CNI
Confederação Nacional da Indústria

OPPORTUNITIES FOR INDUSTRY 4.0

DEMAND AND SUPPLY ASPECTS IN BRAZIL

Brasília,
2017

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Confederação Nacional da Indústria

CNI. A FORÇA DO BRASIL INDÚSTRIA

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CNI
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FOREWORD

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The emergence of the so-called Industry 4.0 has been transforming industrial production with new processes, products and business models that were unthinkable a few years ago. This phenomenon, which was named as such to refer to the 4th Industrial Revolution, holds the promise of making conventional production models gradually inefficient.

Major industrialized nations have placed the development of Industry 4.0 at the heart of their industrial policy strategies with the aim of preserving and increasing their competitiveness. Brazil needs to do the same.

The transition to the new production models that characterize Industry 4.0 will play a key role in boosting the competitiveness of Brazilian industry and in promoting its more intense and improved integration into global value chains. Industry 4.0 increases the variety and quality of goods and services available both to society and enterprises.

Aware of the importance of this moment, CNI has been conducting studies and research to raise awareness and disseminate information on the topic, such as the study "Challenges for Industry 4.0 in Brazil," published

in 2016. That study presented the main concepts and definitions related to the fourth industrial revolution and listed seven priority dimensions for the development of Industry 4.0 in the country: i) application in production chains and supplier development; ii) mechanisms to drive the adoption of enabling technologies; iii) technological development; iv) expansion and improvements in broadband infrastructure; v) regulatory aspects; vi) human resource training; and vii) institutional coordination.

In pursuance of this agenda, CNI presents this new study on Industry 4.0 and its challenges. The document is focused on an in-depth analysis of two of the dimensions presented in the previous study: *Application in production chains and supplier development; and Mechanisms to drive the adoption of enabling technologies*. In addition to presenting the study presents a set of proposals for developing and adopting these technologies.

With it, we hope to contribute to the debate on Industry 4.0 in Brazil and to defining actions to promote the development and application of digital technologies in the domestic industry.

Developing Industry 4.0 in Brazil implies challenges for both the public and the private sector, but it is, above all, a gigantic opportunity. By using digital technologies, industry has the chance to make a leap in productivity that will make it possible for us to reduce our productivity gap in relation to developed countries.

I wish you all a good reading.

Robson Braga de Andrade

INTRODUCTION

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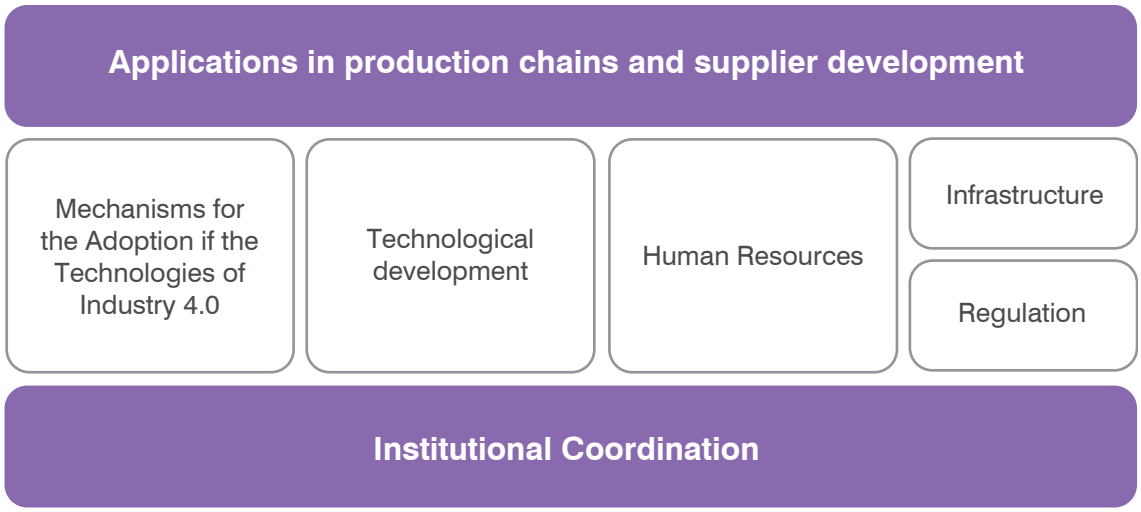
The emergence of the so-called Industry 4.0 has been transforming industrial production with new processes, products and business models that were unthinkable a few years ago. This phenomenon, which was named as such to refer to the 4th Industrial Revolution, holds the promise of making conventional production models gradually inefficient. For this reason, major industrialized nations have placed the development of Industry 4.0 at the heart of their industrial policy strategies with the aim of preserving and increasing their competitiveness.

The speed at which the enabling technologies of this revolution are being disseminated suggests that the arrival and consolidation of Industry 4.0 will also be much faster than similar cases in the past. The ability of Brazilian industry to compete internationally will therefore depend on our ability to foster this transformation. Initially, this need will be more pressing for some sectors than others, but it will eventually be felt by all of them.

Aware of the importance of this revolution, the National Confederation of Industry (CNI) prepared the study

Challenges for Industry 4.0 in Brazil in 2016 [1], which lists seven priority dimensions for the development of Industry 4.0 in Brazil: i) application in production chains and supplier development; ii) mechanisms to drive the adoption of enabling technologies; iii) technological development; iv) expansion and improvements in broadband infrastructure; v) regulatory aspects; vi) human resources training; and vii) institutional coordination.

