Chapter 42
Information and Communication Technology Impact on Supply Chain Integration, Flexibility, and Performance

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ABSTRACT

In this chapter, four latent variables will be analyzed to measure the impact of Information and Communications Technology (ICT) on the integration, flexibility and performance of Supply Chain (SC). The aim of the exposition is to provide greater understanding for those responsible of the supply chain, and focus efforts on clear objectives. These clear objectives should help those responsible for the supply chain achieve a better performance within organizations. The information analyzed was obtained from a questionnaire provided to 284 managers in companies located in Ciudad Juarez, Mexico. The results

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were used to generate a structural equation model in order to learn the relationships between variables. We have postulated six hypotheses regarding the direct, indirect and total effects. The results indicate that there is no direct relationship between ICT integration and SC performance, but an indirect relationship through mediating variables as SC Integration and Flexibility exists.

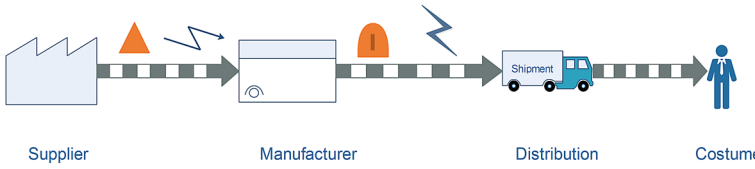
INTRODUCTION

Supply Chains

The Supply Chain study has taken an important role within companies, because it is formed by all the institutions and processes that are involved in meeting the customer needs; starting from the extraction of raw materials to finished product and delivery to the end costumer. Efficient administration of supply chains can provide significant competitive advantage and increase organizational performance.

Supply Chain management is defined as the integration of key business processes from end customer until original suppliers that provide products, services and information, which add value for customers

Figure 1. Components of supply chain



and stakeholders of the company (Lambert, Cooper, & Pagh, 1998; Themistocleous, Irani, & Love, 2004; Yu, Suojapelto, Hallikas, & Tang, 2008).

The main elements of a supply chain are: customers, retailers, distributors, manufacturers and suppliers and along this chain there is a two-way flow of materials, products, services, payment and information. In Figure 1, these elements are shown linearly; however in practice it is a network of companies connected.

In supply chain management, some factors can affect performance, including working capital, proximity to suppliers and customers, stability of government policies, structure of the supply chain, among others (Acar & Uzunlar, 2014; Capaldo & Giannoccaro, 2015; C. Marinagi, Trivellas, & Reklitis, 2015; Vlachos, 2014). Another critical factor is region infrastructure, both physical and technological, in this sense, ICTs have proven to be an important support in the Supply Chain performance (Acar & Uzunlar, 2014; Catherine Marinagi, Trivellas, & Sakas, 2014; Singh & Teng, 2016).

ICTs and Its Integration into Supply Chains

The term information and communications technology (ICT) includes the set of techniques and devices used for the processing and transmission of data. The ICT concept encompasses all information exchange services, telecommunications networks that support the data exchange and terminals used to access to services (Altés, 2013).

The integration of information and communications technology has proved been indispensable not only in the modern world, but also in the business environment, due to companies established offices and branches in any location regardless of distance, focusing on the benefits that site represents, maintaining trade relations with partners in these points and speeding the material flow. Thus, it is important to maintain communication between departments and branches around the world, this can be achieved by integrating information and communication technology, as well as keeping in touch in an effective and virtual way to all of the different functions and partners in the supply chain (Li, Lin, Wang, & Yan, 2006; Ngai, Chau, & Chan, 2011).

ICT provides organizations with elements to collect, store, enter, share, and analyze data (Swafford, Ghosh, & Murthy, 2008), and as a result, they have become into essential tools for companies. Besides other benefits of maintaining an integrated structure of ICT between companies and their SC are mentioned, such as reducing costs and achieve competitive advantages through real-time response (Themistocleous et al., 2004). It also helps the organization through the efficient information flow, tracking market needs and allowing to move resources in a quick way (Ngai et al., 2011).

Focusing on the ICTs impact on the supply chain integration, it is important to maintain a good structure to promote it, providing business information to the appropriate group in an efficient way, timely and transparent, in addition, it reduces the time needed to share knowledge and information (Pearcy & Giunipero, 2008). Therefore, the following hypothesis is proposed:

Supply Chain Integration

The supply chain integration has been considered one of the most important competences in the supply chain management (Pearcy & Giunipero, 2008) and is defined as the formation of a network in which, outside members manage in collaboration with intra- and inter-organizational processes, in order to achieve mutually acceptable results (D. Kim & Cavusgil, 2009; Ngai et al., 2011).

Some benefits associated with the integration of supply chain systems include the acquisition of competitive advantage, reducing operating costs and achieving better collaboration and coordination between partners, which sounds appealing to any administrator (Themistocleous et al., 2004). The integration of intra-and inter-organizational processes is imperative, due to it can increase performance of individual companies as well as the global supply chain, and the internal integration is achieved when a firm effectively coordinates multiple processes throughout a company. In order to achieve integration through different companies (external integration), companies must recognize the importance of suppliers as an integral part in the supply chain and engage in collaborative efforts with them. Some potential benefits of effective integration of the supply chain, include efficiency and interaction through the members, increasing visibility and operational efficiency (Pearcy & Giunipero, 2008). Nowadays, the external integration is achieved through efficiency by information and communications technology.

