SPECIAL
SURVEY
83

INDUSTRY 4.0
FIVE YEARS LATER

CNI
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BRASÍLIA-DF
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SUMMARY

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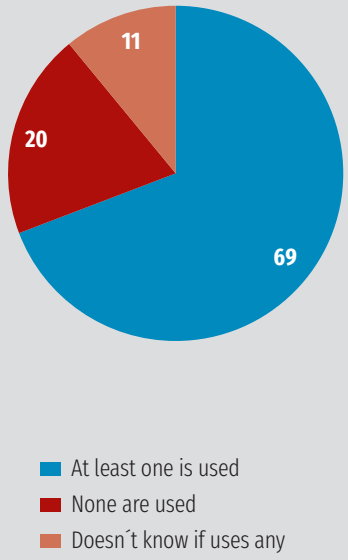
EXECUTIVE SUMMARY

USE OF DIGITAL TECHNOLOGIES RISES IN THE BRAZILIAN INDUSTRY, BUT INDUSTRY 4.0 IS STILL IN ITS EARLY STAGES

Graph 1 - Use of at least one of the 18 digital technologies

Percentage of responses (%)



Among industrial companies, 69% already use at least one digital technology out of a list presenting 18 different applications. When this survey was first conducted, in 2016, 48% of companies used some digital technology out of 10 selected technologies.

Despite the high level of adoption of at least one digital technology, most companies use a low number of digital technologies, showing that they are at an early stage in the digitization process. Among industrial companies, 26% use 1 to 3 technologies, while only 7% use 10 or more.

The sectors that use more digital technologies and in greater variety are those with the greatest technological intensity. In addition, they are pioneers in the adoption of technologies that are still little used in the industry.

Digital technologies focused on improving the production process are still the most used. However, since 2016, there has been an increase in the use of technologies that allow greater customization of products. For example, the use of automation with sensors, allowing flexible production lines, has soared from 8% in 2016 to 27% in 2021. However, more complex technologies, like those involving artificial intelligence, are still hardly used.

Among the main benefits of adopting digital technologies acknowledged by the industry, we have increased productivity, improved product quality and reduced production costs.

Just like in 2016, the high cost of implementation is perceived as the company's biggest internal barrier to adopting digital technologies, with 66% of companies reporting it as being one of the top three barriers. The lack of knowledge and clarity about the technologies' returns is also ranked among the most highlighted barriers.

The lack of qualified workers was the most mentioned external barrier. Then there is the difficulty in identifying technologies and partners, along with the fact that customers and suppliers are not yet ready.

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Brazilian industry is more digital, but has low maturity in this process

Brazilian industry is more digital than five years ago. In 2021, 69% of industrial companies already used at least one digital technology in a list of 18 different applications[1]. In 2016, 48% of all companies made use of some digital technology, considering a list of 10 options[2].

However, most companies use a small number of digital technologies, showing that they are still at an early stage along the digitalization process. More than half of industrial companies either do not use any digital technology at all (31%) or use between 1 and 3 digital technologies (26%). Companies using 10 or more digital technologies account for only 7% of the sample.

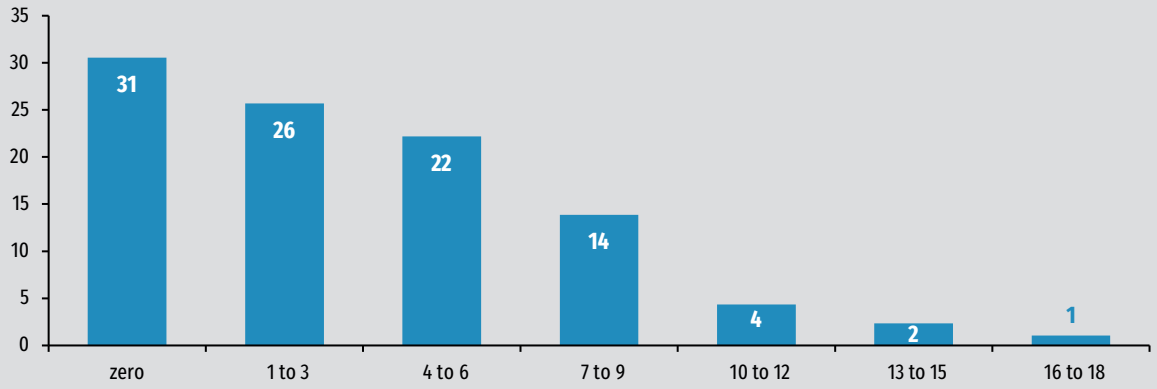
Industry 4.0 is a comprehensive concept, based on integration of a set of technologies that make ecosystems of intelligent and autonomous systems feasible, with decentralized factories and integrated products and services.[3]. It refers to an intelligent network of machines and processes for the industry, with the help of information and communication technologies[4].

