction, "KIS" were considered

to be the combination of the survey categories: "information and communication"; "real estate activities"; "professional, scientific and technical activities"; and "administrative and support service activities". The following categories were considered "other services": "wholesale; repair of motor vehicles, personal and household goods"; "transportation and storage"; "accommodation and food service activities"; "arts, entertainment and recreation"; and "other service activities".

This first analysis was carried out to evaluate the control variables so that they could be taken into account when testing the hypotheses. The models labeled "Model 2" reflect the results, considering the removal of the region variable (not significant in Model 1) and the insertion of the variables of interest (training, digital security/strategy, and social networks).

Based on an initial comparison, it can be seen that when the variables are considered, there are no significant differences for size and sector in most cases, except in the case of size for AI and sector for Big Data. In terms of AI adoption, it is 1,415 and 2,264 times higher for medium-sized and large enterprises, respectively. As for the market in which they operate, there is a significant difference, with enterprises in the KIS sector now less likely to adopt Big Data technology in the presence of the other variables, a reduction of approximately 54%. This reduction in the importance of the control variables when other variables were added may indicate a lack of explanatory variables in Model 1 (omitted variables). With the importance of these variables in explaining the adoption of technologies, their significance means that the differences in size and sector are reduced in terms of the actions enterprises can take to adopt these technologies.

In relation to these actions, the training variable (hypothesis 1) was significant for cloud (both for storage and processing); in these two cases, any type of training increases the chance of adoption compared to not providing training. There was an increase in the chance of adoption of between 2.5 and 3 times, and up to approximately 4 times in the case of the enterprise offering all the training considered. The results also show that, for AI, any combination of training offered increases the chance of adoption of this technology, except in the case of risk management training, which was not significant. Finally, for Big Data and IoT technologies, more training proved to be effective in increasing enterprises' chances of adoption. Only by offering two training sessions for IoT and three for Big Data was there greater importance in terms of the chances of adopting these technologies. These results are similar to those found by Ruiz et al. (2023), who state that training aimed at digital technologies is more relevant than qualifying the workforce to adopt them. However, we expand the results by considering other forms of training.

Compared to enterprises that do not have a digital security policy/strategy (hypothesis 2), having one increases the chance of adopting all the technologies assessed, except IoT, where the policy needs to include awareness-raising and training activities to be relevant to adoption. This result is also in line with Rosa and Kubota (2024), who identified that the adoption of digital technologies is related to the existence of a digital security policy, and that the latter is related to the enterprise size and its ability and need to design a strategy in the area. It is also worth highlighting the expansion of this research topic, as the variable considers two possibilities: "the strategy does not cover awareness-raising and training activities" or "the strategy covers awareness-raising and training activities."

Finally, regarding the social network variable (hypothesis 3), and considering as a reference enterprises that do not have an account on these networks or that have not carried out either of the two actions (involving customers in development and collaborating with partners), the categories had different levels of importance between the technologies, and it can be emphasized that for cloud processing and the use of Big Data and AI, carrying out both actions is needed to increase the chance of adoption. For IoT, the chance is increased by doing both or just one of the two. For cloud storage, collaborating with partners proved to be relevant, increasing the chance of adopting this technology. Thus, all the hypotheses were verified.

TABLE 2

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Estimates for the logistic regression models in relation to the independent variables (technologies)

	Odds ratio									
Coefficients	Cloud storage		Cloud processing		Big Data		IoT		AI	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Size ref. = 20 to 49 employed persons										
50 to 249 employed persons	1.877***	1.233	1.622***	1.03	1.468*	1.024	0.933	0.766	2.143***	1.415*
250 or more employed persons	2.254***	1.07	2.443***	1.131	2.067***	1.204	1.37*	1.021	4.554***	2.264***
Region ref. = North										
Northeast	0.991		0.962		0.982		1.321		0.672	
Southeast	0.954		0.977		1.266		0.708		0.799	
South	1.138		0.94		1.588		1.132		0.724	
Center-West	1.018		1.021		1.565		1.384		0.872	
Market ref. = Manufacturing										
Construction	1.102	1.206	0.974	1.164	0.547	0.55.	1.024	1.048	0.824	0.993
KIS	1.836***	1.16	1.866***	1.176	0.827	0.464**	1.597*	1.211	2.033***	1.278
Other services	0.912	0.794	0.968	0.872	0.984	0.826	1.332	1.271	0.997	0.879
Training ref. = If no training was taken										
If the Internet was used for training		2.645***		2.331***		1.515		0.986		2.302**