According to last paragraphs, the following hypothesis is proposed:

H_1: *ICT integration* has a direct and positive impact on the *SC Integration*.

Supply Chain Flexibility

The flexibility of the supply chain represents the inner workings of a company such as development, purchasing, manufacturing and distribution, as well as reducing product development time, ensuring production capacity and providing different products and at the same time meet to the customer expectations, and it is classified into strategic flexibility and manufacturing flexibility (Swafford, Ghosh, & Murthy, 2008).

Strategic flexibility is competition to identify changes in the environment, commit resources quickly to new courses of action in response to change, recognize and act immediately to stop and reverse the commitment of that resource. Manufacturing flexibility is competition to manage manufacturing resources in order to meet customer requirements (Ngai et al., 2011). Based on this, strategic flexibility is related to fast decision making and commitment to the answer, while manufacturing flexibility is related to the operational ability to implement strategic decisions (Ngai et al., 2011), so flexibility is given to the supply chain, by making decisions, the resources needed to perform appropriate actions and the ability to process these resources. The flexibility of the supply chain can also be defined as the different states that a manufacturing system can take, the ability to shift production from one product to another, and the ability to perform satisfactorily by manufacturing good quality products within a specific range (Ngai et al., 2011; Stevenson & Spring, 2007).

According to last information, the following hypotheses are proposed:

H_2: The *ICT Integration* has a direct and positive impact on the *SC Flexibility.*
H_3: The *SC Integration* has a direct and positive impact on the *SC Flexibility.*

Supply Chain Performance

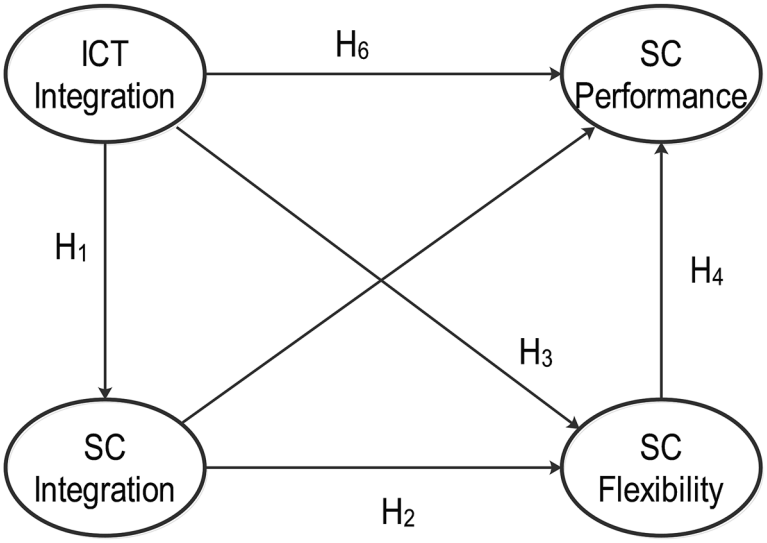
The supply chain performance is measured based on different attributes, which are considered metrics used to determine the ability to deliver products and services of good quality, on time, quantity and lower cost (Böhm, Leone, & Henning, 2007). In order to get a better idea of the SC state, it is recommended to generate metrics associated with marketing, policies and regulations, technologies available to aid in the movement of materials, product development, production process capability, procurement and operations, transportation and logistics (Hassini, Surti, & Searcy, 2012).

Some authors consider that the taxonomy of metrics should include economic aspects (Clemens, 2006; Vachon & Klassen, 2008; Zhu & Sarkis, 2004), environmental factors (Clemens, 2006; Hervani, Helms, & Sarkis, 2005; Sarkis, 2006; Searcy, McCartney, & Karapetrovic, 2007; Vachon & Klassen, 2008; Vachon & Mao, 2008; Zhu & Sarkis, 2004), as well as social elements (Searcy et al., 2007; Zhu & Sarkis, 2004).

However, the generation of financial resources has always been the main objective for industrial enterprises, thus, economic metrics in the SC are traditionally used (Chen & Paulraj, 2004; Mansoornejad, Pistikopoulos, & Stuart, 2013), which help to measure the growth in sales, profitability and return on inventory (Gunasekaran, Patel, & McGaughey, 2004).

Thus, all companies must measure the SC Economic Performance, which will allow them to know their actual status and generate continuous improvement procedures (Popova & Sharpanskykh, 2010; Wlendahl, von Cleminskf, & Begemann, 2003). These metrics obtained in the SC performance, are based on several aspects, such as the SC Flexibility, thus, the following hypothesis is proposed:

Figure 2. Proposed hypotheses



H_4: The *SC Flexibility* of a company has a direct and positive impact on the *SC Economic Performance.*

However, the SC Performance has several sources, one is the integration level that achieve companies that conform it, although, studies realized warn of the risks and dangers when those integration levels and interdependence are high (Wiengarten, Humphreys, Gimenez, & McIvor, 2015), then there may be bullwhip effects in the material flow (Świerczek, 2014) therefore, the supply chain managers face a number of challenges to achieve this integration (Mohammad, Shukor, Mahbub, & Halil, 2014). Even, some authors question whether these integration levels are beneficial from a financial view to the supply chain members (Zhao, Feng, & Wang, 2015). In order to contribute to this research topic, the following hypothesis is proposed.