Industry 4.0 depends on the complementarity of digital technologies. For example, sensors collect information from machines, and this information can be shared with other machines. Decisions, in turn, can be made through the data collected and the use of artificial intelligence, such as predictive maintenance of machines. The value of Industry 4.0 lies in the integration of diverse digital technologies.

The low level of variety of digital technologies adopted by companies reinforces the need to expand the adoption and integration of

Graph 2 - Use by range of digital technologies*

Percentage of use (%)



*Learn more about calculating the number of technologies used by companies in Appendix B.

[1] The whole list of 18 digital technologies is presented in Appendix A at the end of this document.

[2] In 2016, 10 technologies were listed, compared with 18 in 2021. Therefore, the comparison needs to be made with caution. Naturally, with technological evolution and with the greater mastery of the subject by specialists, the list of technologies is enhanced, with the separation of technologies previously presented together, with the addition of new technologies in the list of technologies of Industry 4.0.

[3] UNIDO (2017).

[4] *What is Industry 4.0? Available at*: https://www.plattform-i40.de/IP/Navigation/EN/Industrie40/WhatIsIndustrie40/what-is-industrie40.html. Accessed on: November 3, 2021.

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technologies so that the benefits allowed by Industry 4.0 are indeed achieved.

The company's size influences its level of adoption of digital technologies. The larger the size of the company, the greater the use of at least one digital technology. Among large companies, 86% use at least one of the 18 technologies listed. Among medium-sized companies, the percentage drops to 64%. For small companies, it slides to 42%.

The size of the company also affects the number of technologies adopted. The bigger the company, the larger this figure. Among large companies, the percentage that use up to 6 technologies is about one and a half times higher when compared to use among small companies. The difference increases to fifteen times when observing the use of 10 or more technologies.

The use of digitalization remains focused on process improvement, but there is a search for greater product customization

The different types of digital automation (without sensors, with sensors and with product identification and operating conditions) stand out among the most used production process technologies. *Digital automation with sensors for process control* is more widespread in the Brazilian industry and has remained the main digital technology in use: 46% of companies use it, compared with 27% in 2016.

The use of *Digital automation with sensors with product identification and operating conditions, flexible lines* has more than tripled since 2016, having shot up from 8% to 27% in 2021.

This increase should pave the way for further development of customizable products, where flexible lines are essential. In addition, *Rapid Prototyping, 3D printing and similar technologies*, another important technology for customization, has increased in use. In 2016, up to 5% of companies used this technology[5], compared with 16% in 2021.

Regarding the focus[6] on the product, *Digital Customer Relationship Tools (chatbots, interactive customer service, etc.)* was the most used technology, with 25% of comments.

In terms of product development, the most used technology was *Integrated engineering systems for product development and manufacturing,* with 33% of responses.

Technologies with these focuses can add greater value to products and create a market but are still little used. For example, 3D printing, used by only 16% of companies, allows the production of a highly customized product. The incorporation of digital services in products can add features that were previously absent in the product, yet it is used by only 14% of companies.

The complexity of each technology has an effect on its adoption. It is noted, for example, that technologies using artificial intelligence, such as *Artificial Intelligence-assisted Design (4%) and Artificial Intelligence applications for factory solutions (9%)*, are among the least adopted, regardless of company size.

[5] In 2016, the technology was listed as "Additive manufacturing, rapid prototyping or 3D printing", while in 2021 additive manufacturing was separated as being another technology. For this reason, we can say that at most 5% of companies used the '3D Printing' digital technology 2016.

[6] Digital technologies were classified according to their use in the different stages of the production chain (development, production process and product). See Table 1.

