THE IMPACT OF PROCUREMENT AND INVENTORY MANAGEMENT IN OPERATIVE PERFORMANCE IN A SUPPLY CHAIN

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ABSTRACT
Supply chain is a major opportunity area to reduce costs and obtain operative performance, and that's why companies are looking to have a proper administration of the same. In this paper appears a structural equation model that integrates a total of 14 observed variables integrated in three latent variables, which are the raw materials procurement process, inventory management and operative performance of supply chain, generating three hypotheses related their relationships. A dataset was used containing 306 cases from maquiladoras in México. The model is run using partial least squares method. The results indicate that there is a direct and positive from raw material procurement on inventory management administration of 0.74 standard deviations, but in turn the first impact on 0.50 to operative performance.

Keywords: procurement, supply chain, causal model, PLS.

1. INTRODUCTION

Some authors indicate that at present times the competition between companies is not really in their production systems, but rather in their supply chains (CS), and this is due to the globalization processes that are currently (Hadjimarcou, Brouthers, McNicol, & Michie, 2013). Therefore, companies make a great effort to get a competent and efficient supply chain management (SCM), so there is a need to know the metrics on relations that exist between variables in CS.

A supply chain is a group of activities and entities in a production system ranging from the supply of raw materials to distribution as finished product. However, in a CS exists not only a flow of raw materials as discussed above but also there are flows of information and financial resources (Caridi, Moretto, Perego, & Tumino, 2014), as can be seen in Figure 1.

It is important to note that for some members in the supply chain a component or piece may be the end product, but for another, maybe is a raw material and that is why it is given chain name, which must be analyzed from a scientific point of view, albeit a complex problem (Feng, 2012) given the interactions between components or members of it, where everyone has an important role; however, this complexity has not been discouraged for many researchers, as there are currently a lot studies that focus on the study of some of its components (Bertolini, Bottani, Rizzi, & Bevilacqua, 2007; Hartmann & De Grahl, 2011; Tang, Goetschalckx, & McGinnis, 2013).

Figure 1. Traditional supply chain

It is also important to note that supply chains from one product to another are completely different, but there is general agreement on several points, such as the activities to be carried out (Lu & Swaminathan, 2015). In that sense, a supply chain starts with a procurement process, which is performed by a supplier in the manufacturer warehouses, who by some kind of modeling and administrative rules, is responsible for giving the best use and maintain his inventory. From here, from the raw material warehouses, it goes to the production process to begin their transformation by a set of activities that will make it a finished product that will be shipped to a warehouse or store again. From here, through a distribution system, the company will send the finished product to end customers.

In the northern region of Mexico, specifically in Ciudad Juarez, there are a total of 324 maquiladoras, which are companies with foreign capital mainly, and import 100% of their raw materials from other countries, those companies assemble their products in México and they distribute their final product in countries like United States of America and European Union. This process makes the supply and inventory management are very peculiar and worthy of study (Sargent & Matthews, 2009).

Management of materials throughout the entire production process described above and the efficiency with it will make the company a competitive entity and hence the importance of good management thereof

(Lin, Chow, Madu, Kuei, & Pei, 2005). But surely, that all these activities are interrelated, and that the success of one of them has an impact on efficiency performance ratios for the company. So the aim of this article is to analyze the impact of the activities carried out during the raw material procurement process and their inventory management by the companies in the operating performance index for the supply chain.

1.1 Hypothesis

As mentioned earlier in this article three latent variables which are reported: *Procurement, Inventory management and Operative performance*. For know the impact from one latent variable on another, the following working hypothesis that are illustrated in Figure 2 are proposed.