H_5: The *SC Integration* has a direct and positive effect on the *SC Performance*

Another source of *SC Performance* is the technology level along it, due to they are different enterprises, information and communications technology is great to keep the members of the SC in communication in real time (Acar & Uzunlar, 2014) and currently its application is an industrial trend (El Kadiri et al., 2015). At the present, it is recommended considering the use of ICT as an essential part in the formulation of strategies that can generate a competitive advantage (Mensah, Merkuryev, & Longo, 2015), as they help to achieve better SC visibility and therefore streamline the decision-making process. (Lee, Kim, & Kim, 2014). The following hypothesis is proposed in order to contribute to this research topic.

H_6: The *ICT Integration* has a direct and positive impact on the *SC Performance*

Graphical representation of the hypotheses are illustrated in Figure 2 as a sequential flow and indicating the hypotheses as relationships with arrows from a latent variable to another.

METHODOLOGY

The methodology that is used in this research involves the design of a data collection instrument (questionnaire) and identification of benefits that are obtained after a successful ICTs implementation process. Then the survey has been applied to active managers in manufacturing industries in logistics related areas to collect information, do some statistical analysis and get a conclusion based on findings, so the work is executed on different stages described below.

Survey Development

This stage is focused on the design of a survey and a literature review is conducted. Four latent variables are analyzed in this research, but each one is integrated by another observable variables or items. In Table 1 appears the distribution for every latent variable: *ICT Integration* with 13 items, *SC Integration* with 15 items, *SC Flexibility* with 11 items, and finally, *SC performance* with 6 items, but also appears some authors that are supporting the item integration in that latent variable.

The questionnaire is answered on a Likert-based-scale on subjective assessments, where the lower value (1) indicated that the task never is done, and the highest value (6) represents that the task or operative index is always obtained. But also in the judge's validation, the first draft questionnaire contains blank spaces where the respondents could incorporate some other specific task or items that are not included in the initial questionnaire.

Data Collection

For data collection, the sample is stratified and focused on maquiladora industries that have a mature supply chain in Chihuahua, Mexico. Two hundred and eighty-four (284) managers are contacted via email.

For the survey application, three strategies are applied. The first one consists in face to face interviews with managers who work in supply chain departments or relate to material flow in industries established in Ciudad Juarez, Chihuahua, Mexico.

The second strategy consists of e-mails sent to some company managers to survey and answer within two weeks. After that time, a reminder is send and after three unsuccessful attempts, the case is abandoned. The third strategy consists in sending to every manager a link to answer the survey in a specialized web page for surveys application.

Capturing Information and Questionnaire Validation

At this stage the information is captured and analyzed using SPSS 21® software. Internal consistency or reliability of the questionnaire for each latent variable is performed using the Cronbach coefficient and composite reliability index (Cronbach, 1951; Liu, Ke, Wei, & Hua, 2013), considering a minimum cutoff values of 0.7 (Fornell & Larcker, 1981; Nunnaly, 1978; Nunnaly & Bernstein, 1994; Rexhausen, Pibernik, & Kaiser, 2012). Additionally, some tests are also performed at this stage to improve the quality of the questionnaire and the reliability in analyzed dimensions, since analyzing the elimination of some items, often the reliability in latent variable can increases (Nunnaly & Bernstein, 1994) and the procedure is used by (Blome, Schoenherr, & Eckstein, 2014; Lin, Chow, Madu, Kuei, & Pei, 2005; Ramanathan & Gunasekaran, 2014; Zailani, Jeyaraman, Vengadasan, & Premkumar, 2012) in supply chain surveys.