Figure 1 – Priority dimensions for the development of Industry 4.0 in Brazil



Source: CNI, 2016

The first dimension - applications in production chains and supplier development - is a crucial element for developing the others. This is because the specifics of the different sectors and chains in which industrial companies operate have a bearing on the capacity and need for incorporating the new technologies brought about by Industry 4.0. These specific features include aspects such as the capital or labor intensity of different sectors, the scientific and technological intensity of their production, the technological upgrading of their manufacturing practices, their degree of openness to international competition, among others. Together, these factors determine the unique potentialities and degrees of urgency of each sector to implement the technologies brought about by Industry 4.0.

[1] *Available at: http://www.portaldaindustria.com.br/publicacoes/2016/8/desafios-para-industria-40-no-brasil/*

Once the main opportunities for applying these technologies in production chains have been identified, the second dimension can be defined - mechanisms to drive the adoption of digital technologies.

The correct identification of priorities and the design of instruments capable of driving and speeding up the dissemination of these technologies in the Brazilian industrial fabric will in turn determine the opportunities that the country will have to promote the development of technologies (third dimension) and specify its needs in terms of human resources training (fourth dimension), type and location of infrastructures (fifth dimension), improvements in existing regulations (sixth dimension) and institutional coordination to link these measures to a state policy (seventh dimension).

Thus, to make progress on developing the agenda initially proposed by CNI in 2016, this document is dedicated to exploring in greater detail the first two dimensions - Application in production chains and supplier development and Mechanisms to drive the adoption of enabling technologies.

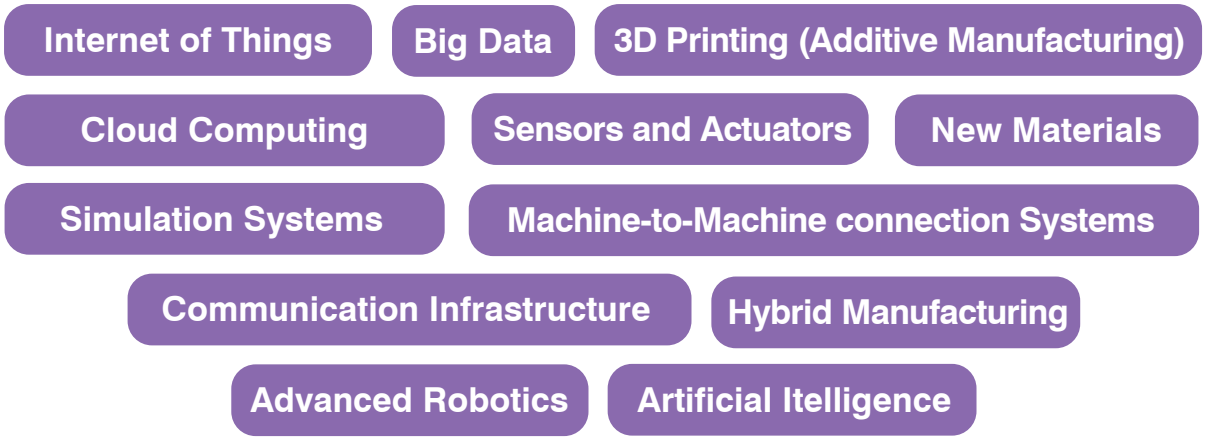
For this purpose, section 1 identifies the main technologies of Industry 4.0 and their impacts on production. Section 2 presents a typology developed through interviews with representatives of institutions and companies designed to provide an understanding of the supply of technology/ solutions by Industry 4.0 in Brazil, which is a fundamental aspect for defining possible mechanisms to disseminate these technologies in the country. Finally, section 4 points out a set of proposals designed to stimulate the development of these technologies and their adoption by Brazilian industry.

1 INDUSTRY 4.0 AND ITS IMPACTS ON INDUSTRIAL PRODUCTION

Foto: Shutterstock

One of the main features of Industry 4.0 lies in the incorporation of digitization to industrial activity, whereby physical and virtual components are integrated into what has come to be referred to as cyber-physical systems.

Figure 2 – Main enabling technologies of Industry 4.0



Source: CNI

The integration of these technologies (glossary in Annex A) into production is what characterizes the revolution. For example, the incorporation of Advanced Robotics, of Machine-to-Machine Connection Systems, of the Internet of Things and of the Sensors and Actuators used in these equipment items makes it possible for machines to "talk" to each other during industrial operations. This allows for the various stages of the value chain to be connected from the stage of development of new products, projects, production, to the after-sales stage.

In addition, devices located in different production units, including devices of different companies, can exchange information on purchases and inventories instantly. This provides logistical optimization by integrating suppliers, companies and customers, that is, it allows for greater **Horizontal Integration** of production.

This greater integration is only viable through components that enable improved data capture, transportation, storage and analysis, which are made possible by Big Data and Cloud Computing. Thus, in addition to traditional internal and external data sources used by companies, connected products (machinery and equipment) also emerge as major sources of information and of data and image processing to support decision-making.

Therefore, using Artificial Intelligence, such information is useful for predictive maintenance of machines and equipment and it ensures greater precision in procedures, efficiency in the use of inputs, and improved service quality. This can lead to the development of autonomous interactive environments, that is, without human intervention.

