Determining Factors in the Implementation of Industry 4.0 in Argentine SMEs

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Summary
Industry 4.0 represents a new paradigm in the production of goods and services, through the unification of digital technologies and the Internet with conventional industry. The objective of this work is to analyze the determinants of the implementation of the industry 4.0 in SMEs. We study the effect on implementation of factors such as size, seniority, gender, level of technical training of management, the presence in the SME of an internal responsible for Industry 4.0 and whether it is a family business or not. To this end, an attempt was made to develop an empirical study based on a sample of 1,142 Argentine SMEs. As a methodological strategy, a model was defined to be developed in two stages. In the first, a confirmatory factor analysis was proposed to determine the latent variable: industry 4.0 by company, and in the second, a linear regression model was developed based on the chosen variables as probable determinants. The main results allow us to affirm that the age and size of the organization can have a favorable implication for the incorporation of Industry 4.0. tools to the organization. We also found a positive association between the male gender of management, the manager's training in related technical issues and the presence of an internal person responsible for the digitalization process, in the implementation of technologies associated with Industry 4.0. At the same time, we did not find a significant relationship between the implementation of the industry 4.0 and the family business. The conclusions may be useful for directing public promotion policies on the youngest and smallest companies and facilitating their possibilities of incorporating the new production paradigm, as well as the formulation of policies with a gender perspective.

Keywords: SMEs; industry 4.0; implementation

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1. Introduccion

Industry 4.0 (I40) is a digital revolution in the industry and constitutes a key factor to improve competitiveness (Basco et al., 2018). It is of great interest to SMEs and government organizations that promote its implementation (Salimbeni & Bianchi, 2019). The I40 represents a significant transformation in the production of goods and services of companies, through the unification of digital technologies and the Internet with conventional industry (Rodic, 2017). Given the turning point and the innovations that Industry 4.0 represents, it is currently considered the fourth industrial revolution (Kayikci, 2018). Its implementation includes the gradual incorporation of the so-called technological enablers (Geremía, 2022), such as internet of things (IoT), augmented reality, big data, cloud computing, cybersecurity, computer simulation, systems integration, additive manufacturing, robotics, and artificial intelligence (Diniz et al., 2022).

Through the implementation of the I40, companies can achieve benefits such as the simplification of business processes, the reduction of errors in inventory management, the reduction of production costs and greater transparency in logistics processes (Mohamed, 2018). In addition, the I40 allows the automation of production processes and increased labor productivity (Gadre, 2020). In SMEs, I40 allows increasing flexibility, efficiency, quality, and cost optimization (Masood & Sonntag, 2020). As well, it improves their production capacity and enhances their ability to compete globally. (Elhusseiny & Crispim, 2021).

Although I40 has been widely studied in large companies, research focused on SMEs has only gained relevance in recent years. The I40 implies technological integration in all links of the productive chains and is a phenomenon preceded by the adoption of ICTs[1]. It is also characterized by an increasing degree of digitalization in general (Feldman & Girolimo, 2020). The panorama of Argentine SMEs in this sense has been the subject of research in recent years (Mon et al., 2022). However, there are few references on works that specifically address the study of the determining factors of the I40 in SMEs in Argentina (Salimbeni, 2021). Consequently, it is necessary to delve deeper into the categorical vectors for the application of I40 in small and medium-sized companies (Cortés et al., 2017).

The aim of this article is to analyze the determinants of the implementation of I40 in SMEs, in particular, the effect of size, seniority, gender, and level of management training, if the SME has an internal I40 manager and whether the ownership model is a family structure or not. To this end, an empirical study has been carried out based on a sample of 1,142 Argentine SMEs, taken from the database of the Ibero-American Observatory of MSMEs[2]. For methodological purposes, a model was defined to be developed in two stages. In the first stage, a confirmatory factor analysis was proposed to determine the latent variable: I40 per company and subsequently, in the second stage, a linear regression model was developed based on the variables posed in

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[2] Ibero-American MSME Observatory 2023 | Foundation for strategic analysis and development of SMEs (upct.es) www.faedpyme.es

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the research questions and hypotheses of this work (Gulayin, 2017). The research questions that will be sought to be answered are how does the size and age of the SME influence the implementation of the I40?. Regarding the implementation of industry 4.0, what is the relationship with the gender and training level of the SME leader? What implications does the provision of an internal digitalization manager generate for the development of the I40? And finally, does the nature of a family business have any relationship with the degree of implementation of the I40? The answers to these questions can constitute significant contributions for SME managers and for the orientation of government public policies.

