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Information and Communication Technology as a Key Strategy for Efficient Supply Chain Management in Manufacturing SMEs

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Abstract

Proper Supply Chain Management (SCM) has proven essential for the competitiveness of organizations, since it ensures the effectiveness of supplies, and the proper coordination with suppliers, intermediaries and market needs. The use of Information and Communication Technology (ICT) in the SCM has proven to have a positive impact in companies that have implemented it, particularly in relation to procurement, since this enhances collaboration, improving the quality of information shared between suppliers and buyers [1]. This paper aims to analyze the relationship between ICT, strategies and SCM. In order to do this, a survey was conducted among managers in 288 manufacturing SMEs in Aguascalientes. Data was analyzed using structural equation, EQ software support, as well as through linear regression models with SPSS software support. The importance of this work is that in the analyzed region (Aguascalientes) there have been few studies about the manufacturing industry, especially in aspects related to factors that influence productivity and hence competitiveness. The study of the SCM and the strategies followed by this industry explains the economic growth of the region in recent years, its improvement in infrastructure, and a substantial increase in jobs; and, above all, it accounts for almost all exports. This study is therefore essential, particularly for SMEs which, in spite of being the most dynamic subsector in the industry, are still having the most challenging problems in terms of how they are organized, how they link with other sectors and in terms of general efficiency. The results show that, indeed, the strategies and ICT have an impact on the performance of the SCM. The use of ICT facilitates the handling of information resources (materials) and the avoidance of delays, which results not only in cost reductions but also in an increase in client compliance [2-3]; and thus it fosters the overall competitiveness of the organization.

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1. Introduction

Small and medium enterprises (SMEs) in the manufacturing industry require the implementation of strategies that allow them to make decisions that influence the process of obtaining results that are consistent with the objectives designed by managers [4-5]. Porter [6] has argued that an appropriate strategy is important for the development of SMEs, which makes it necessary for the businessmen to focus on assessing the specific needs of manufacturing SMEs and thus align their strategies [7- 9].

The increasing integration of information and communication technology (ICT) has led to favorable results in terms of goal accomplishment either generally or specifically in the functional areas of organizations [10-11]. The implementation of ICT in businesses such as manufacturing SMEs should be integrated in dynamic areas, such as the management of the supply chain [12], as this allows for better controls in the management of material resources, avoiding delays in production and thus enhancing compliance with customers [10 y 13]. This raises several research questions: Does the integration of strategies allow for a better usage in the adoption of information and communication technology? Does a greater integration of information and communication technology improve the supply chain management in manufacturing SMEs?

2. Literature Review

2.1 *Strategies and Supply Chain*

Regarding the analysis of strategies, Ansoff [14] considers that the operational expressions within the administrative system define the operational criteria on which specific programs could be implemented in companies; and, once implemented, to introduce the idea that every company has a common thread between performed actions and achieving the objectives for which it was created. Likewise, Mintzberg [15] states that the strategy is not only a notion of how to deal with competitors in a specific market, but also a way to reconcile the principles of the organization with the desired purposes within a uniform collective perception that may seek the development of competitive advantage or the organization's survival.

According to Bantekt and Osborn [16], although there is plenty of literature that discusses the typology of strategies, few studies relate strategy to the performance of operational activities in companies. In this regard, it is important that the integrated strategies in the operational activities of the company are appropriate for the natural activity of organizations [14, 17], and thus it is important to identify the organization's natural operational characteristics. [6 and 9].

The identification of strategy types leads to understanding the answer given by companies often faced with administrative problems [33-35] and therefore it also allows us to distinguish companies by the type of strategy used [9]. Some researchers such as Snow and Hrebiniak [36] pointed out that organizations classified as explorers, analyzers or defensive, are more likely to succeed, while companies classified as reactive are usually unable to react to the demands of the environment and thus they usually get a lower performance compared to companies that are not reactive [33, 37- 38]. Meanwhile, Hambrick [39] argues that in defensive and explorer companies, their performance depends heavily on the nature of their environment, and defensive companies perform better than explorer companies. On the other hand, explorer companies usually have a better performance than defensive ones in terms of gain market share.