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Table 1 - Use of Digital Technologies in the Industry

Percentage of responses (%)

Focus	Technology	2016*	2021
Production process/ business management	Digital automation with sensors for process control	**27**	**46**
	Digital automation without sensors, use of Programmable Logic Controller (PLC) without sensors		**39**
	Digital automation with sensors with product identification and operating conditions, flexible lines	**8**	**27**
	Collection, processing and analysis of large amounts of data (*big data*) of the production process		**21**
	Quality automated or advanced inspection		**18**
	Integrated manufacturing systems such as M2M (machine-to-machine) communication		**17**
	Remote monitoring and production control with MES** and SCADA systems	**7**	**17**
	Additive manufacturing, collaborative robots (cobots)		**12**
	Digital tools that enhance workers' capabilities (*smart glasses, smart watches, etc.*)		**11**
	Artificial Intelligence applications for factory solutions		**9**
Product development	Integrated engineering systems for product development and manufacturing	**19**	**33**
	Rapid prototyping, 3D printing and similar technologies		**16**
	Simulations/analysis of virtual models for project and commissioning (Finite Elements, Computational Fluid Dynamics, etc.)	**5**	**13**
	Process simulation and *digital twins*		**3**
Product/new business models	Digital customer relationship tools (chatbots, interactive customer service, etc.)		**25**
	Incorporation of digital services into products (Internet of Things or *Product Service Systems*)	**4**	**14**
	Collection, processing and analysis of large amounts of data (*big data*) about the market; monitoring the use of products by consumers		**13**
	Artificial intelligence-assisted design		**4**

Note: The sum of the percentages exceeds 100% due to the possibility of multiple answers.

*Data for 2016 are from CNI's 2016 survey (see References). In 2016, 10 technologies were listed, compared with 18 in 2021. The table only compares technologies that were listed in the two surveys performed.

**MES – Manufacturing Execution Systems; SCADA – Supervisory Control and Data Acquisition.

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The automotive sector is the one that employs the widest variety of technologies

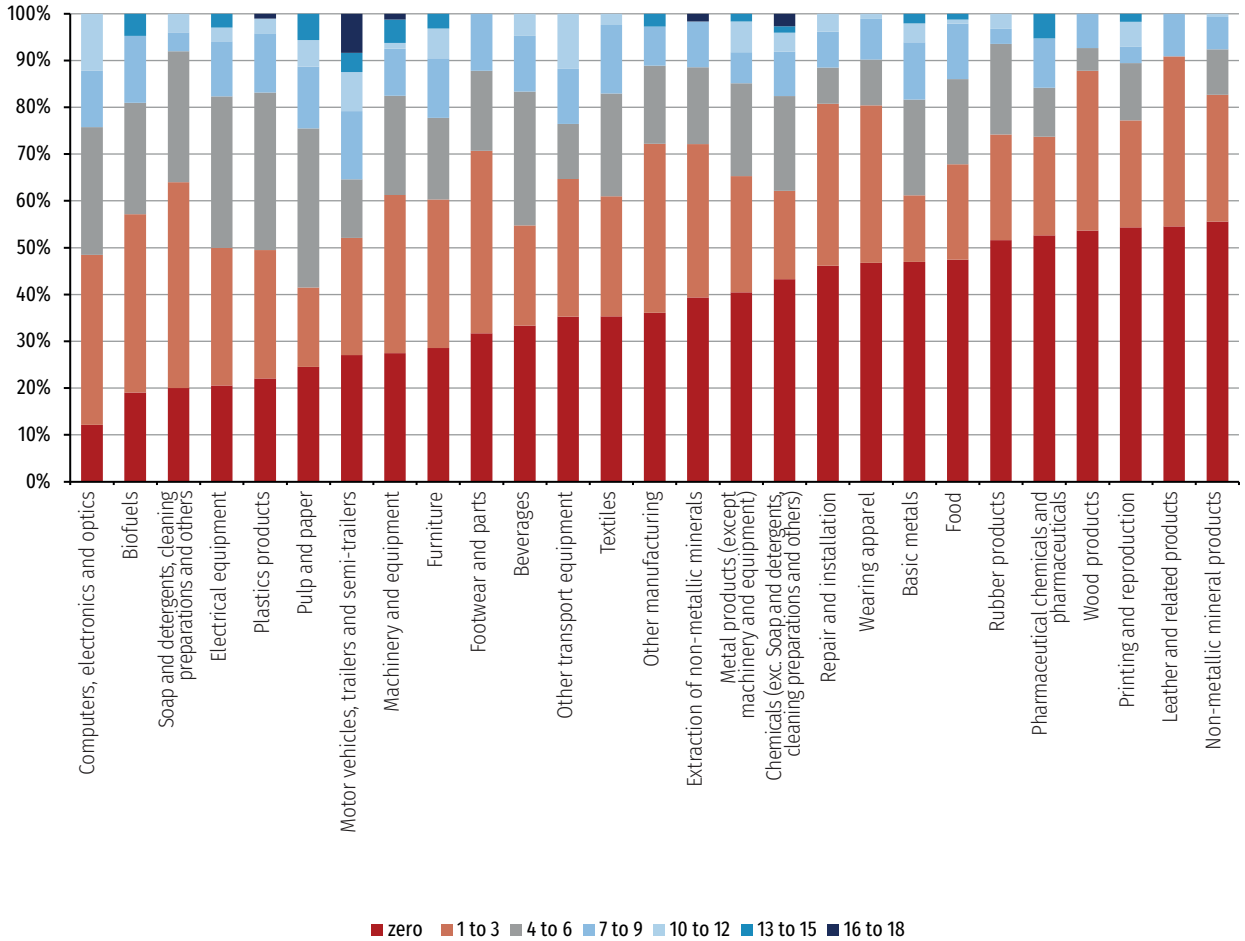
The computers, electronics and opticals products sector stands out, with 88% of companies using at least one digital technology, followed by the Biofuels sector (81%) and Soap and detergents, cleaning preparations and others (80%). Among the sectors with fewer companies using at least one digital technology we have Non-metallic mineral products (44%), followed by Leather and related products (45%) and Printing and reproduction (46%).