The Argentine case is especially interesting for various reasons (Sanchez Cherubin, 2020). Firstly, due to the relevance of SMEs in these national economy with an important contribution to job creation and production and also because they integrate the different segments of local and global value chains (Pedroni, 2022). In addition to, because the fourth industrial revolution, which was accelerated by the COVID-19 pandemic (Batt et al., 2020), forces SMEs to adapt to the new scenario and favors their competitiveness (Elhusseiny & Crispim, 2021). In Argentina, included in the so-called emerging economies (Cáceres et al., 2023), public policies in recent years are aimed at generating instruments that enable SMEs to join this new production model through digital technologies.

We frame our research in the field of applied sciences, which as such uses scientific knowledge from one or several specialized areas of science to solve practical problems (Bardales, 2021). In this sense, the contribution of the research is to highlight the need for the orientation of public policies to promote the implementation of new technologies in smaller and at the same time younger SMEs, SMEs led by women and promote the training in new technologies for both the management level and the operational levels (Andrade Valbuena et al., 2021).

Regarding the contribution of theoretical background, it is expected that this work will contribute to those SMEs that want to incorporate or that are already within the I40 ecosystem, know what the determining factors are in countries like Argentina and can maximize the benefits obtained in their inclusion. At the same time and based on the elements studied, this work contributes to the literature about the effects that determining factors such as: their age, size, the incorporation of personnel with the appropriate training or the training of the existing one, the gender perspective of leadership and whether it is a family business. All of this in the context of emerging economies, where the problems of access to new technologies turn out to be much deeper and more complex than in developed economies (Bernardes et al., 2019).

The work is structured with the present introduction first, followed by a brief bibliographic review and the state of the art of the implementation of the I40. Then the development of the hypotheses that correspond to the research questions is presented. Below, the methodology used, the analysis and discussion of the results, the conclusions, which include identified limitations and possible future lines of study, are detailed.

2. Literature review and development of hypotheses

The trend in current industrial development, with the incursion of the I40, is crossed by a central axis that is explained in the growing digitalization of production processes. In some productive sectors in Argentina, generally integrated into global value chains, large companies have implemented new production systems, with digital technologies, typical of the I40, such as simulation systems with seismic images, wireless sensors, Big Data, Cloud Computing and Artificial Intelligence, to control processes in real time, perform prevention and security analysis, among others. These changes bring a challenge for SMEs that, in order to maintain and grow, need to accompany the digital transformation with the development of digital capabilities in different areas of the company (Cretini & Stubrin, 2022).This scenario that consolidates technologies exponentially, to associate consumption and production, is a new paradigm called cyber physical (Hermann et al., 2016). The fourth industrial revolution, I40, is based on cyber-physical systems. It refers to devices that are composed of a physical part and a virtual part, which can be used in multiple functions and activities (Jacquez-Hernández V. et al., 2018).They are new systems that modify the what and the how in a new standardization of efficiency and effectiveness parameters, which leads to the conjunction of real worlds and virtual representations that present a new organizational management space for all companies in general, including SMEs, the cyber-physical management space (González et al., 2020).

Thus, when the I40 reaches a high level of development, it is expected that production systems will be parameterizable, tools, machines, facilities and products with the ability to communicate among themselves and with operators through augmented reality or in other ways to transmit data immediately, intuitively and efficiently. In addition, intelligent products and parts will provide information that will allow the production system to be automatically adapted to the needs of each product. Instruments, machinery and products will have sensors that will contain data for decision-making. With this automation, staff will be able to generate more value for the client before monitoring the entire process in the traditional way (Sachon, 2018).

In these terms, the I40 constitutes a new model regarding the way in which companies operate and meet market demands using advanced technologies and connectivity solutions (Geremía, 2022). Its composition encompasses key elements such as cyber-physical systems, real-time data analysis, autonomous machines and smart factories (Hermann et al., 2016). This transformative paradigm of the way of working is not limited to specific industries, but also affects companies globally in multiple sectors, including manufacturing, logistics, healthcare and energy, among others. However, the implementation of I40 is not without challenges (Mohamed, 2018). The adoption process requires significant investment in infrastructure improvements, such as Internet connectivity, big data storage, and new machinery. Educating employees with new skills for this digital age is also crucial for successful implementation (Oláh et al., 2020).

