ENTRY BARRIERS FOR INDUSTRY 4.0 IN ARGENTINA

BARREIRAS DE ENTRADA PARA A INDÚSTRIA 4.0 NA ARGENTINA

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Abstract. Industry 4.0 is a topic that has aroused great interest in recent years. The market, which demands more complex and differentiated products, must be attended to. Traditional centrally controlled production processes will be replaced by decentralised ones. Physical systems will be digitised, factories will self-regulate, optimising their own operation. Productivity will be improved; Quick solutions will be provided in case of production problems and abnormal operations. Many challenges must be faced, such as high implementation costs, organisational and process changes, security and data protection and the need for qualified personnel at all organisational levels who are capable of dealing with the growing complexity of future information systems. production. To address these issues, this article provides an analysis of entry barriers for Industry 4.0 in Argentina. First, a literature review was performed. This work revealed a set of 12 entry barrier factors. Second, based on the literature review and coding procedure, a synthesis and framework were developed. Third, a survey was carried out in 108 Argentine companies, obtaining the classification and strength of each of these 12 factors.

Keywords: Entry Barriers; Fourth Industrial Revolution; Industry 4.0; Digital Transformation; Industry sector

Resumo. A Indústria 4.0 é um tema que despertou grande interesse nos últimos anos. O mercado, que demanda produtos mais complexos e diferenciados, precisa ser atendido. Processos tradicionais de produção controlados de forma centralizada serão substituídos por processos descentralizados. Sistemas físicos serão digitalizados, fábricas se auto-regularão, otimizando sua própria operação. A produtividade será aprimorada; soluções rápidas serão oferecidas em caso de problemas de produção e operações anormais. Muitos desafios devem ser enfrentados, como altos custos de implementação, mudanças organizacionais e de processos, segurança e proteção de dados e a necessidade de pessoal qualificado em todos os níveis organizacionais, capaz de lidar com a crescente complexidade dos futuros sistemas de informação de produção. Para abordar essas questões, este artigo fornece uma análise das barreiras de entrada para a Indústria 4.0 na Argentina. Primeiro, foi realizada uma revisão de literatura. Este trabalho revelou um conjunto de 12 fatores de barreira de entrada. Segundo, com base na revisão de literatura e procedimento de codificação, foi desenvolvida uma síntese e estrutura. Terceiro, uma pesquisa foi realizada em 108 empresas argentinas, obtendo a classificação e a força de cada um desses 12 fatores.

Palavras-chave: Barreiras de entrada; Quarta Revolução Industrial; Indústria 4.0; Transformação digital; Setor industrial.

INTRODUCTION

Industry 4.0 (I4.0) is a topic that has aroused considerable interest in recent years, by academics, professionals and governments, and literature production on this topic has grown significantly in a short period of time (For 2018).

The German government introduced the term "Industry 4.0" in 2011. This occurred at the Hannover Fair, in order to describe a strategic approach to the manufacturing industry which was based on the computerization of manufacturing (Matt, 2020) (Sanders et al., 2016). I4.0 is a national strategic initiative of the German government promoted by the Ministry of Education and Research (BMBF) and the Ministry of Economy and Energy (BMWI) (Qin et al., 2016). Its objective is to drive Digital Transformation (DX), increasing digitisation and interconnection of products, value chains, and business models (Liu et al., 2020).

The DX in the Industry, the so-called I4.0, involves very important changes, both in technological factors, as in processes and fundamentally in people. These changes are often seen by companies as entry barriers to I4.0. They are seen as insurmountable obstacles, mainly for small and medium industries (SMEs).

Factors, such as lack of investment, need for capital or lack of training, are frequently heard in the business environment.

The research question that is intended to be answered in this work is what these barriers are, and what is the importance that each industrial sector gives to each one of them. This is the topic discussed below.

MATERIAL AND METHODS

The chosen research approach for this study is qualitative-quantitative, aiming to combine both qualitative and quantitative methods in the research process. The research scope involves an exploratory and descriptive type of work, which utilizes a structured questionnaire to interact with individuals who experience the subject matter on a daily basis. Regarding the research design, it is non-experimental and follows a transactional exploratory approach.

The study's theoretical framework incorporates several methods, including reading cards, mapping method, and conceptual maps.

For data collection, a two-stage technique was employed. The first stage involved quantitative data collection through a survey. The survey utilized a structured questionnaire, enabling a comparison of different responses to the same questions and quantifying the obtained results. This technique was aimed at validating the research hypotheses.

The data collection for the state of the art was conducted between February and July 2021.A systematic review of the literature is carried out in order to explore the current state of Industry 4.0 barriers. A systematic review can be defined as the review of a matter using systematic methods in order to identify, select and critically evaluate relevant research (Martin et al., 2006). Articles were extracted from Scopus, Scielo and databases to guarantee a suitable selection of papers with high impact factor journals.

Web search engines were not used to avoid grey literature, and non-academic material has not been included in this research work.

Searches were limited to as follows: (1) In academic databases with a search string through the combination of the operator “or" between the keywords, the references that met the following criteria were collected; (2) They were published in congresses proceedings, scientific articles, and books between the years 2016 and 2022; (3) contained at least one of the search terms in the abstract, title and / or keywords; (4) Duplicates removed. (5) Those that did not have full texts available were discarded. (6) Documents defining entry barriers to I4.0 outside the scope of this research work were excluded. (7) They were classified according to the research questions. (8) The selected documents were analysed, coding several segments, and the corresponding data of interest for the research questions was collected.

The questionnaire for this research project contains 20 Likert questions with a 4 items scale.

Samples: the survey is administered to a group of industries / people called the sample, with the aim of identifying trends in attitudes, opinions, behaviours, or characteristics of a larger group of individuals called the population.

Processing and analysis techniques: The “e-survey” platform was used to carry out web surveys by generating a matrix of data from the responses. It was converted to a spreadsheet for further processing with a statistics software.