However, the sectors that appear at the top of this ranking are not necessarily those that use digital technologies more intensively, as shown in Graph 3. For example, while in the Motor vehicles, trailers and semi-trailers sector,35% of companies use 7 or more digital technologies, in the Soap and detergents, cleaning preparations and others sector this amount is limited to 8% of companies.

The Motor vehicles, trailers and semi-trailer sector stands out as the one that makes use of the largest number of digital technologies. Some 8% of companies in the sector use at least 16 digital technologies, while the Chemicals sector (exc. Soap and detergents, cleaning preparations and others) is in second place, with 3% for this range of technologies used.

Graph 3 - Use by number of technologies and by sector.

Percentage of responses by usage range (%)



Note: Sectors ranked by the percentage of companies that use at least one digital technology, from highest to lowest.

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The most technology-intensive sectors are pioneers in the adoption of new digital technologies

When observing the use of technologies by the sectors according to their technological intensity[7], we can see that the high and medium-high technology sectors are the ones that lead the adoption of technologies that were still little used back in 2016. By way of example, *Rapid Prototyping, 3D printing and similar technologies*, was marked by 27% and 20% in the high and medium-high technological intensity sectors respectively, while these values reach only 11% in the sectors of medium-low and low technological intensity.

The same phenomenon occurs for other less consolidated technologies in the industry. In the product focus, the high and medium-high technological intensity sectors stand out in the use of all technologies.

In the product development focus, only the *Artificial intelligence-assisted design* technology adoption is not higher in these sectors, indicating that this technology is still underdeveloped and of greater complexity of adoption, meaning that it is little adopted even among the sectors of greater technological intensity.

Technologies directly related to the production process, such as the different types of digital automation, are the most adopted regardless of the technological intensity of the sectors. One example of this is *Digital Automation with sensors for process control*, being the most adopted technology, with at least 35% of mentions at each level of technological intensity.

Also, regarding the process focus, the adoption of the most advanced technologies, such as automated quality inspection, additive manufacturing, collaborative robots, and collection, processing and analysis of large amounts of data (big data) also stand out in the sectors of high and medium-high technological intensity.

[7] See the classification of sectors by technology intensity in Appendix B at the end of the document.

