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Miguel Antonio MASCARÚA[1]
Cristina RODRÍGUEZ[2]
Angélica Belén RUÍZ[3]
Jesús Andrés ARZOLA[4]

ORGANIZATIONAL ARCHITECTURE, INDUSTRY 4.0 AND DATA ANALYSIS FOR SMES

The purpose of this article is to find a relationship between the organizational architecture and technological architecture for Small and Medium Enterprises (SMES) in Tehuacán city, which is a medium size town at southeast of México city, according to two aspects, the first is to know how much the businessmen are educated to apply tactics for industry 4.0 on order to gain competitiveness, based in their perceptions; and the second is, what have they done to make some implementation in their facilities to reach better productivity. The methodology used in this work is a survey for 574 business, through a questionnaire with answer options in Likert scale. The results exhibit that there is high knowledge about the industry 4.0, and the most of the firms which are made implementations are related to Trade, Manufacturing, Construction and Restaurants. This works a good view on the practices for make modern business in a medium size town.

Keywords: organizational architecture; industrial competitiveness; innovation; industry 4.0; SMEs.

1. INTRODUCTION

From a large part of the explanations about decision-making in companies from the microeconomic point of view, organizational architecture and business economics offers a useful framework to understand how companies implement their action strategies, to plan the scope in the markets, the use of technology and relations with governments; to achieve survival and growth (Bricley et al., 2005).

[1] Miguel Antonio Mascarúa, Tehuacán Technology University, Mexico; e-mail: miguel. mascarua@uttehuacan.edu.mx (corresponding author). ORCID: 0000-0002-4068-2814.
[2] Cristina Rodríguez, Tehuacán Technology University, Mexico; e-mail: Cristina. rodriguez@uttehuacan.edu.mx. ORCID: 0000-0002-7504-343.
[3] Angélica Belén Ruíz, Tehuacán Technology University, Mexico; e-mail: Angelica. ruiz@uttehuacan.edu.mx. ORCID: 0000-0002-7785-7569.
[4] Jesús Andrés Arzola, Meritorious Autonomous University of Puebla. Mexico; e-mail: arzolaiq@gmail.com. ORCID:0000-0001-9839-982X.

The research novelty in this paper is as it relates the organizational architecture for SMES with the practices in industry 4.0 tactics and data analysis in a city where the industrial activity is scarce. The added value consists in compare the owner´s self-confident about technical education on business versus the consciousness about the investments on technology appliances over the facilities for the SMES. This paper exposes the perception on technological education for businessmen and what have they done to improve the data analysis and make industry 4.0 tactics for reach scale economies and growth for their business.

The main question here is, What the owners know, what they have done about the tactics implemented and what kind of commercial business have implemented actions in industry 4.0? This paper tries to answer the question through of a quantitative analysis, for understand what way the businessmen follow and how much they must to do for reach serious goals to rise the business. According with the results in this study, it could be important for the regional authorities to suggest better policy actions in the regional environment.

Tehuacán city is largely know for the commerce activities and the production textile mills for exportation in a context of low use of technology, however, since the COVID-19 Pandemic, a large number of businessmen have recognized the importance to improve better quality in education and technological usage to rise their business. There is a gap between the studies carried out on this topic, because most of the literature has focused on large companies and has little addressed small companies. This study aims to look in more detail at the efforts of small businessmen, because there are now conditions that allow those businessmen to participate more actively in export economic activities, according to the T-MEC.

Contrastingly, large companies offer sufficient analysis advantages due to the number of operations they require for their daily operation and because achieving control of all activities requires the establishment of policies and procedures. On the other hand, smaller companies suffer from a shortage of financing schemes, which leads them to experience limitations in their growth and little results in the generation of economies of scale, among others. Regarding both types of businesses, we will refer to small and medium-sized companies.

The interest of scholars about the survival actions of small and medium-sized enterprises (SMEs) is that they constitute 95% of the companies in Latin American countries and contribute 60% of formal productive employment (Aguilar et al., 2021). At the regional level, SMEs in the state of Puebla, according to the National Statistical Directory of Economic Units (DENUE), there are 338,915 SMEs in the entity (INEGI, 2020) and particularly with regard to SMEs in the Tehuacán region, which is the area under study of this work, of the 32,652 economic units, 95.7% are micro-enterprises; 3.0% are small companies and 1.0% are medium-sized companies (Gobierno del Estado de Puebla, 2019).