2.2 *Information and Communication Technology in Supply Chain Management.*

Currently, the supply of material resources is influenced by different factors [18]. One of them is the implementation of ICT strategies; according to Rose, Singh and Rose [19] this should be tactical and applied primarily by segment. Over the last years, companies such as manufacturing SMEs that have integrated the usage of computer systems in their business operating activities, have benefited greatly from information management and from the decision making that the businessman has to do constantly in order to improve organizational development [20], and these benefits are reflected mainly in relation to procurement, having better collaboration and specific support agreements with the purpose of avoiding delays in the delivery of material resources [10 and 21].

For manufacturing SMEs, proper adoption of ICT will enable the SCM to have a reliable management

information system so that the accuracy of the data gives confidence to the business relationship, especially in terms of procurement [22], plus an adequate inventory control, a good forecasts system and a better computer control status of material resources [23] allow these kinds of businesses to have competitive advantages and better performance.

3. Methodology

It is important to evaluate how the manufacturing SME shows special interest in establishing ICT strategies in order to ensure that the company’s business objectives and technological adoptions have favorable results for the development of these kinds of businesses [9 -10]. For this, the following hypothesis is proposed:

H₁: strategy integration allows for a better usage in the adoption of information and communication technology in manufacturing SMEs.

Therefore, for manufacturing SMEs, it is important to mention that when the SCM is influenced by the integration of ICT, its performance and development is favored and this leads to the customer’s confidence becoming stronger for stability in a long-term business [24-25]. In this regard, the following hypothesis arises:

H₂: With greater integration of information and communication technology, there is a greater supply chain management in manufacturing SMEs.

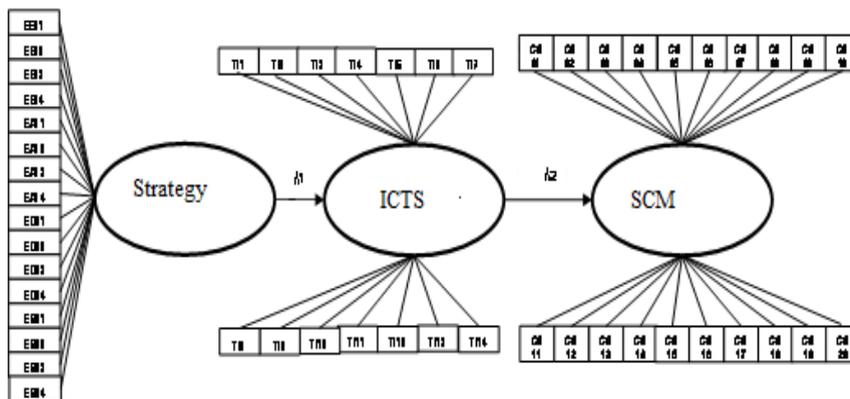


Fig. 1. Conceptual Model

The work is empirical, descriptive and correlational in which data from 288 SMEs in the manufacturing sector was taken as a random sample (of the 442 included in the Business Information System of Mexico for the State of Aguascalientes, 2010). A measuring instrument was applied as a custom survey for managers or owners of such organizations.

Table 1: Internal consistency and convergent validity of the theoretical model

Variable	indicator	t robust	CF > 0.6 factor load	alpha cronbach > a 0.7	IFC > a 0.7 Composite Reliability Index	IVE > a 0.5, Variance Extracted Index
Strategies (F1)	EE02	1.000	0.657***	0.892	0.875	0.501
	EE03	6.768	0.666***			