Table 1. Latent variables and items

ICTs Integration
The company has a network of ICT systems (ERP, CRM, SCM, Intranet, etc.) integrated with key suppliers (Burt, Dobler, & Starling, 2003; Cook, 2001; Gunasekaran & Ngai, 2004; S. W. Kim, 2009; Moon, Yi, & Ngai, 2012; Swafford et al., 2008; Themistocleous et al., 2004)
The company shares information in real time through ICT with key suppliers (Ballou, 2004; Cook, 2001; Geissbauer, Roussel, Schrauf, & Strom, 2013; Moon et al., 2012; Themistocleous et al., 2004)
The company allows access and share sensitive information through ICT with key suppliers. (Burt et al., 2003; S. W. Kim, 2009; Themistocleous et al., 2004)
The company works to get a better ICT alignment with key suppliers (Burt et al., 2003; Moon et al., 2012; Themistocleous et al., 2004)
The company shares information in real-time through ICT within the organization. (Ballou, 2004; Burt et al., 2003; S. W. Kim, 2009; Moon et al., 2012; Themistocleous et al., 2004)
The company allows access and share sensitive information through ICT within the organization (Ballou, 2004; Burt et al., 2003; S. W. Kim, 2009; Moon et al., 2012; Themistocleous et al., 2004)
The company has a network of ICT systems (ERP, CRM, SCM, Intranet, etc.) integrated with key customers (Burt et al., 2003; Gunasekaran & Ngai, 2004; S. W. Kim, 2009; Moon et al., 2012; Swafford et al., 2008; Themistocleous et al., 2004)
The company shares information in real time through ICT with key customers (Burt et al., 2003; Geissbauer et al., 2013; S. W. Kim, 2009; Moon et al., 2012; Themistocleous et al., 2004)
The company allows access and share sensitive information through ICT with key costumers (Ballou, 2004; Burt et al., 2003; S. W. Kim, 2009; Themistocleous et al., 2004)
The company works to get a better ICT alignment with key costumers (Burt et al., 2003; Themistocleous et al., 2004)
The company has a high degree of feedback through ICT (Alfalla-Luque, Marin-Garcia, & Medina-Lopez, 2015)
The company shares demand forecasts and production planning with suppliers (Cook, 2001; Geissbauer et al., 2013)
The company receives demand forecasts and production planning from their customers (Cook, 2001; Geissbauer et al., 2013)
SC Integration
The company develops strategic plans and forecasts in collaboration with key suppliers (Alfalla-Luque et al., 2015; Burt et al., 2003; Hoejmose, Brammer, & Millington, 2012; S. W. Kim, 2009)
The company has a small number of key suppliers (Burt et al., 2003)
The company shares information about purchasing, inventory levels and forecasts with key suppliers (Alfalla-Luque et al., 2015; Burt et al., 2003; Geissbauer et al., 2013; S. W. Kim, 2009)
The company expects a long-term relationship with key suppliers (Alfalla-Luque et al., 2015; Burt et al., 2003)
The company expects a long-term relationship with costumers (Burt et al., 2003)
The company provides services and support to its customers. (Alfalla-Luque et al., 2015; Burt et al., 2003)
The company measures customer satisfaction (Alfalla-Luque et al., 2015; S. W. Kim, 2009)
In the company exist cross-functional working groups which discuss issues about material and design (Burt et al., 2003; S. W. Kim, 2009)
Customers are part of the product design process (Alfalla-Luque et al., 2015; Burt et al., 2003; S. W. Kim, 2009)
The company measures the performance of its suppliers in CS. (Cook, 2001)
The company measures the performance of its customers in CS. (Cook, 2001)
The company has a high-level of internal integration (Alfalla-Luque et al., 2015)
The company has a lot of information about the state of CS (Alfalla-Luque et al., 2015; Ballou, 2004; Burt et al., 2003; Geissbauer et al., 2013; S. W. Kim, 2009)
The company maintains a high-level of interdepartmental communication (Alfalla-Luque et al., 2015; Burt et al., 2003)
The company keeps strategic relationships with key suppliers based on loyalty and trust (Burt et al., 2003; Hoejmose et al., 2012)
SC Flexibility
Regarding competitors, exist processes that can adjust to changes in mass and mix of products. (Alfalla-Luque et al., 2015; Cook, 2001; Geissbauer et al., 2013; S. W. Kim, 2009; Moon et al., 2012; Swafford et al., 2008; Thomé, Scavarda, Pires, Ceryno, & Klingebiel, 2014)
Regarding competitors, the CS of company responds faster to quotes (Ngai et al., 2011)
Regarding competitors, the CS of the company responds quickly and effectively to changes and customer needs. (Geissbauer et al., 2013; S. W. Kim, 2009; Moon et al., 2012; Swafford et al., 2008; Thomé et al., 2014)
Regarding competitors, the company develops and markets new products more quickly and efficiently. (S. W. Kim, 2009; Moon et al., 2012; Swafford et al., 2008; Thomé et al., 2014)
The company has the capacity to ensure the material availability in case of changes (Geissbauer et al., 2013; S. W. Kim, 2009; Moon et al., 2012; Swafford et al., 2008; Thomé et al., 2014)
The company has the ability to adjust to delivery schedules and to meet customer requirements (Geissbauer et al., 2013; S. W. Kim, 2009; Moon et al., 2012; Swafford et al., 2008; Thomé et al., 2014)

Table continued on following page

Table 1. Continued

The company has different SC configurations for multiple customer segments (Ballou, 2004; Cook, 2001; Geissbauer et al., 2013)
The company is based on inventories to meet demand (Ballou, 2004)
The company differentiates its products in relation to the life cycle in which they are. (Ballou, 2004)
The company keeps various channels of CS regarding to product differentiation (product, channel, costumer) (Ballou, 2004; Cook, 2001; Geissbauer et al., 2013)
The company implements structural changes in the organization in an effective way. (Ngai et al., 2011)
SC Performance
The company can modify its products quickly in order to meet customer requirements (Burt et al., 2003; Geissbauer et al., 2013; S. W. Kim, 2009; Swafford et al., 2008)
The company can quickly introduce new products on the market. (Burt et al., 2003; Geissbauer et al., 2013; S. W. Kim, 2009; Swafford et al., 2008)
The company responds quickly to changes in market demand. (Geissbauer et al., 2013; S. W. Kim, 2009; Swafford et al., 2008)
The company meets delivery times and amounts pledged. (Geissbauer et al., 2013; Swafford et al., 2008)
The cycle time to meet customer orders is short. (Ballou, 2004; Burt et al., 2003; S. W. Kim, 2009)
The company provides a high-level customer service (Ballou, 2004; Geissbauer et al., 2013; S. W. Kim, 2009)

Also, this stage included a data screening process in order to detect missing values, which are then replaced using the median, because data is obtained by using an ordinal scale (Likert-based scale), although it is always kept in mind that there should be a maximum of 10% missing values for every item (Hair, Anderson, & Tatham, 1987; Hair, Black, Babin, & Anderson, 2009). Also, the values in the database are analyzed for outliers or extreme values and for this, a standardization process is executed for every item considering a standardized value as an outlier if its absolute value is bigger than 5 (Giaquinta, 2009; Hair et al., 2009; Kaiser, 2010; Rosenthal & Rosnow, 1991; Wold, Trygg, Berglund, & Antti, 2001).

