International Transport Forum

Supply chain performance measurement in Latin America

Prepared for the Roundtable on
Logistics Development Strategies and their Performance Measurements
(9-10-March 2015, Queretaro)

Gaston CEDILLO
National Council of Science and Technology, Mexico

February 2015

OECD

TABLE OF CONTENTS

INTRODUCTION

According to the International Labor Organization (ILO), the real salaries in Asia between 2000 and 2008 increased almost 1% per year, whereas in China, they increased 10% per year between 2000 and 2005 and 19% between 2005 and 2010. These figures, added to the increasing energy and logistical costs, have damaged the competitive advantages of the Asian Giant as the main manufacturing platform to the West, and initiated a new step to the global hyper-competitiveness, a "*regionalization of the global economy*"

For any industrial organization, controlling operational costs has been a main issue for decades. The transfer of the Lean Manufacturing concepts to the logistics and supply chain area has enabled developing concepts based on efficient operations (Lean Logistics, Lean Supply Chain, etc.). However, nowadays, the increasing volatility of the markets, as well as the variability in demand and the increasing risk of disruptions in the supply flow (either caused by natural disasters or intentionally by men) are driving the design of more agile, cheaper, and above all, more resilient supply chains (Gaonkar and Viswanadham, 2004; Giunipero and Eltantawy, 2004; The White House, 2012; Bueno and Cedillo-Campos, 2014; Cedillo-Campos et al., 2012; Cedillo-Campos et al., 2014a; Cedillo-Campos et al., 2014b). In fact, uncertainty is making companies go from a "*lean*" approach (efficient) to integrated effective solutions in which efficiency is only important when it guarantees a proper level of resilience in the supply chain to face operational unexpected events (Waters, 2007; Wilson, 2007; Wu et al., 2007; Stecke and Kumar, 2009; Thun and Hoening, 2011; Vilko and Hallikas, 2011).

Nowadays, both companies and regions are facing a complex set of ever changing factors that constantly transform their business environment. This situation requires major analytical abilities, a comprehensive perspective when designing a competitive model, and a substantial improvement of their decision-making abilities to respond to the demand. With the increasing globalization, manufacturing companies have standardized, and replicated process with some success almost everywhere companies have decided to settle. However, only a few countries have achieved distinctive capabilities to reach an economical development more based on supply chain, engineering, and continuous innovation than on low-cost labor. With an increasing amount of regions with high manufacturing capabilities, we see today a major global interaction, where supply flows are the key element of the global trade (Notteboom and Rodrigue, 2012; Rodrigue, 2012).

Today, the region is considered as the physical context that facilitates the development of relational strengths and drives the success, innovation, and competitiveness of the industrial operations and services (Marshall, 1961; Storper, 1997; Porter, 1998; Theo and Roelandt, 2000; Li and Cai, 2004). Consequently, the most competitive companies at a global level acknowledge that success is mainly because they are located in regions able to go along with them in their

own competitive challenges (Cedillo-Campos et al., 2006; Cedillo-Campos and Perez-Araos, 2010).

This is why an "*efficient*" (low-cost) answer is no longer considered enough to compete in the current global market. In fact, companies in areas such as hi-tech, automotive industry or aerospace will not only require major logistical innovation within organization, but also a major dexterity and accuracy in decision making from the public agencies. The future of both companies and of the region will always be more interrelated in dynamic interactions that have not until now been properly analyzed (Cedillo-Campos, 2012; Cedillo-Campos and Sanchez, 2013).

Since "*supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request*" (Chopra and Meindl, 2013), to improve supply chain performance measurement in emerging regions as Latin American one is increasingly complex. Since in the Latin American region there are operational risks due to factors like market and financial volatility, quality fade, supply chain disruptions, security issues, infrastructural challenges, and lack of transparency; a systems approach in logistics is needed (Bertalanffy, 1968).

Accordingly, based on literature review, this paper proposes a threefold discussion for improving supply chain performance measurement in the region. First, this paper offers an overview of supply chain performance measurement approaches currently applied in the academic world identifying the most common metrics and methods. Second, it provides a critical analysis and proposes a Latin American perspective when measuring supply chain performance based on logistics costs. Third, it exposes information about an emergent supply chain approach that could be important to integrate as part of a future supply chain performance measurement framework.

This paper is organized as follows. Section 2 exposes a statistical analysis based on a large literature review related to supply chain measurement techniques and attributes, and at the same time, discusses about logistics cost as a Latin American concern when measuring supply chain competitiveness in the region. Section 3 exposes a methodology based on an integral approach to measure logistics cost, that is not correlated to a specific transport mode or supply chain stage, and considers both public and private stakeholders. Section 4 develops a discussion regarding a potential novel supply chain approach that could be part of a renovate supply chain performance measurement framework as well as issues in data availability and coverage with emphasis in the Mexican circumstance. Finally, Section 5 exposes relevant conclusions.

SUPPLY CHAIN PERFORMANCE MEASUREMENT

In 2001, Perchet was already expressing that "*the world economy is now structured according to a double competition: a) the competition between companies that are increasingly globalizing; and b) the competition between the regions that try to attract the best investments.*

The competition between companies keeps on looking for major parts of the world market, so the competition between regions must take into account not only perseveration, but also maximization of the attraction of productive investments, generating major incomes for the region, and must at the same time, develop at least some significant competitive advantages".

From this perspective, based on Chopra and Meindl (2013), the modern concept of supply chain also involves now the region (the local geographic space) where supply chains operate. A territory where local and global supply chains interact building the global value chains. For decades, international trade was based on three main flows: i) exchange flows of manufactured products between industrialized nations; ii) export flows of products from industrialized nations to developing nations; and iii) export flows of raw material and primary goods from developing nations to industrialized ones. However, since offshoring strategies became a critical part of most of the manufacturing business models, nowadays this context is fundamentally different. The geographical dispersion around the globe of different value components of the same value chain, allowed emerging countries to be part of the manufacturing and trading fragments of goods where they did not participate before (Blyde, 2014). Today, according to Accenture (2014), between the success factors achieved by leader companies when operating their supply chains in emerging markets as Latin American, four count with a strong local component:

i) Investments in assets located in the region (plants, supplier basis, etc,);

ii) Service providing from local sites;

iii) Hiring local talent;

iv) Set up a joint venture or partnership with a local organization.

Considering the current Latin American context where companies and regions are in front of the competitive challenge for integrating global supply chains with more local content, local governments are in a fierce battle to attract industrial investments. Still, the question about how local regions can effectively support in the long term the supply chain competitiveness of the different industries remains (beyond the initial fiscal incentives, development of dedicated infrastructures and resources, among others).

Today it is clear that monitoring supply chain performance is critical to transform strategic planning into concrete competitive actions across different entities (companies, public agencies, universities, non-profit organizations, etc.). Nevertheless, to identify the right measurement techniques and attributes when measuring supply chain performance remains a significant challenge.

Measurement techniques and attributes: a global perspective

A measurement technique is here understood as a procedure or set of rules, standards or protocols, which aim to achieve a particular result, whether in the field of science, education or any other activity (Avelar-Sosa et al., 2014). On the other hand, an attribute is understood as a set of metrics used to express a value, which is related to company's competitive strategy. The measurement and control of these attributes must provide direct or indirect feedback information that support a better control of business processes (Chan, 2003; Abu-Suleiman et al., 2004).

Thus, since supply chain is a concept emerged in the business context, currently, most of the measurement techniques take into account industrial attributes leaving aside the territorial component. Thus, Elgazzar et al. (2012) and Chen and Gong (2013) argue that because one of

the main companies' objectives is to compare their own performance with others in the same industry when measuring supply chain performance, measurement should be extended to all supply chain members from a global perspective.