The research project has been carried out in three phases (figure 1): during Phase 1, a systematic review of the literature was carried out regarding Industry 4.0´s Barriers. During Phase 2 the study of the different entry barriers was deepened and classified by categories, and in Phase 3 a survey n = 108 was carried out and its subsequent analysis.

For this research, the e-encuesta™, Mendeley ™, VOSviewer ™ and MAXQDA ™ software were utilised.

Figure 1. Research Phases. Source: author's own (2022)

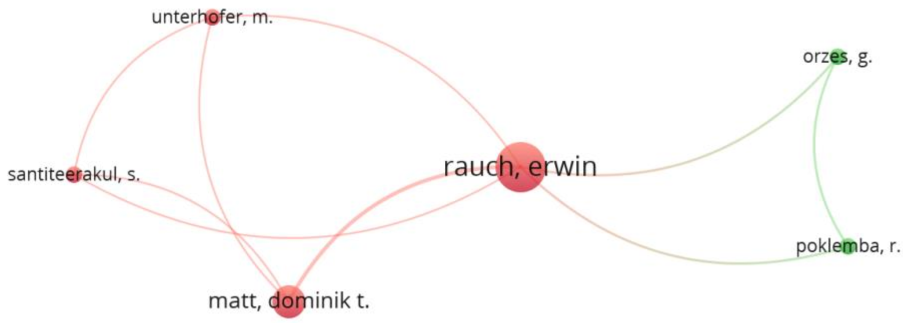


Figure 2. Keywords network analysis. Source: author's own (2022)

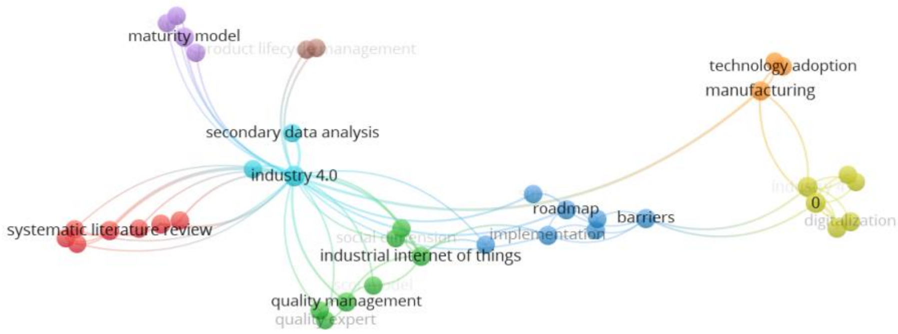


Figure 3. Key Authors network analysis. Source: author's own (2022)

INDUSTRY 4.0

Definitions and Concepts

The ability to autonomously interconnect products via the Internet, the expansion of wireless communications, the development of robots and intelligent machines, and real-time data analysis, have the potential to change the way people work in this new era, that is the reason why it is considered the fourth industrial revolution (4IR) (Nedelcu et al., 2018).

Unlike previous industrial revolutions, which were led by innovations in manufacturing processes and systems, 4IR advancements are driven by an intelligent, interconnected, and ubiquitous environment (Müller et al., 2018).

While the previous industrial revolution focused on improving physical manufacturing processes, expanding human power with additional energy sources, such as machinery and steam power, a process for mass production through the introduction of assembly lines, electronics, and automation, the 4IR is primarily focused on creating a digital representation of physical processes in order to gain a better understanding of what is happening with the process. For instance, a machine could show signs that something is wrong and that a breakdown could occur. Those signals could be processed by predictive models that would indicate deviation from normal operating conditions. Consequently, the digital model can provide early information on the status of the equipment, allowing maintenance personnel to determine the best time to repair it, moving from a reactive to a planned repair (Dalzochio et al., 2020).

The key to the 4IR is the digitization of "things". Digitization is understood as taking analog information and encoding it using zeros and ones, so as computers could store, process, and transmit information. Meanwhile, digitalization is the process of change in itself (Powell et al., 2018).

Digital technologies have become key factors for those companies seeking to achieve their goals. The application of these technologies to business and to the entire society is called Digital Transformation (DX) (Salimbeni & Mamani, 2020).

The world has changed the way people live, travel and work, all thanks to the Internet and new applications that make use of new technologies (Sivagami et al., 2021). The different devices, sensors and "things" that can communicate with each other, is what is called the Internet of Things (IoT).

The concept of Internet of Things (IoT) dates back to 1999 and was originated by Kelvin Ashton, a British technology pioneer. Most physical objects were made "smart" by connecting them to the internet and also utilising ubiquitous sensors (Oluwaseun & Numbu, 2019). IoT joins the digital world and the physical world being considered the next generation network or the future Internet (Lu et al., 2016). IoT is generating an industrial transformation, the so-called I4.0, and it is the key to the DX of organisations, cities, and society as a whole.

I4.0 is the integration and interaction of technologies, both in the digital and physical fields, and this is what differentiates it from other industrial revolutions (Demartini & Tonelli, 2018). The physical and virtual world are integrated into the so-called cyber-physical systems (CPS) (Sommer, 2015). I4.0 enabling technologies are cyber-physical production systems, the industrial internet of things (IIoT), cloud computing, data analytics, augmented and virtual reality, additive manufacturing, simulation techniques, and digital twins (Mantravadi & Møller, 2019) (Javaid et al., 2021).

Unterhofer et al. (2019) states that researchers, in general, agree that the enabling technologies of I4.0 are the following: (1) Internet of things (IoT): which establishes a value chain through the interconnection of machines to machines (assets-assets). (2) Cloud computing: which provides enormous storage, network, and computing capacities that allows the interaction between technologies. (3) Big Data and Data Analytics: those who build capabilities to support real-time and intelligent decision-making by reducing downtime and waste. (4) Additive Manufacturing, also known as 3D: reduces lead time from product design to launch, enabling efficient customization and small batch or prototype production. (5) Augmented reality: uses mathematical models, artificial intelligence, and virtual reality to improve business generation. (6) Robotics: improves productivity through automated manufacturing processes. (7) Cybersecurity: guarantees secure communication protocols that ensure data security. (8) Machine Learning (ML): uses industrial sensors and instruments to record and communicate data directly with software, to learn from them and make decisions. (9) Simulation and digital twin: mimicking the operation of a real-world process help to visualise the design and identify problems that could occur at a much earlier stage.