Another major feature of this integration is that it matches scale with flexibility in production lines, making the so-called mass customization possible. Instant communication between different links in the production chain and the development of highly flexible automation systems make it possible to produce customized goods according to the preferences and needs of different customers in the same production line. As a result, the costs for producing customized products are lowered, which until

very recently was only possible for standardized goods produced in large batches. Until now, the flexibility of production processes was limited and determined by manufacturers of industrialized goods.

From the point of view of companies, this allows for products to be differentiated according to the preferences and needs of different consumers and for new business models to be developed. For Brazil, these technologies can make it economically feasible to manufacture goods that in the past would face insurmountable entry barriers associated with minimum production scales.

PATHWAYS FOR INDUSTRY 4.0 IN BRAZIL

As in other countries, the technologies associated with Industry 4.0 will not be disseminated in Brazil to all sectors in the same way or at the same time.

If we separate the impacts of digitization on products and processes, it is very simply possible to classify the Brazilian industrial production in the four quadrants below.

Figure 3 – Product x process matrix in Industry 4.0

		Product	
		Traditional	Technological
Process	Conventional	1	2
	4.0	3	4

Source: CNI

In an economy marked by strong intrasectoral and intersectoral heterogeneity, it can be reasonably assumed that these four realities will coexist with each other for some time.

Companies that produce traditional goods and services through conventional production processes, without using digital technologies, fall under quadrant 1. These companies will need to adopt strategies that will make it possible for them to fall under quadrant 3 and, in some cases,

quadrant 4, depending on the degree of technology they can add to their products. In the textile industry, for example, in addition to the production revolution, new materials have been adding technological components to products, which can make commodities currently available obsolete. There are cases where mere digitization of production will not be enough to ensure long-term competitiveness.

In continuous process industries [2], with minimum interruptions, impacts will likely be concentrated on improvements in production processes and on digital integration of the chain between customers and suppliers (quadrant 3). Unlike discrete process industries [3], these companies will need to devise a two-pronged strategy, with investments in more technological products and incorporation of enabling technologies into production. More detailed information on these aspects will be provided in the next section.

Quadrant 2 is that of companies that produce goods referred to as technological goods, i.e. products that incorporate greater technical and scientific knowledge. In the context of Industry 4.0, most technological products incorporate digital technologies, such as the Internet of Things[4] or smart products or products with sensors that provide advanced specifications, but companies falling under this quadrant use conventional processes. For them, the road to digitization will play a decisive role in ensuring competitiveness.

Overall, the goal is to move the economy to quadrant 4. The extent and speed of this shift will depend on the internal characteristics of the sectors and companies, on increased competitive pressure as other companies in Brazil and abroad take the path toward Industry 4.0, and on the capacity of government to implement policies designed to stimulate this technological transition. It should be noted that in quadrant 4 both products and production processes are impacted by the technological wave of Industry 4.0 and, therefore, it is where the technological effort required is greater than for transitioning from quadrant 1 to quadrant 3.

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[2] Continuous process industries (CPIs): production processes with minimum interruptions, production through mixing, separation, conformation or physicochemical reactions.

[3] Discrete process industries (DPIs): production process divided into stages of assembly of parts and components.

[4] Examples include smart TVs, IT goods and electrical and electronic components, household appliances that can be connected to the internet, connected vehicles, etc.

These technologies can be combined in different ways and this revolution can have a wide range of impacts, which will vary from company to company according to the technologies they adopt, their degree of integration and their business strategies. For most companies, this process will be gradual and customized according to the investments they make and to their existing technological and productive capacity. This transition may include integrating technologies into machines and equipment in use by, for example, implementing sensors and software and buying new production assets, as in the case of additive manufacturing and robotics.

Changes in production processes may be accompanied by innovations in the products manufactured. The trend is toward more intelligent and autonomous products than those available today. Driverless cars and home robots are two examples of emerging products, although there is a multitude of innovations to be incorporated into existing products, such as home appliances connected to the Internet with a greater or lesser degree of autonomy to perform certain tasks.