Currently, there two main types of measurements to evaluate the overall performance of companies, which are: i) financial; and ii) operational. The first considers strategic indicators derived from economic and financial outcomes, while the second considers indicators regarding tactical attributes critical for short or mid-term activities. However, authors as Gunasekaran et al. (2001) note that companies do not achieve a balance when measuring these two groups of attributes. It is because, when designing measurement frameworks, managers mainly focused their analytics efforts on financial attributes, and researchers on operational ones. In fact, Bhatnagar and Sohal (2005) highlight that academic literature has tended to emphasize on quantitative factors, and consequently, operational attributes have gained more importance. As a result, it seems that modern approaches to diagnose supply chains should not only include quantitative attributes, but also qualitative ones. Actually, Jiménez and Hernández (2002) have mentioned that to improve measure attributes oriented to planning, material procurement, production and distribution as well as customer service an integrated qualitative and quantitative approach is a need.

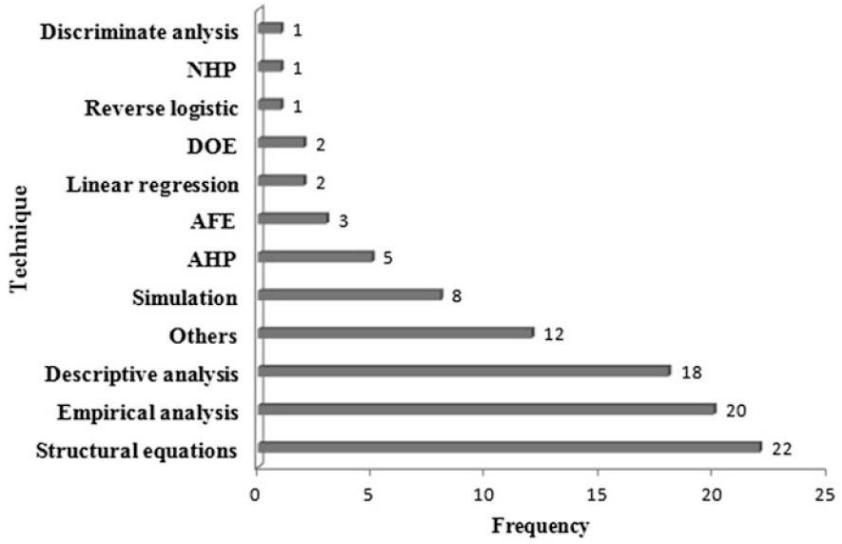
More operationally, modern supply chain literature highlights the importance of complementary attributes of cost (Otto and Kotzab, 2003; Guiffrida and Nagi, 2006), as collaboration among partners (Ramanathan, 2014), globalization (Caniato et al., 2013), risk of disruptions (Cedillo-Campos and Bueno, 2014) carbon food-print (Velázquez-Martínez et al., 2014), corporate social responsibility (Cruz, 2013), among others. Some other authors include local advantages when analyzing supply chain performance (Veltz, 1993; Veltz, 2000; Dzever et al, 2001; Saives, 2002; Bhatnagar et al., 2005; Cedillo-Campos et a., 2006; Cedillo-Campos and Perez-Araos, 2010; Cedillo-Campos and Sanchez, 2013).

Other authors analyzing supply chain performance measurement highlight important attributes as collaboration (Ramanathan and Gunasekaran 2014), environmental management (De Giovanni and Esposito 2012; Perotti et al. 2012), dynamism in the supply chain (Wiengarten et al. 2012), responsibility and partnership (Gallear et al. 2012).

In that sense, based in a large literature review and laborious statistical analysis, that involved 95 scientific articles published from 2000 to 2012, Avelar-Sosa et al. (2014) identified the main techniques used when measuring supply chain performance. The study found that multivariate analysis was the most widely technique used by 30 references during the last 13 years. Case study was the second most used technique by 29 research works in different industrial sectors. Other quantitative techniques based on mathematical models, multi-criteria approaches, intelligent systems as neuronal networks or genetic algorithms, and six sigma were identified.

Concerning multivariate techniques, structural equation modeling (SEM) was the most used (see Figure 1). This technique allows researchers to find causal relationships among latent variables. In fact, SEM is used by researchers because of its capacity to isolate observational error from measurement of latent variables. On the other hand, regarding the case study technique based on empirical analysis of different sectors, the main advantage argued by researchers who used this technique was its flexibility to perform comparisons among companies, as well as an in deep analysis of the real operational context.

Figure 1. Multivariate techniques Avelar-Sosa et al. (2014)



Even if there is a number of analysis in supply chain measurement where only one technique is used, the number of studies using hybrid techniques to better understand the topic is increasing. Currently, academic documents as well as practitioner reports agree that cost still the main attribute when measuring supply chain performance, however, quality, service, reliability and lead-time are now critical elements to be considered (Accenture, 2014; Hausman et al., 2013).

Other commonly used attributes are, delivery time, fulfillment rate, perfect order, information transparency, but other attributes as risk or reliability are starting to be considered as key elements for measuring global supply chains. Furthermore, there are other attributes related to how green the supply chain activities are, as well as agility and innovation involved in the operations management.

A Latin American perspective: the logistics cost

As mentioned above, logistics costs are an important part of supply chains. However, they are not the unique component. It is probably because Latin American countries face important challenges in terms of lack of logistics infrastructure, trade facilitation agility including customs procedures, transparent market regulations, supply chain security as well as efficiency and quality of logistics services, measurement perspective, still based on logistics costs. In fact, challenges exposed above are causing not only important costs to regular operations, but also over costs by creating a lack of coordination, inefficiencies in the export and import processes, and inappropriate public policies. In that sense, the supply chain concept as an opportunity for improving economic competitiveness is taking time to arrive to the region. Furthermore, as mentioned before, since supply chain is a concept emerged from the business world, a delay is foreseen in its adoption in less industrialized countries (since a less dynamic government-industry interaction), as an integral part of the public policies for improving national competitiveness.

Actually, as Pérez-Salas et al. (2014a) argue, in the region logistics costs represent a high percentage of the total value of products. For example, for tomato exports in Central America, logistics costs represent 49% of their total value while its price at the farm accounts only for

31% of the total cost. Thus, González et al. (2008) provide evidence concerning the critical impacts of logistics cost on competitiveness, regional development, and poverty levels in the Latin American region.

Since logistics costs are defined as resources required for moving goods from an origin to a point of consumption, they involve a spatial dimension as well as a temporal dimension. The first is associated to transport and warehouse activities. The second is associated to process as inventory, dead times for loading and unloading operations, stock-out costs, and the variability of lead-times.

According to Pérez-Salas et al. (2014a), there are two main approaches in the literature to measure logistics costs: i) a macro-economic perspective, and ii) a micro-economic perspective. The macroeconomic methodologies aim to determine the logistics performance of a country based on the global estimation of its logistics systems and its relative importance with respect to the country's productivity and its competitiveness. In most of the Latin American countries, those studies are currently been part of the basis to design and operate their public policies and investment decisions. At the same time, due to a lack of reliable national entities measuring logistics cost, strategic decision-making in private sector are also based on this approach.

Macro-economic methodologies are mainly based on descriptive tools (qualitative approach) and econometric methods (quantitative approach), where the variables do not necessarily include all of those involved in the total logistics cost, but represent general estimations of national logistics performance. For doing this, primary and secondary information sources are employed.