CONTINUES ▶

	Odds ratio									
Coefficients	Cloud storage		Cloud processing		Big Data		IoT		AI	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
If ICT training was provided		2.475***		2.345**		1.053		1.102		3.603***
If risk management training was promoted		2.492*		3.027**		0.258.		1.332		1.27
If two of the three training programs were offered		2.887***		2.812***		1.947		1.782*		3.61***
If all three training programs were offered		3.665***		4.119***		3.251**		2.15*		5.296***
Strategy ref. = Does not have a digital security policy/strategy										
The strategy does not cover awareness-raising and training activities		1.837***		2.297***		2.774*		1.443		2.548***
The strategy covers awareness-raising and training activities		2.551***		3.361***		6.212***		1.487.		3.591***
Social networks ref. = Does not have a profile or account on social networks or has not involved customers in development or has not collaborated with partners										
Did not involve customers in development, but collaborated with partners		1.647*		1.26		1.971.		1.814*		1.299
Involved customers in development, but did not collaborate with partners		0.848		1.322		1.434		2.13**		1.463

CONTINUES ▶

	Odds ratio									
Coefficients	Cloud storage		Cloud processing		Big Data		IoT		AI	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Involved customers in development and collaborated with partners		1.421*		1.404*		2.161**		2.777***		2.309***

Note: significance codes: '***' p < 0,001; '**' p < 0,01; '*' p < 0,05; '.' p < 0,1.
Source: prepared by the authors.

Conclusion

Given the growing importance of digital technologies, analyses are needed to properly assess their adoption, which is a challenge due to their pervasiveness, intangibility, and speed of progress. Previous studies have analyzed the adoption of digital devices to identify relevant characteristics of adoption by enterprises. However, there is still room to provide evidence on determining factors for the adoption of these digital technologies.

In light of this opportunity to broaden the discussion and better understand the complexity of evaluating digital adoption, three hypotheses were raised, mainly considering: (a) training activities, given the internal obstacles of the enterprise's culture and the lack of technical knowledge for implementing digital technologies; (b) the existence of a digital policy/strategy that considers training, since the success of a strategy depends on the existence of an organizational structure, as well as the capabilities that support it; and (c) social networks in relation to their role in engaging with customers and collaborating with partners, which can increase the adoption of digital technologies.

To evaluate the proposed hypotheses, the authors used the ICT Enterprises survey microdata base and specific definitions for the variables related to the factors to be tested in relation to the adoption of the following technologies: cloud storage, cloud processing, Big Data, IoT, and AI. The results, in general, are compatible with expectations and have already been found in other studies in relation to the differences in technology adoption between enterprises of different sizes: the larger the size, the greater the chance of adoption. In terms of sector, KIS were more likely to adopt cloud storage and processing and AI and IoT than the manufacturing market.

Specifically in relation to the hypotheses and the novel contribution, it was found that training increases the chance of adoption of the technologies, especially the cloud (both for storage and processing), with the chance of adoption increasing more when enterprises offered more training. One point worth noting for AI is that any combination of training offered increased the chance of adoption of this technology, except in the case of risk management training, but it was not possible to identify its importance. For Big Data and IoT, only a greater amount of training was effective in increasing the chance of adoption.