It could be said that nowadays I4.0 is starting, and great promises have emerged with it, so as to face the latest challenges in service and manufacturing systems. I4.0 is reinforcing this trend using the just mentioned enabling technologies, changing the way of life, creating new business models and new ways of manufacturing, thus, renewing the industry for the so-called Digital Transformation (Alcácer & Cruz-Machado, 2019). This new paradigm refers to the creation of value from digitization (Veile et al., 2020).

I4.0 introduces several changes to the original approach to industrial automation. IoT and CPS technologies play a key role in this context by introducing cognitive automation, and consequently, implementing the concept of smart production, which leads to smart products and services (Dalzochio et al., 2020).

Standards

Several associations and institutions, mostly in Germany, have cooperated in the creation of the Reference Architecture Model for I4.0 (RAMI4.0) (Cotrino et al., 2020). This model is represented in three axes: (1) life cycle of the value stream, (2) levels of hierarchies and (3) layers. It allows a clear identification of the constituent elements and enables an integration between them, both vertically and horizontally. Its importance lies in the areas of engineering, production, marketing, and supply chain, everything connected creating a collaborative system integration scenario, according to the flow of information and considering the levels of automation. RAMI4.0 represents the I4.0 horizontal and vertical system integrations, and these two types of integration permit real-time data exchange.

Horizontal integration occurs between different companies and different areas within the same company. It is the basis for close and high-level collaboration between organisations, using information systems to enrich the product life cycle, creating an interconnected ecosystem within the same value creation network. That is why an independent platform is necessary to achieve interoperability in the development of these systems, based on industrial standards, that allow the exchange of data and information.

On the other hand, vertical integration is a network system; it is the integration within departments within the same company and is the basis for the exchange of information and collaboration between the different levels of the business hierarchy, such as corporate planning, production scheduling or management. This is where the conjunction of Information Technology (IT) and Operational Technology (OP) occurs (Salimbeni, 2019).

In short, vertical and horizontal integration "digitise" the whole process within the entire organisation and the supplier-company-customer system, and compose all the data of the processes, for example, quality management, process efficiency or operation planning, which are available in real time. It is characterised by intelligently connecting, horizontally and vertically, people, machines, objects, and information and communication technology (ICT) systems. Therefore, future value creation is located in digitised factories and production networks, with real-time capacity, intelligent, connected, and autonomous (Veile et al., 2020).

Finally, it can be said that RAMI 4.0 proposes: (1) the IEC 62890 standard as a consistent data model for the entire product life cycle, distinguishing between type and instance, (2) the IEC 62264 and IEC 61512 standards as a functional hierarchy for all the components of Industry 4.0, and (3) a layer model that allows integrating different technologies to represent the components from different points of view (Sarachaga et al., 2019).

Benefits

Kovács et al. (2019), conclude that the results of application of the DX and I4.0 are: physical systems will be digitised, customers who demand more complex and unique products in small quantities will be satisfied, traditional centrally controlled and monitored production processes will be replaced by decentralised controlling, factories will be self-regulating optimising their own operation, productivity will be improved and fast solutions can be provided in case of production problems and abnormal operations.

Researchers in New Zealand assert that with lower cost, better quality and higher ability to serve customers, I4.0 makes the manufacturers a preferred supplier to current and potential customers. It also opens up the way for companies to innovate rapidly, offers customised products with high-quality and thus achieves higher revenues (Hamzeh et al., 2018). Darnley et al. (2018) also said that in the Danish industry, robotics improves time efficiency. From the literature review, he found out that augmented reality (AR) improves communication in industry across the globe, reducing response time and machine downtime. Inspection service companies revealed that drones help surveyors complete their work faster and more safely. Additionally, additive manufacturing producers and users showed that additive printers increase the speed of prototyping and promote greater product customization. Besides, Mezentseva (2021) states that it is too early to predict how global and local economies will deal with the consequences of I4.0. No more than 7% of studies concerned with Industry 4.0 focus on the issue of sustainability. The concept of Industry 4.0 entails necessary changes in the operational processes of companies. However, the macro and microeconomic points of view of I4.0 remain a relatively little explored area (Correia Simões et al., 2020).

There are studies focusing on innovation processes in companies, on the replacement of labour by capital, and the consequences in the increasing unemployment rates and globalisation (Maresova et al., 2018). (Turisová et al., 2021) confirm that thanks to these studies, several activities are favourably affected in smart factories, among them: the acquisition of product design data, the programming of process times, the planning of production processes, resource planning (design proposal, identification number), the planning of the factor of use and the layout of processes and workplaces, the systematisation of costs, the assurance of planning results, and the transfer of data to plan operations (Nedelcu et al., 2018). In sum, it is considered that I4.0 qualifies to maintain the competitiveness of companies while guaranteeing future competitiveness (Veile et al., 2020).

Among those challenges, it is important to mention, high implementation costs, organisational and process changes, security and data protection, the need for qualified staff at all organisational levels able to handle the increasing complexity of future production systems (Ganzarain & Errasti, 2016). On the other hand, and as it has been already said, the benefits in the adoption of new technologies are clearly identified: improvement of product quality, improvement of communications, time and costs saving, improvement in the relations with customers/consumers and more efficiency in development of customised products/services (Graafmans et al., 2021). This emerging framework, driven by the I4.0, brings not only advantages, but also great challenges, due to the huge number of devices and data to manage. For this reason, specific solutions must be designed in order to cope with the typical issues related to the IoT, such as energy and storage constraints, and challenging scenarios (Bisio et al., 2018).

On the other hand, (Kowang et al., 2019) states that the utilisation of I4.0 technologies results in a reallocation of personnel from unskilled to technically skilled labour. A major concern among employees in companies implementing I4.0 technologies is that technology would replace the workforce.