Also, considering that the survey is answered on an ordinal scale using only assessments and not measurements, then the Q-squared coefficient is used since it is a nonparametric measure traditionally calculated via blindfolding. Q-squared coefficient is also used for the assessment of the predictive validity (or relevance) associated to each latent variable in the model. Acceptable predictive validity in connection with an endogenous latent variable is suggested by a Q-squared coefficient greater than zero (Kock, 2013) and preferably, must be similar to R-Squared values.

Descriptive Analysis

This stage focuses on a univariate analysis for identifying the central tendency and deviation measures in items collected in latent variables. As a central tendency measure, the median or percentile 50th is obtained; where high values indicate that the task is always done; lower values indicate that those tasks are not done or the operative index is not obtained. Also, as deviation measure, the interquartile range (IR) is obtained (difference between percentile 75th and percentile 25th). High values in IR indicate that the task listed does not present agreement or consensus among respondents, while lower values represent little dispersion in those items (Tastle & Wierman, 2007) and therefore, a greater consensus among respondents.

Table 2. Industrial sectors analyzed

Industrial Sector	Frequency	Accumulated Frequency
Automotive	128	128
Electric/Electronic	80	208
Medical	19	227
Metal Mechanics	16	243
Plastics	12	255
Communications	8	263
Services	5	268
Textile	5	273
Undeclared	11	284

Structural Equation Model

In order to prove the hypotheses stated in Figure 1, the model is evaluated using the Structural Equation Modelling (SEM) technique, due to its widely and recent use in causal relations validations and specifically in the supply chain. For example, the impact of JIT in supply chain performance (Green Jr, Inman, Birou, & Whitten, 2014), the flexibility, uncertainty and firm performance in supply chain (Merschmann & Thonemann, 2011) and the effect of green supply chain management on green performance and firm competitiveness (Yang, Albert, & Carlo, 2013).

The SEM model is executed in WarpPls 5.0® software because its main algorithms are based on Partial Least Squared (PLS), widely recommended for low sample size (Kock, 2013). The model here presented is specifically executed using the WarpPls5 PLS algorithm, with a bootstrapping resampling method for a better coefficients values convergence and diminish the effect of possible outliers.

Six model fit indices are analyzed: average path coefficient (APC), the average R-squared (ARS), average adjusted R-squared (AARS), average block VIF (AVIF), average full collinearity VIF (AFVIF) and Tenenhaus goodness of fit (GoF), that are recommended by (Kock, 2013) and used by (Ketkar & Vaidya, 2012) in the supply chain environment. For the APC, ARS and AARS, the p-values are analyzed in determining the model efficiency, establishing a maximum cutoff p-value of 0.05, which mean that statistical inferences are made with 95% of confidence level, testing the null hypotheses that APCs, ARSs and AARSs are equal to 0, versus the alternative hypotheses that APCs, ARSs and AARSs are different to zero; while for AVIF and AFVIF, values low than 5 are desirable. For Tenenhaus goodness fit index, values high than 0.36 are desirables for a stable model.

Three different effects are measured in the structural equation model: (1) direct effect (that appears in Figure 1 as arrows from a latent variable to another), (2) indirect effect (given for paths with two or more segments), and (3) total effects (the sum of direct and indirect effects), and with the aim to determine their significance, the P values are analyzed, considering the null hypothesis: $\beta i = 0$, versus the alternative: hypothesis $\beta i \neq 0$.

Table 3. Years of experience against gender

Years of Experience	Gender		Total
	Male	Female	
Less than 1 year	23	24	47
1 to 2 years	48	20	68
2 a 5 years	69	22	91
5 a 10 years	29	12	41
Greater than 10 years	15	6	21
Total	184	84	268

RESULTS

The results are presented for a better understanding and are carried out in different stages, according to the information being presented.

Descriptive Analysis of the Sample

The descriptive analysis of the sample was made in which it can be observed a total of 284 valid surveys in companies located at Ciudad Juarez, Mexico. Table 2 refers to industrial sectors that were surveyed, which are listed in descending order according to the frequency, which shows that the automotive sector was the most participatory in this study with 128 participants, followed by electrical/electronic industry with 80 surveys. It is noteworthy that these two sectors account for 73.23% of the entire sample. The remaining percentage is represented by the medical, metalworking, plastics, among others industry sectors.

Table 3. refers to the years of experience in the position against gender of each of the respondents, which are listed according to first variable. It is noted that the composition of the sample is 184 male participants, 84 female and 14 undeclared, which is why the sum is only 268 respondents. It is observed that 68.64% representing to 184 males is bigger than 31.34% representing 84 male. According to the information in Table 3, shows that the most representative category is displayed in 2 to 5 years, followed by category 1 to 2 years.

Questionnaire Validation and its Variables

Before any analysis of the information, we proceeded to perform data validation. The information associated with such tests is illustrated in Table 4, where according to the R-square values and adjusted R-square, the overall model has predictive validity from a parametric point of view, since all values are greater than 0.2 on the dependent latent variables. Similarly, according to indexes of composite validity and Cronbach's alpha, it has internal validity, since all the values obtained are higher than 0.7, minimum value allowed.