Regarding having a digital security policy/strategy, it was found relevant for all technologies, except for IoT, where the policy also needs awareness-raising and training activities to be relevant. Finally, the use of social networks had different levels of importance between the technologies: Involving customers in development and collaborating with partners increases the chance of adoption for cloud processing, Big Data, and AI just by carrying out both activities. For IoT, the chance is increased by doing both or just one of the two, and for cloud storage, collaborating with partners proved to be relevant, increasing the chance of adopting this technology.

These preliminary results were promising enough to indicate a path to be explored. Enterprises can consider certain factors as facilitators of the adoption of digital technologies and can reflect on how to invest, for example, in training actions and the way they act on social networks, evaluating the benefits in relation to the adoption of these technologies. Some limitations regarding the information available on the secondary database used may limit the choices and possibilities for analysis, but future studies may consider other databases to enrich the data.

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Artificial Intelligence and privacy: Assessing the risks and potentials

Karina Kaehler Marchesin[1]

Over the last few decades, we have witnessed the emergence of a new era in which the barriers between the physical, digital, and the biological have become increasingly blurred. Driven by unprecedented integration between these domains[2] and the use of advanced technologies,[3] the Fourth Industrial Revolution[4] is promoting profound transformations in the structures of society. This era of digital innovation, characterized by a more ubiquitous and mobile Internet, is reshaping economies and leading to an unprecedented acceleration of digital evolution.

Regarded as one of the pillars of Industry 4.0, AI[5] has revolutionized various sectors,[6] providing valuable opportunities for improving efficiency and decision-making. Within this field, generative Artificial Intelligence stands out, consisting of systems built on large language models (LLM). These systems use sophisticated machine learning techniques to answer questions and perform tasks, based on statistical probabilities. In addition, they are trained with extensive and varied data sets, which can include publicly accessible information.

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[2] Professor Klaus Schwab, founder of the World Economic Forum (WEF), believes that this phase will be built around "cyber-physical systems" in which the boundaries between the physical, the digital, and the biological are blurred (Schwab, 2016).

[3] Some examples are Big Data, the Internet of Things (IoT), Artificial Intelligence (AI), machine learning (ML), robotics, augmented reality, and blockchain.

[4] Industry 4.0, or the Fourth Industrial Revolution, refers to production techniques and automation technologies, with a focus on improving the efficiency and productivity of production chains.

[5] The concept of AI, as we know it today, emerged in the 1940s, highlighted by the "Turing test" in 1950, when scientists began to explore the possibility of creating machines capable of simulating human intelligence.

[6] Over the past decade, innovations in AI have made it an essential component of contemporary society, impacting sectors such as health, finance, transportation, and entertainment.

The impact of AI on economies and enterprises is revolutionary. According to a report by the McKinsey Global Institute, generative AI could add between US$2.6 and US$4.4 trillion annually to the global economy, increasing the total impact of AI by 15% to 40% (Chui et al., 2023). The consulting institute foresees that between 2040 and 2060, this technology will automate half of all jobs, bringing the change forward by a decade compared to previous projections. Goldman Sachs (2023), in turn, estimates a 7% growth—around US$7 trillion—in global gross domestic product (GDP) due to this automation.

Governments have intensified efforts to establish guidelines and measures that promote innovation while safeguarding individual and collective rights, seeking to balance technological advancement with data protection.[7] In a historic initiative, the European Union approved the Artificial Intelligence Act (EU AI Act) in March 2024, establishing a comprehensive legal framework for the governance of these systems. In Brazil, Bill No. 2238/2023, approved by the Senate, proposes the creation of an ethical and regulatory environment on the subject, which is being closely monitored by various sectors of civil society, academia, and enterprises.

The implementation of privacy regulations worldwide underscores the growing need to protect data in emerging technologies such as AI. Establishing strict standards and oversight mechanisms is a vital step toward creating a future in which AI is used for the benefit of society, without compromising individual rights and freedoms.

Although the benefits derived from this technology are numerous, its increasing application also intensifies concerns about the potential associated risks. This raises questions about security and privacy, especially in view of the dependence on these systems to collect and process large volumes of data, including personal data, for learning and performance improvement purposes.