With respect to the Latin American panorama and the implementation of the I40, researchers have indicated that, in most countries in the region, structural problems of the industry persist, such as reduced production scales, low supplier development, obsolete technologies and old organizational models. That is to say, except for a few sectors in some of the countries in the region, the rest have not completed the third industrial revolution[3], so the need for appropriate policies to lead the region to incorporate the new paradigm and thus compete internationally becomes evident. An example of this can be analyzed in the behavior of patents, their registration is much lower than that of the central countries (Castillo et al., 2017). Latin American countries generally face financial limitations to support technological scaling and innovation projects, and particularly a generalized deficit regarding the formation of human capital (Gallegos Ramírez & Sztulwark, 2018). Cooperation with other countries would allow us to achieve synergies and optimize the use of limited resources. An example would be support for the formation of private consortia, with the participation of companies from several countries in the region interested in participating in a joint innovation and marketing project. Industry 4.0 in the countries of the region is in an incipient phase given that even the main Latin American countries, Mexico, Brazil, Chile and Argentina have not yet reached the minimum capacities, simultaneously, in the five enabling technologies of Industry 4.0. This is connectivity, data storage infrastructure, cloud computing, big data analytics and the Internet of Things (Feldman & Girolimo, 2021).

In response to the stated objective, we investigated which are the different variables that can act as facilitators or, on the contrary, disadvantage the inclusion of SMEs in this different work scenario. Therefore, we sought to know the relationship between the development of the new paradigm for SMEs with the variables chosen for the construction of the analysis model, such as their age and size, their ownership model (family or not), gender and level of training of the management line and the presence in the work team of a person responsible for the execution of new technologies.

Age of the SME

The age of companies generally implies the accumulation of knowledge from practice, trajectory, background, greater structure and organizational development.(López et al., 2010). It is important to highlight that access to the technology associated with the I40 requires, in addition to the aforementioned factors, availability of capital and possibilities of access to productive financing, both factors largely related and positively with the age of the firms (Liu et al., 2022). And in this sense, companies with a long presence in the market have better access to financing sources (Alvarez et al., 2021). Empirical studies show that the SMEs that have made the most progress in implementing the new production model are older companies, which have their own resources to invest and at the same time have some track record in basic digital skills (Motta et al., 2019). As regards to Argentina, some research affirms that the average age of the SMEs that adopted the model, even partially, have an average age of between 15 and 20 years (Panizzi et al., 2023).

According to the literature, the age of SMEs is a relevant determinant, given that they have different behavior depending on the stage of the life cycle that the company is going through. Thus, for example, it is observed that greater seniority is positively related to the possibilities of diversification in terms of incorporating new technologies (Guercio et al., 2020). At the same time, other studies agree that the intensity of growth in research and development (R&D), an area directly related to the incorporation of the I40, shows a positive relationship with the age of the companies (Nunes et al., 2013).

Based on the arguments presented, we formulate the following hypothesis:

H1: There is a positive relationship between the age of the SME and the adoption of I40 technologies.

SME size

The size of the companies can be a condition for the implementation of the I40. Larger companies have better access to equipment, specialized personnel, software, skills, and resources for the adoption of new technologies (López et al., 2010). This significantly influences the opportunity for adoption of the I40, given that new technologies require the capacity and financial structure of the SMEs that acquire them, and, in this sense, the small size is also a drawback (Alvarez et al., 2021).

The literature indicates that there is a positive relationship between the size of the SME and access to technology and diversification, which implies that larger SMEs, measured in terms of number of employees, have greater probabilities of success in implementation from I40 (Guercio et al., 2020). Likewise, other studies refer to the relationship between the size of companies and the flexibility to adopt new technologies and, in this sense, they find that larger companies in general have a higher rate of adoption of information and communication technologies (ICT), which are essentials for the I40 (Bauer et al., 2020). Regarding what is happening in Argentina, it has been observed that this process of technological change can be favored in larger SMEs, which generally have better human resource conditions, greater possibilities for innovation and in some cases with export records (Blanc et al., 2019).

The above indicates that the attributes necessary for the implementation of the I40 are more likely to be configured in larger companies, which moves us to propose the following hypothesis:

H2: The larger the size of the company, the greater the possibility of adopting I40 technologies.

[3]The concept of the third industrial revolution refers to the modifications in production processes based on the use of electronics and computing to promote automated production.