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Table 2 - Use of digital technologies

Percentage of responses by technological intensity (%)

Focus	Technology	Technological intensity			
		high	medium-high	medium-low	low
Development	Integrated engineering systems for product development and manufacturing	29	44	25	22
	Rapid prototyping, 3D printing and similar technologies	27	20	11	11
	Artificial intelligence-assisted design	2	5	2	3
	Simulations/analysis of virtual models for design and commissioning (Finite Elements, Computational Fluid Dynamics etc.)	15	19	9	5
Process	Digital automation without sensors, use of Programmable Logic Controller (PLC) without sensors	27	38	31	28
	Digital automation with sensors for process control	37	39	35	36
	Digital automation with sensors with product identification and operating conditions, flexible lines	27	20	17	22
	Remote monitoring and production control with MES and SCADA* systems	17	15	11	10
	Integrated manufacturing systems such as M2M (machine-to-machine) communication	15	14	9	14
	Artificial Intelligence applications for factory solutions	8	9	5	6
	Process simulation and digital *twins*	0	5	1	1
	Additive manufacturing, collaborative robots (cobots)	12	14	8	6
	Collection, processing and analysis of large amounts of data (*big data*) of the production process	21	18	16	14
	Quality automated or advanced inspection	25	17	11	12
	Digital tools that enhance workers' capabilities (*smart glasses, smart watches, etc.*)	6	12	9	8
Product	Incorporation of digital services into products (Internet of Things or *Product Service Systems*)	15	15	10	10
	Collection, processing and analysis of large amounts of data (big data) about the market; monitoring the use of products by consumers	21	13	8	9
	Digital customer relationship tools (*chatbots*, interactive customer service, etc.)	31	28	18	22

Note: The sum of the percentages exceeds 100% due to the possibility of multiple answers.

*MES – *Manufacturing Execution Systems; SCADA – Supervisory Control and Data Acquisition.*

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Increased productivity is the most recognized benefit

Regardless of the company size or sector analyzed, the main benefits obtained from the use of digital technologies are related to those technologies most adopted by the industry, that is, those that focus on the production process.

7 out of 10 companies (72%) showed *Increased productivity* as one of the top five benefits obtained by the company from the use of digital technologies, making this the most highlighted benefit.

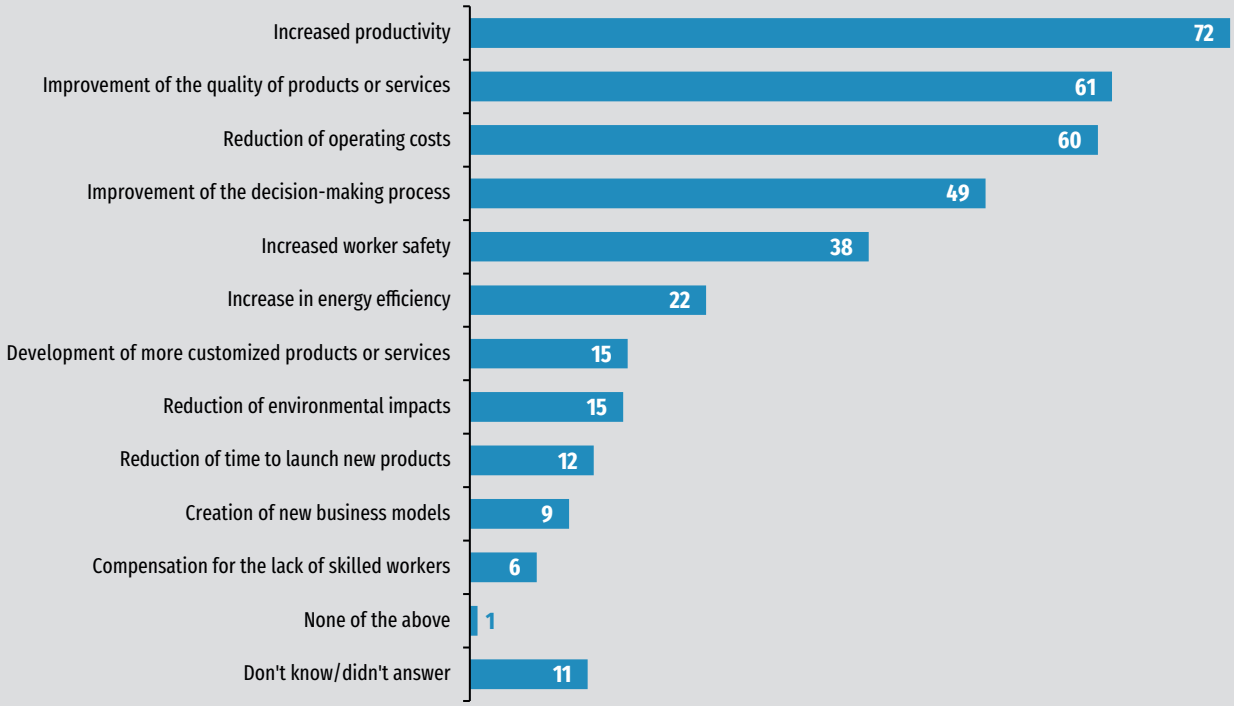
Tied for second place, *Improvement of the quality of products or services and Reduction of operating costs*, were marked by about 6 out of 10 companies (60%).