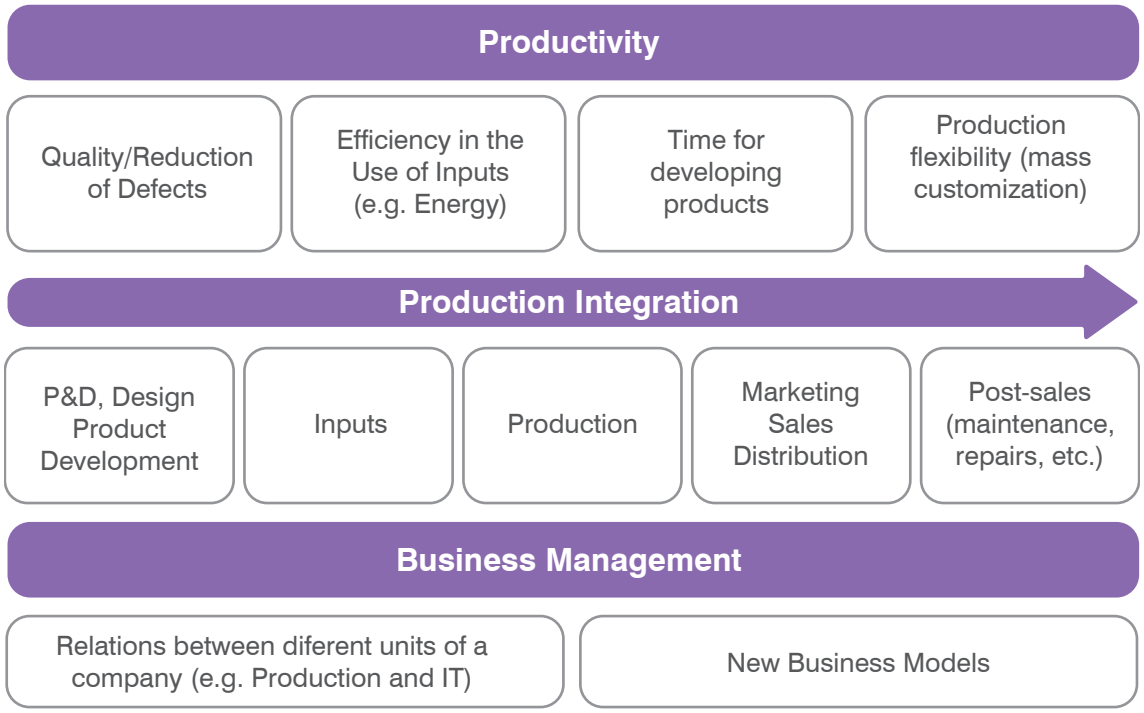
The adoption of these technologies also has repercussions on the internal framework of companies. In terms of business management, cooperation between different departments, mainly between IT and production units, is one of the main transformations. IT departments will need to develop systemic links with other units to promote the necessary integration of the new technologies implemented.

Internal cooperation between different stages will become a must. Swift feedback between development, production and marketing stages will be necessary. External cooperation will also be essential. Sound communications with suppliers of both inputs and technologies require related strategies to ensure the necessary agility, confidence and security in the exchange of information.

Another key action is that of developing multisectoral plans and ensuring the feasibility of this integration (clients, company and suppliers), for which purpose competences lacking in companies will have to be acquired through partnerships, mergers and acquisitions. In addition, companies will

need to develop and/or refine their business models, especially in relation to customer relationships. The provision of services linked to industrial goods will play a strategic role in some sectors.

Figure 4 – Expected impacts on industrial production



Source: CNI

In short, this new industrial revolution will bring about significant impacts on production, such as increased efficiency in the use of resources, greater ability to integrate and increased flexibility in production lines. It will also imply transformations in business management, mainly in two aspects. The first one is related to the strategy adopted to implement technologies, such as cooperation between IT and production units. The second one is associated with the results of adopting these technologies, which require companies to develop and/or improve their business models, especially in what regards their relationship with suppliers and customers.

2 STRUCTURE OF SUPPLY OF THE ENABLING TECHNOLOGIES OF INDUSTRY 4.0[5]

Foto: Shutterstock

As described in the first section, the technologies mentioned in this study involve a wide range of machinery, equipment, devices and integrated software. There are linked and integrated companies more or less specialized in manufacturing these elements, depending on the business model adopted by each of them in the market. This set of industrial companies and service providers constitutes the supply of digital solutions of Industry 4.0. To provide a better understanding of the supply and unique features of companies operating in this sector, they will be divided into three segments here, as specified below.

The first segment consists of large **Companies that Produce Enabling Technologies**. They can supply complete or partial digital systems, including machinery, equipment, sensors and software. What is important is that these are companies that operate in almost all the technological fields of Industry 4.0 whose technological and productive capacity is recognized internationally. They are usually large solution providers whose hardware and software are designed and produced worldwide for the global market. These companies are technologically qualified in various branches of engineering, such as in those of mechanics, electronics, software and materials. From a commercial point of view, they have sufficient capacity for technical sales in different industrial sectors, which means that the technical

[5] *This section was prepared based on interviews with professionals specializing in the subject, free of any responsibility.*

know-how of their sales force is relatively comprehensive and capable of providing technical cooperation in the design of complete systems. Since they can provide the complete digital systems that characterize Industry 4.0, they can also, for business reasons, provide their customers with only portions of their own production solutions and the rest in partnership with other companies.

This segment develops new products and materials, hardware and software that can meet the unique demand of the market. The integration and development of software with automation products feed back into technological qualification and make it possible for solutions to be offered to industrial companies, which constitute their market, to be largely customized.

In Brazil, this segment is largely made up of transnational companies. Almost all their units in charge of technological development and project design are located abroad. Given the very broad set of enabling technologies of Industry 4.0 and the great diversity of knowledge involved, which requires different skills, there is no single country in charge of all the technological development brought about by this new industrial revolution.

These companies develop adaptations for their global products in Brazil to sell them in the domestic market. Adjustments are relatively minor in terms of technological effort and at the same time they provide a great advantage over competitors due to the fact that their solution development platform is already being marketed in other more developed countries. Even in the domestic market, if the industrial companies involved in disseminating the technologies of Industry 4.0 are multinational companies, there is a preference for systems already adopted by other units of the corporation, which favors the strength of companies that produce enabling technologies in the domestic market. This reduces the room for some local solutions usually employed by relatively smaller national companies as compared to large international groups operating in Brazil.