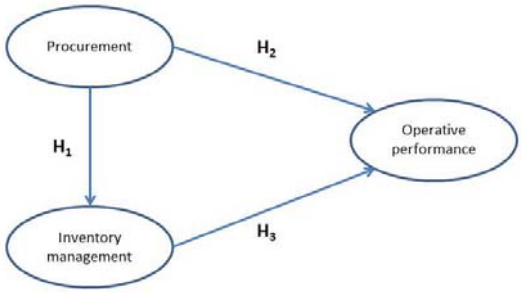

Figure 2: Proposed hypotheses

As mentioned above, supply chain starts with the supply of raw material from a supplier (Miocevic & Crnjak-Karanovic, 2012), that has been selected following strict quality standards and always looking to integrate him into the production process, so in large companies the supplier for a product are a few just because confidence levels generated between producer - provider are very high, enabling the establishment of philosophies as just in time purchasing. That relationships and how manufacturers are making the purchasing process will surely have an impact on inventory management by the company throughout the entire production system (David & Eben-Chaime, 2003).

Here it is important to note that the company manages inventory not only in their warehouses, but it should be done throughout whole production process (Dong, Carter, & Dresner, 2001; Selvarajah & Zhang, 2014). Very often, the companies for achieve their goals by managing their inventories; have stablished some regional distribution centers to help them do so quick shipments to their workplaces. However, to achieve all this, it requires the integration of many information and communication technologies to follow up the status of materials in each production stages (Jiang & Liu, 2015). Thus there are two types of policies here, those that relate to the process of sourcing from a supplier and that relate to the inventory management by manufacturer, which without doubt are related, therefore, it is proposed the following hypothesis.

H_1. There is a direct and positive relationship between the process of raw material *Procurement* by supplier and the *Inventory management* by manufacturer.

However, cooperation and good relations that have between manufacturer and supplier and their confidence levels, as well as the integration of both production systems, may also result in a number of benefits, which are reflected in operating performance index (Dey & Giri, 2014; Tseng, Wu, Lin, & Chiu, 2014). Thus, timely delivery by the supplier can represent very low cycle times, but also those deliveries to customers on time and complete production orders (Bertolini et al., 2007). But if production systems are properly integrated by information and communications technologies, then the SC has a virtual visibility to both, and that will facilitate decision making along the same (Caridi et al., 2014; Musa, Gunasekaran, & Yusuf, 2014). Thus, it appears that the process of raw materials procurement and the way how it is made, it will impact the operating efficiency ratios in manufacturer SC surely, so the following hypothesis is proposed.

H_2. There is a direct and positive relationship between the *Procurement* system of a company and the *Operative performance* in a supply chain.

In last hypothesis is assumed that there is a relationship between *Procurement* policies and *Operative performance* indices; however, there must be a relationship between *Inventory management* policies that the company has with the *Operative performance* (Brox & Fader, 1997), because if an *Inventory management* throughout the company is applicable in every departments, making use of just-in-time philosophy (Alcaraz, Maldonado, Iniesta, Robles, & Hernández, 2014) and with adapted information and communications technology, then it is possible to obtain timely deliveries to the end customer, have visibility in supply chain throughout the entire company and shorter cycle time (Karimi & Davoudpour, 2015; Selvarajah & Zhang, 2014).Therefore, the following hypothesis is proposed:

H_3. There is a direct and positive relationship between *Inventory management* policies and *Operative performance* indices in supply chain.

2. 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 JIT implementation process. Then the survey has been applied to active managers in manufacturing industries to collect information, do some statistical analysis and get a conclusion based on findings, so the work is executed on different stages described below.

2.1 Survey development

This stage is focused on the design of a survey based on findings reported by (Soin, 2004) and a literature review is conducted. Three latent variables are analyzed in this research, but each one is integrated by another observable variables or item. In Table 1 appears their distribution, *Procurement* with 4 items, inventory management with 6 items and finally, Operative performance with 4 items.

