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The Effect of the Adoption of Green Information Technologies on Manufacturing SMEs' Performance in Aguascalientes, Mexico

José Antonio Nieves Alvarez[1], Sandra Yesenia Pinzón Castro[2] and Gonzalo Maldonado Guzmán[3]

Abstract

Green Information Technologies (GITs) are getting focus worldwide, particularly with the current need to make production processes sustainable. At the beginning, GITs were considered mostly a tool and all research on them were aimed at creating either a framework or guidelines for its application. Recently, ITs have gained importance in every company as their role is now present in every aspect of business. That is why the proper use of GITs within companies provide the opportunity to improve sustainability and performance. Therefore, the objective of this research is to analyze and discuss the effect of the adoption of GITs on manufacturing SMEs performance in the state of Aguascalientes, Mexico. A sample of 244 companies was used and the data was analyzed through the use of the structural equations model, applying the partial least squares technique (PLS-SEM). The results obtained suggest that there is a positive and significant relationship between the adoption of GITs and the performance of manufacturing SMEs. These results show that when the adoption of GITs is implemented in manufacturing SMEs, performance increases as well, while promoting a more sustainable production way.

JEL classification numbers: M21.
Keywords: Performance, Green Information Technologies, SMEs.

[1] Universidad Autónoma de Aguascalientes, Centro de Ciencias Económicas y Administrativas, Estudiante del Doctorado en Ciencias Administrativas.
[2] Universidad Autónoma de Aguascalientes, Centro de Ciencias Económicas y Administrativas, Departamento de Mercadotécnica.
[3] Universidad Autónoma de Aguascalientes, Centro de Ciencias Económicas y Administrativas, Departamento de Mercadotécnica.

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1. Introduction

In general, any company needs to have an appropriate level of performance, since it is an essential element for its sustainability (Beer and Micheli, 2018). Likewise, performance can also be considered as the operational capacity that is available and that entails a continuous evaluation of the organizational objectives (Zulkiffli and Perera, 2011). Thus, in the current globalized environment of production, having competitive advantages that allow better performance is essential to remain in the market (Raymond and St Pierre, 2009). However, in the last decade, at a global level, efforts have been made for production processes to adapt to new ways of working with less impact on the environment. Therefore, finding points of organizational improvement that provide the means to increase performance and to improve processes at the same time, all in adherence to sustainability, is the goal of most companies mainly in developed countries, since regulations in them are increasingly rigid (Dezdar, 2016).

As a result of this, Information Technologies (ITs) represent an area of opportunity to achieve these objectives through the adoption of improved practices in their use, since they form the technological infrastructure of businesses and serve as support for Information Systems (ISs) (Molla et al., 2011). Until a few years ago, SMEs considered the acquisition of ITs to be too high of an expense, since new technologies were generally expensive (Chapman, 2000). Nowadays, however, the cost of ITs has decreased considerably, and new technologies are increasingly available to everyone (Sandberg et al., 2014). In addition, technology ceased to mainly play a supporting role and now takes on a strategic role as well, which is why investment in ITs has increased notably.

In 1992, ITs went through a series of changes to turn them into a sustainable technology, brought on through the creation of the Energy Star program by the United States Environmental Protection Agency (EPA), which introduced a voluntary labeling program for equipment that promoted the use of energy in a more efficient way (EPA, 2019). In 2007, these types of technologies and their study was branded as Green Information Technologies (GITs), and from this point on they have been conceptualized with different scopes and approaches. Consequently, various terminology and concepts emerged to refer to them, but in the end, everyone agrees that the purpose of GITs is to reduce the negative impact on the environment caused by the production and use of ITs (Deng et al., 2017). Research on GITs is considered to be in its early stages, thus no consensus in a founding theory to support their study exists (Deng et al., 2017). However, some authors who have carried out research on them, and their relationship to other variables, have used the theory of the technological perspective, the theory of the diffusion of innovation, and the Resource Based Theory (RBT), to name a few. For the purposes of this research, RBT will be considered as the founding theory in this study, which is discussed below.