The benefits obtained also show that digital technologies can bring specific solutions to each sector. For example, among the five sectors of the manufacturing industry that most highlighted the *Increase in energy efficiency* as a benefit, four rank among the 10 most electro-intensive in the industry[8].

In another example of this, the *Development of more customized products or services* was indicated mainly in sectors where the characteristics of the products allow greater customization, such as Machinery and equipment (30%), Footwear and parts (29%), Motor vehicles, trailers and semi-trailers (29%), Computers, electronics and opticals products (24%).

Graph 4 - Benefits obtained by adopting digital technologies

Percentage of responses (%)



Note: The sum of the percentages exceeds 100% due to the possibility of multiple answers.

[8] The Pulp and paper; Textiles; Food and Plastics products sectors, which rank among the 5 that most highlighted the benefit of an Increase in energy efficiency, are among the 10 largest consumers of electricity in the industry, according to EPE (2021).

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The high cost of implementation remains the biggest internal barrier

The *High implementation costs* is considered the biggest internal barrier to the adoption of digital technologies, regardless of company size. This option was indicated by at least 6 out of 10 companies (66%). The result repeats what was observed in 2016. The difference from the options tied in second place in the ranking gets as high as 40 percentage points.

After the high cost, the following barriers appear as tied: *Corporate structure and culture, Lack of clarity in defining return on investment, and Lack of technical knowledge about digital technologies*, these being identified by about a quarter of industrial firms as one of the top three internal barriers that hinder the adoption of digital technologies.

For small and medium-sized companies, the barrier *Lack of technical knowledge about digital technologies* appears alone in second place, being mentioned out by almost 30% of these companies. On the other hand, this barrier was mentioned by 20% of large companies, ranking fifth. This difference stresses the need to spread knowledge of the technologies among smaller companies to expand their adoption.

In addition to being considered the biggest obstacle to the adoption of digital technologies by company size, the high implementation costs were perceived by all sectors as being the biggest internal barrier.

Graph 5 - Internal barriers that hinder the adoption of digital technologies

Percentage of responses (%)

Note: The sum of the percentages exceeds 100% due to the possibility of multiple answers.

*Data for 2016 are from CNI's 2016 survey (see References). The options "Lack of technical knowledge about digital technologies" and "Long implementation time" were not present in the 2016 survey questionnaire. This means that **the percentages from the 2016 survey cannot be compared with the percentages from the 2021 survey. However, one can evaluate the ranking in both surveys.**

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Lack of qualified workers is still the main external barrier

When asked about the external barriers to the company that hinder the adoption of digital technologies, 37% mentioned *the Lack of skilled workers* among the three main barriers, most highlighted option by companies, regardless of size. This same barrier was the most highlighted by companies in 2016.

In second place comes the barrier *Difficulties to identify technologies and partners,* indicated by at least 3 out of 10 companies (33%), as one of the three biggest external barriers to the adoption of digital technologies, reinforcing the difficulty with the lack of technical knowledge to regarding technologies.