One of the main advantages offered by current macro-economic approaches is the availability of indicators that are critical in decision-making. However, since this type of analysis deal with aggregated data, and there is, for instance, a lack in product differentiation (bulk products, perishable items, dangerous cargo, etc.), then, specific logistics requirements of products are not properly considered. Furthermore, the specific operational characteristics related to every industry are not sufficiently taken into account. As a result, distortions related to the real costs of operations and times involved are part of those studies. On the other hand, micro-economic studies involving total cost of ownership are the most common analysis supporting enterprises decision making in Latin America. Those studies are mostly used when selecting suppliers or identifying opportunities for collaboration in design, planning and fulfillment. Since they are performed from a business perspective, most of them do not take into account induced cost derived of all public services inefficiencies. Consequently, an integral vision of logistics cost is needed

AN INTEGRAL APPROACH FOR LATIN AMERICA

Based on Pérez-Salas et al. (2014a), this section presents an integral approach to measure logistics cost. This methodology was already used in countries as Bolivia and Paraguay (Pérez-Salas et al. (2014b). In fact, United Nations - Economic Commission for Latin America and the

Caribbean (UN-ECLAC) is promoting an integral framework when analyzing every trade processes, identifying the potential inefficiencies, in terms of time and costs involved. This analysis is not correlated to a specific transport mode or supply chain stage, and considers both public and private stakeholders. The proposed framework is structured in three steps that are further described.

Definition of the scope of the study and selection of the logistics chains

Identification of the most relevant logistics chains

This activity consists in the analysis of the export and import transactions of the country under analysis, with the aim to determine a set of representative logistics chains to be include in the study. This considers the identification of logistics chains and modeling the main process and stakeholders involved, as well as the main transport corridors used to transport cargo. Historical data of trade volumes and the coverage of the transport modes that are more frequently used for each logistics chain are an important basis for this analysis.

Regarding export transactions, the analysis should consider those logistics costs from the origin of the product (i.e. at the farm) to the point of consumption. Related to import transactions, the analysis should consider since the product arrives to the point of origin until it arrives to the warehouse of the importer.

Selection of logistics chains

It consists in the identification and selection of the main logistics chains based on a multicriteria analysis. For this and as a first step, a pre-selection of the most relevant logistics chains is performed. Then, criteria to select a set of logistics chains are defined. Criteria to be considered could be the relative importance of each productive sector with respect to trade volumes, value of the cargo, innovation opportunities, among other criterion that may be important to consider. Finally, based on the relative importance of each criterion, the pre-selected logistics chains are evaluated and those with a higher score are selected.

Definition of costs categories

Costs have to be categorized in order to be measured. Table 1 presents a general categorization of costs that may be used and should be adapted to the specific considerations of each case study.

Table 1. **Cost categories by transport mode and trade** (Pérez-Salas et al., 2014a).

Cost Category	Description
Pre-shipment	Costs related to the activities performed for cargo handling prior to its shipment to its final destination such as: i) packing; ii) labeling; iii) consolidation of cargo and storage of products; and finally, iv) transport of cargo among facilities. It also includes the cost of the activities related to cargo inspection and certifications required by any public agencies.
Shipment to the port of origin	Costs of the land transport from the warehouse of the exporter to the port terminal where it will be transferred.
Port/ Airport/ Border entry	Costs for cargo handling at the port/airport terminal where the cargo will be loaded to a ship. It also includes all the related costs for delays at the gate and within the terminal.
Customs and control agencies	Costs incurred for Customs and other control agencies for the inspection, control and clearance procedures. It also includes those costs incurred for certifications and inspections required by the customer or the country of destination. For the case of road transport, it also includes those costs incurred at the borders.
Shipmet to destination	Costs related to the freight shipment that could be either by road, air or sea. It also considers any other handling costs as well as insurances.
Inventory and Finance	Costs such as in-transit inventory costs as well including those incurred due to waiting times. In addition, supplementary costs that resulted because of delays or lead times variability are considered in this category.

Identification of information sources

It consists in the identification of main information sources both primary and secondary for data gathering. Primary sources of information consider those relevant stakeholders involved in the process either of export or import of each logistics chain. An agenda should be planned, with the dates for interviews and focus group.

Costs, over costs and processes analysis

Development of a logistics processes mapping

This activity consists in the analysis of the export and import processes of each logistics chain under study, with the aim of determining potential impacts that these factors and its regulation have respected to the efficiency of the logistic chains. For this, in-deep interviews should be performed with those stakeholders previously selected of each logistics chain. With the information gathered during the interviews and the secondary information also obtained, a logistics processes map should be designed, such that the main physical and information flows are identified with their corresponding costs. Other techniques such as Business Process Analysis (BPA) to model the process could be also employed.

Costs and over costs analysis

A diagnostic of the current situation of each logistics chain may be elaborated, based on the logistics process mapping. The costs and over costs incurred at each stage of each logistics chain must be identified. For this, a base scenario is determined first, where the costs of the logistics chain are identified under a "normal" operation.

Then, the over costs are determined considering other scenarios that can occur (based on in-field observations and interviews), such as inefficient operations that resulted in additional costs

(i.e. a late arrival of export cargo for the stacking period at a port that resulted in an additional fees for the exporter). Furthermore, costs associated to waiting times or delays in each of the stages of the logistics chain (i.e. waiting times at the gate of the port or at an empty container park). This estimation may be computed according to average observations or probabilities of occurrence.

Logistics inefficiencies analysis

This activity aims to provide a general analysis of the most relevant inefficiencies observed for the logistics chains under study, and current gaps with respect to other economies and best practices. Impacts on the competitiveness of foreign trade at a macro level of those gaps and potential benefits obtained by the reduction or elimination of those over costs observed should be estimated.

Recommendations identified to reduce those gaps should be provided and analyzed with the stakeholders involved in the processes in order to prioritize them and generate a roadmap of the specific actions required to significantly reduce those over costs per product and transport corridor. This process is not proportional to the scale economies of the potential solutions recommended, and is actually a complex process in which political and social variables may be also considered.

Recommendations and proposals for public policies

A summary of the recommendations to improve current export and import processes as well as public policies recommendations should be reported. It is based on the results obtained with the logistics costs analysis, as well as the priorities defined for the specific projects to be implemented and its impacts on national productivity and competitiveness.

Today it is clear that for the average of the Latin American region, to measure and reduce logistics cost is an important first step to be achieved in order to improve their competitiveness. However, in emerging industrialized countries as Brazil and Mexico, even if logistics costs are still a challenge, in order to remain competitive these countries should pass to the next logistics step and should adopt a supply chain paradigm in their public policies.

SUPPLY CHAIN CLUSTERING: THE NEXT LOGISTICS PARADIGM?

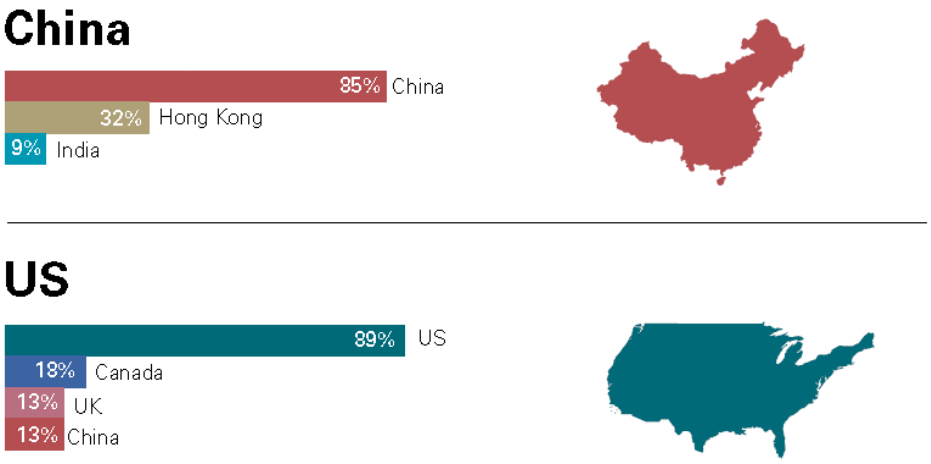
The global-local structure of key industries, as well as the economic losses because of the fierce competition between bordering regions, is providing the incentives to propose more collaborative, efficient, and innovative solutions.

