

## Development of A Methodology Through Genetic Algorithmst Suggest the Probability of Success of a MSME in Mexico

Israel Patiño-Galvan<sup>1</sup>, José Alberto Hernández-Aguilar<sup>2</sup>, Stella Vallejo-Trujillo<sup>3</sup>

### Abstract

The economic development of the regions depends on several factors, including the living conditions of the population, the economic potential of the region, a favorable context for sustainable development, among others. In this sense, the Micro, Small and Medium Enterprises (MSMEs) are a strategic factor to collaborate with this development, since it concentrates more than 66% of the workforce, 45% of the gross income of the country, and represents around 99% of the total economic units in Mexico(INEGI, 2018). Added to this, conforms the intellectual capital of entrepreneurs in the country, which demands opportunities and alternatives to channel creativity and innovation to create new MSMEs, which can be a source of income, employment, taxes and revival of the economy. However, these initiatives require tools, information, advice and funding sources to support decision making and reduce the risk of failure. Based on the integration of INEGI information, business plan indicators and socioeconomic indicators, a methodology that uses genetic algorithms was developed to suggest the probability of success of a MSME in Mexico

**Keyword:** Economic development, MSMEs, Methodology, Decision making, Failure

### 1. MSMEs and economic development in Mexico

According to Andersen(1999)a company is an economic entity which through the organization and coordination of factors such as capital and work, seeks a profit by producing and marketing products or services in the market. Other authors define MSMEs as an economic unit that produce goods and services, which are managed by their owner in a personalized and autonomous way, having a small size in terms of number of workers and a certain market coverage(Gilman & Edwards, 2008), (Fernández, 2008) and (Ueki, Tsuji, & Cárcamo, 2005). The background of the MSMEs in Mexico goes back to April 1954, when the Ministry of Finance begins to classify enterprises according to their accounting capital and considers as microenterprises those whose capital is less than 50,000 Mexican pesos, small and medium enterprises with capital exceeding 50,000 or less than 2,500,000 Mexican pesos. In this decade the MSMEs began to gain importance from the validity of the import substitution model, which showed a good dynamism and allowed an accelerated learning, growth, and development process. In 1961 the categories underwent a change, and the margin was extended from 25,000 to 5 million pesos to classify small and medium enterprises. The theme of their integration was varied from companies in which their organization, structure, business management and paid work were distinguished, to those that had a family origin where their concern was to survive; leaving aside the strategy and focusing on planning, capital, or investment, which would allow its growth. Two years later, in 1963, the classification parameters of the companies changed again, leaving as MSMEs those whose capital was less than 10 million pesos (Bárdan Esquivel, RiveraPaz, & González, 2002). In the 70s, the levels of international competition reached so far fell; leading to the closure of many of them, due to an economy without opening abroad; causing micro and macroeconomic instability in the country until the 80s. From the economic opening implemented in Mexico in the 1990s and the availability of external financing, a rebound in MSMEs was expected; however, due to the weak internal economy, many of them closed, others went bankrupt, and others were merged or absorbed by other companies. Currently the classification of companies is carried out taking into account the economic sector to which they belong, the number of employees and annual sales are shown in *Table 1*(H. Ruiz & Del Rivero, 2017), a classification that places MSMEs in 99% of the country's economic units(INEGI, 2018).

<sup>1</sup>Professor and researcher, Tecnológico de Estudios Superiores de Ecatepec, Mexico, [ispagalvan@tese.edu.mx](mailto:ispagalvan@tese.edu.mx).

<sup>2</sup>Professor and researcher, Universidad Autónoma del Estado de Morelos, Mexico, [jose\\_hernandez@uaem.mx](mailto:jose_hernandez@uaem.mx)

<sup>3</sup>Professor and researcher, Instituto de Educación Técnica Profesional de Roldanillo, Colombia, Valle – INTEP, [vallejo.trujillo.stella@gmail.com](mailto:vallejo.trujillo.stella@gmail.com)

**Table 1.** Classification of the SMEs in Mexico according the INEGI

<b>Mexican</b>		
<b>Concept</b>	<b>Small</b>	<b>Medium</b>
Employees	01 - 100	101–250
Turnover (EUR Million)	0.44	0.99

Source: Micro, Small, Medium and grand enterprise (INEGI, 2018), page 12, exchange rate 1EUR = 20.01 Mexican Pesos, recovered June 16, 2017

According to the economic census of INEGI (2018), the classification of MSMEs companies in México is carried out by their number of employees and their range of annual sales amount. To identify the economic sectors of the country and their classification, it is broken down according to the economic sector. As can be seen in *Table 1*, there are variations in the amounts of personnel and sales of small and medium enterprises and the economic sector, and the commercial has the least amount of personnel and amounts. The stratification changes of the Mexican company, although it has had a statistical purpose, show the importance of MSMEs in economic development, since in all cases, the number of economic units has been located at a percentage greater than 90% of the national total; although the figures are not strictly comparable between the different stratifications (H. Ruiz & Del Rivero, 2017). Stratifications that coincide with the economic moments that the analysts refer to the country has lived: import substitution in the 40s, stabilization development from 50s to 60s, shared development 70s, economic and commercial opening 80s, contraction 90s, imbalance and poverty in 2000 and recovery (Huerta & Chávez, 2003), (Casais Padilla, 2009), (Salas, 2013), (Martínez Arellano, 2017). Without a doubt, the productive sector collaborates in an important way with the economic development of the regions, since it is a comprehensive socio-economic process, which implies the continuous expansion of the economic potential and the self-sufficiency of this expansion in the total improvement of society. Process known as the transformation of the society or process of successive increases in the living conditions of all people or families in a country or community (Castillo Martín, 2011). Therefore, initiatives that collaborate with its creation of economic units, require a satisfactory development in such a way that they promote a sustainable growth of these units and thus of the economy in Mexico.

## 2. Classification of MSMEs at international level

The classification of micro, small and medium enterprises at international level and according to the Development Organization for Economic Cooperation-OECD, it is supported according to the number of employees and the annual sales volume, as shown in *Table 2* (OECD/Eurostat, 2005).

**Table 2.** Classification of the SMEs in European countries and countries that integrate the OECD

<b>European / OECD</b>		
<b>Concept</b>	<b>Small</b>	<b>Medium</b>
Employees	01 - 49	50 – 249
Turnover (EUR Million)	10	50

Source: Small and Medium-sized enterprises, OECD (2006), <https://stats.oecd.org/glossary/detail.asp?ID=3123>, European commission (2016), recovered June 16, 2017 [http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition\\_es](http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_es), recovered June 16, 2017

In the international context there is no classification of microenterprises; although the classification is made based on the number of employees and volume of sales, as in the case of Mexico. To compare the classification of companies in Mexico with the international context, micro and small companies were grouped as shown in *Table 3*.