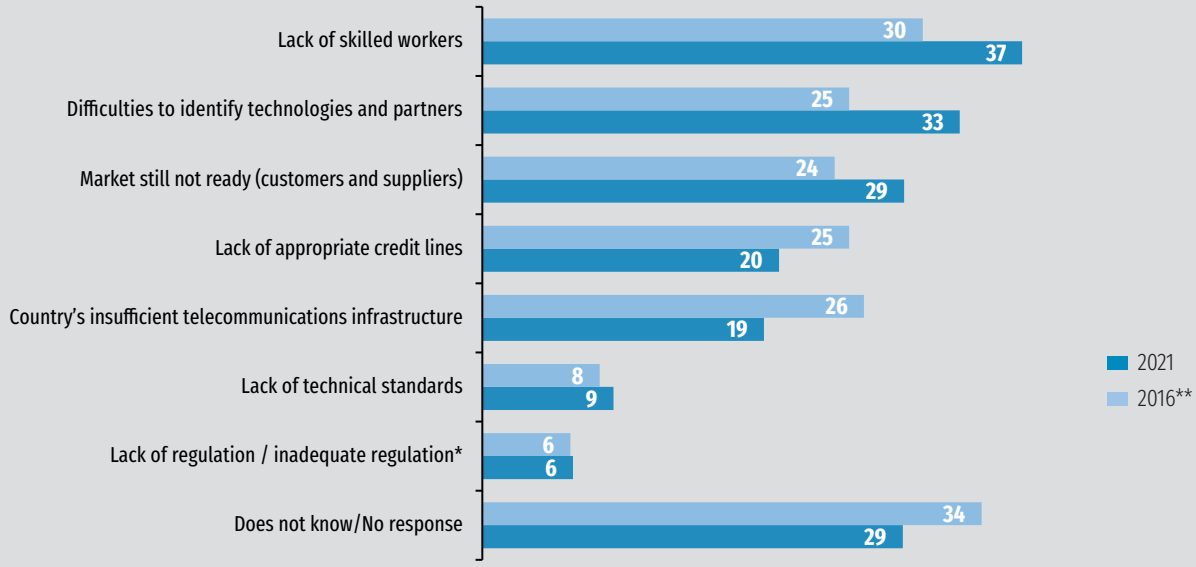
With a similar percentage, but in third place, we have *Market still not ready (customers and suppliers),* a barrier highlighted by 29% of the companies.

Even though industrial companies point to the high cost of implementation as the biggest internal barrier to the adoption of digital technologies (66% of mentions), the external barrier *Lack of appropriate credit lines* appears only in fourth place, tied with *the country's insufficient telecommunications infrastructure.* About 2 out of 10 companies (20%) identified these barriers as one of the top three external barriers that hinder the adoption of digital technologies.

In recent years, these barriers have lost importance compared to others. In 2016, they were in second place in the ranking. Credit lines focused on industry 4.0 technologies were created in 2019 (Finep InovaCred 4.0, BNDES Máquinas 4.0 and BNDES Serviços 4.0), and may have contributed to this change in perception.

Graph 6 - External barriers that hinder the adoption of digital technologies

Percentage of responses (%)



Note: The sum of the percentages exceeds 100% due to the possibility of multiple answer.

*This option in 2016 appeared as "Lack of regulation", being changed to "Lack of regulation / inadequate regulation" for the 2021 questionnaire.

**The 2016 data are from a 2016 survey by CNI (see References).

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APPENDIX A

LIST OF THE 18 DIGITAL TECHNOLOGIES RESEARCHED AND CAD/CAM

	TECHNOLOGIES
1	Integrated engineering systems for product development and manufacturing
2	Rapid prototyping, 3D printing and similar technologies
3	Artificial intelligence-assisted design
4	Simulations/analysis of virtual models for design and commissioning (Finite Elements, Computational Fluid Dynamics, etc.)
5	Digital automation without sensors, use of Programmable Logic Controller (PLC) without sensors
6	Digital automation with sensors for process control
7	Digital automation with sensors with product identification and operating conditions, flexible lines
8	Remote monitoring and production control with MES and SCADA* systems
9	Integrated manufacturing systems such as M2M (machine-to-machine) communication
10	Artificial Intelligence applications for factory solutions
11	Process simulation and *digital twins*
12	Additive manufacturing, collaborative robots (cobots)
13	Collection, processing and analysis of large amounts of data (*big data*) of the production process
14	Quality automated or advanced inspection
15	Digital tools that enhance workers' capabilities (*smart glasses, smart watches, etc.*)
16	Incorporation of digital services into products (Internet of Things or *Product Service Systems*)
17	Collection, processing and analysis of large amounts of data (big data) about the market; monitoring the use of products by consumers
18	Digital customer relationship tools (chatbots, interactive customer service, etc.)
	CAD/CAM computer manufacturing designs (although not considered digital technology, we would like to know if the company uses them)

Note: The list presented to the companies also included "CAD/CAM Computer Manufacturing Projects", adding up to 19 items. CAD/CAM projects are software licenses. Even though they would suggest greater automation in the factory, they are not digital technologies per se. This inclusion was made to mark a difference from digital technology of "Integrated engineering systems for product development and manufacturing". Of the total number of industrial companies, 3% only use "CAD/CAM computer manufacturing designs".