Of the three fields of action of Organizational Architecture, the use of technology will be addressed. The closest antecedent about the use of technology applied to electronic commerce was observed during the year 2020, a significant number of small businesses, located in the city of Tehuacán, faced the effects of the pandemic seeking to maintain sales, retaining workers (See Table 1) and using technology to advertise on social networks, in addition to other actions; The analysis of the data collected in that year showed that the use of technology, through social networks and electronic means for electronic commerce,

increased, but once the State Government authorized the controlled return of activities, managers of small businesses significantly reduced the practices of technology use.

Table 1. Electronic commerce of micro and small companies in Tehuacán during the year 2020

Technology	Never	Before	During	After
Promotion of products or services				
Social networks (Facebook, Twitter, Instagram, YouTube)	53,12%	26,3%	26,04%	8,07%
Social networks (What´s App, Telegram)	45,57%	31,25%	30,99%	10,42%
Mass email	79,43%	11,46%	9,64%	2,6%
Internet advertising	79,43%	12,5%	8,33%	2,86%
By Telephone	51,82%	30,21%	23,44%	8,59%

Source: From Aguilar, et al. (2021).

As observed in Table 1, the percentages of the use of social networks involved the social networks of Facebook, Twitter, Instagram and YouTube, observing the behavior of increased activity for the closing months; the media such as What's App and Telegram for the attention of information and the sale of products; mass email, the use of which was less than the other means of communication; and the use of the telephone, which is of the same importance as the other means of communication. Given this behavior, a question that emerged was to know the perception of the owners of SMEs about how they implement their organizational architectures in the face of the new economy and the increasing use of industry 4.0 strategies, through data analysis, to build the business survival and growth, even with its limitations.

2. LITERATURE REVIEW

There are investments around the acquisition of physical capital aimed at raising the productivity of small companies, but the process to implement elements of industry 4.0 is complex (Llanes et al., 2023) and takes place in different parts of the world, in different economic sectors and the technologies that are incorporated, are related to the production that requires cyber-physical systems, in the different stages of the product life cycle, in articulated processes that allow the analysis of information without the presence of people (Buenrostro, 2022).

For their part, Foladori and Ortiz (2022) mention that the term industry 4.0 is related to the interrelation of various technologies that are made up of cyber-physical systems and connectivity, within the new technological revolution.

It is important to note that in sectors that have managed to digitize their value chains and that are tied to a network that allows the use of the Internet of Things, it implies an effort and translates into flexible manufacturing schemes and low-cost structures. But Ortiz, Fernández and Ledesma (2018) warn that the costs of implementing such structures require an investment; Options such as cloud computing have advantages such as installing a modem and having the services of the provider that can configure the handling of the information for your consultation in an appropriate way. Cloud computing has a framework called Service Oriented Architecture (SOA) and with the new developments for the cloud, it is suggested that acquiring the services for SMEs is relatively easy, however, before

moving on to the schematics of Industry 4.0 and business in the cloud, small companies have to go through a prior digitization process (Buenrostro, 2022).

The problem for SMEs is summed up in their difficulty to insert themselves into industry 4.0 schemes because the use of technologies and knowledge management, which translates into the generation of goods with low technological intensity and low competitiveness but "variables to implement prospectively are related to education for entrepreneurship and the management of an articulated and systemic regulatory framework that results in technological development and innovation" (Gutarra, Valente, 2018). A study prepared by Carrillo, Gomis, De los Santos et al. (2020), mentions about a study made to measure the knowledge of engineers in different companies, their knowledge about industry 4.0 exhibited low knowledge about the subject and to achieve its implementation in the companies where they work.

However, companies that have adopted industry 4.0 technologies can hire specialized personnel in Information and Communication Technologies, implement better systems for material requirements planning (MRP) and enterprise resource planning (ERP), in addition to who collaborate more actively with universities and research centers and have a better perception of their own comparative advantages (Junior, Carrer, 2022). But different authors maintain that it is important to move towards the new schemes because in the end, companies can manage to increase their competitiveness (Ynzunza et al., 2017).

On the other hand, data analysis is a subject that has allowed managing the information that companies have because decision-making based on data allows us to look with greater certainty at daily decisions to achieve business survival and the path of expansion. towards the future, in the case of Mypes, conscious decision-making allows guiding a business strategy (Figueroa-López, García de la Torre, 2018).

3. METHODOLOGY

According to the DENUE, in Tehuacán there are: 21,334, so a sample with 95% reliability, 5% error and 50% probability of success was calculated. Micro and small companies, of all lines of business, that have between 2 and 10 workers.

The hypothesis from which the present work was based has to do with perception and performance being related:

H_0: The organizational architecture of SMEs is related to data analysis to implement industry 4.0 strategies.