In fact, since the concept of supply chain strongly emerged, the industrial companies try to develop new capabilities to coordinate internally and externally their technical, commercial, and relational dimensions. These dimensions enable them first, to adapte to the current changes and then, to improve their capabilities to react more swiftly to the changing requirements imposed

by the technological change and the final customer. However, these issues are not always identified or not considered as critical by the government agencies focusing on the regional development. As such, a key component of the industrial competitiveness is that the region remains outdated, generating competitive "*losses*" to the company-region system (or interaction between global-local supply chains and the local industrial cluster). In a global economy that moves to increasing complexity, improving the "*synchrony*" of flows will become a key element for both global supply chains as well as for industrial clusters interacting with the local environment to optimize their common competitive opportunities.

On the other hand, mainly because of the risk mitigation strategies in global supply chains, manufacturing is expected to increase, as well as the business interchanges within the limits of the free-trade zone, that is to say, a regionalization of the global economy. This phenomenon is confirmed by the Global Manufacturing Competitiveness Index [30], which highlights the trend of the companies to make regional supply decisions (see Figure 2).

Figure 2. **Percentage of answers regarding supply decision** (Deloitte and U.S. Council on Competitiviness, 2013).



The strategies of "*nearsourcing*" try to reduce costs between 5 to 20% according to estimations done by different consulting companies (GCI, 2008; Deloitte and U.S. Council on Competitiviness, 2013; EIU, 2013). However, although the increasing labor and energy costs represent a critical part, they remain a small part of the total landed costs. The greater added value a product has, the more expensive its components are. As such, regarding products with high added value, the most important costs are not the ones related to labor and energy, but the total costs within the supply chain and the ones related to intellectual property rights. The location of the production plants near their target market and in countries with greater intellectual property rights enables at the same time reducing supply chains and guaranteeing respect of the transactions deriving from patenting innovations.

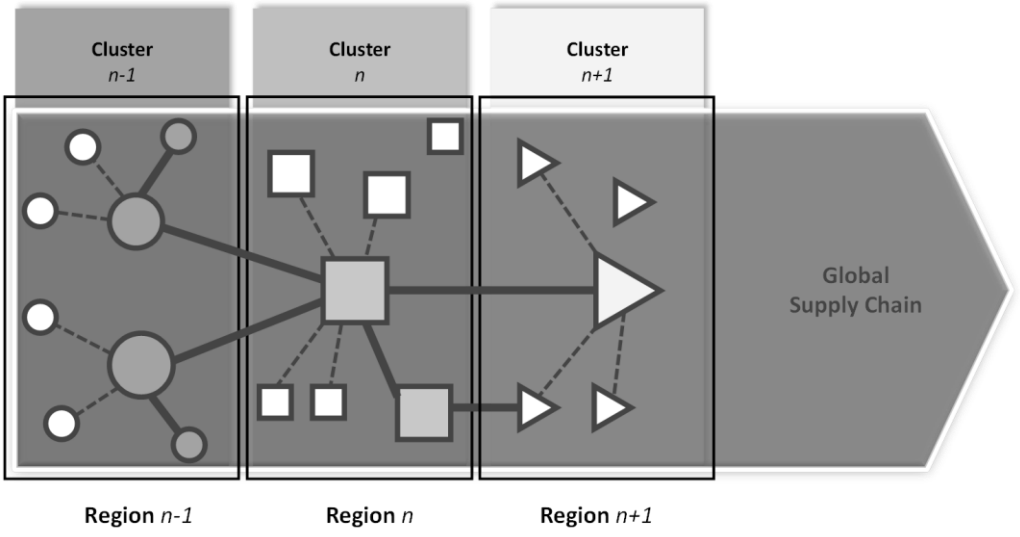
In this sense, because of current industrial changes, it is foreseen that the next logistics frontier would be defined by a competition between industrial clusters and their supply chains operating along the freight transport corridors, more than between the supply chains of individual companies.

This approach is spreading to collaborations every time more related to the region where the company (industrial cluster) is located. This is due to the fact that the company clearly remains in a geographical space in which it is constantly in interaction. Under the influence of the interchanges or transfers of flows between the company and its extern environment (throughout its supply chain), the "*company*" system evolves and its variables (performance indicators) are constantly changing. In fact, while operating in environment of dynamic change, the company develops its operations with a stated "*imbalance*". However, thanks to its capability to keep through time its competitive advantage lined up with its company business model, it could remain a winner in the market.

These interactions between the "*original business model*" of the company and the reality of its economical, industrial and regional environment shape is what Boyer, Freyssenet (2000) define as "*hybridization*". These authors argue that a business model, because of its dynamic interactions with its external environment, evolves up to the point of taking its own personality depending of its local operational environment. This way, the local environment of operation (industrial cluster) influences the competitiveness of the company-region system throughout the flow of processes (global supply chain).

As such, the emergence of new manufacturing regions makes the current manufacturing regions wonder constantly about their abilities to attract and keep investments with high added value. As a result, observing, and understanding the behaviors and evolutions of cutting-edge industrial sector, as well as what other regions are developing to be more attractive is every day more critical. The existence of transversal "*meta-systems*" (global supply chains) enables the collaboration-cooperation, but also the competitiveness between the different industrial clusters where some of the links develop operations (see Figure 3). Therefore, since these industrial "*meta-systems*" called global supply chains ease the comparison of performance between different regions of location through their industrial clusters, a dynamic and transversal analysis approach have become a key element to improve the competitiveness of both the industries as well as of the regions that receive them (Mélèse, 1979, 1990).

Figure 3 **Integrated structure industrial cluster and supply chai**n (Cedillo-Campos, 2012).



Implications of a supply chain clustering approach

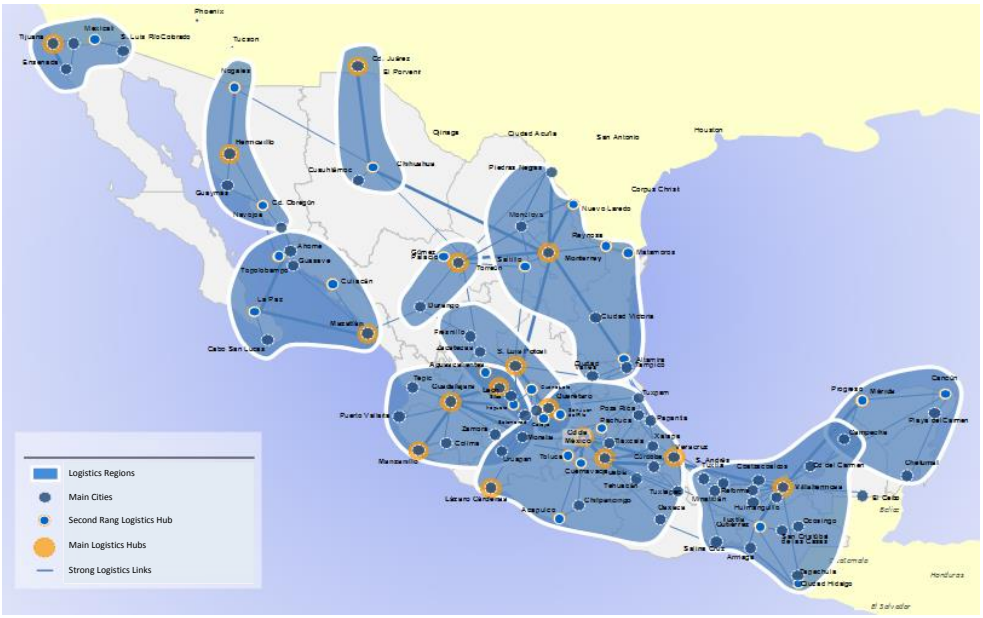
Every day, the industrial manufacture becomes a more global sector. Competition moved from between countries to between companies and their supply chains, and nowadays, between global supply networks and their local components operating inside the regional industrial clusters.