Table 1: Latent variables and items

Procurement
Cooperation and relationship with suppliers (Ahi & Searcy, 2015; Bhagwat & Sharma, 2007; Cho, Lee, Ahn, & Hwang, 2012; Merschmann & Thonemann, 2011; Soin, 2004)
Reduction in the number of suppliers (Blome & Schoenherr, 2011; Jayaram, Dixit, & Motwani, 2014; Soin, 2004)
Delivery of raw material using JIT philosophy (JL. García-Alcaraz, Rivera, Blanco, Jiménez, & Martínez, 2014; Inman, Sale, Green Jr, & Whitten, 2011; Soin, 2004)
Raw material buying process are looking the best price (Mansoornejad, Pistikopoulos, & Stuart, 2013; Soin, 2004)
Inventory management
There is coordination and inventory management in whole Company (Soin, 2004) (Cirtita & Glaser-Segura, 2012; Falk & Hogström, 2000)
Deliveries inside the company are made using a JIT philosophy (Inman et al., 2011; Singh & Garg, 2011; Soin, 2004)
There is a management inventory control in all production process (Avelar-Sosa, García-Alcaraz, Vergara-Villegas, Maldonado-Macías, & Alor-Hernández, 2014; Caridi et al., 2014; Ramanathan, 2014)
The Company is focused in use low inventory level (Y.-M. Lee, Mu, Shen, & Dessouky, 2014; Pan & Liao, 1989)
There are regional distribution centers (Cheng & Tsai, 2009; Hu, Lu, Li, Zhang, & Zhang, 2014; Ou & Chou, 2009)
There are automatized warehouse systems (Berné, García-González, García-Uceda, & Múgica, 2015; Bertolini et al., 2007; Mensah, Merkuryev, & Longo, 2015)
Operative performance
Deliveries to customers are on time and complete (Cater & Cater, 2009; Fawcett, Calantone, & Smith, 1997)
The lead time between vendor and manufacturer are low (Bertolini et al., 2007; Li, Xu, & Ye, 2011)
There is a visible supply chain (Caridi et al., 2014; H. Lee, Kim, & Kim, 2014; Williams, Roh, Tokar, & Swink, 2013)
There is a high product customization level (Brun & Zorzini, 2009; Ngniatedema, Fono, & Mbondo, 2015; Yao & Liu, 2009)

The questionnaire 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 (5) represents that the task or operative index is always obtained. But also in the judge's validation, the first questionnaire contains blank spaces where the respondents could incorporate some other specific task that are not included in the initial questionnaire.

2.2 Data Collection

For data collection, the sample is stratified and focused on maquiladora industries that have a maturity supply chain. 324 companies 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 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.

2.3 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 increases (Nunnaly & Bernstein, 1994) and the procedure used were by (Blome, Schoenherr, & Eckstein, 2014; Lin et al., 2005; Ramanathan & Gunasekaran, 2014; Zailani, Jeyaraman, Vengadasan, & Premkumar, 2012) in supply chain surveys.

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 4 (Giaquinta, 2009; Hair et al., 2009; Kaiser, 2010; Rosenthal & Rosnow, 1991; Wold, Trygg, Berglund, & Antti, 2001). A similar procedure was used in supply chain research by (JL García-Alcaraz, Maldonado-Macias, Iniesta, Robles, & Hernández, 2014).

The discriminant validity is measured by the average variance extracted (AVE), and this measure is used by (Avelar-Sosa et al., 2014; JL García-Alcaraz, Maldonado, Alvarado, & Rivera, 2014) in a supply chain survey, and the minimum cutoff acceptable value for AVE is 0.5; while, for convergent validity assessment, the AVE's and correlations among latent variables are used (Fornell & Larcker, 1981; Kock,

2013). This procedure was used for discriminant validity by in supply chain research (Avelar-Sosa et al., 2014; JL García-Alcaraz, AA Maldonado-Macias, et al., 2014; JL García-Alcaraz, AidéA Maldonado, et al., 2014).

However, in regression analysis is important to measure the collinearity among latent variables, because if there is a high collinearity, then the inverse matrix estimation is very difficult, and then the full collinearity VIFs (variance inflation factor) value is used and the maximum cutoff value is 3.3 (Cenfetelli & Bassellier, 2009; Petter, Straub, & Rai, 2007). But some authors suggest more relaxed values, i.e. bigger than 10 (Hair et al., 1987; Hair et al., 2009; Kline, 1998; Petter et al., 2007).