2. Preliminary Notes

Investment in ITs worldwide has increased considerably, and by the year 2018 an approximate amount of 3.7 billion dollars was invested, which represents a growth of 4.5% compared to the previous year (Gartner, 2018). It is due to this growth in production and usage that it becomes more relevant to find a sustainable solution to offset the negative impact it has on the environment. In their journey to achieve this objective, different authors have defined GITs befitting their own intents and purposes towards a common goal. For instance, Calero and Piattini (2015) define it as the study and design of both software and hardware components and communication networks, whose purpose is to generate a positive impact on the environment. However, there are various other definitions that have been used by researchers to try to clearly specify the scope or application of GITs in each case. Nonetheless, all these definitions concur in their basic principles in that the purpose of GITs should be to reduce the negative impact on the environment caused by the production and use of ITs (Deng et al., 2017).

The Organization for Economic Co-operation and Development (OECD) suggests that ITs can be classified into two types. The first one (direct impact) is that in which ITs have an impact on the environment due to their physical existence, as well as their production and use. The second one (enabling impact) is that in which ITs is have an impact on the environment in an indirect way and can be used to mitigate the impact that other productive activities have on the environment (OECD, 2010).

One of the problems of introducing GITs to an organizational environment, as suggested by Patón-Romero, Baldasarre, Rodríguez and Piattini (2017), is that there are still no standards for their application; something that does not happen in traditional ITs where there are accepted reference frameworks for it, such as COBIT5. Thus, as is the case with SMEs in Mexico, in addition to considering the lack of the standards, the limited investment capacity and the cultural resistance to change must also be considered (Dressel, 2003). Even with these limitations, authors such as Hanne (2011) have pointed out the importance of carrying out analyzes in relation to the adoption of GITs in emerging countries, given that to date most of the research has been carried out in developed countries and in large companies.

Although research of GITs in relation to other variables is still in its early stages, there are studies (Lunardi, Ferreira and Salles, 2014; Ainin, Naqshbandi and Dezdar, 2016; Chuang and Huang, 2016; Hottenrott, Rexhäuser and Veugelers, 2016; Hosseini et al., 2017; Loeser et al., 2017) in which empirical approaches have been performed to analyze the possible environmental and economic benefits of their application.

This research uses RBT for theoretical support as it states that companies can generate a competitive advantage from the resources and capabilities they possess, which provides them with an element of diversification over their competitors and the perception of the market (Barney et al., 2011). RBT considers ITs as part of the resources that a company owns, which allows it to develop different capabilities as

opposed to competitors (Sandberg et al., 2014). Likewise, the fact that technology is currently available to most companies in general (Breznik, 2012) allows Mexican SMEs, which have limited resources, to have access to them. It also provides an opportunity for the internal practices of the company to grant better use of ITs to achieve a green effect in the production process. This is accomplished by making changes in the hardware or software that are physically used in the workplace, or by the way in which these are used by the staff in charge of the equipment, in order to obtain the best performance feasible with the maximum possible efficiency in its use and in the energy consumption associated with it.

2.1 Performance and GIT

Performance is considered a multidimensional concept that can be measured objectively and subjectively from different perspectives (Leal-Rodríguez et al., 2018). Alonso et al. (2016) suggest that non-financial information has become more relevant, since it shows the generation of financial resources and indicates how those resources were generated, if there are input needs, and what impact they have for society and the environment directly and indirectly. In addition, the performance can be explained by the increase in the efficiency and quality of production processes, the price of shares, positioning and suppliers (Lopes de Oliveira and Moneva, 2013). Ferrero (2013) indicates that a strategy that applies sustainability favors the reputation and creation of the company's image in the eyes of investors, customers, and the market in general, which can lead to better levels of performance. In their study Leal-Rodriguez et al. (2018) show the relationship between eco-innovation and the performance of organizations, and state that the application of GITs to obtain improvement focused on reducing the environmental impact of the production process is not only necessary, but also has a positive impact on the performance of companies.