In countries of the Global South, where challenges related to Internet infrastructure and access to electricity are still significant, the impact of AI on privacy takes on even greater importance. Vulnerable populations are at greater risk of surveillance, discrimination, and biased or inappropriate decisions, often stemming from AI systems designed without considering local contexts. The challenges associated with these technologies highlight the need to reevaluate design policies and conduct situated studies that take into account the specific realities of these countries (Dubber et al., 2020). Failure to adapt the technology to these particularities could jeopardize not only its effective implementation, but also the ability to protect the privacy of their citizens and address the associated risks.

Given these concerns, there is a need to address the social, ethical, and legal impacts of using these systems, as well as compliance with privacy laws, to ensure not only adequate protection, but also responsible and ethical use of information.[8]

[7] While China adopts specific standards and the United States chooses general guidelines in its AI Blueprint, the United Kingdom and Peru seek to balance innovation and existing regulations.

[8] Recently, the European Union Parliament took an important step to protect privacy in the age of AI, with most of its members supporting a proposal to ban AI surveillance in public spaces, reflecting concerns about the violation of fundamental rights.

The need for privacy in AI systems

Machine learning and AI are becoming established as transformative solutions across various sectors of society. With the accelerated advance of technology, AI has a constant presence in everyday life. From generative systems that produce content based on simple commands to smart home devices that learn and adapt to our habits and preferences, this revolutionary potential promises to radically change our interaction with technology, taking efficiency and personalization to new heights.

However, the data-driven nature of AI systems requires large volumes of information to train and optimize algorithms, making the access to and processing of personal data practically inevitable.[9] Given the exponential growth in the sharing and generation of data online, privacy concerns are becoming increasingly urgent. This reality forces us to confront the ethical challenges and responsibilities that emerge as we navigate a world where technology and privacy often clash.

Privacy is a fundamental right that grants individuals control over their personal information, preventing unauthorized access, and its importance in the digital age cannot be underestimated. In the context of AI, ensuring privacy is essential to avoid manipulation of or discrimination against individuals.

As they process data on a large scale, AI systems intensify existing threats and introduce new challenges. The Future of Privacy Forum (2017) classifies the potential damage caused by these automated systems into four main areas: economic losses, loss of liberty, loss of opportunities, and social detriment. These impacts transcend the individual sphere, affecting society as a whole in ways that cannot be mitigated by the exercise of individual rights alone.

The growth in data collection and analysis raises questions about the compliance of these systems with the right to privacy, considering that much of the data processed can be sensitive. Even in the absence of identifiable information, advanced techniques can be employed to extract sensitive personal data, which further reinforces the need for protection mechanisms. To address this, their development must incorporate solutions that identify and mitigate privacy threats at all stages of the life cycle, integrating protection into the device design and ensuring its management throughout the entire process (Jagtap, 2024). Furthermore, the ability to analyze large volumes of information can lead to excessive surveillance and the silent collection of data by third parties, often without the proper consent of users, as highlighted by Meinhardt and King (2024). Such large-scale monitoring can result in discrimination, prejudice, and exclusion, especially if systems are poorly tailored or improperly implemented.

In addition, training algorithms data can embed biases. These biases, often linked to a lack of diversity in the sector, have the potential to introduce and intensify existing forms of oppression and discrimination. This not only impacts how the technology is applied, but also affects the distribution of benefits and risks, reflecting on the fairness

[9] Examples include providing personal and financial information to determine eligibility for financial support and collecting cookies and browsing history to offer personalized advertising.

of its adoption. Therefore, it is essential that the development and implementation of AI considers the protection of privacy, diversity, and inclusion, ensuring that these technologies are both fair and accessible to all.

According to the European Data Protection Supervisor (EDPS, 2024), Generative AI systems must be transparent, explainable, consistent, auditable, and accessible in order to ensure the fair processing of personal data. AI must be used responsibly and in compliance with the law. This implies the ethical and legal development of systems, considering unintended consequences and adopting a risk-based approach, as well as ensuring transparency regarding the use of training data, the creation of algorithms, and the identification of possible biases.