**Table 3.** Classification of MSMEs in Mexico

<b>Sector</b>	<b>Micro</b>		<b>Small</b>		<b>Medium</b>	
	<b>Personal</b>	<b>Sales amount (mmp)</b>	<b>Personal</b>	<b>Sales amount (mmp)</b>	<b>Personal</b>	<b>Sales amount (mmp)</b>
Industrial	1-10	To 4	11 - 50	To 95	54 - 250	100.1 to 250
Commerce	1-10	To 4	11 - 30	To 93	31 - 100	100.1 to 250
Services	1-10	To 4	11 - 50	To 95	54 - 100	100.1 to 250

Source: Micro, Small, Medium, and large enterprises INEGI (2018), page. 12. mmp= Millions of Mexican Pesos

As can be seen, companies in European countries demand less labor and are more efficient in terms of sales generation, comparatively with Mexican companies of similar size. That is, public policies for SMEs in Latin America, face various challenges that have to do with integration, coordination and sustainability (CEPAL & OCDE, 2012).

### 3. Contribution of MSMEs to the economic development of Mexico

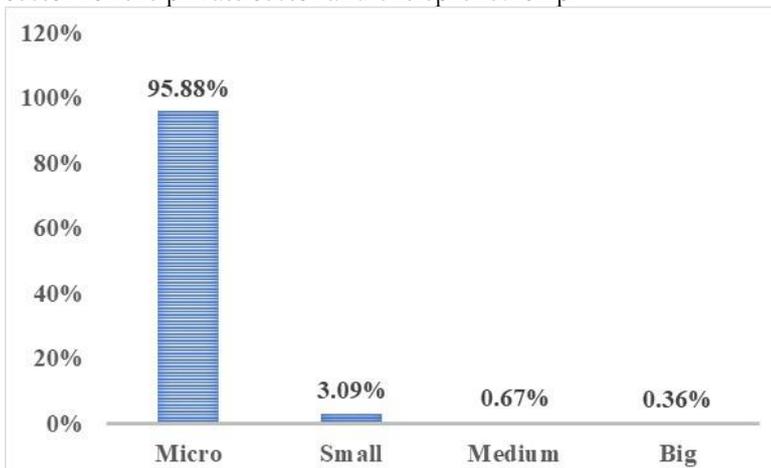
The Union Nations (2016) suggests fostering innovation, industry and economic growth, with initiatives and methodologies to enhance the growth and development of the regions, strategic sectors and the boost to MSMEs (See *Table 4*) through the implementation of electronic government for the achievement of the objectives of sustainable development in this case a decent work and economic growth. In this sense, to give an idea of the dimensions and contribution of this economic sector in Mexico, some statistics of its representation divided by manufacturing, commercial and services sectors according to the INEGI (2018) are shown.

**Table 4.** Number of establishments by sector

Sector	Micro	Small	Medium	Big
Manufacture	458,096	20,455	7,413	3,548
Commerce	1,978,887	43,967	14,454	5,333
Service	1,560,949	64,274	5,923	6,216
Total	3,997,932	128,696	27,790	15,097

Source: Own (2019), taken of the INEGI (2018)

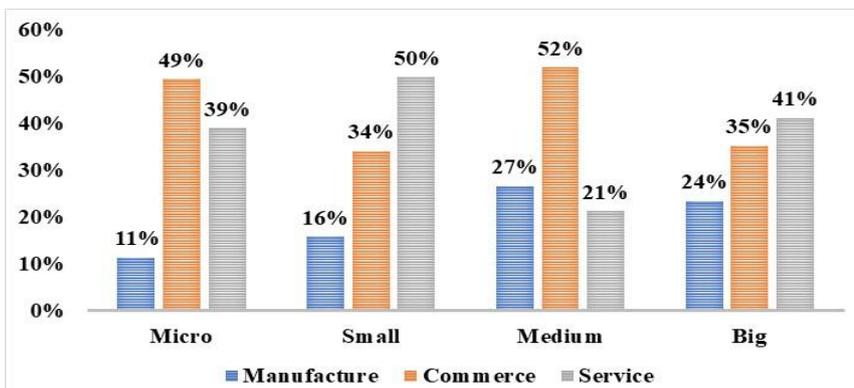
In the *Illustration 1*, just over 96% of establishments correspond to MSMEs, which is why it represents a strategic sector for the private sector and entrepreneurship.



**Illustration 1.** National total by establishments and company size

Source: Own (2019), taken of the *Table 4*

On the other hand, in the *Illustration 2* and *Table 4*, it is observed the largest number of establishments is focused on MSMEs, with the commercial sector being the main one, followed by services, and finally, by the manufacturing sector.



**Illustration 2.** National total by sector and number of establishments

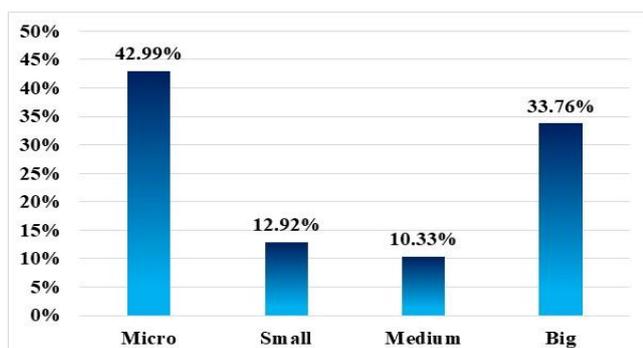
Source: Own (2019), taken of the *Table 4*

As shown in *Illustration 3* and *Table 5*, the number of employees in MSMEs establishes that the service sector concentrates the largest number of employees, followed by commerce and finally manufacturing.

**Table 5.** National total by number of employees and sector

Sector	Micro	Small	Medium	Large
Manufacture	1,057,456	446,181	851,506	2,718,289
Commerce	3,866,223	745,253	764,713	1,013,459
Service	3,528,093	1,348,207	414,660	2,904,086
Total	8,451,772	2,539,641	2,030,879	6,635,834

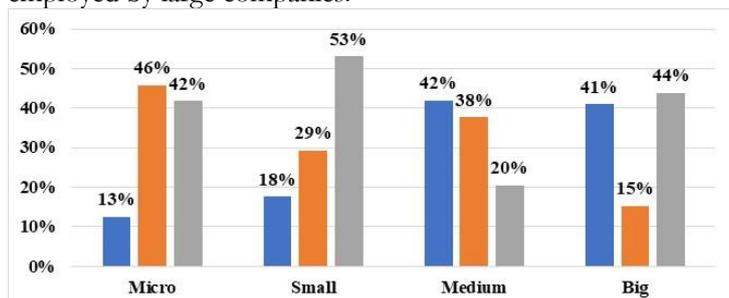
Source: Own (2019), taken of the INEGI (2014)



**Illustration 3.** National total by number of employees and size of company

Source: Own (2019), taken of the *Table 5*

According to *Table 5* and *Illustration 4*, MSMEs employ more than 66% of the country's workforce, and the rest is employed by large companies.