A second segment of supply is composed of **Integrating Companies**, which are predominantly skilled in software solutions and in automating specific processes or equipment, such as robots. The majority of these

companies are service providers that adapt and customize programs or develop programs used in parts of the production and management processes of industrial companies.

To develop technological solutions, integrating companies specify the necessary equipment items, ancillary units, commands and sensors to be used. Their difference in relation to the previous segment lies in the fact that integrators do not produce technologies. They have the comprehensive training required for designing each element of the system and are at the same time skilled in integrating its parts. Integrators usually have greater competence in designing solutions that use parts and components from different suppliers and therefore their focus is on proposing customized solutions.

This segment is heterogeneous in its capacity to provide services and design customized solutions, which will depend on the familiarity of the integrating company with the technologies of Industry 4.0. In this segment, there are smaller companies that define themselves more as business representatives of producers of solutions than as service providers in customizing solutions.

Integrators are companies that play a major role in developing software for electronic automation for production processes and management of industrial activities. As mentioned earlier, an integrator may also be a supplier of a product or service that is part of an Industry 4.0 solution.

Integrators play a key role in disseminating technologies. Due to their economic nature and size and to how easy it is to set up companies of this type, they have a deep penetration and may be located very close to their potential market. It should be noted that the diffusion of technologies does not merely consist in repeating or reproducing solutions already tested and implemented in other companies. Throughout the diffusion process, innovations are also developed, but less sophisticated ones, which does not mean that they are less important to meet the needs of a large number of customers. These companies are instrumental in helping companies to adopt technologies at a faster pace.

No studies are available in Brazil on this segment of supply of digital solutions for industry. The interviews carried out for conducting this study, however, indicate that few large integrators have the capacity to design customized solutions with the features of truly innovative processes. These large integrators face competition from solutions developed abroad adopted by the subsidiaries of multinational groups set up in Brazil while seeking new markets overseas. Service exports can be categorized as of medium complexity, but their marketing strength lies in their lower development costs, which make it possible for solutions to be offered at relatively lower prices than those charged in the first segment.

As mentioned above, the first segment also plays the role of an integrator, since it is not restricted to offering complete solutions only. The size of the domestic market does not ensure the feasibility of the specialization of large suppliers in this market and their relatively higher costs require that they operate in a more diversified manner in the market, acting as integrators as well.

In another position there are usually nationally-owned or smaller integrating companies with more limited capacity and less power to reach different industrial sectors demanding the digital solutions offered by Industry 4.0. However, this does not mean that they are companies providing services of a lower quality, but rather companies with limited conditions to meet the needs of the entire potential market of users of the technologies of Industry 4.0 by themselves. This is a segment of companies that need to be more supported in structuring and strengthening themselves in Brazil.

It should also be noted that there is a relevant contingent of companies, which are mainly nationally-owned corporations, that fit this model of specialized suppliers of parts for digital solutions involving the technologies of Industry 4.0. They supply both programs and machinery, equipment, components, parts, instruments and devices that incorporate the developments of the new technological generation. These companies can offer their products directly to users or can partner with integrators to gain new markets. However, these suppliers do not purport to be providers of projects that qualify as complete solutions for digitizing

industrial production. Although they operate in a more specialized field, the importance of these companies should not be underestimated, as they possess specific and useful knowledge for disseminating the technologies of Industry 4.0. For the most part, these are ICT companies or companies operating in the capital goods segment, two pillars of the new technological wave. Therefore, industrial policies focused on these industrial sectors must be devised and proposed.

The third segment of supply is made up of new, smaller companies, **Startups**, with technical competence for developing partial and very specific solutions for digitizing industrial production processes or product controls in industrial companies. Production costs in this segment are relatively low, but technical qualification in them is the most circumscribed among all segments of supply of technological solutions. These companies have great potential to develop products with embedded technologies. Nowadays, companies operating in the first segment are increasingly similar to startups and a major source of technological solutions for large companies.

This segment of supply of digital solutions of Industry 4.0 also plays a key role in training qualified human resources. Large-scale training of personnel for developing solutions in this market occurs as these companies carry out their specific activities. Learning is acquired in the process of developing solutions for customers. Human resources trained in this way are a major source of knowledge to be explored by other segments of supply of automation systems and constitute the basis for implementing national Industry 4.0 programs.

The role played by universities and science and technology institutions (STIs) in the ecosystem of Industry 4.0 should be highlighted. Although they are not directly involved in implementing technologies in companies, they play a major role in developing human resources and basic science. They are strategically related to producing companies and are, in most cases, the place of origin of startups.