The SCC can be identified when they show three fundamental features: i) physical proximity; ii) common processes, activities, products and/or services to different supply chains operating within a same cluster; and iii) collaboration relations between providers. The supply chain cluster provides opportunities for organizations that try to ease and shorten their supply chain making it more resilient, and as a consequence, more reliable. This implies interacting with partners and resources on a specific region. Companies operating in a supply chain cluster scheme can take advantage of the economies of scale, without being compelled to deal with the inflexibilities of a vertical integration.

In this sense, a supply chain cluster (SCC) is defined as a geographical concentration of processes, activities and/or services that can be put together to add value to one or more supply chains. It mainly focuses on three aspects (see Figure 4):

- **Global-Local integration of flows**. Designing and operating local hubs enabling the global-local integration products, services, and information flows is one of the key factors to the effective development of a SCC. Thanks to a local logistics hub, the members of a SCC become more efficient regarding operation and coordination costs of their global supply chain. At the same time, they boost the cluster's competitiveness, trust, and innovation.
- **Global-Local collaboration network**. In a SCC, most organizations are directly or indirectly related to one or various industrial systems that are close (for example: the automotive industry, the electronic and the aerospace ones are industrial systems highly based on technological innovation as well as on logistical competitiveness for the assembly activities). There is then a relation between companies inside one supply chain, but also a relation of competition-collaboration inside similar companies that collaborate with other supply chains. As such, each member of a SCC can take advantage of economies of scale for buying, financial support, and technological development (with other similar organizations), as well as economies of scope when identifying and satisfying specific niches based on their size and flexibility.
- **Focus on the differentiated competitive advantages**. By introducing a cluster model, Porter (1998) suggested that in the future, the competitive advantages would not be determined by a major efficiency in providing products, but rather by the companies' ability to explore the resources available in the environment they are operating in. By doing so, he suggested that a main competitive advantage could derive through assessing the immediate environment outside the company instead of focusing only on what happens inside the supply chain the company participates. The support service system a SCC can provide enables collaborating more productively in the local development of the inputs which are required by the global supply chain when going through local clusters, as well as access to information and coordination between related companies.

Figure 4 **Potential supply chain clusters in Mexico**, (IDB, 2013).



Since a diversity of the companies can be located in an industrial cluster (see Figure 5), gathering processes, activities and/or services in common to different supply chains, reduce complexity of operations in the cluster and enables mitigating the variability in competitiveness (see Figure 6).

Hence, the regions go through different tensions, derived from the different competitive cycles of each industrial sector located in them. This implies two main challenges for them: a) to ease the productive linking within the cluster, looking for common processes or services that would link the companies without worrying about the industrial system they are in; b) to design a local flow system that would interact with the global flow system.

Considering the integrative role logistics platforms play in the Global-Local flows, they could potentially become the ideal location around which supply chain clusters could be operate (see Figure 7). As such, not only common processes would be integrated to different supply chains, but logistics platforms would also support a reduction in logistics by taking advantage of the economies of scale that intermodal corridors can offer to companies.

Figure 5 **Global supply chains interacting in a local industrial cluster.**

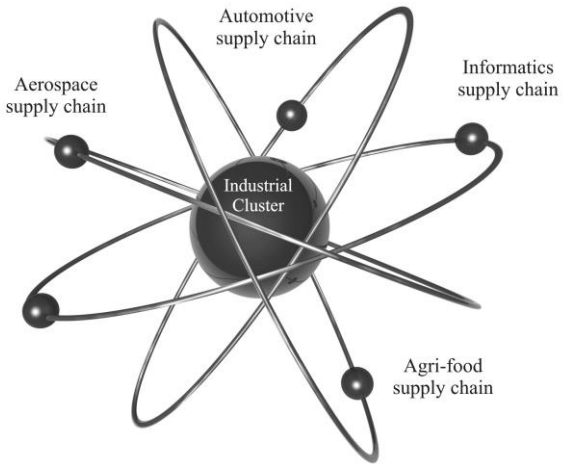


Figure 6 **Competitive variability in the local industrial clusters, induced by the variability of the global supply chains.**

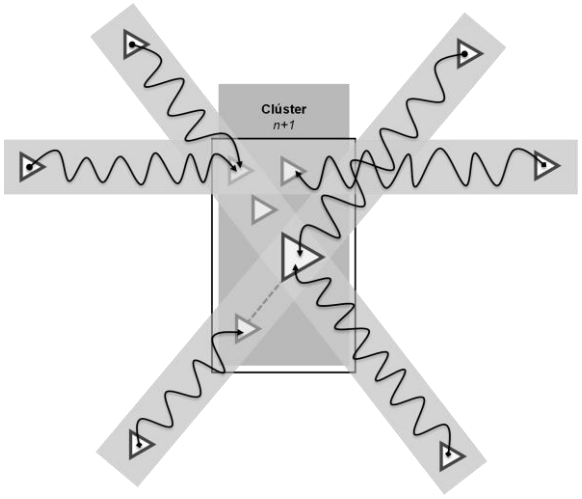
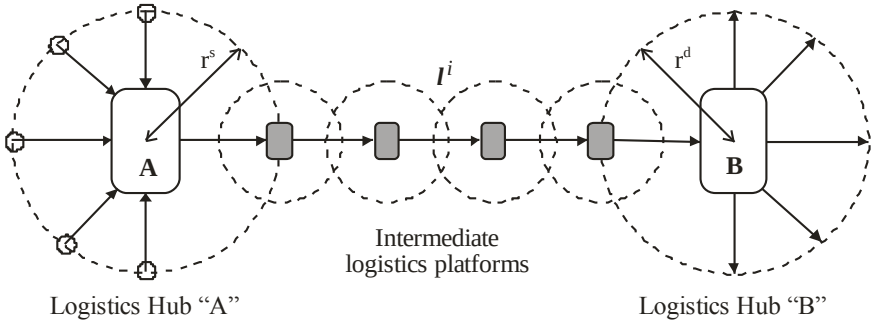


Figure 7 **Logistic platforms as Supply Chain Clustering Hubs.**



Nowadays it is a fact that when a company is looking for an effective global integration of the supply chain, the capabilities of the local environment in which the plant is located can become crucial. In successful SCC such as Silicon Valley, although the companies' supply chain must respond to global requirements, the local capabilities have enabled them not only facing the challenges, but also innovating to propose better responses.