Ha: The organizational architecture of SMEs is not related to data analysis to implement industry 4.0 strategies.

574 surveys were collected, with the help of 120 students of the Business Development PE of the Technological University of Tehuacán, which were collected between the months of October and November of the year 2022.

In order to analyze the data, two types of tables were created. In the first, the perception variables were placed, which includes the question about knowledge about industry 4.0 and the questions about the benefit for companies, the reduction in production time, the optimization of quality levels, cost savings, greater process security, flexible production, efficient data flow, increased business competitiveness, adaptation of new methods and social inequality. Questions with Likert scale response options were used where 1 = Strongly disagree; 2 = Disagree; 3 = Indifferent; 4 = Agree and 5 = Totally agree.

For the second table, the action questions were placed, which include: implementation of sensors and programmable logic controllers; supervisory control in data acquisition;

manufacturing execution systems; enterprise resource planning; machine-to-machine communication (M2M); virtual commissioning; process simulation; artificial intelligence for predictive maintenance; AI for production planning; and industrial robots.

In the case of industry 4.0 practices, questions were asked about the installation of sensors, actuators and programmable logic controllers (PLC); supervisory control and data acquisition (SCADA); manufacturing execution systems (MES); enterprise resource planning (ERP); machine-to-machine communication (M2M); virtual commissioning; process simulation; artificial intelligence for predictive maintenance; artificial intelligence for production planning and industrial robots. For the response options, they were ordered as follows: poor implementation = 1; low implementation = 2; median implementation = = 3; high implementation = 4; advanced implementation = 5.

Tests of descriptive statistics, cross tables and a linear regression were applied that correlates each table and its components with the turn of the company, knowledge of industry 4.0 and data analysis (Cronbach's alpha: 0.916) and the implementation of actions. that use the technology (Cronbach's alpha 0.976) which were analyzed with the SPSS software.

4. RESULTS

In the case of the table about the perceptions of entrepreneurs about the benefits of implementing industry 4.0 strategies (See Figure 1), it was obtained as descriptive statistics that the data exhibited normality and that there is knowledge of the term and its benefits in the processes of the companies, however it is important to note that the answers that made the most count are located in option 3 (same as reflecting indifference) and answer 4 (which denotes knowledge on the subject and strategies about industry 4.0.

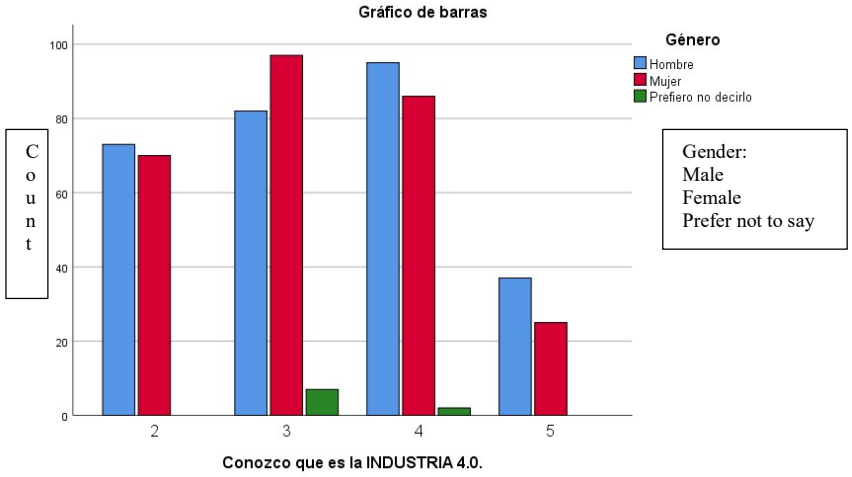

Figure 1. Control question on knowledge about industry 4.0 by gender

Source: Prepared with survey data (2022).

In the crossed tables (See Figure 2), it was found that the commercial lines of wholesale trade (206 responses), retail trade (833 responses), construction (44 responses),

manufacturing industry (68 responses), technology development (4 answer) and restaurant services (218 answers) are those that expressed their answers with value = 5, which denotes high importance on the subject, the other sectors manifest ignorance.