**Illustration 4.** By sector, size, and number of employees

Source: Own (2019), taken of the *Table 5*

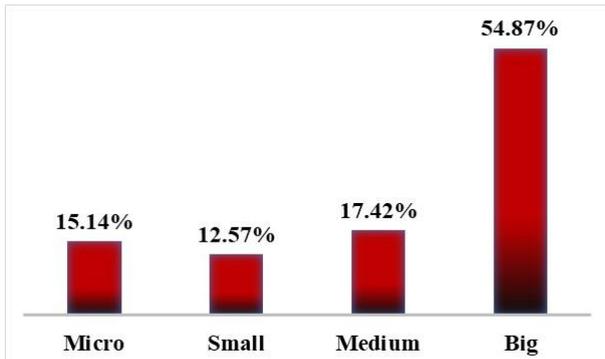
Regarding the income in accordance with *Table 6*, the MSMEs represent 45%, an issue that contrasts with 99% of the number of companies, and labor with 66%.

**Table 6.** Total national gross income

Sector	Micro	Small	Medium	Big
Manufacture	182,811,105	330,121,527	1,062,226,379	5,170,613,035
Commerce	1,515,639,541	1,106,589,790	1,333,502,755	1,636,354,163
Service	520,670,383	406,962,053	158,336,671	1,238,198,863
Total	2,219,121,029	1,843,673,370	2,554,065,805	8,045,166,061

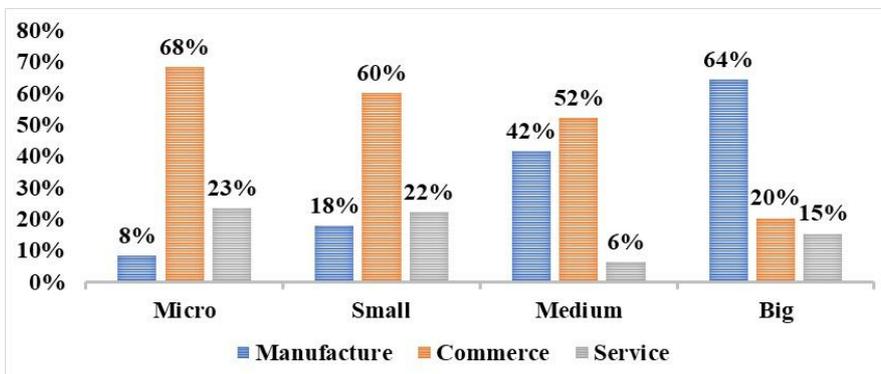
Source: Own (2019), taken of the INEGI (2014)

As shown in *Table 6* and *Illustration 5*, in MSMEs, the sector that generates the most income is commerce, followed by manufacturing, and finally, services.



**Illustration 5.** National total by income and company size (cite)  
Source: Own (2019),

In this section we can conclude that the manufacturing companies in the MSMEs sector have a high growth potential in relation to the volume of sales (See *Illustration 6*).



**Illustration 6.** National total by income and sector  
Source: Own (2019), taken of the *Table 6*

**4. Case study: Comparative and contributions of the MSMEs of the manufacturing sector: Mexico, Portugal and Germany**

To identify the importance of the MSME sector in the economic development of the regions, particularly with the manufacturing sector, a comparison is presented between the number of economic units by sector and their representation by economic activity. This, information was taken from two countries of the European Union considering the infrastructure and the impetus given to the MSMEs through their innovation ecosystems (Enterprise, 2018),(Cornell, WIPO, INSEAD, & Organization, 2017).

**4.1 Universe of economic activities and their percentage of representation**

According to *Table 7*, in general the services, commerce and manufacturing sectors account for more than 96% of establishments, which in the case of Mexico represents the concentration of labor, income in sales.

**Table 7.** Enterprise universe in Mexico

Economic Activities	Economic units	Percentage
Services	1,637,362	38.70%
Commerce	2,042,641	48.28%
<b>Manufacture</b>	<b>489,530</b>	<b>11.57%</b>
Transport, mail and storage	17,989	0.43%
Building	17,063	0.40%
Electricity, water and gas	2,721	0.06%
Fisheries and aquaculture	20,407	0.48%
Mining	3,032	0.07%
<b>Total</b>	<b>4,230,745</b>	<b>100.00%</b>

Source: Number of enterprises by size and main sector 2016, INEGI (2018)

In the case of Portugal and Germany, the sector with the greatest representation is the service sector with 80% and 78% (respectively), while trade represents just over 10% and 12%. Finally, the manufacturing sector is the lowest in representation of economic units with 8% and 9% (See *Tables 8 and 9*)

**Table 8.** Enterprise universe in Portugal

Economic Activities	Economic units	Percentage
Services	620,534	80.77%
Commerce	81,335	10.59%
<b>Manufacture</b>	<b>66,423</b>	<b>8.65%</b>
<b>Total</b>	<b>768,292</b>	<b>100.00%</b>

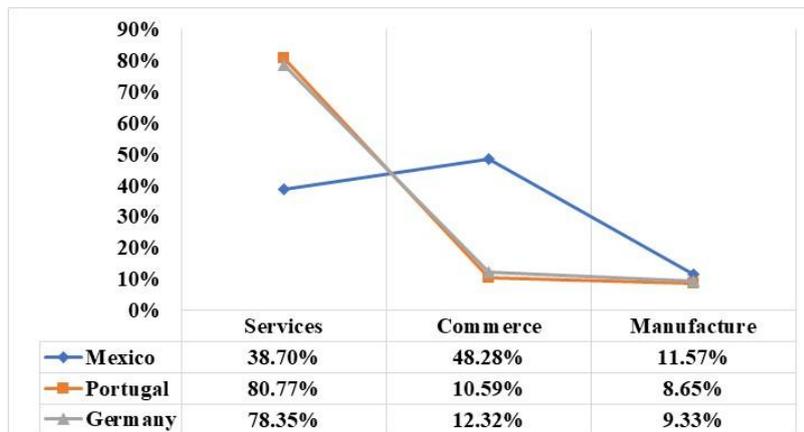
Source: Number of enterprises by size and main sector 2015,OECD (2015), p. 36

**Table 9.** Enterprise universe in Germany

Economic Activities	Economic units	Percentage
Services	1,703,437	78.35%
Commerce	267,849	12.32%
<b>Manufacture</b>	<b>202,824</b>	<b>9.33%</b>
<b>Total</b>	<b>2,174,110</b>	<b>100.00%</b>

Source: Number of enterprises by size and main sector 2015(OECD , 2015)p. 36

Comparing the three sectors among the countries in the case study, Portugal and Germany have a greater number of MSMEs in the service sector with just over 78%, while Mexico has little more than 38%. This difference is more than 40%. On the other hand, in relation to the commercial sector they represent between 10 and 12% for European countries, while for Mexico they represent 48%, representing a difference of 20%. Finally, in relation to the manufacturing sector, perhaps the one that has greater similarity, in Mexico they represent 11% while for Portugal and France little more than 8 and 9% respectively (See *Illustration 7*).



**Illustration 7.**Total economic units by sector of the countries: Mexico, Portugal and Germany

Source: Own (2019), taken of *Tables 7, 8 y 9*

According to the information presented in the classification of sectors by economic sectors, total establishment or economic units and labor, it is confirmed that the MSMEs sector represents a great opportunity for economic and social development of the regions in any of the economic sectors.