In young democracies, institutional instability makes it urgent to promote diverse forms of citizen engagement, involving civil society to prevent digitization from perpetuating oppression and inequality. Given the potential impact of AI on the economies of these countries and their role in the global economy, it is essential to adopt a plural approach that considers the specific needs and concerns of the affected communities, recognizing the intersectionality and diversity between regions. To achieve this, it is essential to transform how decisions regarding design, data, and implementation are made, ensuring that the populations of the Global South have the necessary tools to effectively engage with issues that directly impact them. The life cycle of AI systems encompasses stages such as collecting, cleaning, analyzing, integrating, and processing information, each of which can pose threats to privacy and ethical handling. To ensure that AI technology respects individual rights and freedoms, it is essential that it is subject to effective regulations and supervision. This involves not only the collection and use of data, but also the design and development of systems that guarantee transparency, explainability, and impartiality in order to ensure that decisions are fair and equitable. Therefore, it is essential to adopt robust measures that safeguard data protection and compliance with individual rights at all stages of development.

In Brazil, although the adoption of emerging technologies has begun to spread among enterprises, data from the ICT Enterprises 2023 survey (Brazilian Internet Steering Committee [CGI.br], 2024) revealed that the use of advanced technologies, such as cloud services, IoT, and AI, remains at only 14%, with a higher concentration in large organizations and in the information technology sector. This indicates that, despite the increase in connectivity, the implementation of technological innovations in Brazil faces challenges. With 84% of use related to facility security, the use of more complex devices to automate processes is still limited.

The use of AI has remained stable, standing at 13% in 2021 and 2023. It was more common among large enterprises and in the information and communication sector, with 66% of organizations using AI for process automation and 32% for image recognition and processing[10] (Chart 1).

[10] More advanced resources, such as machine learning and NLG, are mentioned less frequently, at 16% and 13% respectively, indicating that although the digitization of enterprises has advanced in the pandemic, the adoption of digital technologies such as IoT and AI is still limited to specific processes.

CHART 1

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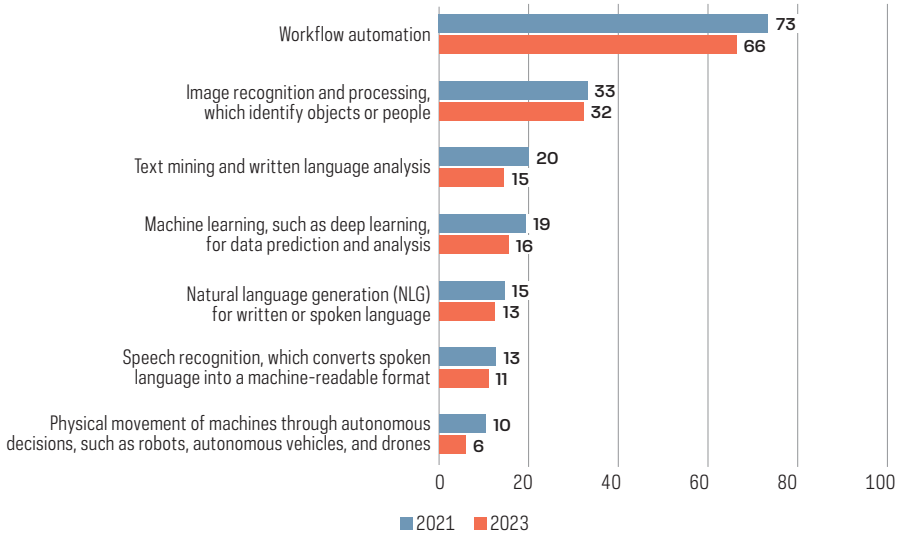
Enterprises that used AI technologies, by type (2021–2023)

Total number of enterprises that used AI technologies (%)



Source: CGI.br (2024).

