

RESEARCH AND DEVELOPMENT  
(R&D) AND ITS COLLABORATION  
TO THE GENERATION OF  
INNOVATIONS IN THE  
ORGANIZATIONAL CONTEXT OF  
THE MANUFACTURING INDUSTRY  
IN CIUDAD JUÁREZ

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— Abstract—

The purpose of this article is to analyze the relation between the Research and Development (R&D) variable and the generation of innovations within the organizational context, and which factors contribute to strengthening these constructs. This study was conducted through a methodology that uses factorial analysis and structural equations model. Findings are important for academic and practical goals due to the model's design that explains a significant relation between R&D and innovations development at the manufacturing industry. This will contribute to those enterprises that will be more effective in developing innovations in order to be competitive.

### Keywords

*Research and Development; Innovations; Organizations; Manufacturing Industry.*

Organizations today have an opportunity to be competitive by generating innovations. Innovation is decisive for companies to adapt to changes in the environment and thus survive; therefore, its generation must be promoted and it must be properly managed (Parga, Martín & Rios, 2013). Research and Development (R&D) is an activity that is considered to promote engineering advances, which significantly intensifies innovation generation within organizations, providing valuable capabilities for companies to achieve high production performance and be competitive (Zhang, Hoening, Di Benedetto, Lancioni & Phatak, 2009; Perez, 2008).

The business environment is increasingly competitive, making the generation of innovations a significant and preponderant factor, because with them they manage to face unexpected events and develop an adaptability to them (Drucker, 1985). Innovation generation should be a common practice in the industry, because companies that carry it out in an adequate way will be more competitive, generating greater productivity and better product quality. Therefore, it is important to analyze what factors provide significant robustness for the generation of successful innovations in organizations, such as companies in the manufacturing industry.

Therefore, it was decided to carry out a literature review to examine the relationship between Research and Development and the development of innovations in the industry, because R&D has taken off as a significant factor in high performance companies and is a source for achieving competitive advantages.

The next section reviews different theoretical approaches to try to answer the research question: How does R&D influence the generation of innovations in manufacturing companies in Ciudad Juárez? Subsequently, the aspect of the research methodology is detailed, to finally present results and findings between the relationship of R&D and the development of innovations; conclusions and limitations of this research and proposals for future research are detailed at the end.

## RESEARCH & DEVELOPMENT (R&D)

A significant factor for the generation of innovations within organizations is Research and Development (R&D), where the investment made by companies in this department boosts their capacity to innovate (Schmiedeberg, 2008; Shefer, 2005). To strengthen and increase the implementation of innovations, effective and efficient investment is necessary (Huanambal, 2014). On the contrary, there are companies that face difficulties and deficiencies for innovation development due to a deficient investment in R&D (Fernández & Montalvo, 2019). For Huergo (2006), in the United States high technology industry, investment in R&D is a significant factor for the

generation of innovations, unlike countries like France and Japan where R&D is not a preponderant factor for this task. The biotechnology industry generates a large number of innovations, due to the vast amount of resources allocated to R&D, so these resources invested provide companies with a great opportunity to develop new and better quality products for their clients (Song, Im & Song, 2011; Xu, 2009). Investment by companies in R&D is currently increasing year by year, in 2017, as an example, the investment was double than 2015, five times more than 2012 and ten times more than 2011, as mentioned by Tou (2019).

Within this approach, knowledge should be considered as an important driving force in the generation of innovations. R&D becomes an internal source of that knowledge for companies, involving discovery, learning and application of technologies and techniques (Roper, 2008; Tang, 2006; Padmore, 1998). For this reason, the activities of the R&D department, together with other company's departments cooperation, are essential for innovations' success (Simonen, 2008).

Wang (2009) maintains that the R&D department is a key piece in the generation of innovations because of its direct impact in companies' performance, due to the fact that an investment increase in this department provides increasing the innovations number that are generated, and, with it, an increasing in productivity level. This point is valid only in high technological level industries. The R&D can be considered then as a cornerstone in the generation of innovation projects in companies, and also being a form of acquiring an advantage over competitors (Dossi, 1997).