Gender of the leader or manager of the SME

The literature considers that the adoption of the I40 is an incorporation with significant potential for the company and asks at the same time how this disruption of digital transformation is perceived considering the gender perspective. That is, if the phenomenon is experienced in the same way by SMEs led by men or led by women. This implies knowing what the perceptions of the owners and/or managers of SMEs are in relation to digital opportunities and how gender inequality impacts the determinants of digital transformation in this sense (Alam et al., 2022). Although there are few studies that relate the forms of innovation related to cutting-edge technologies in organizations with the gender of the manager, some of them indicate that men carry out more innovation activities in this sense than women (Salas-Arbeláez et al., 2018).

Thus, studies on SMEs found that the gender of managers can have an impact on the adoption of new technologies and innovation. Along these lines, they conclude that male entrepreneurs are more likely to adopt ICTs, which is directly applicable to the I40. They also indicate that SMEs run by men are more likely to adopt I40-related alternatives, and the same is generally true for innovation capabilities and risk tolerance (Alam et al., 2022)

Regarding the results, the studies also find that there is a greater probability that companies run by men make investment decisions in software and ICT equipment than those run by women (Kiefer et al., 2022).They also highlight that they find a trend that female managers are not usually aware that the incorporation of cutting-edge technologies can promote business growth and be a facilitator of internationalization (Orser & Riding, 2018).

Along these same lines, other research that addresses the topic studies the participation of female people in innovation proposals and technologies associated with the I40 and explains that both genders have the capacity to generate innovation, but women rarely execute them (Quiroz-Rojas & Teruel, 2021)

It is also important to highlight that there are other studies that consider the incorporation of new technologies to be neutral with respect to the gender of management and that in any case contextual factors also play a role, such as the type of activity of the company, productive sector, and the characteristics of the company each company (Expósito et al., 2022).

In Argentina, research on this topic is limited. However, an insightful publication by women in science explores the question of why gender differences exist in the relationship with technology and innovation. The publication suggests that this phenomenon likely originates from childhood and is rooted in cultural patterns that need to be changed, as well as family education and gender-specific children's games. Consequently, fewer women in Argentine Engineering Faculties choose careers related to technology. According to specialists, addressing these gender differences and fostering a more inclusive approach to technology should start with education (Castro et al., 2020).

Considering the above and the relationship between the gender of the people and the incorporation of the I4.0, the following hypothesis is formulated:

H3: There is a positive relationship between the male gender of leaders or managers and the implementation of I40 technologies in SME companies.

Level or type of educational training of the leader or manager

Numerous investigations conclude that training regarding new technologies and related disciplines is a necessary and mandatory factor in the implementation of the I40. This extends to the workforce and particularly to the management of company (Masood & Sonntag, 2020). Within the concept of human capital, issues fundamentally linked to knowledge, education, experience, and skills intervene, which is extensive to managerial human capital (Helfat & Martin, 2015). Other Studies have found that managerial competencies on processes, services and products related to the incorporation of digital resources by SMEs act as facilitators for the implementation of the I40 (Alam et al., 2022).

Likewise, they find results that indicate that a degree in engineering sciences, for example, that is, related to digital skills, appears positive for a CEO and/or founder of an SME that works on the implementation of I40. At the same time, there is evidence about some impact of management training on the efforts and results of strategic changes such as the incursion into the I40 (Helfat & Martin, 2015).

The adoption of digital technologies requires a modification in most company practices, it is a redesign of the business model (Matt et al., 2015), the way in which it produces or provides a service, the way in which decisions are made, human resources policies, including the training required for managers, are no exception (Frez Orellana, 2021). The reality is that SMEs in general do not always have management staff with the necessary training to understand the logic of the new challenge presented by the adoption of new technologies (Motta et al., 2019).

In Argentina, studies in this regard explain that to promote the adoption of the I40 model, it is necessary to expand the capabilities of managers in SMEs, since most of the time they do not have the minimum capabilities to operate these technologies and optimize its use. Among these capabilities, knowledge in programming, mechatronics or telecommunications was mentioned (Franco et al., 2022).

Considering the above, we propose the following hypothesis:

H4: There is a positive relationship between the highest level of educational training of the leaders or managers of SMEs and the implementation of industry 4.0 technologies.

Presence in the organization of personnel specialized in technologies

In the new I40 model, people are included as a significant variable(Bravo et al., 2018), so their involvement and leadership are necessary. Likewise, in the new dynamic, interaction with technology is vital and for this, specific training of the human operator and the development of digital leadership capabilities become necessary (Heavin & Power, 2018). In this sense, a qualification in digital transformation is needed by the leader and planner to interact with technology (Chacón-Ramírez et al., 2020).The fourth industrial revolution brings with it a reconfiguration of job profiles strongly oriented towards automation and artificial intelligence. This requires professional or academic training related to computing, mathematics, engineering, among others (Cerda-Leiva et al., 2020). Consequently, the incorporation of new technologies can generate an adverse scenario for SMEs, which translates into a lack of infrastructure and personnel with the technical preparation and management skills that are required (González et al., 2020).