In the context of the digital economy, AI is emerging as a promising technology capable of transforming the global production structure. The growing focus on industrial policies aimed at incorporating AI reflects the urgency for economies to lead this development. However, implementation challenges, especially among small enterprises, indicate significant obstacles related to costs and lack of human resources, limiting broader digitalization. As noted in Chart 2, 12% of enterprises that did not adopt AI pointed to a lack of clarity about the legal consequences of its use, while 12% expressed concerns regarding violation of data protection and privacy. In addition, 9% of these enterprises raised ethical issues and 16% faced difficulties related to the availability or quality of the data needed to implement the technology.

CHART 2

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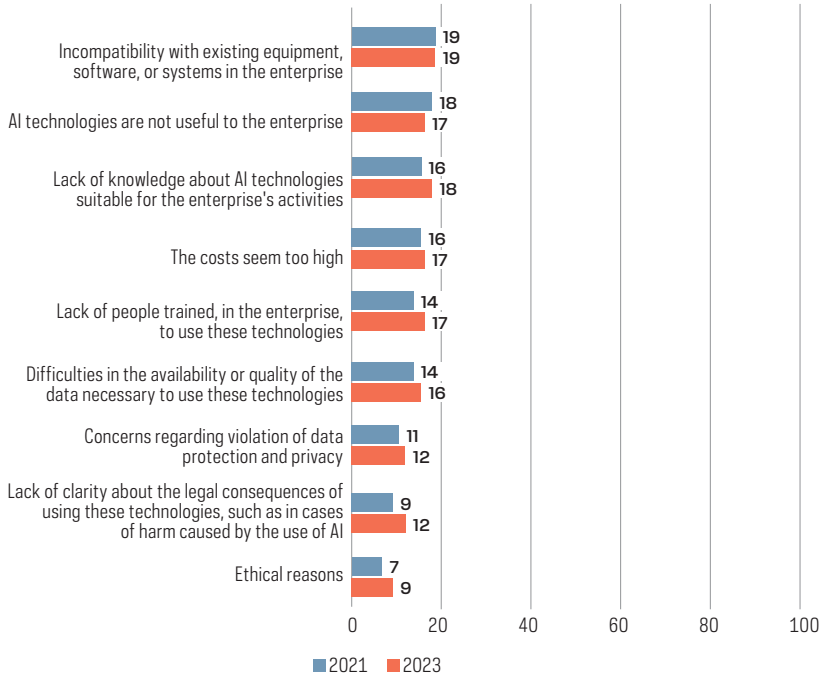
Enterprises that did not use AI, by type of barrier (2021–2023)

Total number of enterprises that did not use AI technologies (%)



Source: NIC.br (2024).

The evolution of online privacy risks over the last two decades reveals an increase in consumer surveillance and individual profiling, driven by the targeting of ads based on user behavior. This phenomenon has been exacerbated by the growth of social media platforms, which have expanded data collection beyond its initial scope. Shoshana Zuboff (2019) described this practice of extracting value from individuals as surveillance capitalism, which "unilaterally claims human experience as free raw material for translation into behavioral data" (p. 15). This process generates a new kind of power, which knows and shapes human behavior toward others' ends, using the automated structures of an increasingly ubiquitous computer architecture of "smart" and "interconnected" devices, things, and spaces. Although AI in Brazil is primarily used to automate internal processes, it is more prominently applied in digital security and marketing. This is concerning, as the use of AI in marketing often involves handling personal data by enterprises that, in many cases, do not adopt proper protection practices,[11] which can result in surveillance and tracking of users' activities without notice or consent (Chart 3).

[11] The Privacy and Personal Data Protection 2021 survey indicated that 67% of enterprises stored personal data of customers and users, but the adoption of good practices for its storage and processing was low (CGI.br, 2022).