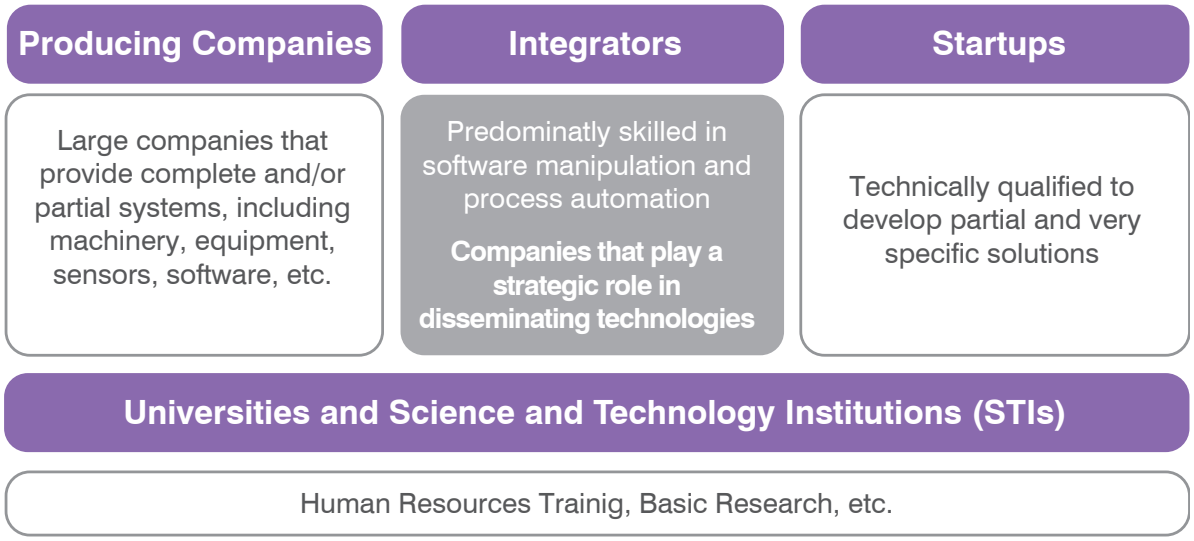
The entrepreneurial movement for setting up startups in Brazil has become more intense in recent years. The dissemination of business opportunities, difficulties to place qualified people in the labor market and the greater national effort being made to promote and foster startups are factors that have been contributing to expanding this segment of supply in Brazil. However, there is still a lot of work to be done to make these companies more sustainable. The business vision of associates is one of the dimensions to be better structured in this type of business. Usually, startups are set up by young graduates from universities with a good academic background but little experience and training in business. Supporting training of innovative entrepreneurs should be a strategy to be followed by development institutions in Brazil.

However, the marketing difficulties faced by startups are more pronounced than those related to the lack of a business vision. There is a structural problem to be solved. Several large companies find it difficult to maintain a business relationship with startups because the latter are not prepared to comply with the routines and requirements defined by large enterprises. Legal difficulties and shortcomings related to operational procedures are major constraints to be addressed. On the other hand, some small and medium-sized companies restrict their business with startups based on the belief that these companies lack sufficient tradition in the market. In both cases, a more favorable business culture must be developed to enable startups to develop themselves as fully as in other countries.

Finally, a fourth segment of supply could be mentioned, one that does not define itself as a provider of digital solutions, but rather as a service provider that prepares industrial companies for absorbing the technologies of Industry 4.0 through its solutions. This fourth segment is made up of **Specialized Consulting Firms**, which focus on planning the implementation of technologies in companies. These consulting firms provide a plan of customized solutions based on the planned financial expenditures and strategic objectives of their customers. In order to implement these solutions, these companies associate themselves with other producers and/or integrators according to the size of the project in question. However, in some cases producing and integrating companies can also provide this type of service.

Despite its differences, the Senai System can also be mentioned here as an important institution working to identify and disseminate the technologies of Industry 4.0 to the Brazilian industrial system as a whole or as an entity working to identify specific innovative solutions for certain companies.

Figure 5 – Structure of Supply of the Enabling Technologies of Industry 4.0



Source: CNI

Regardless of the simplification problems of typologies or segmentations, they are instrumental for understanding the structures and behaviors of companies and are ancillary tools for proposing public policies and business strategies. Based on what has been presented above, the next section of this study presents some proposals for that purpose.

3 POLICY PROPOSALS FOR SUPPLY OF AND DEMAND FOR TECHNOLOGIES OF INDUSTRY 4.0

Foto: Shutterstock

The policy proposals developed in this study took into account the attributes of enabling technologies, as described in section 1, mainly the technological integration component and the degree of customization for companies.

A. PROPOSALS FOR DEMAND FOR ENABLING TECHNOLOGIES

i. National Program for Preparing and Implementing a Strategic Corporate Digitization Plan

Goal: structuring a network of institutions capable of drawing up corporate digitization plans for companies operating in the industrial sector.

For the enabling technologies of Industry 4.0 to be introduced, a qualified diagnosis must be conducted first for each industrial company considering their strategic goals and a list of priorities prepared for adopting technologies. This diagnosis is expected to result in a Strategic Corporate Digitization Plan

(PEED, in the Brazilian acronym). The involvement of multiple companies or institutions with the capacity to carry out this work and with operations throughout the national territory is required to draw up this plan.

A first action to be taken is that of structuring at least one network of institutions that provide services of this kind. Once this program is initiated, it is expected that companies will take new initiatives in the process of establishing services in this market, even if they are not part of the initial network of qualified institutions to draw up a PEED.

The objective of a PEED is to stimulate each company to develop its own digitization plan according to its strategic objectives. Such a plan must contemplate orders of magnitude of investment in implementing a PEED, that is, budget restrictions faced by companies must be considered in the process of preparing it.

ii. Financing for implementing a PEED

Goal: raising funds to finance the implementation of each Strategic Corporate Digitization Plan.

Preparing a PEED should be seen as a key phase for companies wishing adopt some of the technologies of Industry 4.0, either because it helps them rationalize their decision-making processes or because they are faced with alternatives for technological improvements toward Industry 4.0.