Entry barriers to I4.0

Digitalization is no longer a choice; it is a necessity for all those companies that intend to adapt to the new requirements of customers, both internal and external. The importance of DX is such that it was included as one of the five dimensions of the Digital Economy and Society Index (DESI - Digital Economy and Society Index) used by the European Commission to analyse the evolution of member states.

During the systematic literature review (SLR) on SMEs and I4.0, the following problematic dimensions have been identified: (1) financial and economic, (2) technical, (3) skills and competences, (4) implementation, (5) political and legal, (6) strategic, (7) cultural and (8) resource.

It should also be mentioned the limited knowledge that companies have about the impact that I4.0 produces, in terms of business opportunities and disruption of the business models (Mezentseva, 2021) (Turkyilmaz et al., 2020) (Ling et al., 2020). Access to I4.0 could also be hampered by workers' lack of skills and competencies (Schröder, 2016) (Horváth & Szabó, 2019) (Orzes et al., 2020) (Stentoft et al., 2019) (Kruszewska et al., 2021) (Ling et al., 2020).

Horváth & Szabó (2019) and (Turkyilmaz et al., 2020) admit that having a leader without the appropriate qualifications, experience and knowledge of I4.0, could be considered a significant barrier. In addition, long learning times in staff training and the need for continuing education constitute a challenge.

Some of the obstacles most mentioned by the authors are those that refer to technical and technological issues, such as the lack of technical knowledge and of infrastructures and technological facilities. (Orzes et al., 2019) (Mezentseva 2021) (Stentoft et al., 2017) (Veile et al., 2020) (Sony et al., 2021) (Ling et al., 2020) (Huang et al., 2019) (Raj et al., 2019).

The increase in remote work represents a technical challenge for companies (Kruszewska et al., 2021). Additionally, technological immaturity represents a barrier for those enterprises that want to go into I4.0, together with the complexity of its application, both technically and practically (Orzes et al., 2020). The emerging model cannot ignore environmental factors; sustainable solutions that consciously use natural resources must be devised (Kruszewska et al., 2021).

One of the main requirements to develop technological integration is to have a unified communication protocol (Horváth & Szabó, 2019). The author recognizes this integration could be affected without a "common thinking" and that it is important to develop back-end systems with artificial intelligence (AI) to support the processing of large volumes of data, which constitutes another technological challenge (Kruszewska et al., 2021).

Technological integration lessens the risk of fragility, reducing uncertainty in the ecosystem. In turn, the lack of understanding of the interaction between technology and people constitutes a barrier to go into I4.0 (Kovács et al., 2019).

Regarding the computer system, organisations have concerns about information security and possible data ownership problems when storing large amounts of data. The reliability of the systems is also questioned due to a weak Information Technology (IT) infrastructure. It is essential to have an adequate bandwidth structure since obtaining data quickly and securely is a basic condition for Industry 4.0 (Schröder, 2016).

Regarding financial obstacles, the lack of monetary resources makes it difficult to go into I4.0, since it requires a large investment that companies are not prepared to face (Horváth & Szabó, 2019).

In addition to this, the economic benefits to be obtained and the competitive advantage are not clearly defined, so organisations do not see an undoubted motivation for the implementation of I4.0 (Suleiman et al., 2021) (Hoyer et al., 2010) (Sony et al., 2020). Along the same line, Kruszewska, Michna, and Forces (2021) remark that companies need to reduce their costs to stay competitive by having products with a reduced life cycle and time to market. Likewise, the implementation of these new technologies must be accompanied by support policies, both from companies and governments (Mezentseva 2021) (Kruszewska, Michna, and Forces 2021) (Sauer, Orzes, and Davi 2020) (Ling, binti Abdul Hamid, and Chuan 2020) (Huang, Chicoma, and Huang 2019) (Javaid et al. 2021). Complementarily, the employees and middle managers' acceptance of those measures is needed by any organisation (Horváth and Szabó 2019) (Julian M. Müller 2019) (Raj et al. 2019). Guido Orzes, Poklemba, and Towner (2020) also allude that the preference for self-employment or the difficulty in finding a suitable research partner end up being barriers to I4.0. Adding to the above, there is currently a lack of standards related to technology and processes (Horváth and Szabó 2019) (Mezentseva 2021) (Guido Orzes, Poklemba, and Towner 2020) (Stentoft et al. 2019) (Raj et al. 2019). Moreover, lack of standardisation could lead to inoperability and incompatibility between machines, companies, and infrastructure. For I4.0 implementation, in general terms, a big problem is the absence of a methodical approach and conscious planning: definition of objectives, steps, activities, and necessary resources. According to those authors, with I4.0 comes the need for new business models with flexible organisational structures and high coordination. This is also hampered by the working conditions and environment, such as: a lack of cooperation between departments and the will to do so, as well as contradictory interests in different organisational units and by the organisational resistance of some employees (Horváth and Szabó 2019) (Julian M. Müller 2019) (Sony, Antony, and Douglas 2021). In addition to organisational resistance, there are other organisational factors that make it difficult for a company to enter I4.0. Focusing on the company operations at the expense of its development and an inadequate organisational structure and processes, also constitute barriers for I4.0 (Horváth and Szabó 2019) (Stentoft, Rajkumar, and Madsen 2017).

Getting into I4.0 is also hampered by legal challenges. Legal uncertainty occurs because changes in new technologies befall at a faster rate than changes in legislation (Schröder 2016). The author affirms that the complexity of the inconveniences to be regulated represents a barrier for SMEs, especially for those that do not have their own legal department. The legal challenges include: the protection of corporate data, commercial restrictions, problems in granting responsibility for a problem, and the handling of personal data. Other bureaucratic factors that function as barriers are deficiencies in bidding systems and their long evaluation period (Horváth and Szabó 2019).