	EE04	11.707	0.759***			
	EA04	9.352	0.677***			
	ED01	11.570	0.739***			
	ED03	11.041	0.705***			
	ED04	11.292	0.746***			
	Σ		4.949			
Information and Communications Technology (F2)	TI01	1.000	0.864***	0.976	0.965	0.661
	TI02	35.480	0.837***			
	TI03	29.009	0.827***			
	TI04	26.012	0.807***			
	TI05	22.268	0.808***			
	TI06	16.055	0.798***			
	TI07	25.514	0.810***			
	TI08	15.514	0.787***			
	TI09	29.731	0.828***			
	TI10	29.080	0.838***			
	TI11	26.885	0.801***			
	TI12	27.036	0.792***			
	TI13	28.620	0.804***			
	TI14	28.966	0.781***			
	Σ		11.382			
Supply Chain Management (F3)	CS01	1.000	0.717***	0.970	0.954	0.520
	CS02	12.092	0.753***			
	CS03	12.414	0.756***			
	CS04	9.623	0.761***			
	CS05	10.603	0.759***			
	CS06	10.564	0.745***			
	CS07	5.761	0.627***			
	CS08	10.606	0.728***			
	CS09	10.963	0.755***			
	CS10	10.561	0.751***			
	CS11	8.049	0.661***			
	CS13	8.344	0.674***			
	CS14	9.187	0.695***			
	CS15	9.588	0.730***			
	CS16	9.310	0.699***			
	CS17	7.863	0.676***			
CS18	10.020	0.748***				
CS19	7.173	0.707***				
CS20	9.642	0.737***				

Σ **13.679**

S-BX2 (df = 736) = 1427.5581; $p < 0.0000$; NFI = 0.940; NNFI = 0.968; CFI = 0.970; RMSEA = 0.089

^a = Constrained parameter to this value in the identification process

*** = $p < 0.001$

Table 2: Discriminant validity of the theoretical model

Variables	Strategies		Information and Communication Technology		Supply Chain Management
Strategies (F1)	0.501		(0.292) ²		(0.362) ²
			0.085		0.437
Information and Communication Technology (F2)	0.292	0.035	0.661		(0.338) ²
	0.222	0.362			0.114
Supply Chain Management (F3)	0.362	0.033	0.338	0.034	0.520
	0.296	0.428	0.270	0.406	

The survey uses a Likert scale from 1 to 5; for the strategies block 16 items were used; the Information and Communication block was composed by 14 items and the Supply Chain Management block was composed by 20 items.

As a first step, a confirmatory factor analysis was performed (CFA) with the purpose of evaluating the reliability and validity of each of the variables in each block. Likewise, a structural equation model was used (SEM), to check if the structure of the Model was well designed, using the EQS software version 6.1; for this, the reliability was evaluated considering Cronbach α coefficient and the composite reliability index (CRI) [26].

Table 1 shows that each of the blocks (Strategies, Information and Communication Technology and Supply Chain Management), exceed the value of CRI recommended of 0.7 [27 -28] suggesting that the model provides a good fit:

$$(S-BX^2 = 1427.5581; df = 736; p = 0.0000; NFI = 0.940; NNFI = 0.968; CFI = 0.970; y RMSEA = 0.089).$$

All items of the related factors were significant ($p < 0.05$), the size of all the factor load was greater than 0.6 [26] and the extracted variance index (EVI) of each pair of constructs was greater than 0.5 [29].

The discriminant validity analysis was performed using two tests. First, with an interval of 95% reliability, none of the individual elements of the factors contains the value 1.0 [30]. Second, the extracted variance between each pair of modeling constructs is higher than its corresponding EVI [29]. By performing the correlation of Strategies blocks and ICT, the addition of the values 0.222 and 0.362 does not exceed the value of 1.0 [30]. In the correlation Strategy of SCM the values 0.296 and 0.428 do not exceed the value of 1.0. Finally, in the correlation of the blocks ICT and SCM the sum of the values 0.270 and 0.406 does not exceed

the value of 1.0. Therefore, it could be concluded that there is sufficient evidence of reliability and convergent validity besides discriminant.

As a second step, the statistical technique of Linear Regression was used, to check how much influence the two variables have (ICT and Strategies) over the SCM by using the statistical software IBM SPSS v19. For which a third hypothesis was generated:

H₃: The interaction of strategies and the adoption of ICT, significantly improves the supply chain management in these manufacturing companies.

4. Results

A Model of Structural Equation was conducted to check the structure of the conceptual model and contrast the proposed hypotheses, using the blocks contained in the evaluation instrument, which are described as follows: the first block consists of variables that measure Strategies, the second block has variables measuring Information and Communication Technology, and the last block is for the Supply Chain Management. The nomological validity of the model was tested by performing the Chi square test, in which the theoretical model was compared with the measurement model [45-46].