Regarding convergent validity, it is observed that all the latent variables analyzed have values greater than 0.5, so it is concluded that this requirement is met. Also, regarding the collinearity for final model reported in Table 4, it is observed that none of the values of the VIFs are greater than 3.3, so it is considered that the latent variables are clear of collinearity problems.

Table 4. Data validation

	ICT Integration	SC Integration	SC Flexibility	SC Performance
R-squared		0.54	0.633	0.572
Adjusted R-squared		0.539	0.631	0.569
Composite reliability	0.941	0.873	0.873	0.908
Cronbach's Alpha	0.93	0.825	0.781	0.878
AVE	0.591	0.535	0.696	0.623
Full VIF	2.351	3.206	3.273	2.346
Q-squared		0.541	0.633	0.571
Initial items	13	15	11	6
Final items	11	6	3	6

It is important to note that in the last two rows is illustrated the number of items with that the model was initiated, and which were described in Table 1; however, to solve the problems of collinearity that are existed, it was necessary to remove some items on the latent variables, so the row labeled as *final items*, denotes the number of items that keeps the latent variable, due to the elimination some of these items. For example, the latent variable *SC Integration* initially had 13 items, but 2 items were eliminated due to collinearity problems and evaluated the final model has only 11 items. Here is important to note that latent variable named *SC Flexibility* initially had 11 items but the final model is reporting only 3 dur to collinearity problems.

Finally, the values of Q-square are very similar to R-square and adjusted R-square, and they are above zero, so it is concluded that the model has predictive validity from a nonparametric point of view too.

Descriptive Analysis

Following is show the descriptive analysis of the variables remaining in the model, the percentiles; 25^{th} (Q_1), 50^{th} or median (Q_2), 75^{th} (Q_3) and interquartile range (IR) are shown, as described above in the methodology section. Table 5 illustrates this descriptive analysis and the items are sorted in descending order in each of the analyzed latent variables.

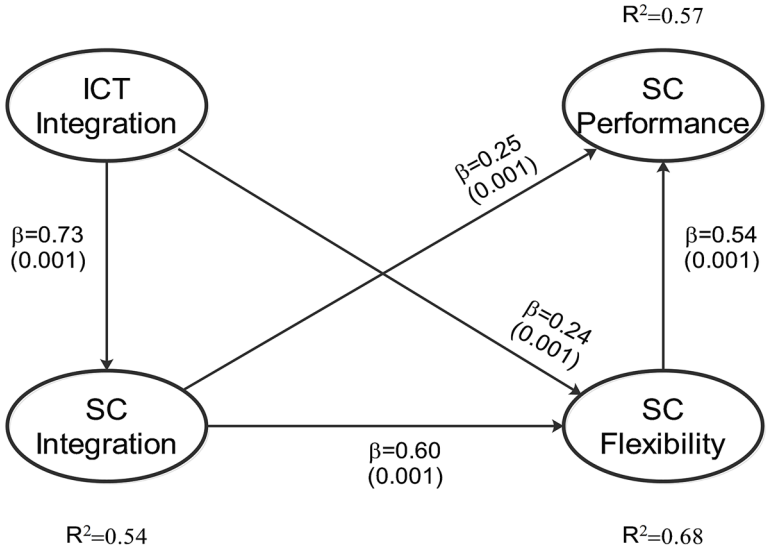
As shown in Table 5, the median, which is represented by the 50^{th} percentile, the variable with the highest value in the category *ICT Integration* is corresponding to the availability of a system of information technologies that find integrated with suppliers who supply raw materials. Note that the other variables in this category remain medians above 4, meaning that the *ICT integration* is present in most scenarios and which is considered of great importance by the managers surveyed. In the category of *SC Integration*, the variable with the highest median is referred to service and support granted by the company to its customers, so it comes as a landmark for people in charge of supply chain administration. As can be seen the other variables have medians greater than 4 in the same manner as in the first category or latent variable. It is noteworthy that this same item has the smaller IR in the category, which indicates that there is consensus on the value that it has, since it reports a lowest dispersion.

Table 5. Percentiles of variables in final evaluated model

Latent Variable	Items	Q_1	Q_2	Q_3	IR
ICTs Integration	The company has a network of ICT systems (ERP, CRM, SCM, Intranet, etc.) integrated with key suppliers.	3.67	4.78	5.64	1.97
	The company receives demand forecasts and production planning from their customers.	3.68	4.74	5.6	1.92
	The company has a network of ICT systems (ERP, CRM, SCM, Intranet, etc.) integrated with key customers.	3.52	4.6	5.52	2
	The company works to get a better ICT alignment with key customers.	3.43	4.48	5.39	1.96
	The company shares information in real-time through ICT within the organization.	3.41	4.46	5.36	1.95
	The company shares demand forecasts and production planning with suppliers.	3.32	4.46	5.42	2.1
	The company has a high degree of feedback through ICT.	3.34	4.39	5.32	1.98
	The company works to get a better ICT alignment with key suppliers.	3.27	4.36	5.28	2.01
	The company allows access and share sensitive information through ICT within the organization.	3.12	4.27	5.24	2.12
	The company allows access and share sensitive information through ICT with key customers.	3.16	4.27	5.19	2.03
	The company shares information in real-time through ICT within the organization.	2.89	4.02	4.97	2.08
SC Integration	The company provides services and support to its customers.	3.89	4.83	5.63	1.74
	In the company exist cross-functional working groups which discuss issues about material and design.	3.78	4.73	5.57	1.79
	Customers are part of the product design process.	3.7	4.73	5.6	1.9
	The company has a high-level of internal integration.	3.38	4.41	5.31	1.93
	The company shares information about purchasing, inventory levels and forecasts with key suppliers.	3.04	4.15	5.09	2.05
	The company has a small number of key suppliers.	3.09	4.14	5.08	1.99
SC Flexibility	The company is based on inventories to meet demand.	3.59	4.66	5.57	1.98
	The company implements structural changes in the organization in an effective way.	3.76	4.66	5.48	1.72
	Regarding competitors, exist processes that can adjust to changes in mass and mix of products.	3.44	4.41	5.29	1.85
SC Performance	The company can modify its products quickly in order to meet customer requirements.	3.54	4.58	5.44	1.9
	The company meets delivery times and amounts pledged.	3.67	4.58	5.43	1.76
	The company considers the SC management is vital in business activities.	3.59	4.53	5.41	1.82
	The company can quickly introduce new products on the market.	3.36	4.43	5.36	2
	The cycle time to meet customer orders is short.	3.39	4.4	5.32	1.93
	The company offers incentives for performance in SC.	2.75	4.05	5.09	2.34