#### 4.2 Stratification of manufacturing companies

It is particularly important to focus on the manufacturing sector, which although represents the lowest percentage in relation to the services and commercial sectors in number of economic units and labor, this represents the highest percentage in generation of gross annual sales. Therefore, it is considered relevant to analyze their contribution and the creation of opportunities in the MSMEs. According to *Table 10*, the MSMEs of the manufacturing sector for Mexico represent more than 99% of the economic units, while the large company represents only 1%, while in the case of Portugal and Germany, they represent 99.7% and 98% (respectively) according to *Tables 11 and 12 and Illustration 8*.

**Table 10.** Stratification of manufacturing in Mexico

Stratification of manufacturing	Economic Units	Percentage
Micro	458,096.00	93.58%
Small	20,455.00	4.18%
Medium	7,431.00	1.52%
Large	3,548.00	0.72%
<b>Total</b>	<b>489,530.00</b>	<b>100%</b>

Source: Number of enterprises by size and main sector 2016, INEGI (2018)

**Table 11.** Stratification of manufacturing in Portugal

Stratification of manufacturing	Economic Units	Percentage
Small	64,187.00	96.63%
Medium	1,988.00	2.99%
Large	248.00	0.37%
<b>Total</b>	<b>66,423.00</b>	<b>100%</b>

Source: Number of enterprises by size and main sector 2016, OECD (2015), p. 36

**Table 12.** Stratification of manufacturing in Germany

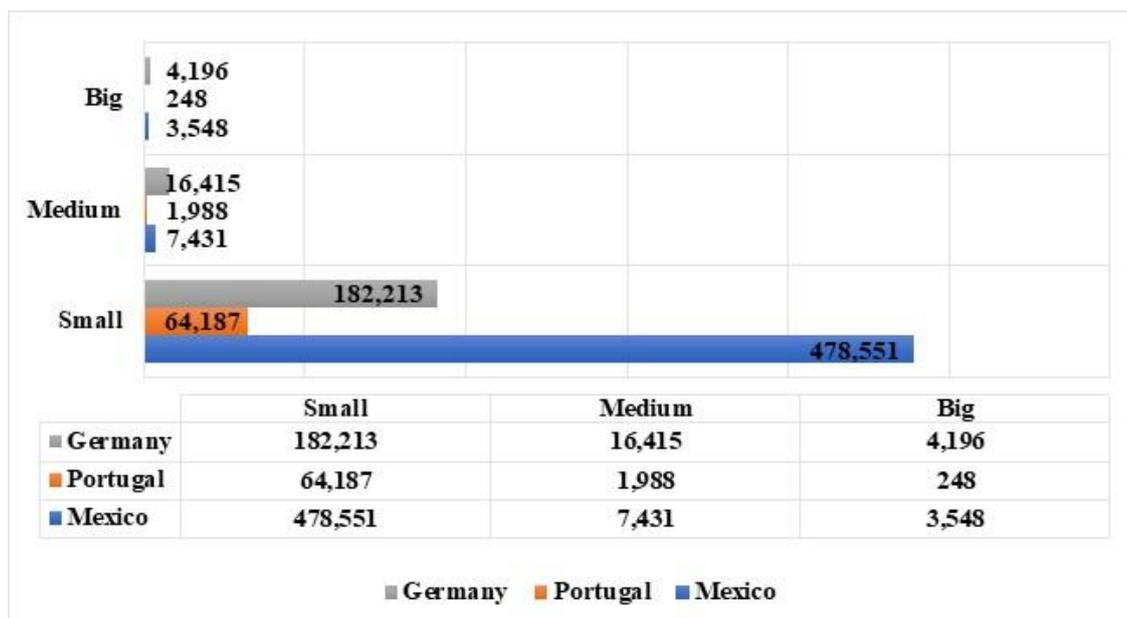
Stratification of manufacturing	Economic Units	Percentage
Small	182,213.00	89.84%
Medium	16,415.00	8.09%
Large	4,196.00	2.07%
<b>Total</b>	<b>202,824.00</b>	<b>100%</b>

Source: Number of enterprises by size and main sector 2016, OECD (2015), p. 36

It is noteworthy that the number of economic units of MSMEs, where for the Mexican case are just under half a million, while for Portugal and Germany are just under 65 thousand and just under 198 thousand (respectively), Mexico duplicates the number of MSMEs by adding this sector in both European countries (See *Illustration 8*). In this comparative, Germany stands out, that despite representing a little more than 50% less in total of economic units with respect to Mexico, it exceeds in the sector of medium and large companies in relation to Mexico (See *Illustration 9*).

**Illustration 8.** Percentage of establishments by sector - manufacturing size: Mexico, Portugal and Germany

Source: Own (2019), taken of the *Tables 10, 11 y 12*



**Illustration 9.** Economic units by size of the manufacturing sector: Mexico, Portugal and Germany  
Source: Own (2019), taken of the *Tables 10, 11 y 12*.

To be able to compare the data of *Illustrations 8 and 9*, in the case of Mexico, the information of micro and small enterprises was grouped, given that in the case of Portugal and Germany, only small, medium and large companies are included.

### 5. Causes of failure or closing of operations of the MSMEs

An important aspect that determines the permanence of the MSMEs a business plan, planning and contextual analysis adequate, that finally lead to the closing of operations and / or failure of these. In this sense, there are different factors that determine these causes in MSMEs that have between three and five years of operation.

In the national context, organizations such as INADEM, point out different causes of failure of MSMEs in Mexico. According to the National Institute of the Entrepreneur - INADEM (2018) causes are:

- Lack of brand positioning
- Low quality of products and services
- Low sales volume
- Lack of planning
- Difficulty of integrating to supply chains of high added value
- Lack of certifications that prove the quality of their processes and products
- Excessive requirements of government agencies
- Lack of access to financing funds
- Lack of offer of attractive financial services focused on SMEs

The National Institute of Statistics and Geography - INEGI, in the Demography of Establishments Study of 2009-2012, states that the causes are (INEGI, 2013):

- Little profitability
- Lack of liquidity
- High income
- Insecurity
- Personal motives

For its part, the National Commission for the Protection and Defense of Users of Financial Services - CONDUSEF indicates that the main causes or factors are (García Canseco, 2015):

- Absence of a business culture: Mission, Vision, and values
- Lack of strategic analysis: What the market requires
- Mismanagement: Administrative errors in decision making
- Personal incompetence: Lack of training to manage the business
- Poor financial planning

- Indebtedness without foresight
- Centralization of power: Family ties motivate the disappearance of companies
- Absence of controls: The younger the company, the more important it is to incorporate control measures
- Lack of planning

Continuing with the national context according to Domenge& Imanol (2010), the causes of failure or closure of MSMEs operations in Mexico are internal and external, as indicated below:

- Internal
  - Income is consumed in personal expenses
  - Poor delegation of responsibilities and decision making
  - Lack of strategic planning
  - Production and inventory insufficiency
  - Low sales
  - Poor general management
  - Staff management and poor hiring
  - Financial problems
  - Lack of staff training
- External
  - Excessive bureaucratization
  - High financing costs
  - Lack of accessibility to financing programs
  - Lack of fiscal incentives
  - Lack of ethics
  - Piracy

In the international context, MSMEs in the United States fail because of the following causes(Garcia Canseco, 2015):