Table 3: Results of the SEM Conceptual Model

Hypothesis	Structural Relationship	Standardized Coefficient	Robust t Value	FIT Measure
H ₁ : strategy integration allows for a better usage in the adoption of information and communication technology in manufacturing SMEs	Strategies----ICT's	0.321***	12.932	S-BX2 = 1834.6204; df = 733; p = 0.0000; NFI = 0.979; NNFI = 0.987; CFI = 0.988; RMSEA = 0.073
H ₂ : With greater integration of information and communication technology, there is a greater supply chain management in manufacturing SMEs.	ICT's ---- Supply Chain Management	0.380***	24.382	

The proposed hypotheses in this research show favorable results that let us identify the results described below: Regarding the first hypothesis **H₁**, the results shown in Table 3 ($\beta = 0.321$, $p < 0.001$), indicate that strategies have a favorable impact on Information and Communication Technology in approximately 32.1 % companies such as the Manufacturing SMEs, indicating that any strategy, once identified and implemented in these businesses, favors the use of ICT in the operational activities of the organizations. Regarding hypothesis **H₂**, results shown in Table 3 ($\beta = 0.380$, $p < 0.001$) indicate that ICT has a major impact on operating activities as SCM in approximately 38 % of manufacturing SMEs, which indicates that it is appropriate to integrate ICT in these organizations, regardless of their SCM complexity, since this will allow companies to have better results in the supply of material resources, thereby leading to an efficient materials flow.

When doing regression analyses, regarding the relationship of Strategies variables, ICT with the SCM, the obtained R value was 0.750, and an R² of .563, indicating that the strategies and ICT are correlated in 75.0% with the SCM, and with the integration of these variables, the theoretical model is explained in a 56.3%. As for the collinearity statistics, an inflation factor of variance (IVF) of 1.000 was obtained, which indicates that the model does not have multicollinearity problems [28].

Table 4: Model Summary

Model	R	R square	R square corrected	Standard error of the estimate	Durbin-Watson
1	.750 ^a	.563	.560	.49245	1.792

a. Predictor variables: (Constant), Strategies, ICT's

b. Dependent variable: SCM (Supply Chain Management)

The obtained results ($\beta = 0.750$, $p < 0.001$), indicate that strategies and ICT integration, have positive and significant effects on the SCM in manufacturing SMEs, with an influence of 75.0%. The **Y1** value, which represents the SCM in manufacturing SMEs in Aguascalientes, the influence of strategies and ICT in the SCM, is represented by the following expression:

$$Y1 = \beta_0 + (\beta_1 * Strategies) + (\beta_2 * ICT's) \pm e$$

$$Scm = 0.500 + (.737 * Strategies) + (.245 * ICT's) \pm 0.065$$

5. Discussion and Conclusions

According to what Bell and Schnetzler describe [31 -32], businessmen must consider working heavily on having efficient business strategies to ensure the effectiveness of supplies, and, of course, those strategies must integrate the participation of suppliers, intermediaries and market needs. In the present study, we observed that manufacturing SMEs in Aguascalientes could be mainly classified as explorer and defensive, which is in line with the contributions made by Miles and Snow [9]. And this indicates that these companies, having exploratory strategies, have important intentions in seeking new development of opportunities and know that they must face important challenges to stay in the market. However, a high percentage also have defensive strategies, have difficulty showing initiative in seeking new growth opportunities, and do not consider that having skilled and qualified personnel can become a differentiating factor.

Regarding the integration of ICT in the activities of these businesses, according to studies by González et.al. [10] businessmen use some form of ICT to control documents, information and records related to the operating activities of the company. On the one hand, they also use these tools to coordinate with suppliers; and on the other hand, they use such tools with customers in supply management, agreements and collaborations with suppliers in order not to affect the supply of material resources. Likewise, businessmen consider that the use of ICT must be appropriate for the characteristics and conditions of the company in order to have better corporate control; they also consider that the quality of service is optimal both in the relationship with suppliers and with customers. However, it is important to mention that the use of ICT in operational activities does not guarantee the appropriate performance of these companies, since this depends not only on the type of technology used, but also on the degree of adaptation of the technology to the business needs and the ability to use it correctly [40]. It is important not to forget that the integration and use of any technological adoption in particular attention to SCM requires evaluating aspects such as operation and negotiation skills with both suppliers and with the companies that buy the products. [41-42].