Thus, considering the information presented, it is possible to propose the following research hypothesis:

H1. The adoption of GITs has a positive and significant impact on the performance of manufacturing SMEs in the State of Aguascalientes, Mexico.

To confirm the research hypothesis, an empirical study was carried out by applying a structured survey instrument to a sample of 244 SMEs from the manufacturing branch in the state of Aguascalientes, Mexico. According to the National Institute of Statistics and Geography (INEGI for its acronym in Spanish), companies in the manufacturing sector within the country with at least 11 employees and up to 250 are classified as SMEs. These were chosen to be analyzed for the research due to the importance of their economic contribution since the INEGI data, as of 2019, shows that manufacturing companies have a 27.7% share and a contribution of $62,165 million pesos in Aguascalientes, in the Gross Domestic Product (GDP) category (INEGI, 2019). The sample was obtained by applying the statistical formula for finite populations on the total number of manufacturing companies in the state, which was 668 economic establishments belonging to various activities of

the manufacturing branch, found by consulting the National Statistical Directory of Economic Units (DENUE for its acronym in Spanish) published by the INEGI on April 15, 2021. The instrument used was a survey based on measurement scales previously validated and employed by other researchers. The GITs scale that was used in it was designed by Lunardi et al. (2014), as it proposed a way of measuring GITs adoption in a way similar to that of the productive context of Latin America. It was divided into 5 dimensions and 28 items measured with a 5-point Likert scale. Similarly, the scale designed by Leonidou et al. (2013) for performance was included, as it is based on RBT. This scale was divided into 3 dimensions and 21 items measured with a 5-point Likert scale.

The data obtained in the instrument was first analyzed to check its reliability and validity through Cronbach's alpha and the Composite Reliability Index (CRI). Furthermore, since this analysis focuses on the relationship between the variables studied, the statistical model of structural equations through PLS was used. The values found for the Cronbach's alpha test and the CRI showed satisfactory coefficients for all the factors analyzed, resulting in values greater than 0.7 (Hair et al., 2014). For the Average Extracted Variance Index (AVE), no values were found below the minimum expected of 0.5, in accordance with what is suggested by Fornell and Larcker (1981). Likewise, the factor loads for each dimension comply with values greater than 0.707, which indicates that there is convergent validity. Table 1 shows the result in greater detail.

Table 1: Reliability and validity tests

	Cronbach's Alpha	**CRI**	**AVE**
Sustainable Actions	0.838	0.886	0.609
Social Environmental Awareness	0.785	0.852	0.535
Financial Performance	0.907	0.926	0.641
Organizational Performance	0.862	0.895	0.548
Social Environmental Expertise	0.870	0.900	0.564
Green Marketing Impact on Competitive Advantage	0.904	0.924	0.635
Environmental Orientation	0.833	0.889	0.668
Monitoring of IT Activities	0.870	0.911	0.720

In addition, the evaluation of the discriminant validity of the model considers three elements: the Fornell - Larcker criterion (Table 2), which considers the amount of variance that a construct obtains from its indicators, and which must be greater than the one shared with other constructs; and the Heterotrait-monotrait matrix (HTMT), which is formed by the correlations between the indicators that measure the same construct, which must be lower than 1 (Table 3) (Ringle, Wende and Becker, 2015).