*MES – *Manufacturing Execution Systems;* SCADA – *Supervisory Control and Data Acquisition*.

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APPENDIX B

CALCULATION OF USE BASED ON DIGITAL TECHNOLOGY RANGE

In order to get an approximate idea of the degree of digitalization of companies, we calculated the total number of digital technologies used by each respondent company. The higher the indicator, that is, the greater the use of digital technologies, the greater the maturity of the company in Industry 4.0.

Here we should note that the interpretation must be done with caution, as the use of different types of digital technologies varies according to the industrials sectors' characteristics.

Furthermore, it can be assumed that some applications are just steps in a digitization process, meaning that the use of one type may lead to the abandonment of another type. This tends to happen in the case of the three types of automation listed ("digital automation without sensors"; "digital automation with sensors for process control" and "digital automation with sensors with identification of products and operating conditions, flexible lines").

To obtain the total number of digital technologies used, each of the 18 digital technologies is assigned a score of 1, except for "digital automation with sensors for process control" and "digital automation with product identification and operating conditions/ flexible lines".

The company that marks "digital automation with sensors for process control" receives 2 points. But if the company also indicates the use of "digital automation without sensors", it does not receive any points for this use.

Similarly, the company that registers the use of "digital automation with sensors with product identification and operating conditions, flexible lines" receives 3 points. If the company also indicates the use of "digital automation with sensors for process control" and/or "digital automation without sensors", then the company does not receive any points for these uses.
Thus, the maximum score a company can obtain remains unchanged at 18, as the total number of technologies listed.

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APPENDIX C

CLASSIFICATION BY TECHNOLOGICAL INTENSITY

SECTORS	CATEGORIES
Pharmaceutical chemicals and pharmaceuticals	High
Computers, electronics and opticals products	
Chemicals (exc. Soap and detergents, cleaning preparations and others)	Medium-high
Soap and detergents, cleaning preparations and others*	
Electrical equipment	
Machinery and equipment	
Motor vehicles, trailers and semi-trailers	
Other transport equipment	
Biofuels	Medium-low
Rubber products	
Plastics products	
Non-metallic mineral products	
Basic metals	
Metal products (except machinery and equipment)	
Repair and installation	
Foods	Low
Beverages	
Tobacco	
Textiles	
Wearing apparel	
Footwear and parts	
Leather and related products	
Wood products	
Pulp and Paper	
Printing and reproduction	
Furniture	
Other manufacturing	

Source: Classification prepared by the CNI, based on the OECD. ISIC VER. 3 *Technology Intensity Definition*, 2011.

*Soap and detergents, cleaning and polishing preparations, perfums and toilet preparations.

APPENDIX D

USE OF THE 10 DIGITAL TECHNOLOGIES LISTED IN THE 2016 SURVEY

PERCENTAGE OF RESPONSES (%)

Focus	Technology	Use
Process	Digital automation with sensors for process control	27
	Digital automation without sensors	11
	Digital automation with sensors with product identification and operating conditions, flexible lines	8
	Remote Monitoring and production control with MES and SCADA systems (*)	7
Development	Integrated engineering systems for product development and product manufacturing	19
	Additive manufacturing, rapid prototyping or 3D printing	5
	Simulations/analysis of virtual models for design and commissioning (Finite Elements, Computational Fluid Dynamics, etc.)	5
Product	Collection, processing and analysis of large amounts of data (*big data*)	9
	Use of cloud services associated with the product	6
	Incorporation of digital services in products (Internet of Things or *Product Service Systems*)	4

Note: The sum of the percentages exceeds 100% due to the possibility of multiple answers.

(*) MES – *Manufacturing Execution Systems;* SCADA – *Supervisory Control and Data Acquisition.*

TECHNICAL SPECIFICATIONS

Sample profile: 1,691 companies: 684 small, 607 medium and 400 large.

Data collection period: 1 to 16 of April 2021.

LEARN MORE

For more information on the survey, visit: www.cni.com.br/sondespecial

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