As for category *SC Flexibility*, two variables are observed with the same highest value of 4.66, and refer to the use of inventories to satisfy demand in the supply chain and the implementation of structural changes in the company quickly and effectively. This means that logistics managers consider of great importance these skills of supply chain. The remaining variable maintains a median greater than 4 and the second variable having the lowest IR, indicating consensus regarding the value of that item.

Figure 3. Final model- direct effects validation



Finally, the last category or latent variable named *SC performance*, for the item with the highest median value it is has again a tie, and these relate to the ability to quickly make changes to products to meet changing customer needs, and the ability of the company to comply with the agreed delivery dates and quantities. However, the smaller of the IR is in the second variable with the highest median value.

Structural Equation Model

The structural equation model was evaluated according to the methodology described above, where some items have been removed due to collinearity problems. Following appears the efficiency indices for the final model and Figure 3 presents such model:

- Average path coefficient (APC)=0.474, P<0.001
- Average R-squared (ARS)=0.582, P<0.001
- Average adjusted R-squared (AARS)=0.579, P<0.001
- Average block VIF (AVIF)=2.394, acceptable if <= 5, ideally <= 3.3
- Average full collinearity VIF (AFVIF)=2.794, acceptable if <= 5, ideally <= 3.3
- Tenenhaus GoF (GoF)=0.596, small >= 0.1, medium >= 0.25, large >= 0.3

For the first three indexes, which have a P value measure, it is observed that have values lower than 0.05, so it can make statistical inferences in the model in general terms, and that mean that in average the final model has sufficient predictive validity and that the values assigned to betas or parameters that measure the relationship between latent variables are statistically significant. Similarly, regarding the two indices that measure the collinearity in the model (VIF and AVIF), since there are values lower that 3.3, this lets to conclude again that the model in general terms is efficient and predictive.

Also note that the arrow representing to H_6, relationship between *ICT Integration* and *Performance SC*, does not appear and it is because it was not statistically significant. The other five hypotheses were statistically significant.

Direct Effects

The direct effects helped to validate the hypotheses made above in Figure 1, which according to the values shown in Figure 2, the conclusions are:

H_1: There is sufficient statistical evidence to declare that the *ICT integration* has a positive and direct effect on *SC Integration*, since when the first latent variable increases its standard deviation in one unit, the second one goes up by 0.73 units.

H_2: There is sufficient statistical evidence to declare that *ICT Integration* has a direct and positive effect on *SC Flexibility*, since when the first latent variable increases its standard deviation in one unit, the second one goes up by 0.24 units.

H_3: There is sufficient statistical evidence to declare that the *SC Integration* has a direct and positive effect on *SC Flexibility*, since when the first latent variable increases its standard deviation in one unit, the second one goes up by 0.60 units.

H_4: There is sufficient statistical evidence to declare that *SC Flexibility* in a company have a direct and positive effect on the *SC Economic Performance*, because when the first latent increases its standard deviation in one unit, the second goes up by 0.54 units..

H_5: There is sufficient statistical evidence to declare that *SC Integration* has a direct and positive effect on *SC Performance*, since when the first latent variable increases its standard deviation in one unit, the second one goes up by 0.25 units.

H_6: There is not enough statistical evidence to declare that the *ICT Integration* has a direct and positive impact on *SC Performance*, since the P value obtained in statistical significance test results exceed 0.05, maximum value allowed for inferences made at a 95% confidence level.

Direct Effect Size

The model evaluated in Figure 2 shows that the latent variables that refers to *SC Performance* and *SC Flexibility* receive effects from more than one independent latent variable, so it is necessary to decompose the percentage of variance in which are explained:

1. In the case of latent dependent variable called *SC Performance*, it is explained by 57%, due to R^2= 0.57 from the latent independent variables *SC Flexibility* and *SC Integration*. However, 0.173 is due to the first variable and 0.399 is due to the second one, so based on the sizes of these effects, those values let's to conclude that the *SC Flexibility* is the variable that best helps to explain *SC Performance*.
2. In the case of latent dependent variable called *SC Flexibility*, it is explained by 63% due to R^2 = 0.63 from the latent independent variables *SC Integration* and *ICT Integration*. However, 0.467 is due to the first variable and 0.166 is due to the second one, so based on the sizes of these effects, it is concluded that the *SC Integration* is the variable that best helps to explain *SC Flexibility*.