In addition to the above, investment in R&D also offers other benefits, such as the realization of an improvement in a product's manufacturing process, reducing costs and increasing production efficiency. In this way, products can be offered to customers at more competitive prices. This type of improvement is known as incremental innovation

## GENERATION OF INNOVATIONS

It is complicated for a company to remain competitive, due to the important globalization effects. Therefore, organizations are forced to develop strategies that allow them to improve their performance. These strategies must be based on organizations improvements, resulting in innovations that allow them to face economic crisis, providing different forms of production, product modification or some administrative modification to be more competitive (Eugenia, 2012; Mathison, 2007). There are several ways for a company to develop innovations, for example, a new product, process or product improvements and changes at organization's management (Cobo,

2018). This way, innovations allow production cost reduction, improve product functions and achieve a more competitive product (Hu *et al*, 2019).

In increasingly competitive market conditions within a globalized context, companies should not allow themselves to be indifferent, but rather, according to the COTEC Foundation for Innovation (2004, p. 11), they should:

(...) react by continuously improving and renewing its products, services and processes to fight in increasingly demanding and dynamic markets. In other words, innovation becomes a mandatory requirement not only for growth but also for business survival. It is therefore necessary for companies to accept the challenge of innovation, which implies that they must innovate frequently, efficiently and with confidence, and that innovation must be the rule rather than the exception.

For companies, the generation of innovations opens the way to new markets, in addition to expanding the existing ones, improving their competitiveness and taking their current businesses further; it also promotes the new markets development through innovation to prevent stagnation, regardless of whether these innovations end up being imitated, becoming industry standards, thus having the merit of creating value and pushing societies through the growth and welfare produced by this value (González, García, Lucero & Romero, 2014; Varela, Contesse & Silva, 2009)

Generation of innovations in companies greatly depend on the problem wished to face, being administrative or technological, where administrative innovations arise, related to organizational structure, control systems and company coordination and on the other hand, technological innovations centered in idea transformation into new and useful products and processes; being considered both as key factor for any company with the desire to be competitive, where productivity increasing and cost reduction will greatly depend on these innovations (Freeman, 2004; Damanpour, 1998; Daft, 1978).

The speed in which such innovations are generated is highly important because it allows them to remain competitive. The Research and Development department allows to fulfill this goal, due to internal collaboration with other departments, integration of work-teams and flow of knowledge, which facilitates the generation of innovations, allowing companies to specialize in tasks that require an intensive use of knowledge, increasing the innovation by means of the sequential model consideration where the generation of ideas goes through its construction in engineering, then by its implementation and ending at the market diffusion or introduction (Zhang, 2017; Hobday, 2005).

## R&D AND GENERATION OF INNOVATIONS WITH A COMPETITIVE APPROACH

Competitiveness can be understood as the result of all those innovations and technological processes generated by various stakeholders, which are developed within a given context, such as companies, institutions or organizations, which through technical and/or organizational transformation activities meet their needs in increasingly competitive markets with more consumers demanding quality products and services (Bianco, 2007; Millán & Marín, 2014:).

Therefore, organizations must be always in search for information and procedures to achieve excellence facing market competition. According to Manucci (2010, p. 95):

[...] Competitiveness is the result of a game of necessary positions and movements to maintain the leading role (personal, group or corporate) in the current environment dynamics. It does not have to do with strength, size or material power, but with the interaction capability to be perceived and valued at volatile actors and variable game rules context.

Factors that make up the generation of innovations in organizations reveal their important role within the new techno-economic paradigm in current contexts, since factors such as adaptability and innovative capability are seen as priorities and essential for competitiveness in markets, from local to global (La Rovere & Hanseclever, 2001).

Within this conceptualization, Porter's contributions (1990; 2004) are relevant and pertinent, since they define competitiveness as a generating axis for competitive advantages defined by different factors (supply, demand, company structure, their environment, relations with suppliers and customers, among others). Porter (1985) explains how a company can be competitive, that is, how it can implement competitive strategies that differentiate its products and/or services, so they are perceived as "unique" in different dimensions valued by customers. These differentiation strategies, coming from a creative and innovative instinct, become necessary capabilities through the ability to market and engineer the product.

As previously mentioned, divergences in organizations innovative capability arise from the fact they are different in their ability to innovate, since is not easily generated due to the tacit, cumulative and localized nature of their technical and scientific knowledge, making organizational learning difficult for the design of the fundamental strategy of knowledge acquisition and the construction of advantages that help the company to be competitive in medium and long term (La Rovere & Hanseclever, 2010; Perez & Cortes, 2007).