The incorporation of advanced technologies produces favorable results in companies (Queiroz et al., 2022). However, reality indicates that mere investment in these technologies is not enough because it is their effective use that optimizes productivity (Roman & Rusu, 2022). From this it follows that the intensity of effectiveness will have to do with other investments related to knowledge capital (Philbin et al., 2022) and the hiring of personnel with specific skills not only in technology but also in management of organizational transformation and new models and processes (Bravo et al., 2018).

In the Argentine case, for the implementation of I40 technologies, the researchers explain that the presentation of the topic to personnel, induction, as well as the provision of technological resources for the personnel who join and especially training. That is also a priority aimed at the operational level because sometimes it is not considered (Alvarez Caldeira, 2022).

In accordance with what we have learned about the need observed in companies to have specialized personnel in the areas related to the incorporation of the I40, we propose the following hypothesis:

H5: There is a positive relationship between the presence in companies of personnel with technical training in digital technologies and the implementation of the I40 in SMEs.

Business ownership model: family or not

A family business is defined as one in which most of the ownership and management are in the hands of a family and at the same time it has a desire for continuity in this sense (Muñoz et al., 2017). The literature agrees in explaining that the family business ownership model is composed of three central axes: power, which indicates family dominance in ownership, management, and government, which indicates family participation through the number of members and generations of the family actively involved in the business and the culture that values the family's commitment to the company and its values (Tàpies, 2011). The definition is presented to introduce the ownership model, given that it is observed in the review of the literature that most research deals with the form of government of these companies and fundamentally with the implications that derive precisely from the succession of their property or in the continuity of the management of their children and strategic direction, among others. There are fewer publications regarding the relationship between the implementation of the I40 and the ownership model of the family business or not. That is observed is mentions that the I40, with its new ways of conceiving clients, suppliers, logistics systems, etc., may bring about a transition in the forms of government in family businesses. In accordance with this, the authors recommend that companies that present particularities in their form of government should specifically plan the transition to the I40 taking precisely those singularities into account (Muñoz et al., 2017).The studies explain that the competitiveness factor is usually a major challenge for family businesses, since all SMEs need to be competitive and the adoption of I40 technologies is closely related to that capacity. Furthermore, in family businesses it is necessary to address these types of challenges in a different way, because in general everything is crossed by an emotional burden that requires adequate treatment, in addition to observing a more pronounced attachment than in other types of companies, to traditional practices and structures (Pérez Ibáñez, I. (2023).

In Argentina, there is not much history of publications regarding family businesses and the implementation of the industry 4.0 model. However, it is important to consider that a high percentage, around 70%, of SMEs in Argentina are family businesses (Beltramino et al., 2022). Local research explains that very few family SMEs do manage to professionalize until the third stage of your development, which is why it usually happens that the owners or founding directors show resistance to incorporating innovative technologies that the I40 implies. Furthermore, there are not so many formal processes in decision making, but rather unstructured ones (Colombo, 2019).
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The above leads us to propose the following hypothesis:

H6: There is no relationship between the type of family business ownership model and the implementation of the I40.

3. Investigation Methodology

This section describes the methodology addressed for the development of the empirical work (Campo-Redondo & Labarca Reverol, 2009) that is presented. The structure of the sample and the rationale for the choice of variables to answer the research questions and objectives formulated are detailed. Likewise, the statistical development implemented to account for the formulated research hypotheses is presented (Freire Espinosa, 2018).

3.1 Sample structure and data compilation

The empirical study was carried out from a sample as a source of primary data originating from a data collection work carried out by the Ibero-American Observatory of MSMEs.[4] The work was the result of the collaborative work of researchers from different Ibero-American university institutions and public organizations for regional development and support for MSMEs. The observatory is an academic cooperation alliance made up of an institutional network composed of: the Foundation for the Strategic Analysis and Development of SMEs (FAEDPYME), the Ibero-American University Network on Business Creation and Entrepreneurship (MOTIVA), the Latin American Innovation Network and Entrepreneurship (RLIE) of the Latin American Council of Schools of Administration (CLADEA) and the University Entrepreneurship Network (REUNE) of the Colombian Association of Universities (ASCUN) (García Pérez de Lema et al., 2022).