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.

2.4 Descriptive Analysis

This stage focuses on a univariate analysis for identifying the central tendency and deviation measures in items collected. 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 among respondents, while lower values represent little dispersion in those items (Tastle & Wierman, 2007) and therefore, a greater consensus among respondents. Similar interpretations were applied in supply chain research by (JL García-Alcaraz, AA Maldonado-Macias, et al., 2014; JL. García-Alcaraz et al., 2014).

2.5 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 3.0® 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 WarpPls3 PLS algorithm, with a bootstrapping resampling method for a better coefficients values convergence and diminish the effect of possible outliers.

Three model fit indices are analyzed: average path coefficient (APC), the average R-squared (ARS) and average variance inflation factor (AVIF) that are proposed by (Kock, 2013) and used by (Ketkar & Vaidya, 2012) in the supply chain environment. For the APC and ARS, the p-values are analyzed in determining the model efficiency, establishing a maximum cutoff p-value of 0.05, which mean that the inferences are made with 95% of confidence level, testing the null hypotheses that APC and ARS are equal to 0, versus the alternative hypotheses that APC and ARS are different to zero; while for AVIF, values low of 5 are desirable.

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 $\beta i \neq 0$.

3. RESULTS

3.1 Survey validation

Before starting with the information analysis obtained through the questionnaire, the validation statistical validation process was done in order to see if it was reliable. In Table 2, the indexes obtained for each of the latent variables are illustrated.

Table 2: Latent variables coefficients

Index	Procurement	Inventory Management	Operative Performance
R-squared		0.54	0.521
Adj. R-Squared		0.539	0.518
Composite Reliability	0.857	0.903	0.86
Cronbach´s alfa	0.778	0.87	0.783
Avg. var. extracted	0.601	0.607	0.606
Full collin VIF	2.654	2.306	1.999
Q-squared		0.541	0.517

Note that Cronbach's alpha index is greater than 0.7 in every latent variables analyzed, which also occurs with the composite reliability index, so it is concluded that the measuring instrument has internal validity. Regarding convergent validity, it is observed that the

average variance extracted (AVE) is greater than 0.5 in every variables, so also it is concluded that the questionnaire is adequate. Likewise, it is observed that the square R-squared and R - square adjusted have values above 0.2, so it is concluded that the questionnaire also had predictive validity.

Regarding the linearity in dataset, it appears that none variable is higher than 3.3, the maximum allowed value and this lest to conclude that there is no problem with collinearity. Given the above, it is concluded that the used questionnaire for obtain information from companies is adequate, so it can be used for further analysis.

3.2 Descriptive analysis

Table 3 briefly illustrates the descriptive analysis for variables analyzed, which contain the median as measure of central tendency and interquartile range (IR) for deviation.

Table 3: Descriptive analysis

Procurement	**Median**	**IR**
Cooperation and relationship with suppliers	4.39	1.31
Reduction in the number of suppliers	3.81	1.54
Delivery of raw material using JIT philosophy	4.23	1.48
Raw material buying process are looking the best price	4.27	1.38
Inventory management		
There is coordination and inventory management in whole company	4.28	1.40
Deliveries inside the company are made using a JIT philosophy	4.3	1.38
There is a management inventory control in all production process	4.13	1.40
The Company is focused in use low inventory level	4.17	1.49
There are regional distribution centers	3.96	1.46
There are automatized warehouse systems	3.81	1.72
Operative performance		
Deliveries to customers are on time and complete	4.39	1.21
The lead time between vendor and manufacturer are low	4.14	1.43
There is a visible supply chain	4.12	1.37
There is a high product customization level	4.18	1.35

In relation to the *Procurement* process, it appears that the *Cooperation and relationship with suppliers* has the highest median value, followed closely by *Raw material buying process are looking the best price*. Note that in this dimension interquartile ranges have all values above the unit, indicating a high dispersion in assessments from responders.