- Inadequate sales
- Weakness in the face of competition
- High operating costs
- Difficulties to collect
- Difficulty with inventories
- Excessive investment in equipment
- Inadequate location
- Negligence
- Claims
- Frauds

On the other hand, the OECD groups the following causes of failure of the MSMEs (Hernández, 2007)

- Internal
  - Little access to information
  - Unqualified staff
  - Badly planned product
  - Non-competent prices
  - Lack of knowledge
  - Lack of logistics
  - Bad negotiation
- External
  - Inadequate or inadequate infrastructure
  - Scarce financial resources
  - Non-existent regulatory policies
  - Scarce business environment
  - Lack of support

Finally, the European Commission groups the following causes or obstacles that lead MSMEs to failure (Hernández, 2007):

- Linked to knowledge
  - Lack of market knowledge
  - Lack of experience
  - Lack of information about supports

- Little knowledge about regulation and competition
- Ignorance of culture
- Linked to the lack of resources
- Lack of financial planning
- Insufficiency of human and technological resources
- Linked to procedures
- Tariff barriers
- Lack of knowledge in the behavior of the MSMEs
- Lack of transportation and documentation of processes
- Bad talent management
- Lack of certifications / permits to operate and certify their production process
- Exogenous type
- Political and economic instability
- Corruption
- Excess of bureaucracy
- Country risk
- Confidence in the market

In relation to this research that gave rise to the present article, it is suggested that the following should be taken as causes of failure, in order that this information forms part of the inputs or parameters of the Genetic Algorithms. The foregoing, since the objective is to suggest the creation of a new MSMEs; therefore, external factors will be omitted, leaving only those that are identified as determinants to collaborate with their permanence and success. The lack of substantiation of the following sections is considered as grounds for failure (not limiting):

- Strategic planning
- Market study
- Business plan
- Sources of financing
- Targeting of supply chains
- Certifications that prove the quality of your production process
- Adequate organizational structure that supports the operation of the company
- Control measures through indicators
- Years of experience in the management and operation of MSMEs by human resources

## 6. Methodology to determine the success of an MSMEs

To develop a methodology to determine the success of an MSMEs, the task was to carry out a search and analysis of research that suggests the items and percentages of weighting. Of these, the suggested by the authors' research Sanchez, Garcia, & Holguin(2019) was considered as a basis, where they performed an econometric analysis of indicators that suggest the success of a company, giving a central role to "economic profitability" as Medullary indicator to determine its success. However, for the purposes of this research, two more indicators were added from the researches of the authors Theodorakopoulos, Kakabadse, & McGowan(2014), Akenaton, Hernández, Del, Monserrat, & Hernández (2017) and Özdemir & Şehitoğlu (2013), where development-related indicators are suggested to success of MSMEs. These indicators are the "seniority" and the "utilities", to give greater argumentation to the economic performance, since if a company has a good economic performance is not a symptom of success, if there are no profits and a seniority that accompanies the generation of experience and knowledge of their environment.

Finally, and using the indicated research as a suggestion, a table was generated with the weights of the three selected items (economic profitability, seniority and profits), which in total cover 50% of the total value of this indicator of business success. Where the economic profitability index has a minimum percentage of 5% and maximum of 30%. The seniority has a minimum value of 2.5% and maximum of 10%, and finally the profits have a minimum of 5% and a maximum of 10%. It should be noted that the items of seniority and profits may be assigned if they have a positive rate of economic return.

To analyze the success indicators, the information of these items is retrieved from the INEGI (2018). To identify the detail of the values assigned to each item, *Table 14* is presented. To complete the success indicators, since these are newly created MSMEs, two other groups of indicators were contemplated, one related to a business plan. and another one to socioeconomic indicators.

In summary, the model is divided into three groups. The first group corresponds to the initial value that will be integrated by successful MSMEs with a percentage value that will go from 30 to 50%, the second group will contain the values derived from the Business Plan (0 to 25%) and finally the third group will have the socioeconomic indicators (0 to 25%). These three items will give a total of 100% maximum. To know in detail the value of these three items is presented its detail and generation (See *Table 13*).

**Table 13.** Groups that make up the weighting of successful companies

Group	Percentage of value
First group: Successful Enterprise	50%
Second group: Business plan	25%
Third group: Socioeconomic indicators	25%
<b>Total</b>	<b>100%</b>

Source: Own (2019)

### 6.1 First group: Successful Enterprise

MSME successful. To know the success of a MSME, there are different sources that suggest the following indicators.

According to Theodorakopoulos, Kakabadse, & McGowan (2014), Akenaton et. al (2017) and Özmedir & Şehitoğlu(2013):

- Survival rate of incubated companies
- Sales growth
- Number of jobs created
- Utility growth
- Financial increase of companies
- Tax payment growth
- Export growth (if applicable)
- Number of intellectual property rights (if applicable)

On the other hand Bergek & Norrman(2008)suggest:

- For efficiency. Relationship between financial income, results, and economic value)
- For effectiveness. The extent to which the objectives have been achieved)
- Sustainability. Sustain the operations and durability of the results obtained

According to Sánchez, García & Holguin (2019), the following items are of importance:

- Financial profit
- Economic profitability

This option, says that it is imperative to give value to the positive economic profitability, since this will depend on the decision making of a company.

On the other hand Expansion(2019):

- Evolution of sales
- Actual income and expenses
- Cash flow movements
- The acquisition cost of each new customer
- The state of the inventories
- The productivity of workers

Considering the previous contributions, the following weighting percentage was determined for the first group of indicators to determine the success of a newly created MSME (See *Table 14*).

**Table 14.** Weighting of successful MSMEs

<b>Annual economic profitability index</b>	<b>Percentage: Minimum: 5%Maximum: 30%</b>
Between 0.01 – 1%	5%
Between 1.1 - 5 %	10%
Between 5.1 - 10 %	15%
Between 10.1 - 15 %	20%
Between 15.1 - 20 %	25%
Plus of 20%	30%
<b>Average age in years of the MSMEs. yes, and only yes, they have profitability</b>	<b>Percentage: Minimum: 2.5%Maximum: 10%</b>
Between 0.5 to 2.9	2.5%
Between 3 - 5.9	5.0%
Between 6 - 8.9	7.5%
More than 9	10.0%
<b>Utilities millions of pesos. yes, and only yes, they have profitability</b>	<b>Percentage: Minimum: 5%; Maximum: 10%</b>
Between 5 - 30	5%
Between 31 - 50	6%
Between 51 - 70	7%
Between 71 - 90	8%
Between 91 - 110	9%
More than 110	10%
<b>Total percentage</b>	<b>50%</b>

Source: Own (2019), taken as reference the Research of the authors Theodorakopoulos et al.(2014), Akenaton et al.(2017), Özdemir & Şehitoğlu (2013),Sanchez et al. (2019), related to identifying the indicators of success of companies, as well as the econometric analysis of indicators that suggest it success

Although in the literature no values or weights were found, they show the importance to the profitability indicators to the Economic Profitability. For this reason, this indicator will have a greater value and will condition the seniority and earnings indicator.