Table 2: Fornell – Larcker Criterion

	SA	SEA	FP	OP	SEE	GMICA	EO	MITA
SA	0.780							
SEA	0.515	0.732						
FP	0.180	0.259	0.801					
OP	0.160	0.203	0.509	0.741				
SEE	0.476	0.518	0.315	0.331	0.751			
GMICA	0.150	0.389	0.427	0.410	0.258	0.797		
EO	0.670	0.448	0.167	0.239	0.652	0.186	0.817	
MITA	0.282	0.468	0.309	0.288	0.616	0.399	0.365	0.849

SA: Sustainable Actions; SEA: Social Environmental Awareness; FP: Financial Performance; OP: Organizational performance; SEE: Social Environmental Expertise; GMICA: Green Market Impact on Competitive Advantage; EO: Environmental Orientation; MITA: Monitoring IT Activities.

Table 3: Heterotrait - Monotrait Ratio (HTMT)

	SA	SEA	FP	OP	SEE	GMICA	EO
SEA	0.602						
FP	0.212	0.305					
OP	0.190	0.246	0.571				
SEE	0.529	0.635	0.370	0.388			
GMICA	0.180	0.467	0.466	0.458	0.305		
EO	0.810	0.526	0.192	0.277	0.726	0.211	
MITA	0.328	0.564	0.349	0.330	0.722	0.444	0.416

SA: Sustainable Actions; SEA: Social Environmental Awareness; FP: Financial Performance; OP: Organizational performance; SEE: Social Environmental Expertise; GMICA: Green Market Impact on Competitive Advantage; EO: Environmental Orientation; MITA: Monitoring IT Activities.

3. Main Results

The descriptive analysis of the most relevant information for each construct is presented in this section. It begins with the values found in the dimensions that make up the GITs, which are analyzed one by one below.

- Companies use equipment with low energy consumption.
- There are strategies and policies for the use of natural resources such as water, electricity, paper, etc.
- Companies seek information from other companies in the industry about the benefits of using GITs in their processes.
- The use of equipment, such as printers and copiers, is controlled.
- There is a strict control in the expenses for ITs equipment.

However, negative elements were also found in the practices that allow opportunities for improvement, such as:

- A decrease in the maximum possible life cycle of the equipment leading to

immediate replacement.

- Insufficient awareness of the rational use of the company's computing resources.
- Communication about the actions of companies in recycling aspects is limited.

On the other hand, in the performance dimensions analyzed, the following elements stand out:

- The discharge of waste has been significantly reduced.
- The company actively participates in protecting the human rights of its employees.
- The return on investment has increased.
- Customer retention has increased significantly.
- The market share has increased.

However, negative elements were also found in the practices that allow opportunities for improvement, such as:

- In some instances of the sample, the waste treatment performed by the company has not decreased significantly.
- In some instances of the sample, economic benefits, return on assets and cash flow have not increased significantly.
- Customer loyalty has not increased significantly.

To confirm the hypothesis, techniques such as bootstrapping are highly recommended (Jackson, Gillaspy and Purc-Stephenson, 2009). To determine the nature of the relationship of the variables and obtain the level of significance and the contribution of the relationships, the values of the standardized coefficients, t value and p value are used. The Bootstrap analysis process was performed with a two-tailed Student's t-distribution for 10,000 subsamples. The result is shown in Table 4.

Table 4: Structural Relationship of the Variables

Hypothesis	Structural Relationship	Path Coefficient	Standard Deviation	t value	p value
H_1. The adoption of GITs has a positive and significant impact on the performance of manufacturing SMEs in the State of Aguascalientes, Mexico.	GITs->Performance	0.416	0.060	6.892	0.000

With the information shown, the proposed hypothesis is accepted by demonstrating that in the structural relationship GITs explain 41.6% of the performance for a t value of 6.892 and significance of p of 0.000. Figure 1 shows the values of the standardize factor loadings of GITs and performance, and they are mostly higher than 0.70, which indicates internal reliability (Hair et al., 2014).