CHART 3

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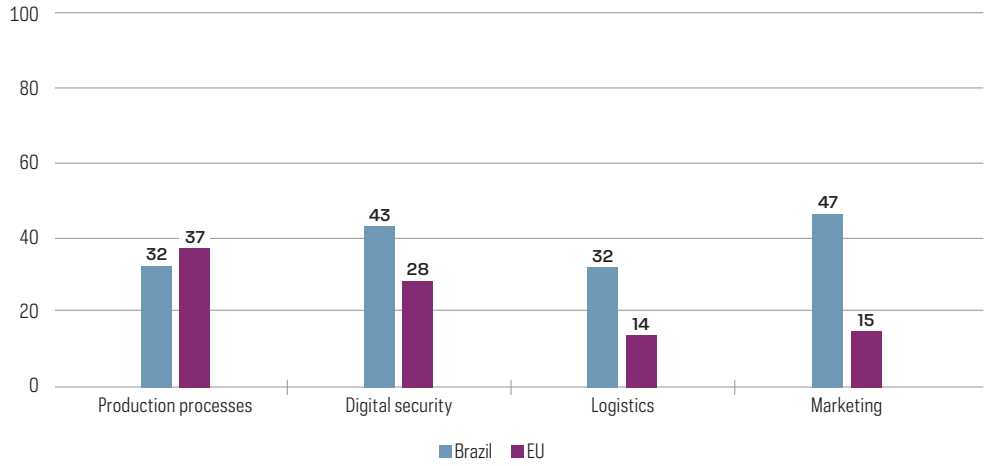
Enterprises that used AI technologies, by purpose of use (2023)

Total number of enterprises that used AI technologies (%)



Source: CGI.br (2024).

This data underlines the urgency of establishing clear regulatory parameters and frameworks that guarantee the responsible use of AI by promoting innovation and protecting users' rights, especially in the Global South, where legal frameworks and awareness of digital rights are still developing.

As society becomes increasingly digitized, there is growing pressure for data-driven development, leading to the management of public services by private platforms. This results in private control over access to essential services such as health, education, and security, as well as impacting social interactions and the public sphere. Given this scenario, it is necessary to reflect on the design of automation and AI systems, considering for whom and with what objectives they are designed. This reflection is essential to identify vulnerabilities, ensuring that technology benefits everyone and does not perpetuate inequalities or exclude already marginalized groups.

According to Castells and Cardoso (2005, p. 3), "we know that technology does not determine society: it is society." As emerging technologies become increasingly integrated into everyday business life, the need for an ethical and legal framework becomes imperative. Protecting privacy rights and ensuring responsible use are key not only to fostering consumer trust, but also to mitigating the risks associated with disinformation and data manipulation. The development of inclusive and transparent policies must be a priority to ensure that digital transformation benefits society.

Although the Global South has made progress in implementing digital technologies, there are still significant gaps in access, fairness, and connectivity. To address these challenges, it is essential to understand the shortcomings in the management of personal

data throughout the life cycle of systems, adopting robust data protection practices at all stages to mitigate risks and ensure compliance with privacy and ethical standards in the handling of information.

It is not just about identifying risks, but about implementing effective solutions. To ensure privacy protection in AI systems, it is essential to integrate data minimization, anonymization, and encryption practices from the earliest stages of development. This approach must include controls to restrict access to sensitive information and ensure transparency in the use of data through the informed consent of users. By adopting data governance policies and conducting privacy impact assessments, organizations not only mitigate risks but also strengthen user trust.

It is also essential to carry out regular audits and implement continuous monitoring to improve privacy practices, ensuring compliance with standards and guidelines. Techniques such as differential privacy,[12] anonymization, diversification of training data, and restricting data sharing to authorized parties are also important for protecting individual privacy and prevent re-identification, ensuring compliance with anti-discrimination laws.

As AI expands, it is crucial to adopt a multi-faceted approach that involves cooperation between governments, organizations, and individuals, maximizing the benefits of the technology and ensuring that citizens' rights are respected and protected.

Conclusion

The interaction between AI and privacy is complex and fraught with challenges. While AI offers valuable opportunities, it also raises important issues such as data breaches, the collection of sensitive information, excessive surveillance, and algorithmic bias. To mitigate these risks, it is important to ensure compliance with privacy legislation.