Once a PEED has been drawn up, the following step is that of implementing it, for which purpose technological services will have to be hired. Depending on the complexity of the PEED, such services may consist in implementing the plan itself. For example, if a company decides that it only wants to integrate certain machines electronically, it will have to adapt its machinery for seamless interoperability. For this purposes, all it has to do is hire a company with the required knowledge and the appropriate business model to do so.

However, if a company decides to invest more and purchase machines with wireless capability, purchase and implement programs to bring engineering units closer to each other within the company, integrate production with production management and the company with its suppliers, implementing a PEED may, due to its comprehensiveness and complexity, require that another type of company be hired with the capacity to act as an integrator of solutions and digital systems.

iii. Public procurement programs

Goal: stimulating the purchase of goods and services that incorporate technologies also used by Industry 4.0

Through the public procurement mechanism, government could encourage the generation and adoption of digital solutions, even though its procurement is not necessarily characterized as acquisition of industrialized products.

State demands related to the management of transportation systems and to the energy and safety areas, for example, would be initiatives that would contribute to disseminating technologies based on the same principles of Industry 4.0. The idea is that by generating demand for application in economic fields other than industrial activity, government would support the promotion of technical training initiatives, which could also generate solutions for Brazilian industry.

It is in this context that the formalization of government programs designed to contribute to the provision of public services in a more intelligent and connected way, as made possible by Industry 4.0, is being proposed.

Government procurement could also generate demand for digital solutions through the acquisition of smarter products demanded by the public sector, mainly in the areas of defense, public safety and management of health care systems. Public administration itself is also a field in which the technologies of Industry 4.0 can be expanded and help

to disseminate these technologies and training in them. Making public management more efficient and flexible, which are principles of Industry 4.0, is also a need of public administration. It is worth noting that the Industry 4.0 paradigm will only be fully disseminated as institutions also adopt this new technological standard.

Due to the potential impact of the technologies of Industry 4.0 on health care, it should be dealt with separately. This is because health care includes the management of the system itself and the adoption of artificial intelligence to support the development of new drugs either for diagnosis purposes or for developing new therapies. At this point, it is worthwhile stressing and recalling that health care deserves a specific policy for Health 4.0.

Finally, special mention should be made of technological orders, defined as the purchase of specific technological development that may or may not be associated with the procurement of goods and services by the public sector.

Technological orders are provided for in the Brazilian law, but they still account for a very low percentage of total public procurement and of other mechanisms designed to promote technological development.

In several areas, technological orders could be proposed as a mechanism to address concrete problems faced by the public sector. Because it is a technological development, the resources required for investment in R&D by the electricity, oil and IT sectors could be used to finance these demands in the respective sectoral areas. Solutions based on data digitization, on the Internet of Things, on artificial intelligence and on additive manufacturing technologies could be specified and demanded by the direct public administration or by companies and institutions linked to the Brazilian public sector.

Public agents should take advantage of the solutions afforded by the technologies of Industry 4.0 to disseminate them in the public sector.

B. PROPOSALS FOCUSED ON THE SUPPLY OF ENABLING TECHNOLOGIES

i. Incentives for Integrating Companies

Goals: training entrepreneurs and technical staff for integrating companies, advising new integrating companies on their strategic definitions for their market positioning and granting of finance for training integrators.

It is considered that the number of existing companies with the capacity to provide technological integration solutions for the domestic industry is relatively small in view of the enormous effort that must be made to update and innovate products and processes in line with the technologies of Industry 4.0. Therefore, the assumption is that there is a need for supporting the establishment of integrating companies in Brazil and for strengthening them. Creating such companies involves training human resources at two levels: training of entrepreneurial personnel and of technical staff to work in those companies.

In addition to training those interested in establishing new integrating companies as mentioned above, a mentoring program could be offered to new entrepreneurs to guide them in the process of organizing their companies and defining their business strategies. For this purpose, a team of consultants should be set up to provide these services for a period of time to be defined later.

In the past, when Brazil made the strategic decision to stimulate the establishment of consulting firms as a necessary mechanism for building technological capacity domestically, two specific financing lines were established: the Program in Support of Users of Consultancy Services (AUSC, in the Brazilian acronym) and the Program in Support of Domestic Consulting Firms (ACN, in the Brazilian acronym). The AUSC program financed the demand and market for consulting firms, while the ACN program provided funding to consulting firms.

Similarly, the focus is now on integrating companies because they can be used as a key mechanism for disseminating the innovations brought about by the technologies of Industry 4.0. On the demand side, this study has already presented a financing proposal with more favorable cost conditions.

In relation to supply, it is proposed that innovation financing agencies - such as the National Economic and Social Development Bank (BNDES) and the Financier of Studies and Projects (FINEP) - should offer a specific financing line to integrators with more favorable cost conditions for acquiring industrial automation programs and fixed assets, working capital and training of human resources. With the aim of reducing costs for final borrowers, an amendment is proposed to the Information Technology Law to include a provision designed to make it possible to use a portion of the funds to equalize interest rates.

ii. Programs to encourage the establishment of startups

Goal: creating an economic environment conducive to establishing startups skilled in the technologies of Industry 4.0.

The technologies brought about by Industry 4.0 provide plenty of room for small startups to develop specific programs related to engineering, production or business management and to integrate all these spheres for developing a specific product or parts and components thereof, devices, etc.