In relation to *Inventory management*, the items that have the highest value in the medium concern inside the company *Deliveries are made using a JIT philosophy* and *There is coordination and inventory management in whole company*, which indicates that just in time (JIT) programs, coordination and materials management throughout the production system are of vital importance for the company. This latent variable is also noted that all values and interquartile ranges in items are greater than one, and even in the latter, which refers *There are automatized warehouse systems* has a value very close to two, which indicates that there were variability by respondents.

Finally, the third dimension refers to Operative performance, is the only one with medium highest than four in all items that integrate it and the most important item concerns is *Deliveries to customers are on time and complete*, that also has the smallest interquartile range.

3.3 Structural equation model

In Figure 2, it was proposed a structural equation model containing three different hypotheses. In Figure 3 appears the solved model using the algorithm explained in the methodology section.

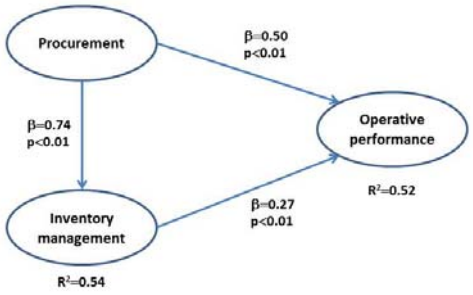

Figure 3: Structural equation model evaluated

In Figure 3 is observed a value for beta and a value for p for each relationship between the latent variables analyzed. Importantly, the beta values are standardized, thus representing an intensity change measured in standard deviations. P values represent the hypothesis test performed to determine if the beta value is zero or not. Also remember that all hypothesis tests were performed with a confidence level of 95%, indicating that the level of significance was only 5%. Accordingly, since all p-values are less than 0.05, we conclude that all relationships are statistically significant.

Similarly in each dependent latent variable appears a value for the R-squared, which is a measure of the dependence between a variable and another. However, it is important to split the value of R-square *Operative performance*, as it is influenced by two variables, the raw materials *Procurement* and *Inventory management*. In this case, the total R-square is 0.52, but 0.35 is from *Inventory management* and 0.17 comes from

Procurement, leading to the conclusion that first variable given its level of influence is much more important.

4. CONCLUSIONS

As mentioned in paragraphs above, based on the values related to relationships between latent variables, we can conclude in relation to the initial hypotheses, but also inferences applicable to the industry can be done, which are described below.

4.1 Conclusions regarding hypothesis

H_1. There is enough statistical evidence to declare that the raw materials *Procurement* has a direct and positive impact on *Inventory management*, because when the first latent variable increases it standard deviation by one unit, the second one goes up in 0.74 units.

H_2. There is enough statistical evidence to declare that the raw materials *Procurement* has a direct and positive impact on *Operative performance* indexes of supply chain, because when the first latent variable increases its standard deviation in one unit, the second one goes up by 0.50 units. However, there is also an indirect effect of two segments that is given through the *Inventory management* process, which is 0.1998 units. Thus, the total effect is 0.6998, indicating a strong relationship between these variables.

H_3. There is enough statistical evidence to declare that Inventory management has a direct and positive impact on *Operative performance* in supply chain, because when the first latent variable increases its standard deviation in one unit, the second one goes up 0.27 units.

4.2 Industrial inferences

Based on conclusion regarding the hypotheses and the statistical results obtained, the following industrial inferences can be done:

1. Depending on the relationships the company has with its suppliers, the ability to supply they have and the level of integration with the manufacturer, the latter must generate a policy for handling materials inventories received.
2. According to univariate statistical analysis, it was found that the most important item in dimension associated with Procurement is the relationship between purchaser and manufacturer, so both should pay attention to it.
3. While the raw material deliveries are made by applying a just in time philosophy, it is important that the manufacturer perform inventory management throughout the production process and not only in storage at the beginning of production process.
4. The company will always make a great effort to deliver production orders on time and complete, and that was the item that received the median with a higher value, and apparently is an index highly valuated by managers.
5. The manufacturer must pay special attention to the raw materials *Procurement* process, since the total effect (sum of direct and indirect effects) is 0.6998, a very high value.

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