Privacy must be integrated into the design, operation, and management of systems at every stage of their life cycle. This involves careful analysis of the threats at each stage, ensuring that measures are taken from the outset. It is essential to carry out privacy impact assessments (PIA) to identify and mitigate risks and apply minimization techniques, anonymization, encryption, and access controls to protect sensitive information. In addition, informed consent must be obtained from users to ensure transparency, while vendor assessments, training, and awareness-raising programs must be implemented to foster a culture of privacy in organizations.

Everyone involved in the creation and operation of AI systems must adopt ethical and responsible practices. The continuous improvement of governance practices must be monitored and adjusted in response to emerging risks and regulatory changes, ensuring a balance between technological advancement and the protection of citizens' rights.

[12] Data anonymization is a technique that ensures privacy protection in data sets by adding noise to obscure sensitive information, allowing secure analysis without compromising privacy.

For countries in the Global South, the opportunity arises to establish data protection and AI regulation frameworks that consider local specificities and the needs of their populations. By doing so, these countries can mitigate negative impacts and promote responsible and inclusive innovation.

Privacy is a fundamental right that must be prioritized in the development and use of advanced technologies. A proactive approach that recognizes the evolution of associated risks is essential to protect the rights of individuals and align technological advances with social values. Without adequate regulation, the increased use of technology can result in the erosion of privacy and civil liberties, and in the exacerbation of inequalities.

While AI challenges traditional notions of privacy and demands a review of data protection practices, it also has the potential to strengthen them in the digital age. Promoting a balance between technological innovation and privacy protection, empowering individuals with transparency and control over their information, is essential to developing socially responsible AI that creates long-term public value.

By prioritizing privacy and adopting data protection policies, we can ensure that AI is developed and used ethically, allowing it to fully build up its transformative potential without sacrificing fundamental rights. Only in this way will we ensure that the benefits of this technology are widely shared, promoting a sustainable future.

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List of Abbreviations

AAI – Applied Artificial Intelligence

AI – Artificial Intelligence

DA – data analysis

APP – digital platforms and applications

BRICS – Brazil, Russia, India, China, and South Africa

CATI – computer-assisted telephone interviewing

Cempre – Central Register of Enterprises

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

CGI.br – Brazilian Internet Steering Committee

CI – competence indicators

CNAE 2.0 – National Classification of Economic Activities

CNI – National Confederation of Industry

CNPJ – Company Registration Number

Concla – National Classification Commission

CRM – Customer Relationship Management

ERP – Enterprise Resource Planning

Eurostat – Statistical Office of the European Union

FPAS – Social Security and Assistance Fund

GDP – Gross Domestic Product

IBGE – Brazilian Institute of Geography and Statistics

ICT – information and communication technologies

IoT – Internet of Things

ISIC 4 – International Standard Industrial Classification of All Economic Activities

IT – information technology

LGPD – Brazilian General Data Protection Law

LLM – large language models

ML – machine learning

NIC.br – Brazilian Network Information Center

NLG – Natural language generation

OECD – Organisation for Economic Co-operation and Development

PIA – privacy impact assessments

PRT – 3D/4D printing and modeling

Rais – Annual List of Social Information

RBT – robotics

SME – small and medium enterprises

Sebrae – Brazilian Micro and Small Business Support Service

Senac – National Service for Commercial Learning

Softex – Association for the Promotion of Brazilian Software Excellence

UN – United Nations

UNCTAD – UN Trade and Development

UNESCO – United Nations Educational, Scientific and Cultural Organization

UNIDO – United Nations Industrial Development Organization

Unifesp – Federal University of São Paulo

UNSD – United Nations Statistics Division

XR – extended reality

WEF – World Economic Forum

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under the auspices
of UNESCO

cetic.br
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Studies on the
Development of the
Information Society

nic.br
Brazilian Network
Information Center

cgi.br
Brazilian Internet
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