According to Saldívar, García, Valenciana and Roa (2012), competitiveness in companies has been addressed from two approaches. First, from an external (macro-economic) approach where companies have little influence to solve problems they face, due to a low react capability to competition. La Rovere and Hanseclever (2010) argue that large companies have necessary resources to generate innovation and competitiveness, unlike small companies that depend more on external groups. Second, from an internal approach (business management and the economic sector to which they belong), where there is a close relationship, according to Millán and Marín (2014), between competitiveness and the performed business management, which indicates the importance that this management has over the impact on its employees and on the company's priority issues. This ill set course for a innovation generation in pursuit of competitiveness. Then, is identified the need to develop a knowledge management (R&D) that acquires relevant information to design competitive strategies.

It is relevant for companies to review and analyze these approaches, to understand and assimilate them with the firm purpose of obtaining a response, which will be only discovered as a result of R&D that must be performed to generate innovations that provide competitiveness (Cardona & Gutiérrez, 2010). Therefore, the capability to generate these innovations to face these changing scenarios must be an essential part of companies in order to be competitive.

Associating R&D to that competitiveness described by Porter (1990), it can be observed that the theory referring to these variables conceives the generation of innovation as a valuable company asset, but protecting this asset is complicated if an adequate knowledge management is not implemented. However, it is understood that all these factors that conform the generation of innovation based in knowledge are uncertain, within the business context, whether internal or external,. They must be specifically addressed as an organizational asset that provides certainty, risk adaption with less uncertainty, in order to focus on its ability to innovate and remain competitive. R&D is a strategic capability and ability when developing innovations, as well as a strength for company competitiveness (Tumelero *et al*, 2019).

R&D must therefore occupy a central and decisive role in achieving business competitiveness, so the proper systematic and organized management of the generation of innovation factors becomes obligatory. In this way, these factors turn into intangible assets and must be valued as well with company's tangible assets, since they provide significant competitive advantages.

In this sense, it is pertinent to affirm that competitiveness is related directly to the generation of innovation, for an adequate strategic design as a response to changing environmental scenarios. A company is competitive when it has the capability to recognize and account its environmental, economic

and social realities, incorporating them into its R&D, as part of its innovation generation (Aras & Crowther, 2009).

### PROBLEM STATEMENT

Currently, organizations have seen diminished their capability to successfully face their competitors, so they are looking for solutions to generate greater capability to react to existing competition and rivalry. The generation of innovations then become a key aspect for organizations, as well as for companies, since they increase the possibility of remaining competitive with it, along with adaptability generation to face constant changes appearing in their context. The generation of innovations is important for any type of industry, because with them it can be achieve productivity increase, better quality new products development, as well as production processes improvements.

In Ciudad Juarez' manufacturing industry there are several (positive and negative) intervening factors that generate successful innovations. That makes this activity complex, and many of these companies fail when trying to generate them, triggering bad implementation. This causes a lack of expected results, such as production increasing, product and process quality, competitiveness and profitability.

### RESEARCH QUESTION

How does R&D influence the generation of innovations in manufacturing companies in Ciudad Juarez?

### OBJECTIVE

To determine the influence degree of R&D on the generation of innovations in manufacturing companies in Ciudad Juarez.

### METHODOLOGY

This research is correlational, due to a seek of the relationship between two variables. The information was collected in a single period of time, therefore is cross-sectional, and ex post facto due to the analyzed events that have already occurred.

The manufacturing industry at Ciudad Juarez, Chihuahua, Mexico is this article's research object. The association of Maquiladoras Juarez Index A.C. was consulted to acknowledge the number of existing companies, which are approximately 326, in different industrial sectors.

## HYPOTHESIS AND STRUCTURAL MODEL

To clear the research hypothesis, where R&D significantly affects the generation of innovations in manufacturing companies in Ciudad Juárez, a structural model was designed, graphically described in Image 1.