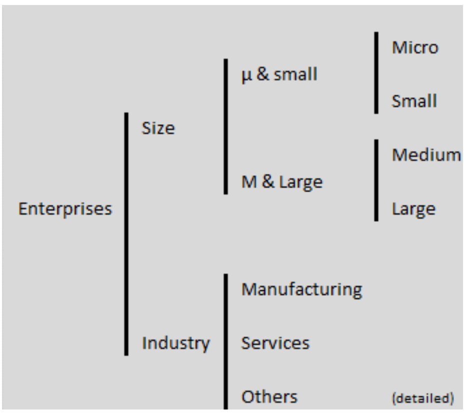
RESULTS

Questionnaire

In this study, a total of 20 questions were used to gather information and insights from the participants. The first six questions focused on classifying the 108 samples based on specific criteria. These criteria included: (1) the country where the company is located; (2) whether the company is national or multinational; (3) the size of the company, determined by the quantity of employees; (4) the vertical market segment to which the company belongs; and (5) the role of the respondent within the company.

Questions 6, 7, and 8 were dedicated to assessing the participants' knowledge and understanding of Industry 4.0 (I4.0) and the benefits associated with its implementation. Moving on to questions 9 to 20, these questions focused on exploring the 12 factors used to analyze the barriers of implementing Industry 4.0. Participants were asked to provide their views and opinions related to these factors.

For the purpose of segmentation and analysis, the main classification and rating scale utilized in the study were represented in figures 4 and 5. These figures provided visual representations of the data, facilitating the interpretation of the results.



▪ Strongly agree
▪ Moderately agree
▪ Moderately disagree
▪ Strongly disagree

Figure 4. Questionnaire structure. Source: author's own (2022)

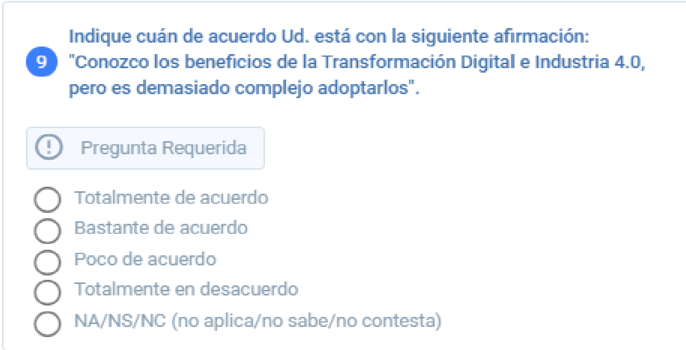


Figure 5. Likert scale. Source: author's own (2022)

Anderson-Darling test (normality test) was performed to uphold that the data came from a normally distributed population and an Alpha Cronbach test was performed: α Cronbach = 0,94. Figure 6.

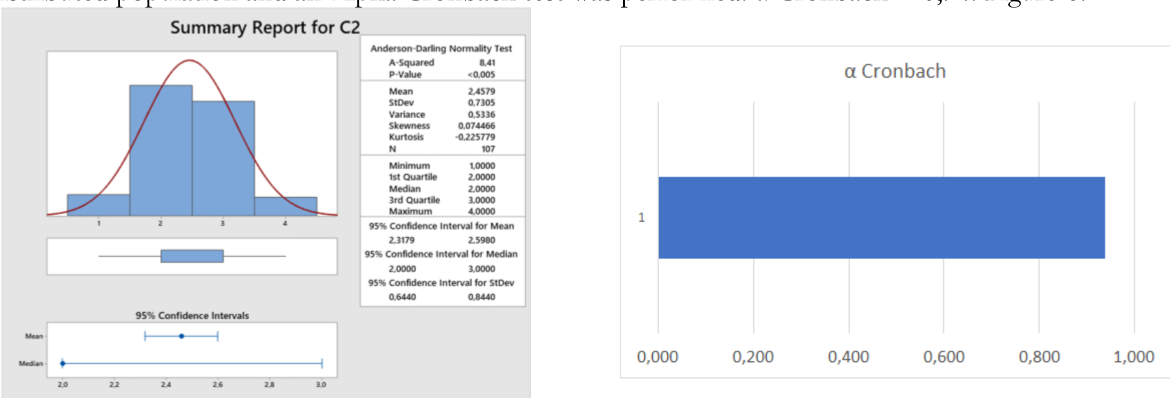


Figure 6. Anderson Darling and Cronbach Tests. Source: author's own (2022)

To determine the statistical acceptability of the similarities or differences between the means, the study utilized two-sample T-tests and Confidence Intervals (CI). Before conducting the T-tests, normality tests were performed to assess the distribution of the data. Additionally, to test the medians, a Mann-Whitney test was also carried out as part of the analysis. This test is useful when the data does not meet the assumptions of normality required for T-tests.

FINDINGS

General results

For the execution of this research project, a total of 500 forms were randomly distributed among various companies in Argentina. Out of the 500 forms sent, 115 responses were received, resulting in a response rate of 23%.

Upon review, 7 responses were found to be irrelevant and not applicable to the study, and thus they were excluded from the analysis. After this filtering process, a valid sample size of n = 108 remained for further examination and analysis.

Based on their characterization, they were segmented into:

- 48 SMEs and 60 large companies
- 76 of national origin and 32 multinationals.
- Two market niches were analysed for this paper in particular: (1) service companies and (2) electronics, IT, and telecommunications companies.

Among the most important findings it can be said that:

- 9 out of 10 of respondents reported having heard about I4.0.
- 7 out of 10 of those surveyed said they have knowledge about the economic and competitive benefits that entails the adoption of DX.