The sample design was carried out based on the principles of stratified sampling. To this end, grading criteria were established in line with the objectives of the study, the availability of information, the composition of the target population, the resources available for field work and the variables that were studied (Saenz Lopez & Tamez González, 2014). The strata defined were sector of activity of the MSME, size (microenterprises, small and medium-sized enterprises). Within each stratum for selection, we worked with the simple random sampling technique.

The data was obtained through a survey carried out among managers of 1,142 Argentine SMEs. Data were taken from micro, small and medium-sized companies according to the current classification. The data collection period extended from February to May 2022.The data collection technique consisted of a survey hosted on an online platform and telephone follow-up, with due care for the confidentiality of the data, protected by statistical secrecy (Meo, 2010).

Given that the result arrived at was not completely proportional to the population universe, pertinent elevation factors were used to obtain the aggregate results.(Freire Espinosa, 2018). The latter contributes to the procedural objectivity and the comparison necessary to consider the adjustment of the sample to the proposed research objectives. However, it is highlighted that the statistical analyzes and controls carried out throughout the research process have a categorical degree of significance given by the data obtained in the surveys (Saenz Lopez & Tamez González, 2014).

The overall sampling error of the selection with which we worked is 1.1% for a 95% confidence level (Hernández & Carpio, 2019). The population data were taken from the institutional source that publishes this information in Argentina[5].

3.2 Measurement of variables

The selection of the variables is a critical point in the empirical analysis and makes it possible to approach the behavior of the companies that are intended to be reached. (Henseler, 2017). The information necessary to understand the behavior of the variables was obtained through a questionnaire administered to MSME managers. The questions were designed in a closed format, in blocks that were as concise as possible. Care was taken to ensure that the wording was clear and relevant to reduce possible interpretation biases and, therefore, a loss in data collection (de Rada, 2022). For the content of the questions, the reference bibliography consulted was taken as a basis, to support a relevant choice of the variables that lead to the achievement of the stated objectives.

The survey asked about company data such as age, size, gender of management and level of educational training, ownership model (family or not) and about the presence or absence of personnel with technical training.

The dependent variable, degree of implementation of I40, was measured by the question about the level of importance of the technologies associated with I40 with a Likert scale 1 to 5 (Matas, 2018). Five items were included in which managers were asked to indicate the degree of importance to their company of the following elements: Corporate intranet (IC), Services to cover cybersecurity (CS), Big Data and data analysis software (BD), Robotization and sensorization (RS) and Location and internet of things (LI) (Laguna, 2017).

And they were used as independent variables:

- Age of the company: it is a dichotomous variable that takes a value of 1 for companies 10 or more years old and 0 for less than 10 years. This variable has been used in previous studies such as:
- SME ownership model (family or not): it is a dichotomous variable that takes a value of 1 if the company is not family and 0 otherwise.
- University studies: it is a dichotomous variable that takes a value of 1 if the management has university studies and 0 otherwise.
- Dig: is a dichotomous variable that takes a value of 1 if the company has an internal person responsible for the digitalization of the company and 0 otherwise.
- Gender: is a dichotomous variable that takes a value of 1 if the management is male and 0 otherwise.
- Small: is a dichotomous variable that takes a value of 1 if the company is small and 0 otherwise.
- Med: is a dichotomous variable that takes a value of 1 if the company is medium and 0 otherwise.

[4] Ibero-American MSME Observatory 2023 | Foundation for strategic analysis and development of SMEs (upct.es)
[5] Argentina Data - MiPyME Registry

4. Results and Discussions

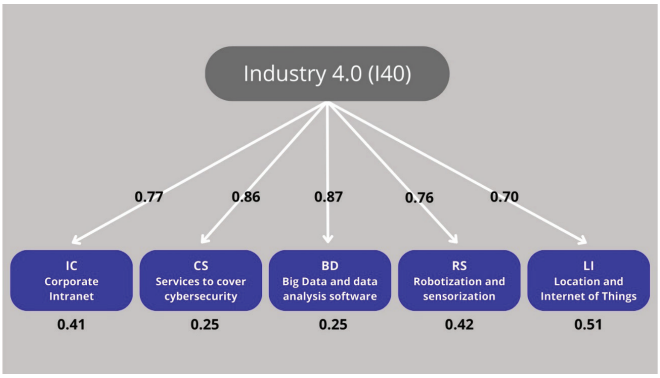
In a first stage, a confirmatory factor analysis (CFA) was proposed (Cárdenas Castro et al., 2012) to identify the level of I40 intensity by company and, in a second stage, a linear regression model (Dagnino, 2014), considering the variables raised in the hypotheses of this work: age of the company, size of the company, gender of the manager or leader, level of training of the manager, ownership model and presence in the organization of personnel specialized in technologies.