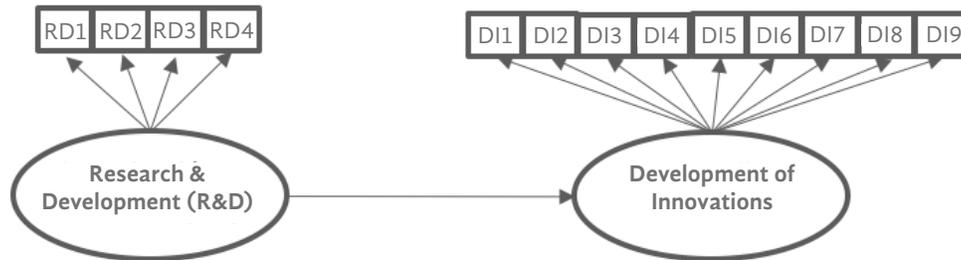


Image 1. Structural model. Source: Own elaboration

### Survey design

The measuring instrument is composed by two sections, each having its own construct and observable variables. These variables are measured through a 5-point Likert scale. The R&D construct was evaluated using the criteria of Molina and Manuera (2009) and Song *et al.* (2011), based on investment level, collaboration of ideas, employees and other R&D departments. In respect to the generation of innovation construct, is based on Pla-Barber & Alegre (2007); Chen, Huang, Cheng & Chen (2009), Jimenez & Sanz (2011) and Laforet (2008), which focused on the amount of innovative activities that were successfully implemented, such as product changes and process improvements. Finally, questions are included to collect data regarding company size, business sector the surveyed person's position.

To determine the questionnaire's validation, according to Levy & Varela (2003), a 40 application pilot of the questionnaire was conducted. The Cronbach's Alpha index obtained from this sample was 0.96, which is higher than 0.70, per suggested by Hair, Black, Babin & Rolph (2010) as the minimum validity index.

### Application of the questionnaire

The questionnaire was applied in several companies from the manufacturing industry in Ciudad Juárez. The sample surveyed is composed by managers, engineers, supervisors and technicians involved in the processes related to the generation and implementation of innovations. To determine the necessary sample, Hair *et al.* (2010) criteria was used, which suggest a number of 4

surveys applied for each item of the questionnaire. In accordance with the above, 250 surveys were collected.

### *Data analysis*

Collected data was analyzed with the Statistical Program for the Social Sciences, SPSS quantitative analysis software. At first instance, those surveys with missing data were eliminated, resulting in a total of 236 valid surveys. Then, to corroborate whether the sample was adequate to perform an Exploratory Factor Analysis (EFA), the Kaiser-Meyer-Olkin test and the Bartlett's Test of Sphericity were performed, as well as the Varimax Rotation method to improve the correlation matrix understanding (Levy & Varela, 2003).

### *Results*

The results are shown below, in the following order: first, a description of the sample, then the questionnaire validation and finally the structural model.

### *Sample description*

250 surveys were applied in different companies in Ciudad Juárez. Of the total of questionnaires applied, not all participants answered completely. Due to this, 14 questionnaires had to be discarded, leaving 236 as valid. Of the people surveyed, 66% hold a position of manager and engineer, the other 34% were operational personnel related to manufacturing processes related to innovation.

On the other hand, information regarding the type of manufacturing industry where each of the respondents works is described, as shown in Table 1.

**Table 1**  
*Type of manufacturing business of respondents*

Industry Sector	Respondents	Percentage (%)
Automotive	103	43.64%
Electricity	25	10.59%
Electronics	32	13.55%
Packaging	7	2.96%
Health care	30	12.71%
Plastics	8	3.38%
Other	31	13.13%

Source: Own elaboration

### *Instrument reliability and validation*

Cronbach's Alpha index was obtained for each of the constructs in the questionnaire (See Table 2).

**Table 2**  
*Different constructs validation*

Constructs	Cronbach's Alpha index
Research and Development	0.907
Development of Innovations	0.905

Source: Own elaboration

As shown in the table above, all constructs have high reliability, since they exceed the 0.70 minimum value recommended by Lévy & Varela (2003) and Hair *et al* (2010).

### *Checking the sample's adequacy*

Kaiser-Meyer-Olkin sample adequacy tests and Bartlett's Test of Sphericity are used to corroborate the adequacy of the data obtained. Table 3 shows the index of Kaiser-Meyer-Olkin sample adequacy tests is 0.926. This indicates that partial correlations are small and therefore they are measuring the same factor. In Bartlett's Test of Sphericity, the significance of the test tends to 0, which indicates that data come from a multivariate normal distribution and lacks of collinearity between variables. This indicates that there are variables that explain the same thing and therefore they can be grouped together.