- In general terms, regarding the complexity of its implementation, half of the respondents agreed that it is a barrier while the other half do not consider it a problem.
- Complexity, lack of public policies, lack of top management support and lack of specialised human resources were the 4 most important barriers according to the respondents.
- 6 out of 10 of the respondents indicated that the lack of favourable government support, legislation, and regulations were important barriers.
- More than a half of the respondents reported a lack of support from the top management of the company.
- About 70% of those surveyed considered they would like to adopt DX technology and tools but that they lacked the personnel and qualified workforce.
- Close to 60% of those surveyed considered they would like to adopt DX technology and tools but affirmed that they do not have a methodology or route plans for that purpose.
- Half of the respondents reported not having sufficient economic / financial resources for this purpose.
- About 45% of those surveyed considered that they would like to adopt DX technology and tools but that the IT infrastructure does not allow it.
- More than half of the respondents did not agree that the business model is inappropriate or should be redesigned.
- Close to 50% of those surveyed considered that they would like to adopt DX technology and tools but that there is a very high resistance to change in the organisation.
- More than 40% of those surveyed consider that they would like to adopt DX technology and tools but that they do not have a supplier / strategic partner for research and development of new applications in our company, they do not allow it.
- More than 50% of those surveyed consider that they would like to adopt DX technology and tools but do not have a Technology Leader with the appropriate skills, competencies, knowledge, and experience resources in exponential technologies.
- None of the respondents named any other entry barrier, apart from what was surveyed and classified from the bibliographic review.
- Respondents, on average, admit that they moderately agree on 6 out of the 12 factors, and moderately disagree on the 6 others, which determines two sets of barriers, as shown in Table 1.

Table 1. Set of Entry' barriers

Moderately agree	Moderately disagree
• Lack of specialised human resources. • Lack of I4.0 roadmap and planning. • High reluctance to change. • Lack of specific knowledge. • Lack of capital/financing. • Poor technical infrastructure.	• Lack of helpful public policies. • I4.0 complexity • Lack of top management support. • Immature organisational structure. • Lack of specialised strategic partners. • Inadequate business model.

Source: authors' own (2022)

When people surveyed were asked about their complete knowledge of DX and I4.0, 7 out of 10 answered to be "strongly or moderately agree" (Figure 7, below).

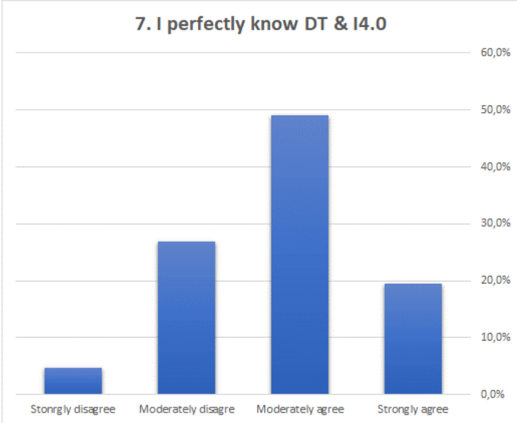


Figure 7. Knowledge of TD and I4.0. Source: author's own (2022)

An overview of the results on the concordance of entry barriers to I4.0 is shown in Figure 8.

Keys: SM: Small and Medium Enterprises. L: Large enterprises. N: National companies. M: Multinational companies. Se: Services. E: Electronic, Information, and Communications.

It can be clearly seen that the "Lack of I4.0 Roadmap & Panning" barrier is stronger for SMEs, service companies, and national companies, than for multinational, large, and technology companies.

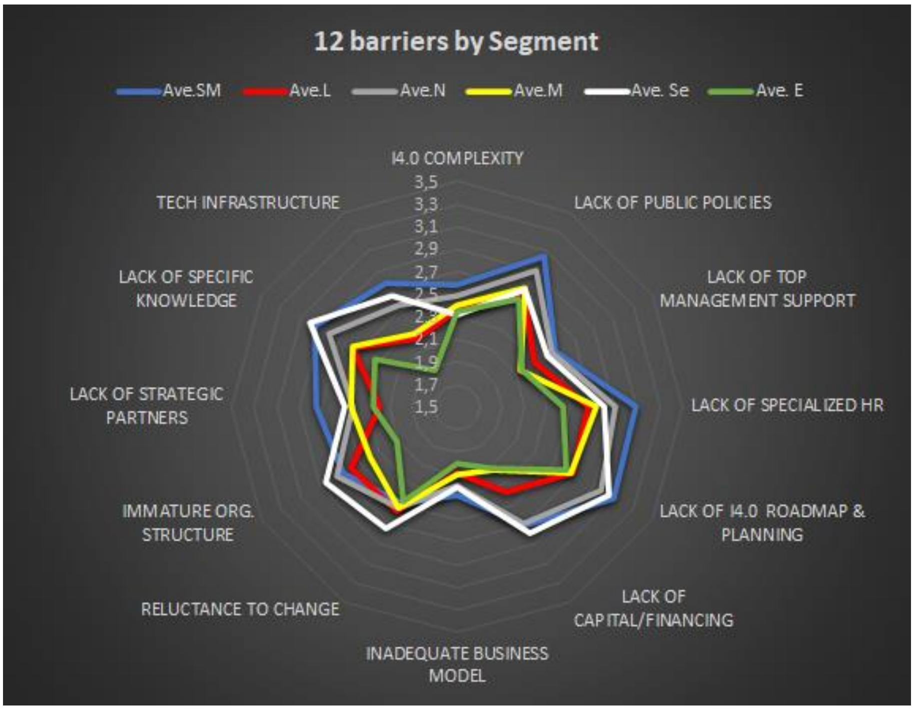


Figure 8. The twelve entry barriers by segment. Source: author's own (2022)

SMEs vs. Large companies

It can be observed that, except for the barriers "Immature organisation" and "Reluctance to change", the differences of opinion between small and large companies are statistically significant. I can be seen in Figure 9:

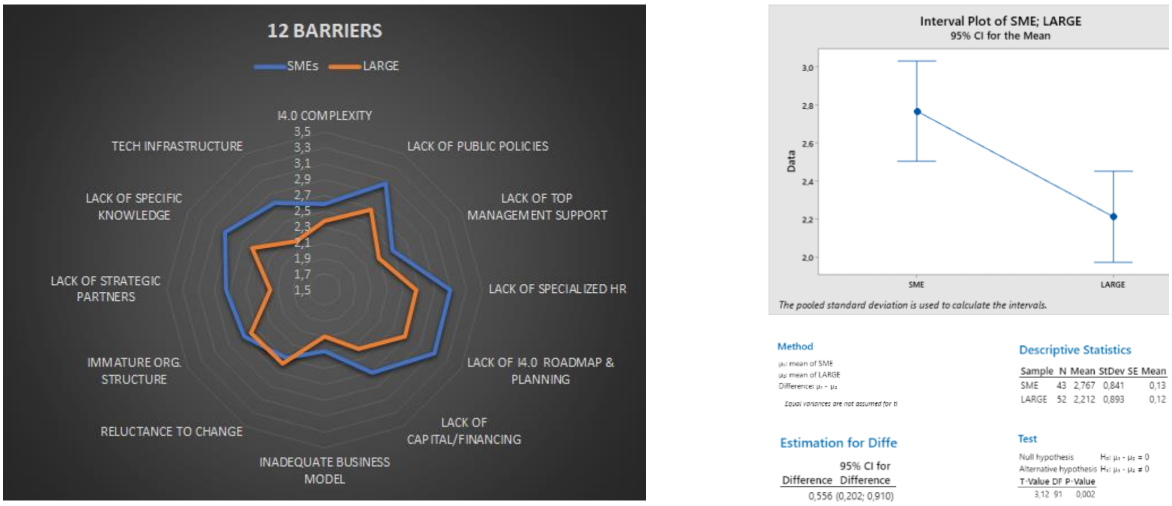


Figure 9. SMES vs. Large enterprises. Source: author's own (2022).

National vs. Multinational enterprises

When companies of national origin are compared with those of foreign origin, also called multinationals, it can be clearly seen that in the twelve factors the differences in opinions between national and multinational companies are not statistically significant (Figure 10).

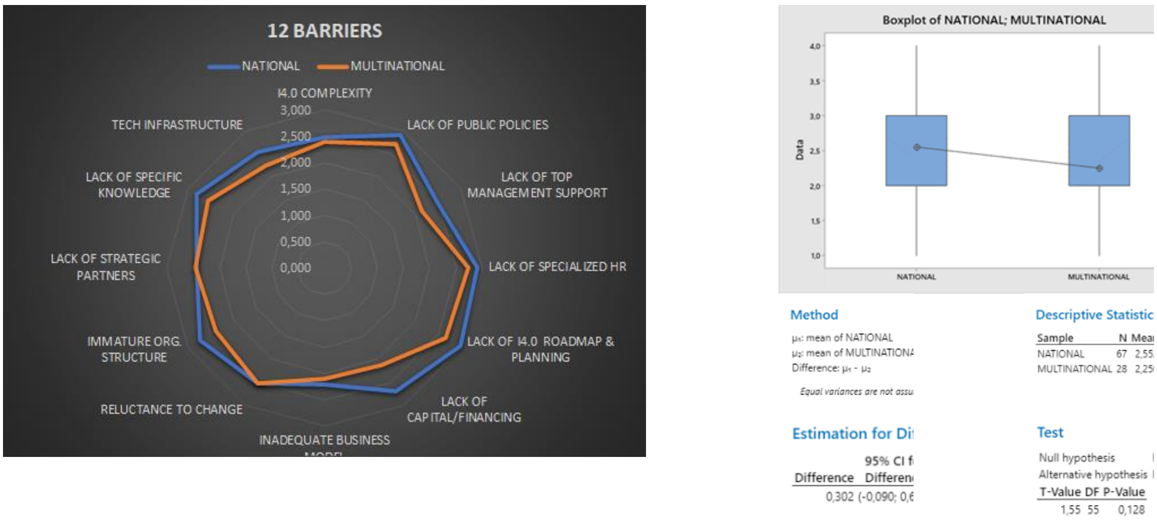


Figure 10. Nationals vs. Multinationals. Source: author's own (2022)

Service vs. TICs enterprises

Several comparisons between types of company have been analysed. Due to length constraints, just one example is shown in this article, and it is Service enterprises versus Telecommunication and Information Companies. It can be seen in the next Figure 11. It can be clearly seen that the ICT business sector sees weaker Entry Barriers to Industry 4.0 than service companies. This contradicts one of the hypotheses put forward in this paper, which assumed that service companies, whatever their origin, were well developed and did not see major entry barriers to TX.

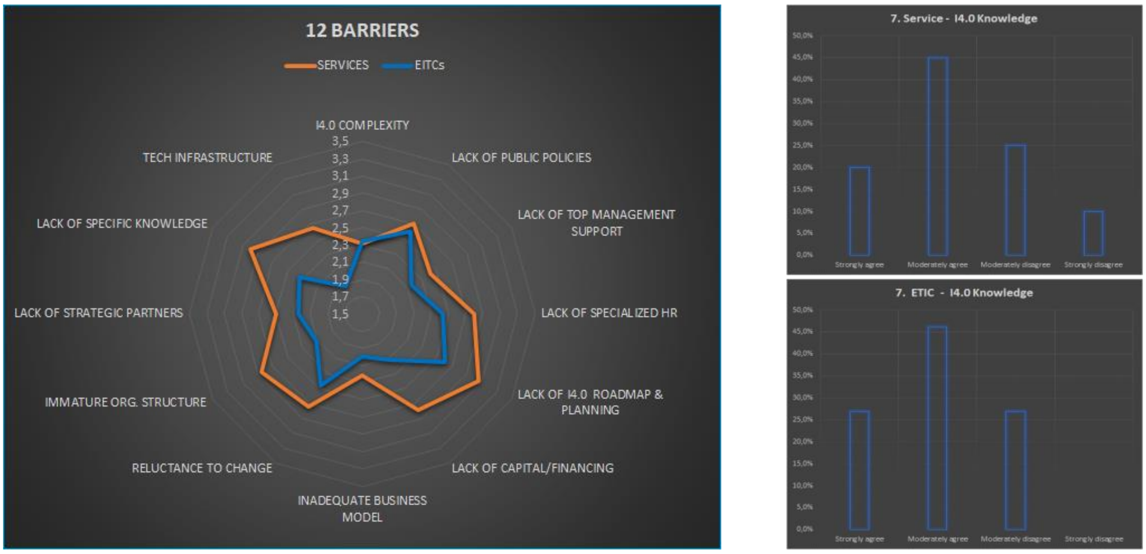


Figure 11. Service vs. ICTs. Source: author's own (2022)