## 6.2 Second group: Business plan

For the integration of these factors, information was considered based on different business methodologies such as Brown's Design Thinking Methodology (2016), the Lean Startup model of the author Ries(2011), the Entrepreneurship Methodology of Christensen, Raynor and McDonald (2016) and the good practices and suggestions of Entrepreneur (2016); which allowed determining the weighting of the items for the MSME failure factors. Likewise, they facilitated to determine the blocks on which the business plan should be structured, which were given a weight or percentage value of 25%, integrating into the following blocks (cite): ideological structure, environment, market, financial resources, human resources, and executive Summary. Additionally, in order to define the percentages of each block and their respective factors, an analysis of a sample of enterprises was carried out, being the ones that have the greatest weight value are the 1. Structure of the environment, to know the context in which the venture will be established, followed of the 2. Financial structure, which provides information on the viability of the project and may indicate the degree of success or failure, subsequently, the 3. Ideological structures that will describe among other points the business idea as well as the objectives it intends to achieve. The next block is the 4. Human resource's structure, which will allow the formation of the work team that, will support the operation and administration of the initiative, as well as defining functions, responsibilities among other data. The fifth block is made up of the Marketing structure which will determine the strategy to create the sales and marketing plan. And finally, the 6. The executive summary aims to synthesize all the activity of the venture which is generated with the blocks that precede it. The analysis performed yielded the results in *Table 15*, with their corresponding weights per item.

**Table15.** Weighting of business plan factors

Block	Factor	Percentage
Structure of the environment	Minimum viable product	0.50%
	Alternate Products Catalog	0.50%
	SWOT Analysis (Strengths, Opportunities, Weaknesses, Threats)	0.50%
	Describe the target audience	0.50%
	Know how often your product and / or service is acquired	0.50%
	Competition detected and study of competitors	0.50%
	Market study	0.50%
	Competitive advantages	0.50%
	Segments and Customer Relationship	0.50%
	Key activities and resources	0.50%
	Partners or Key Alliances	0.50%
	Client's profile	0.50%
	Priority map	0.50%
	Context map (technology, business, trends, needs, prototype)	0.25%
CANVAS business tool	0.25%	
<b>Total Block 01</b>		<b>7.00%</b>
Financial structure	Proforma projected income statement for three years	1.00%
	Pro forma general balance projected to three years	0.60%
	Projected cash flow projected at three years	0.60%
	Breakeven analysis	1.00%
	Scenario Analysis	0.50%
	Sources of financing (own and external income)	1.30%
<b>Total Block 02</b>		<b>5.00%</b>
Ideological structure	Definition of the project	0.75%
	Company name	0.75%
	Mission	0.75%
	View	0.75%
	Values	0.75%
	Commitment	0.75%
<b>Total Block 03</b>		<b>4.50%</b>
Human resource	Organization chart	1.00%
	Job Card	1.50%
	Determine the cost of the template	1.50%
<b>Total Block 04</b>		<b>4.00%</b>
Marketing structure	Strategic planning	0.45%
	Price of your product and / or service	0.40%
	Payment plans	0.40%
	Sales force	0.40%
	Distribution channels	0.40%
	Communication channels	0.40%
	Generation of strategic indicators	0.40%
	Logo and brand	0.50%
	Consumer behavior	0.40%
<b>Total Block 05</b>		<b>3.75%</b>
Executive Summary	Business concept	0.15%
	Financial factors	0.15%
	Financial needs	0.15%
	Current business position	0.15%
	Report on the main achievements	0.15%
<b>Total Block 06</b>		<b>0.75%</b>
<b>Total Blocks</b>		<b>25%</b>

Source: Own (2019), based on the items of the model of Lean Startup of the author Ries(2013), Entrepreneur (2018), Design Thinking de Brown (2009) and disruptive innovation of Christensen (2006).

### 6.3 Third group: Socio-economic indicators

This indicator seeks that entrepreneur investigate the stability and behavior of these socio-economic indicators, which add to the generation of knowledge to achieve the success of the MSME they want to create. For this, various sources were consulted to support the selection of these items. Among the sources consulted are: Morales(2006), Ruiz (2011)Carretero(2012) and Aguilera & Virgen (2014), where socio-economic items that influence the growth of MSMEs are rescued, as well as cases of success and failure in the national and international context. The maximum value that this third group would throw is 25%. The inputs that make up this group are the following (See *Table 16*).

**Table16.**Weighting of socioeconomic indicators

No.	Description	Percentage
1	Study on the culture of market consumption	1.0%
2	Establish efficient customer service mechanisms	1.0%
3	Knowledge of the commercial regulatory framework of the market to enter	3.0%
4	Price Policy Establishment	1.5%
5	Establish cultural differences between different markets to guarantee preferences	1.5%
6	Generate commercial, marketing, legal and labor policies	1.5%
7	Stability in the interest rate (last 5 years)	2.0%
8	Stable exchange rate in the last 5 years	2.0%
9	Stable inflation (last 5 years)	2.0%
10	Economically active population indicator (Incremental)	2.0%
11	Years of schooling of the market population (the higher the schooling percentage)	2.0%
12	Incremental GDP (last 5 years)	2.0%
13	Incremental per capita income (last 5 years)	1.5%
14	Incremental Human Development Index	2.0%
<b>Total</b>		<b>25%</b>

Source: Own (2019), taken of base the studies of the authors Aguilera & Virgen (2014), Morales (2006), Carretero(2012)and Ruiz (2011).

## 7. Application of the methodology developed as an input of a genetic algorithm to determine the probability of success in MSMEs

In order to integrate the factors and weightings that derived from the developed methodology, consultations and analysis of state of the art information were added, identifying similar investigations and techniques used, to be taken as a reference in the selection of the Genetic Algorithm technique and the discipline in question, as were the following two investigations, the first one related to the prediction of the probability of bankruptcy of companies in the manufacturing sector (Gordini, 2014)., and the second investigation of the author Arsovski et al. (2015) whose objective is to evaluate the organizational resilience oriented to MSMEs. From the above, it was decided to use the basic genetic algorithm(Russell & Norvig, 2002), applying the selection, crossing and mutation of individuals (MSMEs). Another element to consider was the effectiveness of the Genetic Algorithms for the optimization of functions, translated into the probability of success of newly created MSMEs, whose advantage places it in one of the most successful techniques for these types of problems. Derived from the above, the design of the genetic algorithm to suggest the creation of MSMEs of the transformation industry with economic development potential in the State of Sonora, Mexico is shown below. Integrating into the groups of indicators obtained from the methodology developed.