First stage:
With the five items described to measure the implementation of the I40, a CFA with a unifactorial structure was proposed:

$$I4.0 = \lambda_1 * IC + \lambda_2 * CS + \lambda_3 * BD + \lambda_4 * RS + \lambda_5 * LI$$

Where I40 represents the latent variable of industry 4.0 based on the observed variables and the pair i=1, ..., 5 are the coefficients that represent the factor loadings. For the estimation, we worked with the psych package of the R software, the adjustment method was Unweighted Least Squares Mean and Variance, which is appropriate for categorical data or when multivariate normality in the data is violated, a typical situation when working with Likert scales. λ_i (Cohen & Migliorati, 2017).

Graph 1: Industry 4.0 single-factor model



Source: own elaboration based on processed data

The upper values in the graph, on each of the arrows, 0.77 for IC: Corporate Intranet, 0.86 for CS: Services to cover cybersecurity, 0.87 for BD: Big Data and data analysis software, 0.76 for RS: Robotization and sensorization and 0.70 for LI: Location and Internet of Things, indicate the standardized factor loadings. All of them meet the criteria of exceeding the recommended level of 0.7 (Calvo-Porral, 2017).

At the lower values, i.e., 0,41 for IC, 0.25 for CS, 0.25 for BD, 0.42 for RS and 0.51 for LI respectively, the residual or unexplained variances of each item are reported after factor analysis has been considered (Rodriguez, 2005).

Table 1: Goodness of fit measures

Cronbach's Alpha	Chi squared	CFI (Comparative Fit Index)	TLI (Tucker-Lewis Index)	RMSEA (Root Mean Square Error of Approximation)	SRMR (Standardized Root Mean Square Residual)
0.893	28,854	0.994	0.988	0.068	0.043

Source: own elaboration based on the processing of the data obtained

Table 1 shows the goodness-of-fit measures of this confirmatory factor analysis and meet the recommended levels according to the criteria established in the specialized literature (Pedrosa et al., 2015).

Second stage:
The factor scores of the I40 variable were calculated for each company to propose the following linear regression model (Dagnino, 2014).

$$I40 = Age + Fam + Univ + Dig + Gender + Small + Med$$

Where:

- ***Age*** It is the age of the company.
- ***Fam*** Is it a type of family business or not.
- ***Univ*** It is a dichotomous variable that takes a value of 1 if the management has university studies and 0 otherwise.
- ***Dig*** It is a dichotomous variable that takes a value of 1 if the company has an internal person responsible for the digitalization of the company and 0 otherwise.
- ***Gender*** It is a dichotomous variable that takes a value of 1 if the management is male and 0 otherwise.
- ***Small*** It is a dichotomous variable that takes a value of 1 if the company is small and 0 otherwise.
- ***Med*** It is a dichotomous variable that takes a value of 1 if the company is medium and 0 otherwise.

Table 2: Linear regression analysis for the response variable I40

Variable	Estimation (B)	Standard error	t value	P-value
Intercept	-0.62751	0.057012	-11,007	< 2e-16***
Age	0.135885	0.039395	3,449	0.000585***
Family	-0.005794	0.039426	-147	0.883196
Univ	0.217260	0.034187	6,355	3.12e-10***
dig	0.386063	0.034938	11,050	< 2e-16***
Gender	0.143941	0.042132	3,416	0.000659***
Small	0.105459	0.042183	2,500	0.012574*
Median	0.335686	0.045255	7,418	2.49e-13***

Grades:

- Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
- Residual standard error: 0.5326 in 1029 degrees of freedom
- Multiple R-squared: 0.2835, Adjusted R-squared: 0.2786
- F-statistic: 58.15 in 7 and 1029 DF, p-value: < 2.2e-16

Source: own elaboration based on the processing of the data obtained

Regarding the global significance of the model, the F statistic is 58.15, with a very low p-value (p-value: < 2.2e-16), indicating that the model is statistically significant and can jointly explain the variability of the I40 variable (Peláez, 2016).