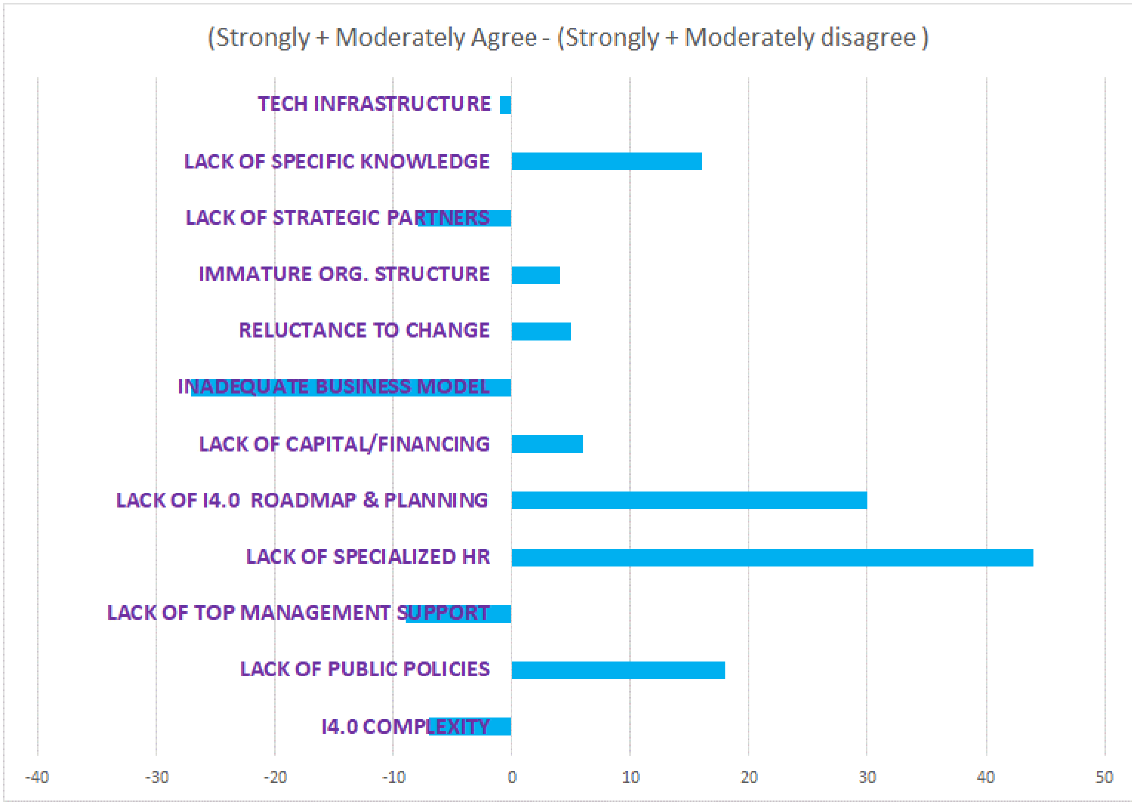
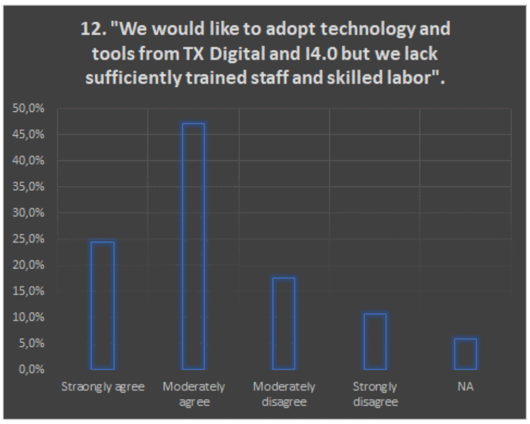


Figure 12. Strongly + Moderately Agree - Disagree. Source: author's own (2022)

Based on the previous analysis, the distributions of responses to these two highlighted factors are shown below. This can be seen in Figure 13.



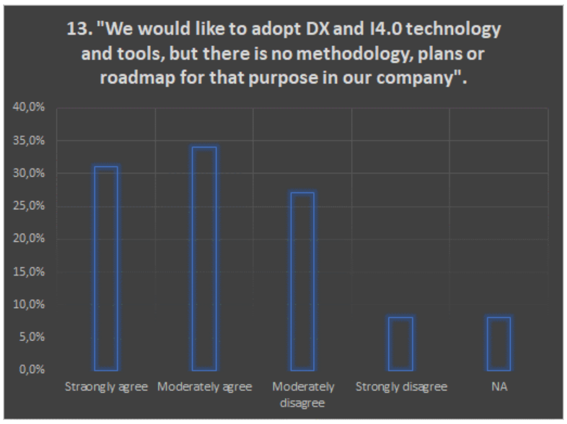


Figure 13. Answers corresponding to questions 12 and 13. Source: author's own (2022)

CONCLUSION

In order to analyse the barriers to entry into I4.0 in Argentina, a systematic review of the worldwide literature was carried out. Following that, inductive data coding was performed where sets of related codes were grouped into 12 basic defining criteria. Dividing the separated factors into groups, allowed to organise and understand the factors influencing decision making for the implementation of I4.0. A survey was carried out in Argentina, receiving 108 valid responses, which were deeply and statistically analysed. In average, the three most important barriers detected were: I4.0 complexity, lack of public policies, and lack of top management support, all of three with a score of 2,9 over 4.0. However, these averages must be considered with great care since a great dispersion has been observed according to the segment of the company interviewed. The limitations of this research work were the limited sampling to draw conclusions from, at the country level and each of its regions, which are quite different. Although the results are quite like those obtained in other countries, it cannot be guaranteed that they are the same throughout the world.

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