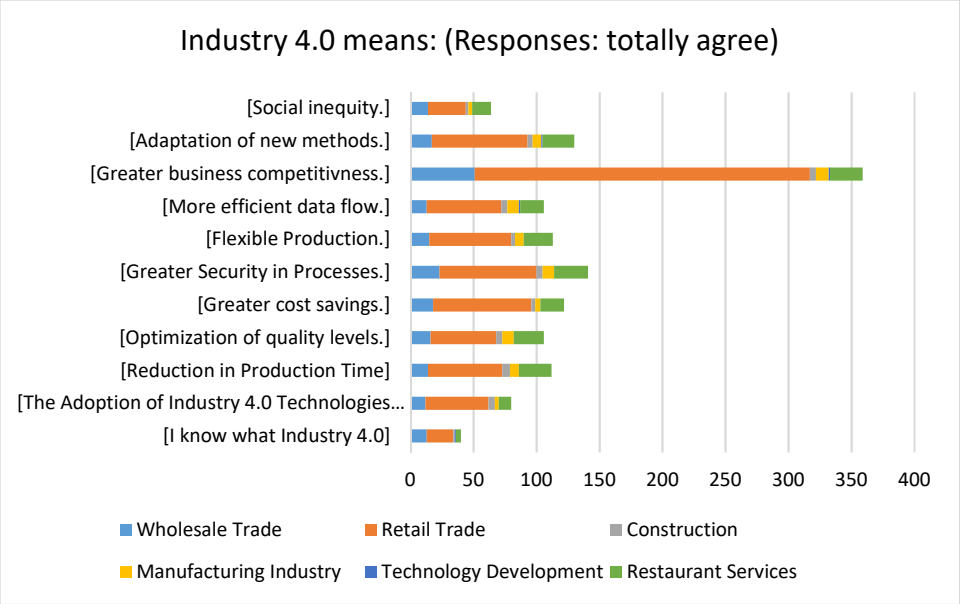

Figure 2. Businessmen's perception of industry 4.0, by line of business

Source: Prepared with survey data (2022).

According to the linear regression that addresses the perceptions of made the variables depend on improvements in the company (0.650); production time reduction (-0.055); optimization of quality levels (0.14); higher cost savings (-0.033); greater security of processes (0.122); flexible production (-0.001); more efficient data flow (-0.057); greater business competitiveness (-0.942); adoption of new methods (0.120) and social inequality (0.098) with a constant of (0.124), all based on knowledge of the four point zero industry strategies.

$$C.IA.= 0.124 + ME\ (0.650) - RT\ (0.055) + OC\ (0.14) - AC\ (0.033) + SP\ (0.122) - PF\ (0.001) - FD\ (0.057) - CE\ (0.942) + NM\ (0.120) + DS\ (0.098)$$

In the case of industry 4.0 activity practices, it was found that the companies that responded 5 (See Figure 3), that is, advanced implementation were wholesale trade companies (124 responses), retail trade (267 responses), construction industry 45 responses), manufacturing industry 31 responses); restaurant services (105 responses), and transport and storage (44 responses).

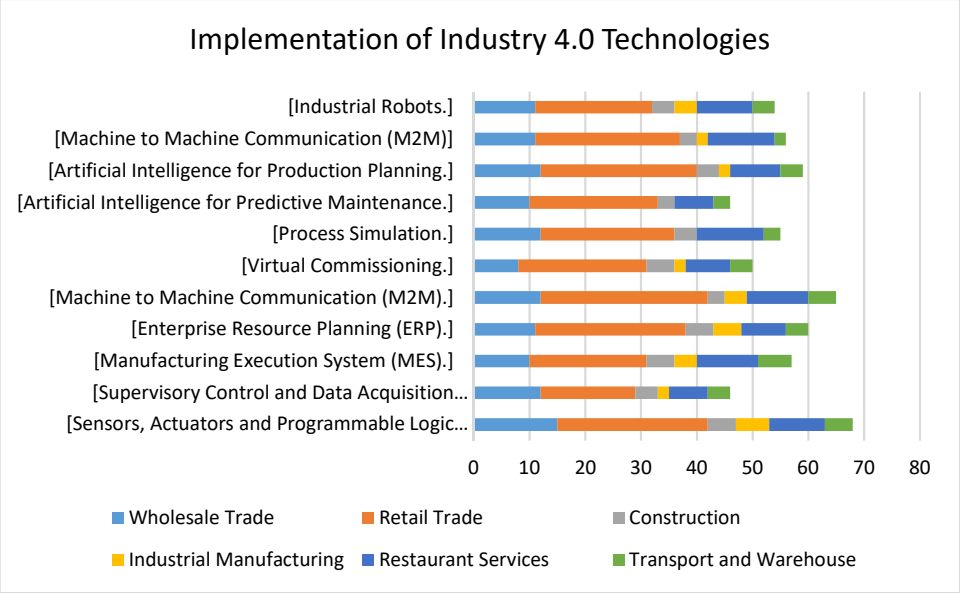

Figure 3. Perception of businessmen about the implementation of industry 4.0 technologies

Source: Prepared with survey data (2022).