Table 6. Sum of indirect effects

To	From	
	ICT Integration	**SC Integration**
SC Flexibility	0.441 P(<0.001) ES= 0.302	
SC Performance	0.556 P(<0.001) ES= 0.329	0.324 P(<0.001) ES= 0.219

Sum of Indirect Effects

The analysis of indirect effects between latent variables analyzed is important because it helps to understand certain phenomena, such as those found in the conclusion about H_6, in which it was determined that there is no direct relationship between *ICT Integration* and *SC Performance*, but indirect effects occur through other variables which are called mediators.

Table 6 summarizes the indirect effects between the variables analyzed, the P value of the statistic test of the estimated parameters, in addition, the effect size (ES) or percentage of variance. It is important to remember that H_6 referred to the relationship between *ICT Integration* and *SC Performance*, and it was statistically rejected because the direct effect was not significant, but indirectly have a very high relation, which is 0.556 (highest indirect effect on the Table 6) and it means that when *ICT integration* incremented by one unit its standard deviation, the *SC Performance* goes up by 0.556 units, which is given through the mediating variables called *ICT Integration* and *SC Flexibility*, but is also able to account for up to 32.9%, because the effect size is 0.329.

Likewise, it is observed that the indirect effect of *ICT Integration* on *SC Flexibility* is higher, 0.441, which indicates that each time the first latent variable incremented by one unit its standard deviation, the second one goes up by 0.441 units, and it is responsible for explaining 30.2% of variability, since the effect size is 0.302. This indirect effect is given through *SC Integration*.

A similar interpretation can be made for indirect effect between *SC Integration* and *SC Performance*, which is given by the mediator variable called *SC Flexibility*.

Table 7. Total effects

To	From		
	ICT Integration	**CS Integration**	**SC Flexibility**
SC Integration	0.73 P(<0.001) ES= 0.540		
SC Flexibility	0.684 P(<0.001) ES= 0.468	0.6 P(<0.001) ES= 0.467	
SC Performance	0.556 P(<0.001) ES= 0.329	0.578 P(<0.001) ES= 0.392	0.54 P(<0.001) ES= 0.399

Total Effects

The total effects are represented by the sum of direct effects and indirect effects. Table 7 illustrates the total effects, the P value for statistical significance test and the effect size.

According to the values of total effects shown in Table 7, the highest value corresponds to the relationship between the latent variables *SC Integration* with *ICT Integration*, its value is 0.73, which belongs to the H_1 hypothesis that has already been explained in the section of direct effects. However, the relationship between *ICT Integration* with *SC Flexibility*, the total effect is 0.684, a high value, but only 0.25 corresponds to the direct effect established by H_3 and the rest is due to the indirect effect, the which is the higher than the previous one.

Also, it is important the relationship between *SC Integration* with *SC Performance*, here the direct effect is only 0.25, but the total effect is 0.578, which indicates that the indirect effect is higher than the direct effect, which is given through *SC Flexibility*.

CONCLUSION

Based on the results shown above, the following conclusions are derived:

1. The relationship between *ICT Integration* and *SC Performance* in a chain supply is indirect and occurs by mediator variables, such as *SC Integration* and *SC Flexibility*.
2. The *SC Integration* has a positive and direct effect on the *SC Performance*, but the indirect effect is achieved through the mediator variable denominated *SC Flexibility*, and is higher than the direct effect.
3. The role of *SC Integration* and *SC Flexibility* as mediator variables in the *SC Performance* is important, due to some of the indirect effects occurring through these variables are higher than the direct effects, indicating that managers should take efforts to achieve these characteristics in the supply chains.
4. Supply chain managers should pay attention in determining the type of ICT to be implemented, since from it depends integration levels and flexibility that are achieved, which directly impact on SC performance.

FUTURE RESEARCH DIRECTIONS

The main limitation of this research is that it has completed in the maquiladora industry located at Mexico, thus inferences are valid only in that environment. Furthermore, when analyzing the final model in Figure 3, it is shown that the values of R^2 in the latent dependent variables are higher than 0.5, an acceptable value in this type of models, but does suggest that there are other variables that help to explain the *SC Integration, SC Flexibility* and *SC Performance*, so it means that in future research there must include the knowledge levels and skills that ICT operators have in supply chain, that maybe helps to increase that R^2 values.

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KEY TERMS AND DEFINITIONS

Customer: A person or an organization who purchases goods or services from another person or organization.

Data: A single piece a body or collection of facts, statistics or information.

Distributor: A person a firm or a company that distributes a line of merchandise generally or within a given territory.

Infrastructure: The facilities or basic structure supporting a system or organization such as transportation, buildings and communication systems.

Integration: To bring together or incorporate into a whole or a larger unit.

Manufacturer: A person, group, or organization that make or produce goods by hand or machinery on a large scale.

Network: An association of individuals having a common interest or any system or group of interrelated or interconnected elements.

Performance: The efficiency with which something reacts or fulfills its purpose.

Retailer: Person or an organization that sells goods to ultimate consumers, usually in small quantities.

Supplier: A person or an organization that provide things necessary for maintaining an army, business or other enterprise.

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