In turn, the intercept -0.6275 of the model shows the average value of I40 for the reference category, which in this case is young, family-owned companies, with management without university studies, without a person responsible for digitalization, female management, and micro business size (Manco, 2018)

The linear regression model shows that variables like 'Age', 'Univ', 'Dig', 'gender', 'Small' and 'Med' have a significant association with the dependent variable 'I40'. However, the 'Family' variable does not show a significant association (Rodríguez-Jaume & Mora Catalá, 2001). The model overall has a good fit and can explain approximately 28.35% of the variability in 'I40' (Pérez et al., 2013).

The P-value indicated in the last column on the right in Table 2 is the value linked to the results of a statistical test, it is the probability of the observed result or a more extreme value if the null hypothesis is true (Badenes-Ribera et al., 2015). Thus, according to the results obtained and reported in Table 2, last column, it can be stated that the positive sign of the 'Age' variable confirms our hypothesis that the older or older the SME is, the easier it is to implement the industry 4.0. This result is presented in line with what is indicated by the literature with respect to the seniority or age of the companies associated with greater maturity, which can be an advantage in comparative terms with other smaller companies for the foray into innovations of the type of those involved in I40.

In a similar way, the positive sign of the variable 'Univ' occurs, which corroborates the hypothesis that when management has technical training, the implementation of the I40 is facilitated; this is probably due to the relationship that the knowledge required for the incorporation of new digital technologies.

In relation to the need to have or not have technical personnel in charge of the new tasks that the I40 implies, the positive sign of the 'Dig' variable allows us to affirm, in line with the proposed hypothesis, that, when companies have a person responsible for digitalization, the implementation of the I40 is favored.

The positive sign of the 'Gender' variable also informs us in relation to its hypothesis, when the gender of the management is male, the implementation of the I40 may be more conducive.

Finally, the positive values and signs of the 'Small' and 'Med' variables confirm the hypothesis developed that the relationship between the size of the SME and the implementation of the I40 is positive.

5. Conclusions

This research aimed to investigate the determinants of the implementation of industry I40 in SMEs. In particular, the incidence of the factors size and age of the SME, gender, and level of training of the managers, presence of an internal person responsible for digitalization and ownership model of the small and medium-sized company, that is, whether it is a family business or not.

To this end, an empirical study was developed based on a sample of 1,142 Argentine SMEs. The results obtained allow us to affirm that the seniority or age of the organization can have a favorable implication in achieving the incorporation of I40 tools.

The conclusions can be useful for directing public policies to promote younger companies and facilitating their possibilities of incorporating the new production paradigm. The results detailed above also indicate a positive relationship between the size of SMEs and the incursion into the field of technological innovation related to the I40, meaning that in principle the process is more difficult to achieve for medium and smaller ones. This is also an issue that can be considered by public policy managers, who with the corresponding precautions could guide support for smaller companies.

It is also interesting, as the results we obtained show, that the gender perspective must be considered when considering the approach to the implementation of new technologies for SMEs. In this sense, SMEs led by women are less likely to implement new digital technologies. This could be addressed through programs aimed at the female gender and the incorporation of new tools.

In this sense, the training of the manager in related technical issues also counts for the consideration of the incursion of SMEs into the new analyzed paradigm, I40. It is observed that it facilitates incorporation when this condition exists in the management of SMEs. In this same sense, it was found that the presence of an internal person responsible for the digitalization process acts as a facilitator for the incorporation studied, therefore, this can be positive for companies that promote the technical training of their collaborators.

It should be considered that no significant relationship was found between the implementation of the I40 model and the family business. In principle, no significant association is observed with this form of ownership of SMEs. It is important to keep in mind that this consideration may be due to the lack of research in this regard.

This study can also be useful for entrepreneurs who can consider for their business ideas the factors that facilitate the implementation of new technologies related to the I40, that is, which factors are facilitators, and which are not so much.

Our work is not exempt from limitations that at the same time constitute opportunities for future research. Firstly, the recent social confinement caused by the global COVID-19 pandemic accelerated the implementation of digital tools and precipitated intensive use in organizational spaces, but it is worth asking what is going to happen with SMEs, when the new reality is consolidated over time, that is, how much of the implementation was due to urgency and necessity and how much of that will result in permanent adoption by choice and with new knowledge of the model.

Secondly, our study was carried out on 1,142 Argentine SMEs. Other studies that confirm our results and generalize them in other countries and emerging sectors may be interesting in this sense.

Thirdly, another line of research that we propose is the gap observed in the literature, which we mentioned when talking about the relationship between the implementation of the I40 in family businesses, there is not much research on the matter and evidently that governance structure of companies with this ownership model may have interesting implications for further study.

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