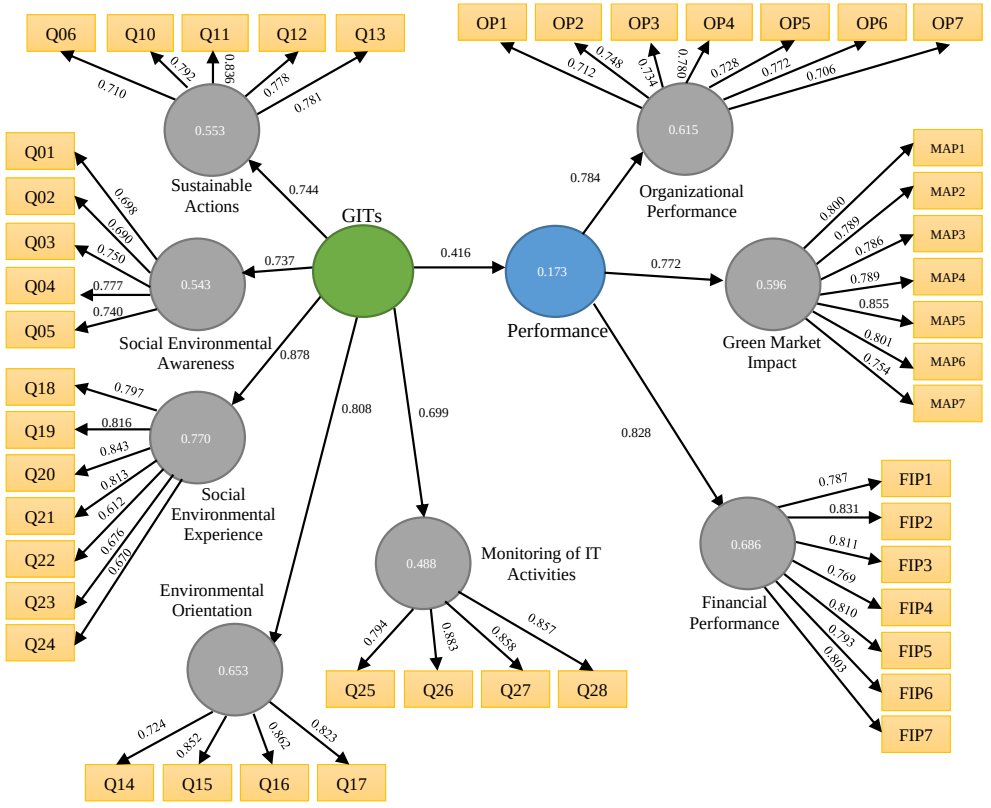

Figure 1: Nomogram of the PLS-SEM application

4. Conclusion

The objective of this analysis was to determine the effect of the adoption of GITs on the performance of the manufacturing SMEs in Aguascalientes. Through empirical evidence, it was possible to determine that there is a positive and significant effect in the adoption of GITs on the performance of SMEs. Although the research provides a precedent, since the analysis is delimited only to this particular geographical space and economic environment, its scope to generalize the result is limited.

The result obtained suggest different conclusions. The first one is that the theoretical model has high internal consistency. The second one is that studies in the field of GITs are starting to analyze them in relation to other variables, and not just to create frameworks. The third one is that GITs related to performance in companies is a relatively recent topic. However, it is attracting the attention of researchers and the business community, albeit mostly in developed countries, and this makes it possible to conclude, in general terms, that this topic is still unfinished and open to discussion (Teixeira et al., 2017). A fourth conclusion is that SMEs have begun to use GITs practices and equipment in the ways in which they produce and work in moderate amounts and their interest in the ability to obtain more benefits associated

with GIT is growing. This, in turn, has a positive direct impact on performance with the reduction of costs, and an indirect impact in the perception of customers regarding the company. However, the adoption process is still in early stages and only a few of the companies in the sample (21.5%) have environmental certifications, so there is a very broad opportunity for study in this area to promote its use and create standards of environmental protection application. Finally, GITs and performance in emerging economies, such as Mexico, have not been explored widely in the current scientific literature. Therefore, this analysis serves to provide empirical evidence of the relationship between these constructs in this country's context.

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