One of the main objectives of ICT in the SCM is to strengthen existent trade agreements with suppliers and customers. This requires speeding up communication and data management, reducing costs and time in the transmission of information. [10 and 25, 43-44].

Regarding Management Supply Chain (SCM), the perception of the businessmen in manufacturing SMEs in Aguascalientes is to keep their guarantees in sharing information with other actors involved in the

process of providing material resources. While security issues regarding information control issues are still discussed in Mexico and especially in the region of Aguascalientes, particularly the businessman has its precautions when establishing a relationship with suppliers so that over time (medium or long term) they can reach that level of trust in which they may share any information that allows to improve and make the relationships (especially with suppliers) more efficient. According to Wisner's opinion [24] regarding the procurement, closeness and management of supplies are important in order to obtain good results in the business of manufacturing SMEs, so it is necessary to work hard on the issue of information sharing by the businessmen of such companies.

When performing an analysis of the correlation between strategies that seek for the company to be innovative, to strengthen its production processes, and generally make it more competitive with good practices in the ICT and SCM, it was found that there is a positive correlation (0.735). When analyzing in more detail we can see, in the cases where companies had higher scores in relation to their strategies, that they also gave greater importance and implemented best practices regarding information technology and supply chain management. One element that could strategically support all analyzed companies would be to design strategies to first identify business opportunities and avoid only adapting their processes to offer similar products and services, but to be pioneers in the market.

It is relevant to dimension that the proposed models reflect the importance that they have for the manufacturing SMEs in the state of Aguascalientes in Mexico when considering the integration of strategies and ICT in the SCM in order to significantly improve management in the operation of material resources in such businesses, as their management is often complex because naturally there are several intermediaries who actively participate in the management and distribution of materials required to be supplied in the manufacturing companies.

It should be mentioned that even though those responsible for operating activities in the manufacturing SMEs have a commitment to customers as well as to the procurement, so that their investments and technological adoptions are successful especially in the SCM, appropriate strategies are required so that these can be adapted effectively to each of the company's needs. In this sense, the businessman must have the intention and attitude to visualize his business situation and identify what type of strategy characterizes the company in order to raise awareness among businessmen in the implementation of any technological tool that is useful to the organization.

The present study has the limitation of the sample since the population of these businesses (manufacturing SMEs) is 442 units. A future line of research consists in applying this theoretical model in other sectors of the region of Aguascalientes, as well as in other regions containing the same sectors in order to analyze the situation of each region regarding the issue of integrating ICT as an important strategy in SCM. Finally, it is our purpose to integrate other blocks that dimension SCM efficiency in companies, such as quality.

The importance of this work is that in the analyzed region (Aguascalientes) there have been few studies about the manufacturing industry, especially in aspects related to factors that influence productivity and therefore competitiveness. This is especially due to the fact that the growth of this industry has increased since the eighties, with the start of operations of the Nissan plant, and the signing of the free trade agreement with North America in the mid-nineties. The study of the SCM and the strategies followed by this industry explains the economic growth of the region in recent years, its improvement in infrastructure, and a substantial increase in jobs; and, above all, it accounts for almost all exports. This study is therefore essential, particularly for SMEs which, in spite of being the most dynamic subsector in the industry, are still having the most challenging problems in terms of how they are organized, how they link with other sectors and in terms of general efficiency. As a result of this research we found that there is a significant relationship between the use of ICT and strategies implemented by the companies in the SCM; hence the proper functioning of this fundamental factor for achieving operational efficiency and financial organizations depends heavily, not only on the use of ICT, but on ICT being directed to achieving the strategic objectives of the organization and not being merely an isolated element, so as to contribute to the achievement of competitive advantages.

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