**Algorithm1.**General design of the Genetic Algorithm to suggest the creation of MSMEs of the transformation industry

1. Begin
2. Declaration of variables
3. The business plan, socioeconomic and success indicators of the companies are obtained
4. Calculating the fitness function
5. Cycle while some chromosome is greater than 1% and less than 96%
6. Begin cycle until reaching stop condition
7. Obtaining the genes of each generation, by the proportion method
8. Cycle for (up to the maximum number of companies)

9. Begin
10. Converting the Company Type to bits in octets
11. Generating the random decimal number between 0 and 1
12. End
13. Getting the best individuals and their conversion to bits
14. Cycle for N (maximum number of companies)
15. Begin
16. Finding and replacing the best individual
17. Converting to bits in bytes the best individual
18. End
19. Generating the crossing and mutation of genes
20. Cycle up to N (maximum number of companies)
21. Begin
22. Random crossover is generated by pairs of genes
23. Random mutation is generated for each gene
24. The resulting generation is stored and replaced
25. End
26. End
27. Converting the value in bits of the mutated gene to decimal numerical value
28. The number of crossings, mutation and iterations is counted and accumulated
29. The result is evaluated, which if it exceeds the fitness function the previous value is assigned
30. "Printing final results"
31. End

Source: Own (2019), taken as reference the similar researches of Arsovski et al. (2015), Gordini (2014), and the methodological contributions of Manrique (2009) and Arranz de la Peña & Parra (2007)

As can be seen in *Algorithm 1*, the fitness function is composed of success indicators, business plan and socioeconomic indicators. In this function the cycles of the genetic algorithm are determined, in addition to the selection, crossing and mutation of individuals until reaching the optimized.

### 7.1 General description of the operation of the Genetic Algorithm designed

A few steps to be able to design the Genetic Algorithm, was the task of obtaining and preparing the data that were used to generate the inputs that correspond to the methodology developed to suggest the probability of success of a MSME. The general description is presented below:

#### Step 1. Data preparation.

- Group the information Economic Profitability and Profits from 2004 to 2014 and 2017, grouped by country, state, and municipality. Until obtaining the average of these indicators of success.
- The average date of permanence of MSMEs per class will be taken (Last level of information provided by the (INEGI, 2018)).
- From the information obtained of the economic profitability, profits and seniority, the maximum value of 50% is obtained in the fitness function of the AG and the other 50% will be the weighting of the Business Plan items (25%) and Socioeconomic Indicators (25%).

#### Step 2. MSME to create

- The entrepreneur is requested to write or select the MSME to be created.
- The entrepreneur is requested to select the business plan items that she/he has researched, documented, and analyzed, in addition to selecting the corresponding socioeconomic indicators.

#### Step 3. Configuration

- It is recommended to the entrepreneur to configure the default parameters of the percentage of crossing and mutation as well as the number of iterations, however, if the entrepreneur requires them to modify it, she/he can do so, being limited by the computing capacity.

#### Step 4. Execution of the genetic algorithm

- The genetic algorithm recovers the weights of success, business plan and indicators, obtained in steps 1 and 2. To start its execution.
- The algorithm to be able to perform calculations of at least fourth companies (Micro, Small, Medium and Large Companies).

- The fitness function will be set between 96% and 100% so that from this, the genetic algorithm begins its execution to iterate the number of times that correspond until finding the best individual (s), for the purposes of the genetic algorithm, there will be a margin of uncertainty of 10%
- The random crossing and mutation method are applied, and the first generation is generated
- The same selection, crossing and mutation process is executed until a company reaches the threshold that is between 96% and 100%.

Step 5. Results

- Once one of the individuals reaches the established threshold, the genetic algorithm will stop
- The number of crosses, mutation and iterations made will be displayed
- Companies and the percentage of success achieved for each of them will be shown, observing the percentage of uncertainty, and remarking that this is a complementary tool to the information of the business plan and socioeconomic indicators.

8. Analysis of results

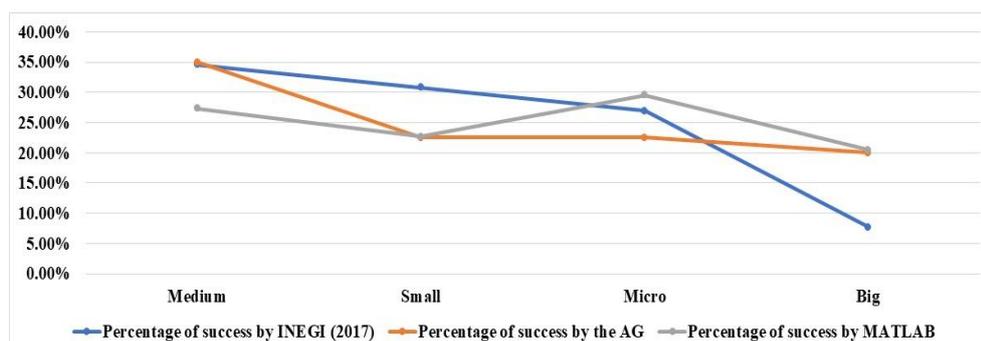
Comparing the same optimal mutation percentages between the TRANSACT SQL Server and MATLAB-GA, maximum differences of 7.7% and minimums of 0.2% were entered, this means that no company size exceeded more than 8% difference, which gave certainty to the values found, as well as the reliability of the results.

The micro and medium-sized enterprises had 7.0% and 7.7% respectively, while the small one a difference of 0.2% and the large company with 0.5%. It is important to note that by grouping MSMEs they obtained the same result as all experiments with a difference of 0.5% (see *Table 17*). Finally, a comparison was made including results generated with information from the corresponding INEGI (2018) with mining sector-related service companies. The results of the Genetic Algorithm developed with Transact SQL Server were similar to the MATLAB algorithm and close to the INEGI information, except for the large enterprise, which maintained the same difference in all experiments. It can be observed that there are similarities in the micro, small and medium which do not exceed more than 8%. When comparing large enterprises among Genetic Algorithms they have a difference of less than 0.05%, while with respect to the information obtained from INEGI they have an average variation of just over 12%. Looking at this difference, this is attributed to the INEGI that large companies generate greater economic profitability, so the weights are higher, and these increase the probability of success in the GA (see *Table 17* and *Illustration 10*).

**Table 17.** Comparison between source information, the algorithm developed in T-SQL Server and MATLAB

213119 (ranking 1) - Mining-related services						
Size	Percentage of success (INEGI, 2017)	Clustered MSME	Percentage of success (AG)	Clustered MSME	Percentage of success (MATLAB)	Clustered MSME
Medium	34.60%	92.30%	35.00%	80.00%	27.30%	79.50%
Small	30.80%		22.50%		22.70%	
Micro	26.90%		22.50%		29.50%	
Big	7.70%	7.70%	20.00%	20.00%	20.50%	20.50%
Total / Average	100%	100%	100%	100%	-----	100%

Source: Own (2019)



**Illustration 10.** Differences between success rates between algorithms and information taken of the INEGI  
Source: Own (2019) taken of *Table 17*

## 9. Conclusions and Future Work

It was possible to validate the suggested methodology to suggest the probability of success of recently created MSMEs, based on the integration of intelligent systems in particular of the genetic algorithms, which were subjected to experiments with information from INEGI and existing technology tools such as MATLAB for guarantee the results produced by the AG and the inputs from the methodology.

On the other hand, it was important that the methodology developed be validated with its application through technology tools to ensure as far as possible that the results are feasible and reliable.

The design of the methodology is not limiting, so it is expected that other indispensable factors will be integrated to enrich the groups of indicators, and this will result in improving the results and the probability of success of MSMEs.

These results can be complemented with existing information and methodologies, which will serve to collaborate with the decision-making of entrepreneurs who wish to create new MSMEs, know the implications, stimulate, propitiate, and channel the initiatives and talent of the entrepreneurs, and outline the implications in the creation of MSMEs as well as risk factors to reduce their failure.