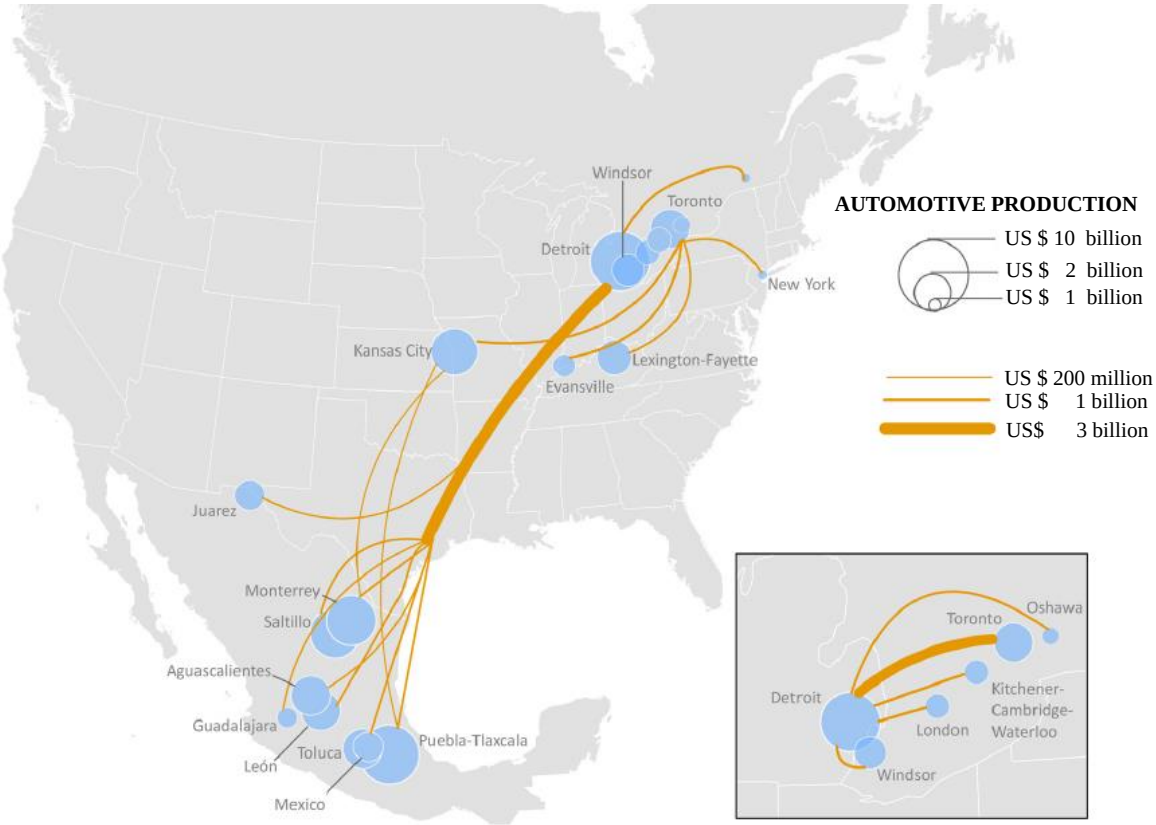
In this sense, and based on the analysis of different cases studied by several authors (De Banville and Chanaron, 1991; Chanaron, and De Banville, 1996; Storper, 1997; Carrie, 2000; Cedillo-Campos, 2001; Theo and Roelandt, 2000; Li and Cai, 2004; Sturgeon et al., 2007; Sanchez et al., 2008; Sturgeon and Biesebroeck, 2010), we could verify that when the industrial cluster and the supply chain approach are integrated in the analysis to build a "*supply chain cluster*", then positive interactions appear:

i. The resources are organized on one specific geographical area, creating opportunities for achieving agility to ease and shorten the supply chains;
ii. The geographical proximity enormously reduces the complexity of the supply chain;
iii. The mutual interdependence and trust are intensified between the companies that are member of the same supply chain. In that sense, regional elements, such as long-term perspective inside the cluster's company improve directly the performance of the supply relationships. An improve interdependence also increases the mutual trust, strengthening the levels of commitment and reducing conflicts;
iv. Motivate and accurately measuring performance of supply chain cluster partners become achievable;
v. Visibility of the processes is improved, thanks to the advantages of the technological, relational, organizational and cultural proximity;
vi. Flexibility increases when supply chain partners are located in the same industrial cluster;
vii. Disruption risk in the supply chain flows is reduced thanks to the gathering and line up of the efforts;
viii. The information is shared faster and more efficiently. The partners of a same cluster promote faster some information about new opportunities;
ix. The feedback cycles are shorter, enabling a faster transformation of the supply chain, creating substantial savings.

Actually, in an integrating process of highly effective providers, the local business environment in which the location is settled becomes crucial to get a sustainable competitive advantage. This is especially true in cases in which the company faces complexity due to dynamic interactions between the local environment and the global pressures from the market.

In fact, a clear example of a supply chain clustering configuration in progress is the automotive supply chains in North America. Over the past two decades, automotive supply chains have been organizing their processes all along the north-south corridor that links different automotive clusters in the NAFTA (North American Free Trade Agreement) zone (Klier and Rubenstein, 2010). Actually, by 2011 Mexico accounted for 31 percent of U.S. motor vehicle parts imports. At the same time, Mexico was the third exporter (it is today the second one) of light vehicles to de U.S. market. This suggest a unique co-production relationship based on supply chain clustering corridors between the two economies (see Figure 8).

Figure 8 **NAFTA supply chain clustering corridors.** Based on Parrilla and Berube (2014).



Thus, accumulations of flows in certain geographic zones along NAFTA's transport corridors are emerging. Those transport corridors are structured along supply chain clusters (SCC) that regulate the flows at the local and regional level. In that sense, NAFTA supply chains clustering corridors could be structured around three main elements:

i) Logistics platforms located along the main transport corridors allowing the use of intermodal technology;

ii) Supply chain clusters organized around logistics platforms, which as control towers regulate freight, and information flows inside their hinterland;

ii) Transport corridors as a "*pipeline*" that not only links supply chain clusters between them, but as platform of services, provide value added logistics services (high technology security services based on tracking and tracing of vehicles, etc).

Thus, given the increasing economic globalization structuring the global network economy, in the future it is very likely that logistics platforms will not only play an important part as modal interchange points by increasing the efficiency of logistical flows or as tools of the territorial development, but also favored points to drive innovation in logistics and supply chain processes. On the other hand, from an information technologies approach, there is an opportunity to pass from enterprise applications software (ERP – Enterprise Resources Planning) to supply chain clusters applications software. Accordingly, technologies responding to a "*real time*" demand will move from an operations management (OM) perspective based on individual companies to a "*4D approach*" that considers at the same time:

i) Optimization of the internal company's operations;

ii) Design and operation of the company's global supply chain;

iii) Coordination of the company's interactions with the local industrial cluster;

iv) Tracking the freight flows and measuring "*supply chain fluidity*" (Eisele et al, 2011)

Data availability and coverage

As Chopra and Meindl (2013) argue, supply chain performance measurement depends on the competitive strategy related to it. Supply chain is not an end in itself. Countries and organizations should define its competitive strategy and then decide what their supply chain strategy ought to be. Thus, the supply chain strategy determines how the supply chain should perform.

Currently, in most of the Latin American countries, there is not a clearly stated national competitive strategy, and consequently, a national supply chain strategy neither. For some public decisions makers, since supply chain is currently an umbrella term for different understanding of the concept, it "*allows*" the application of any performance measurement approach regardless a wide range of methodological considerations. However, if at an academic level, the risks of a wrong measurement are mitigated, since the analyzed problems could be bordered, at the national level, the risk is higher. Based on the Lord Kelvin's paradigm, if we only improve what we can measure, incorrect measurement could be transformed in fact in an attack on competitiveness.

In Mexico, a wide variety of supply chain performance measurement studies exists. Most of them are performed by consulting companies with strong supply chain background from the business perspective of the topic. They perform survey studies trying to cover an important information lack on this matter. Thus, important efforts to enlarge data collection in order to achieve reliable studies have been done by them. Nevertheless, even if the growth of digital technologies has enabled companies to collect increasingly massive amounts of data, they require powerful capabilities in statistics and "*Big Data*" technologies to make sense of that data.

Currently, most of the studies performed in Mexico do not clarify a national supply chain strategy or paradigm on what they are based, and no information about the statistical robustness of the studies are exposed and neither discussed. Thus, results do not have a real link with the

national supply chain landscape. Thus, to provide an update to all supply chain actors, reliable and nationally exposed study is becoming challenging.

Hence, it is today clear that this kind of efforts could be performed by/or under supervision of recognized research centers with strong methodological capabilities. For doing this, a clear identification of a national supply chain strategy is needed. Subsequently, under a high-qualified supervision, to define metrics and the method to measure it could be more reliable.

However, regardless of the strategy or strategies adopted for performing those studies, organization performing these types of studies need to provide a rationale for their choices by articulating the expected benefits and weaknesses of any strategy, method, or sample size they choose.