According to the linear regression where the planning of enterprise resources (ERP) was made dependent on PLC (0.068); SCADA (0.340); MES (0.323); M2M (0.057); virtual commissioning (0.170); Process simulation (0.075); AI for predictive maintenance (-0.045); AI for production planning (-0.012); industrial robots (-0.028). With a constant of (0.268).

ERP = 0.268+PLC (0.068) + SCADA (0.340) + MES (0.323) + M2M (0.057) + PMV (0.170) + SP (0.075) – IAM (0.045) -IAP (0.012) -RI (0.028).

5. DISCUSSION

Based on the results, it is observed that the acceptance of industry 4.0 tactics is relevant for male and female entrepreneurs, but they are few compared to the sample. Figure 1 shows that men (90) and women (85) responded that they know what the concept is and chose response 4, which denotes the perception of agreement. They are 17% of the 574 businessmen surveyed, which demonstrates the What Carrillo, et al (2020) say about there is little knowledge about the topic. It is important to mention that 350 opinions mentioned that industry 4.0 tactics and data analysis will help their businesses achieve more competitiveness, and in second place with 140 surveys, to achieve greater security in processes and in third place (125) to adopt new methods. This result reinforces what was mentioned by Ynzunza et al. (2017), who say that moving to new schemes leads companies to increase their competitiveness.

However, the perceptions about the benefits are far from what was mentioned by Gutarra and Valente (2018), who say that entrepreneurship education, in an articulated and systemic regulatory framework, leads to creating innovations, because in Figure 2,

companies Those dedicated to commerce and services express their agreement about the advantages of using industry 4.0 tactics, but technology development companies are few.

The study highlights what Junior and Carrer (2022) mention that businesses that have invested in specialized personnel to achieve better materials requirement planning (MRP) and enterprise resource planning (ERP) are observed in the Figure 3, where it is observed that wholesale and retail trade and services companies show more use of Industry 4.0 technologies, while companies in the manufacturing industry and transportation and transportation companies logistics to a lesser extent.

6. CONCLUSIONS

According to the answers obtained about the perception of small entrepreneurs about the importance of making industry 4.0 strategies, it can be mentioned that the businesses that show the most interest are the wholesale and retail trade sectors and restaurant services, while the construction, manufacturing industry and technology development businesses show, to a lesser extent, a complete interest in such strategies. It is striking that in the linear regression, the benefits derived from technology such as cost savings, flexible production and efficient data flow are inversely related to the knowledge of industry 4.0 strategies and data analysis.

With regard to the responses obtained in the implementation of technologies, small businesses that operate in wholesale and retail trade, as well as restaurants, state that they have implemented technologies to improve their processes, while businesses such as construction, manufacturing industry, and transport and warehouse have less advanced implementation responses. The linear regression shows that the technological actions of the use of artificial intelligence and the use of industrial robots are inversely related to business resource planning.

The results allow us to see that the small and medium-sized companies that operate in the city of Tehuacán are not large enough to match the knowledge of the use of technology with the implementations, so their organizational architectures are not related to the actions that could be carried out translate into competitiveness and innovation. In the same way, the type of organizational architectures is not prepared to venture into artificial intelligence applications to create predictive maintenance routines, production planning and the use of industrial robots.

Given the previous findings, the null hypothesis cannot be demonstrated, and therefore, the alternative hypothesis is demonstrated, which mentions that the organizational architectures of SMEs are not related to data analysis to implement industry 4.0 strategies, due to the fact that the Owners recognize the importance of the issue, but due to the way the businesses have been built, they are not in a position to make investments that allow them to improve their processes.

The present study yielded substantial information, on one hand, regarding those businesses that mentioned that they have made implementations in the commerce and services sectors, which raises doubts about what type of implementations they managed to do and how these advances in the processes are applied in their facilities, this warrants further study to see if this is the case. Also, and on the other hand, there were sectors that showed little response, which also deserves another study to find out in those companies that said they achieved medium implementations, how they did it and how they have contributed to competitiveness and business growth.

The present study is a measurement of what small and medium-sized entrepreneurs have managed to do regarding the use of technologies and data analysis, but more studies are required, with greater detail to know, with a higher level of precision, how they are educated in technology entrepreneurs. Also know in greater detail how commercial and service companies have used technology. This is an incipient study, which provides important data on learning and the actions undertaken, but more information is required to know specific strategies and possible innovations; that will remain for other studies in the future.

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