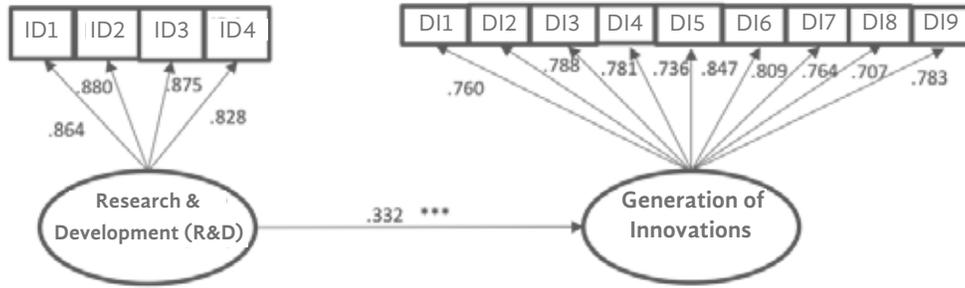
**Table 3**  
*Prueba de KMO y de esfericidad de Barlett*

Kaiser-Meyer-Olkin's measurement of sample adequacy	<b>0.926</b>	
Rough Chi-squared	4171.1	
Bartlett's Test of Sphericity	Degrees of freedom	666
	Significance	0

Source: Own elaboration based on fieldwork

### *Structural model*

Image 2 shows the survey's obtained results within the structural model of R&D and innovation development. The innovation development construct is affected in a positive and significant way by research and development.



\* Significat al 0.05%  
 \*\* Significat al 0.01%  
 \*\*\* Significat al 0.001%

Source: Own elaboration

Table 4 shows convergent validity of this structural model.

**Table 4**  
 Convergent validity

Construct	Item	AVE	$\lambda$	$\lambda$ (Average)
Process Innovation	ID1	0.743	0.864	0.861
	ID2		0.880	
	ID3		0.875	
	ID4		0.828	
Production Performance	DI1	0.606	0.760	0.775
	DI2		0.788	
	DI3		0.781	
	DI4		0.736	
	DI5		0.847	
	DI6		0.809	
	DI7		0.764	
	DI8		0.707	
	DI9		0.783	

Source: Own elaboration

In Table 5, the structural model's goodness of fit is shown. In this table, the CMIN is reported for pure formalism, due to its sensitivity to reject any model when the sample size increases. Therefore Hair *et al.* (2010) recommend reporting the CMIN/DF statistic, whose value should be less than 4 to indicate an adequate fit.

**Table 5**  
*Goodness of fit*

CMIN	DF	CMIN/DF	NFI	RFI	IFI	TLI	CFI	RMSEA
<b>836.34</b>	<b>423</b>	<b>1.977</b>	<b>0.853</b>	<b>0.839</b>	<b>0.922</b>	<b>0.913</b>	<b>0.921</b>	<b>0.065</b>
<b>p=.000</b>								<b>(0.058 - 0.071)</b>
<b>Recommended Values</b>		<b>4</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	

Source: Own elaboration

### *Discussion*

This study shows that activities carried out in the Research and Development department positively and significantly affect the generation of innovations in manufacturing companies. Organizations have undertaken appropriate R&D activities to convert them into key drivers for development of innovations. Reliability tests of the instrument used to measure activities carried out by the R&D department indicated adequate obtained data. The model fit test shows that the model in deed fits. In respect to the variables of each construct's variables, they were grouped where they loaded best, according to the factorial analysis, having high collinearity. That is, the Research and Development construct variables have high relationship and significance. In addition, the Research and Development construct has high relationship with the development of innovations, significantly affecting them. Therefore, results show that R&D has a positive influence on the development of innovations. Furthermore, results show that strategies focused on Research and Development will have satisfactory results in the development of innovations and, with it, companies will achieve high competitive performance.

### CONCLUSIONS

Worrying about survival against their rivals is not the main objective for companies, their goal is to achieve high competitive performance. High performance of organizations depends on the ability to use available resources, such as knowledge, skills and their ability to develop innovations. Several factors intervene in the generation of innovations, which make investment in R&D difficult. In companies, innovations are developed with the purpose of remaining competitive, because they allow to obtain com-

petitive advantages, increase productivity and improve financial performance (Freeman, 2004).

The objective of this study was to analyze the relationship between R&D and the development of innovations. Findings show that research and development (R&D) is a significant factor for companies to develop successful innovations. As shown in the used structural model, it demonstrated the high level of positive significance the construct has for the development of innovations. Per the above mentioned, the structural model helps explain to the industry in a better way the high positive impact that research and development has for the implementation of successful innovations.

Due to the above, companies must use their resources better to generate learning and knowledge that will reflect in the development of innovations, both process and product, that help them to remain competitive. Investment in R&D is a preponderant factor in the development of innovations. This department generates distinctive knowledge and skills that will help generate innovations.

Finally, Research and Development is a fundamental factor in the generation of innovations. This implies high investment, which will return with a high productive level in the company. Therefore, organizations should try to implement a virtuous circle of research and development for the generation of innovations and obtain high performance.

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