CONCLUSIONS

Through our review of the literature on supply chain performance measurement, a statistical comparison of supply chain techniques and attributes was exposed. The most used methodology is multivariate analysis and the most used technique approach is structural equation. However, it was also notice that hybrid methodologies and combined techniques are widely used to achieve a better understanding when measuring supply chain performance.

At the same time, it was possible to understand that – although there is a number of important studies related to supply chain performance measurement – in many cases only a few attributes are taken into account. The importance of the local factors in building the dynamic competitive advantage of global supply chains is still not fully appreciated.

Thus, implementation of systemic approaches for an efficient supply chain performance measurement has become one of the main challenges to take advantage of business opportunities of globalization. In this regard, logistics costs represent the main challenge and play a key role especially in emerging markets as the Latin American one. In the region, logistics costs currently account for a bigger percentage of the total cost of a product with respect to duties and tariffs.

Furthermore, this document exposed a framework for logistics costs assessment based on an integral vision that differs to the traditional approaches found in the current literature. The proposed framework considers a sequential analysis of the foreign trade processes to identify inefficiencies and over costs. Furthermore, a temporal dimension is also incorporated to the analysis. A systematization of the framework proposed on a long run term can be the base for econometric studies that may be further implemented to validate results.

Finally, this work presented a potential new paradigm called "*Supply Chain Clustering*" that could serve as a tool to identify factors that allow the articulation of dynamic competitiveness. The tendency towards flexible organization in production obliges companies as well as governments to adopt a systemic approach in which supply chain competencies are a strong differentiation factor.

Thus, logistics platforms must be seen as logistical elements that enable mitigating the global variability transmitted by different supply chains to the regions, and then, improve supply chain performance. They should also be considered as a coordination, and innovation element since they enable identifying the "*best logistics practices*" developed by the industrial cluster, which are susceptible of being standardized and propagated as "*local*" standard.

AKNOWLEDGEMENT

The author thanks Flora Hammer for several useful comments that improved this paper.

References

Accenture (2014). Supply Chain Success Factors in Emerging Markets. Washington, USA.

Abu-Suleiman, A., Boardman, B. and Priest, J. (2004). A framework for an integrated Supply Chain Performance Management System. Industrial Engineering research Conference. University of Texas Arlington, Arlington, TX., USA.

Avelar-Sosa, L., García-Alcaraz, J. and Cedillo-Campos, M. (2014). Techniques and attributes used in the supply chain performance measurement. Springer, Germany.

Bhatnagar, R. and Sohal, A. S. (2005). Supply chain competitiveness: Measuring the impact of location factors, uncertainty and manufacturing practices. Technovation, No. 25, Vol. 5, pp. 443–456.

Bertalanffy, L. (1968). General Systems Theory. Development and Applications. George Braziller, New York.

Blyde, J. (2014). Synchronized Factories: Latin America and the Caribbean in the Era of Global Value Chains. Springer, IDB. Washington , DC , USA.

Boyer, R., Freyssenet, M. (2000). Les modèles productifs. La Découverte, Paris.

Bueno, A., Cedillo-Campos, M. (2014). Dynamic impact on global supply chains performance of disruptions propagation produced by terrorist acts. Transportation Research Part E: Logistics and Transportation, Vol. 61, pp. 1-12.

Caniato, F., Golini, R. and Kalchschmidt, M. (2013). The effect of global supply chain configuration on the relationship between supply chain improvement programs and performance. International Journal of Production Economics, No. 143, Vol. 2, 285–293.

Carrie, A. (2000). From integrated enterprises to regional clusters: the changing basis of competition. Computers in Industry, Vol. 42, pp. 289–298.

Cedillo, M. (2001). Reconfiguration de l'espace stratégique des firmes automobiles: Quelles nouvelles implications pour la logistique?. Mémoire de D.E.A. Logistique et Organisations. Centre de Recherche sur le Transport et la Logistique (C.R.E.T.-LOG), Université de la Méditerranée Aix-Marseille II, Aix-en-Provence.

Cedillo-Campos, M., Sanchez, J., Sanchez. C. (2006). The new relational schemas of inter-firms cooperation: the case of the Coahuila automobile cluster in Mexico. International Journal of Automotive Technology and Management (IJATM), Vol. 6, No. 4, pp. 406-418.

Cedillo-Campos, M. and Perez-Araos, A. (2010). Hybrid supply chains in emerging markets: the case of the Mexican auto industry. South African Journal of Industrial Engineering, May, Vol. 21, No.1, pp. 193-206.

Cedillo-Campos, M. (2012). Supply Chain Clustering: the next step of industrial competitiveness. Council of Supply Chain Management Professionals Conference, CSCMP-Roundtable Mexico. Mexico City, Mexico.

Cedillo-Campos, M., Gonzalez, R., Jimenez, E., Bueno, A. (2012). Designing supply chains under security threat: the first national exploratory survey in Mexico. Technical Report to the Secretariat of Commerce and National Council of Science and Technology, México (in Spanish). <http://www.elogistica.economia.gob.mx/swb/work/models/elogistica/Resource/3/1/images/2011_Evaluacion_del_Riesgo_en_las_Cadenas_de_Suministro.pdf> (Consulted: 10.05.2014).

Cedillo-Campos, M. and Sanchez, C. (2013). Dynamic Self-Assessment of Supply Chains Performance: an Emerging Market Approach. Journal of Applied Research & Technology, JART, Vol. 11, No. 3, pp. 338-347.

Cedillo-Campos, M., Sanchez, C., Vadali, S., Villa, J. and Menezes, M. (2014a). Supply chain dynamics and the "cross-border effect": The U.S.–Mexican border's case. Computers and Industrial Engineering, Vol. 72, June, pp. 261–273.

Cedillo-Campos, M., Bueno, A., Gonzalez, R., Jimenez, E., Perez, G. (2014b). Dynamic impact on global supply chains performance caused by criminal disruptions. Journal of Applied Research & Technology, Vol. 12, No. 4, pages 684-694.

Chan, F. T. S. (2003). Performance measurement in a Supply Chain. International Journal Advanced Manufacturing of Technology, Vol. 21, pp. 534–548.

Chanaron, J., De Banville, E. (1996). Inter-Firm Relations in Alternative Industrial Models In : Coping with variety. Chanaron, J.,Fujimoto, T., Lung, Y., Raff, D., Oxford University Press, Oxford.

Chen, T. and Gong, X. (2013). Performance evaluation of a supply chain network. Procedia Computer Science, No. 17, pp. 1003–1009.

Chopra, S. and Meindl, P. (2013). Supply chain management: Strategy, planning, and operations. 5th edition, Pearson-Prentice Hall.

Cruz, J. M. (2013). Modeling the relationship of globalized supply chains and corporate social responsibility. Journal of Cleaner Production, Vol. 56, October, pp. 73–85.

De Banville E., Chanaron, J. (1991). Vers un système automobile européen. Economica, Paris.

De Giovanni, P. and Esposito Vinzi, V. (2012). Covariance versus component-based estimations of performance in green supply chain management. International Journal of Production Economics, No. 135, Vo. 2, pp. 907–916.

Deloitte, U.S. Council on Competitiveness (2013). Global Manufacturing Competitiveness Index. Deloitte Global Services Limited.

Dzever, S., Merdji, M., and Saives, A.L. (2001). Purchase decision making and buyer-seller relationship development in the French food processing industry, Supply Chain Management: An International Journal, Vol. 6, No. 5, pp. 216-229.

EIU - Economist Intelligence Unit (2013). Global Manufacturing Outlook, KPMG International.

Eisele, W., Tardif, L.-P., Villa, J., Schrank, D., and Lomax, T. (2011). Developing and Applying Fluidity Performance Indicators in Canada to Evaluate International and Multimodal Freight System Efficiency. Transportation Research Board 90th Annual Meeting, Washington, U.S.A.