Regardless of the possibilities for companies with these profiles to become large enterprises in the future, the major role played by them as agents of innovation cannot be denied today, even if they are eventually acquired by large corporations. Today, several large companies have specific funds for investing in startups precisely because they now recognize them as a key source of knowledge and innovation.

Therefore, encouraging the establishment of this segment of companies is a relevant element in a national strategy for disseminating and generating innovations in line with Industry 4.0.

In relation to small technology-oriented companies and startups, it is widely known that they have two structural shortcomings: investment funds and business management.

In connection with funds, since these companies have no established record of operating in the market and cannot provide sufficient collateral to access credit in the financial market due to their small size, their only alternative to obtain funds for investment is by raising venture capital from other companies. For this reason, the establishment of investment funds for technology-oriented startups focused on Industry 4.0 should be encouraged. The necessary measures are the same as those applied to any venture capital fund, but the difference lies in establishing specific funds for these technologies.

Institutions promoting innovation, such as Finep and BNDES, have mechanisms to promote investment funds. However, a closed investment fund should also be structured with funds provided for in the Information Technology Law, as it covers the area of electronic automation, one of the pillars of Industry 4.0.

In May 2017, Finep issued a public notice for capital contributions for startups. This is a new line of action of the development agency and this initiative should be monitored and evaluated with a view to establishing a concept about its appropriateness. In any case, the notice that was issued was not exclusively meant for companies focused on the technologies of Industry 4.0.

In addition to capital investment in startups, granting economic subsidies is another way of financing technological development in this segment. Despite its limited budget today, the National Fund for Scientific and Technological Development (FNDCT) has the institutional tools and mandate to issue a public call for proposals focused on startups devoted to developing technologies for Industry 4.0. To make this initiative feasible, the National Treasury should earmark funds for this specific action in the 2019 budget. Alternatively, the Technological Fund (Funtec) of BNDES could as well be used by means of a specific public call for proposals, although Funtec's regulation requires an amendment to waive the financial contribution from companies.

In order to overcome the problem of the financial contribution of companies, startups could apply for such funding in partnership with large companies potentially interested in the results of technological development.

On the other hand, to assist small enterprises and startups in developing the technologies of Industry 4.0, specific incubation and mentoring programs could be defined by innovation-promoting agencies, including state-owned research-supporting foundations.

Government has two initiatives under way not specifically related to the supply of technologies of Industry 4.0 that have been yielding positive results and can be instrumental in overcoming these problems: the *Aceleração InovAtiva* program, a large-scale acceleration program for innovative companies carried out by the Brazilian Ministry of Industry, Foreign Trade and Services (MDIC) jointly with the Brazilian Service in Support of Micro and Small Enterprises (SEBRAE) and implemented by the CERTI Foundation - Reference Centers for Innovative Technologies[6]; and, more recently, the *Startup Indústria* program of the Brazilian Industrial Development Agency (ABDI) linked to the MDIC, designed to promote a favorable business environment between startups and industrial companies[7].

iii. Financing lines for smart product innovations

Goal: giving priority to the development of smart products.

Specifically for the development of smart products, the assumption here is that research and development are carried out by private companies. In this case, financing lines for innovations must be of the reimbursable type, but with more competitive interest rates.

For this purpose, using the funds provided for in the IT Law to reduce financial costs would be a possibility. Another option is to use funds from FNDCT's Yellow Green Fund (Fundo Verde Amarelo) for interest equalization purposes.

For cooperative projects between companies and science and technology institutions (STIs), funds contemplated in the public call for proposals provided for in the IT Law could be used, as proposed above, and specific actions could be defined by units of the Brazilian Agency for Industrial Research and Innovation (Embrapii).

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[6] *Information available at: http://www.inovativabrasil.com.br/programa-de-aceleracao/*

[7] *Information available at: https://startupindustria.com.br/*

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Foto: Shutterstock

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ANNEX

Foto: Shutterstock

ANNEX A - GLOSSARY OF ENABLING TECHNOLOGIES OF INDUSTRY 4.0

- **Internet of Things (IoT)**: machines and consumer goods with systems that can be connected to the internet. For example, smart TVs, smartphones, refrigerators, among other equipment items;
- **Sensors and Actuators**: sensors are devices that respond to stimuli (luminosity, motion, temperature) and record information, while actuators are devices that command stimuli (capable of generating an action of some kind);
- **Advanced Robotics**: machines and equipment with integrated communication systems and remote connection, provided with flexibility for carrying out scheduled tasks;
- **Additive Manufacturing (3D Printing)**: machines capable of building up parts and components in layers by depositing material - a process similar to that of a printer;
- **Hybrid Manufacturing**: machines that integrate additive and machining functions;
- **New Materials**: generation of new materials and advanced materials that make possible, for example, 3D printing, sensing of production processes, information processing;

- **Big Data**: central storage and processing units of large databases;
- **Cloud Computing**: infrastructure with large data storage capacity;
- **Machine-to-Machine Connection Systems (M2M)**: integration software that makes it possible for information to be transmitted between machines and equipment;
- **Communication Infrastructure**: physical means that ensure communication between machines within the same establishment between different units of a large corporation or between different companies in different locations;
- **Artificial Intelligence**: systems that develop, through data, capacity for autonomous decision-making in different situations;
- **Simulation Systems**: software that can simulate the use of the above-mentioned technologies in manufacturing environments.

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