Finally, and after the application of the inductive and deductive method, this methodology can be applied to any country and region, adapting it to the specific characteristics of each region.

## References

- Aguilera Castro, A., & Virgen Ortiz, V. (2014). Principales Indicadores De Crecimiento Empresarial En Las Pequeñas Y Medianas Empresas: Caso Santiago De Cali – Colombia. *REVISTA INTERNACIONAL ADMINISTRACION & FINANZAS*, 7(6), 27–44.
- Akenaton, D., Hernández, G., Del, M., Monserrat, P., & Hernández, P. (2017). *Propuesta de indicadores para la evaluación de desempeño en la formación de empresas de base tecnológica*.
- Arsovski, S., Putnik, G., Arsovski, Z., Tadic, D., Aleksic, A., Djordjevic, A., & Moljevic, S. (2015). Modelling and enhancement of organizational resilience potential in process industry smes. *Sustainability (Switzerland)*, 7(12), 16483–16497. <https://doi.org/10.3390/su71215828>
- Arthur Andersen (Firm). (1999). *Diccionario de economía y negocios*. Espasa Calpe.
- Bárdan Esquivel, L., Rivera Paz, C. P., & González, C. (2002). *Micro, Pequeñas y Medianas Empresas en México. Evolución, Funcionamiento y Problemática*. 444.
- Bergek, A., & Norrman, C. (2008). Incubator best practice: A framework. *Technovation*, 28(1–2), 20–28. <https://doi.org/10.1016/j.technovation.2007.07.008>
- Casais Padilla, E. (2009). *Políticas Económicas Y Pobreza: México 1982 – 2007*.
- Castillo Martín, P. (2011). POLÍTICA ECONÓMICA: CRECIMIENTO ECONÓMICO, DESARROLLO ECONÓMICO, DESARROLLO SOSTENIBLE. *Revista Internacional Del Mundo Económico y Del Derecho*, 3, 1–12.
- CEPAL & OCDE. (2012). Políticas de Pymes para el cambio estructural. *Perspectivas Económicas de América 2013*.
- Christensen, C. M., Raynor, M., & McDonald, R. (2016, December). What is disruptive innovation? *Harvard Business Review*, Vol. 2015.
- Commission European. (2016). Classification of the SMEs in European.
- Cornell, WIPO, INSEAD, & Organization, W. I. P. (2017). *The Global Innovation Index 2017*.
- de la Peña, A., & Truyol, P. (2007). *ALGORITMOS GENÉTICOS*.
- Domenge, R., & Belausteguigoitia, I. (2010). Nuevas PyMES: problemas y recomendaciones. Dirección Estratégica.
- Entrepreneur. (2016). tu plan de negocios paso a paso.
- Enterprise, S. G. (2018). *SWISS INNOVATION*.
- Esther Carretero. (2012). Porqué cerró Walmart en Alemania.
- Expansion. (2019). Mide el éxito real de la empresa.
- Fernández. (2008). Estrategias gerenciales en las PyMEs venezolanas en el escenario del desarrollo local. Una reflexión Teórica. *Multiciencias*, 8(2), 197–204.
- García Canseco, L. B. (2015). Causas del fracaso en las pyme. *Emprendedores*, (151), 22–25.
- Gilman, M. W., & Edwards, P. K. (2008). Testing a framework of the organization of small firms: Fast-growth, high-tech SMEs. *International Small Business Journal*, 26(5), 531–558. <https://doi.org/10.1177/0266242608094028>
- Gordini, N. (2014). A genetic algorithm approach for SMEs bankruptcy prediction: Empirical evidence from Italy. *Expert Systems with Applications*, Vol. 41, pp. 6433–6445. <https://doi.org/10.1016/j.eswa.2014.04.026>

- Hernández. (2007). Capítulo 3: La Situación de la PYME en México. In *Las MiPyME* (p. 30). Universidad de las Américas.
- Huerta, H. M., & Chávez, M. F. (2003). Tres modelos de política económica en México durante los últimos sesenta años. *Análisis Económico, XVIII*(37), 55–80.
- INADEM. (2018). Las MiPyME en México: retos y oportunidades.
- INEGI. (2013). Censos Económicos 2014. CE.
- INEGI. (2018). Economic censuses - years 2004 - 2018 partial and total.
- Manrique, D. (2009). Inteligencia Artificial - razonamiento aproximado. *Computación Evolutiva*, 5–10.
- Martínez Arellano, D. (2017). Evolución de la economía mexicana, 1960 - 2017. *Eumed.Net*, (Junio), 759–771.
- Morales, A. (2006). Indicadores socioeconómicos en la toma de decisiones. *Facultad de Ciencias y Administración, UNAM*.
- OECD/Eurostat. (2005). Oslo Manual. In *OECD and Eurostat Publication*.  
<https://doi.org/10.1787/9789264013100-en>
- Özdemir, Ö. Ç., & Şehitoğlu, Y. (2013). Assessing the Impacts of Technology Business Incubators: A framework for Technology Development Centers in Turkey. *Procedia - Social and Behavioral Sciences*, 75, 282–291.  
<https://doi.org/10.1016/j.sbspro.2013.04.032>
- Pieniazek, M. (2016). Design thinking for social innovation. In *Social Entrepreneurship: A Skills Approach: Second Edition* (pp. 65–70).
- Ries, E. (2011). *El método de Lean Startup*.
- Ruiz, H., & Del Rivero, G. (2017). *La Estratificación de la micro, pequeña y mediana empresa en México*. (Junio), 612–626.
- Ruiz, L. (2011). *Caso de fracaso de Walmart en Alemania*. Coahuila: Universidad Autónoma de Coahuila.
- Rural, D., Organismos, B. De, Valores, B. M. De, Bimbo, G., & Electricidad, F. De. (2016). *Declaración del Grupo de trabajo de Naciones Unidas sobre empresas y derechos humanos al final de su visita a México Ciudad de México , 7 de septiembre de 2016*.
- Russell, S., & Norvig, P. (2002). Artificial Intelligence: A Modern Approach (2nd Edition). In *Prentice Hall*.  
<https://doi.org/10.1017/S0269888900007724>
- Salas, J. (2013). Modelos económicos en México 1940-1990. *Modelos Económicos En México 1940-1990*.
- Sanchez, S. E., García, J. O., & Holguin, W. F. (2019). Industria ecuatoriana de elaboración de productos alimenticios: Análisis econométrico de indicadores de rentabilidad, período 2010-2017. *Revista ESPACIOS*, 40(01).
- Theodorakopoulos, N., Kakabadse, N. K., & McGowan, C. (2014). What matters in business incubation? A literature review and a suggestion for situated theorising. *Journal of Small Business and Enterprise Development*, 21(4), 602–622. <https://doi.org/10.1108/JSBED-09-2014-0152>
- Ueki, Y., Tsuji, M., & Cárcamo, R. (2005). Tecnología de la información y las comunicaciones ( TIC ) para el fomento de las pymes exportadoras en América Latina y Asia oriental. *Un, Cepal - Comisión Económica Para América Latina y El Caribe*, 10,11.