Elgazzar, S. H., Tipi, N. S., Hubbard, N. J., and Leach, D. Z. (2012). Linking supply chain processes' performance to a company's financial strategic objectives. European Journal of Operational Research, No. 223, Vol. 1, pp. 276–289.

Gallear, D., Ghobadian, A. and Chen, W. (2012). Corporate responsibility, supply chain partnership and performance: An empirical examination. International Journal of Production Economics, No. 140, Vol. 1, pp. 83–91.

Gaonkar, R. and Viswanadham, N. (2004). A conceptual and analytical framework for the management of risk in supply chains. Proceedings, ICRA, IEEE, International Conference on Robotics and Automation, Vol. 3, pp. 2699–2704.

Giunipero, L.C. and Eltantawy, R.A. (2004). Securing the upstream supply chain: a risk management approach. International Journal of Physical Distribution & Logistics Management, Vol. 9, No. 34, pp. 698–713.

GCI - Global Commerce Initiative (2008). 2016 Future supply chain. Capgemini.

González, J. A., Guash, J, L. and Srebrisky, T. (200(9. Improving Logistics Costs for Transportation and Trade Facilitation. Policy and Research Working Paper 4558, The World Bank, Washington D.C., USA.

Guiffrida, A. L. and Nagi, R. (2006). Cost characterizations of supply chain delivery performance. International Journal of Production Economics, No. 102, Vol. 1, pp. 22–36.

Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001). Performance measures and metrics in a supply chain environment. International Journal of Operations and Production Management, No. 21, Vol. 1-2, pp. 71–87.

Hausman, W., Lee, H., and Subramanian, U. (2013). Impact of logistics performance on trade. Production and Operations Management, Volume 22, Issue 2, pp. 236–252.

IDB – Inter American Development Bank (2013). National System of Logistics Platforms in Mexico. In Spanish. Secretariat of Transportation and Communications and Secretariat of Economy, Mexico.

Jiménez J. E. and Hernández, S. (2002). Conceptual framework of the supply chain: A new logistics focus (Technique Publication No. 215). Mexican Institute of Transport, Sanfandila, Querétaro, Mexico.

Klier, T. and Rubenstein, J. (2010). The changing geography of North American motor vehicle production. Cambridge Journal of Regions, Economy and Society, Vol. 3, No. 3, pp. 335-347.

Li J. and Cai G. (2004). Study on the frame of supply chain system based on cluster. Science Research Management, Vol. 3, pp.77–82.

Marshall, A. (1961). Principles of economics. Cambridge : Cambridge Univ. Press.

Mélèse, J. (1990). Approches systémiques des organisations. Les Editions d'Organisation, Paris.

Mélèse, J. (1979). L'analyse modulaire des systèmes de gestion. Editions Hommes et Techniques, Paris.

Notteboom, T. and J-P Rodrigue (2012). The Corporate Geography of Global Container Terminal Operators, Maritime Policy and Management, Vol. 39, No. 3, pp. 249-279.

Otto, A. and Kotzab, H. (2003). Does supply chain management really pay? Six perspectives to measure the performance of managing a supply chain. European Journal of Operational Research, No. 144, Vol. 2, pp. 306–320.

Parilla, J. and Berube, A. (2014). Metro North America. The Brookings Institution, U.S.A.

Perchet, D. (2001). Sept interrogations autour des systèmes productifs locaux. In : DATAR (Coord.). Réseaux d'entreprises et territoires. Regards sur les systèmes productifs locaux. La Documentation Française, Paris.

Pérez-Salas, G., Cedillo-Campos, M., and González-Ramírez, R. (2014a). A holistic approach for measuring the international logistics costs. International Congress on Logistics and Supply Chain [CiLOG], Mexican Logistics and Supply Chain Association [AML], Huixquilucan, Mexico.

Pérez-Salas, G., Sánches, R.J. and Wilsmeier, G. (2014b). Status of Implementation of the Almaty Programme of Action in South America, ECLAC, Natural Resources and Infrastructure, [Online], Series No. 167, [12 November of 2014]. Available at: http://www.cepal.org/publicaciones/xml/0/53920/StatusofImplementation.pdf

Perotti, S., Zorzini, M., Cagno, E., & Micheli, G. J. L. (2012). Green supply chain practices and company performance: the case of 3PLs in Italy. International Journal of Physical Distribution and Logistics Management, No. 42, Vol. 7, pp. 640–672.

Porter M E. (1998). Clusters and new economics of competition. Harvard Business Review, Vol. 76, No. 6, pp. 77–90.

Ramanathan, U. and Gunasekaran, A. (2014). Supply chain collaboration: Impact of success in long-term partnerships. International Journal of Production Economics, No. 147 (Part B), pp. 252–259.

Ramanathan, U. (2014). Performance of supply chain collaboration—a simulation study. Expert Systems with Applications, No. 41, Vol. 1, pp. 210–220.

Rodrigue, J-P (2012). The Geography of Global Supply Chains: Evidence from Third Party Logistics. Journal of Supply Chain Management, Special Issue on "Global Sourcing: Other Voices", Vol. 48, No. 3, pp. 15-23.

Saives, A.L. (2002). Territoire et compétitivité de l'entreprise. Editions L'Harmattan.

Sánchez, C., Cedillo-Campos, M., Perez, P., and Martinez, J. (2011). Global economic crisis and Mexican automotive suppliers: Impacts on labor capital. Simulation, 87, 711–725. Transactions of the Society for Modeling and Simulation International, August.

Stecke, K.E. and Kumar, S. (2009). Sources of supply chain disruptions, factors that breed Vulnerability, and mitigating strategies. Journal of Marketing Channels, Vol. 3, No. 16, pp.193–226.

Storper, M. (1997). The Regional World: Territorial Development in a Global Economy, Guliford Press, New York, NY.

Sturgeon, T., Biesebroeck, V. and Gereffi, G. (2007). Prospect for Canada in the NAFTA Automotive Industry: A Global Value Chain Analysis. Industry Canada, Research Report.

Sturgeon, T. and Biesebroeck, V. (2010). Effects of the crisis on the automotive industry in developing countries: a global value chain perspective. Report Number: WPS5330, The World Bank.

The White House (2012). National Strategy for Global Supply Chain Security. Washington, U.S.A.

Theo J. and Roelandt A. (2000). Cluster analysis and cluster-based policy making in OECD countries: An introduction to the theme. Boosting Innovation : the Cluster Approach. OECD Proceeding, Paris.

Thun, J.H. and Hoening, D. (2011). An empirical analysis of supply chain risk management in the German automotive industry. International Journal of Production Economics, Vol. 131, pp. 242–249.

Velázquez-Martínez, J., Fransoo, J., Blanco, E., and Mora-Vargas, J. (2014). The impact of carbón footprinting aggregation on realizing emissions reduction targets. Flexible Services and Manufacturing Journal, June, Volume 26, Issue 1-2, pp 196-220.

Veltz, P. (1993). Logiques d'entreprise et territoires: Les nouvelles règles du jeu, in: Savy, Michel and Veltz, Pierre (eds), Les nouveaux espaces de l'entreprise, DATAR-Editions de l'aube.

Veltz, P. (2000). Le nouveau monde industriel. Gallimart, Paris, France.

Vilko, J. and Hallikas, J. (2011). Risk assessment in multimodal supply chains. International Journal of Production Economics, Vol. 140, No. 2, December, pp. 586–595.

Waters, D. (2007). Supply Chain Risk Management: Vulnerability and Resilience in Logistics. Kogan Page Limited, Philadelphia, ISBN-13:978-0-7494-4854-7.

Wiengarten, F., Pagell, M. and Fynes, B. (2012). Supply chain environmental investments in dynamic industries: Comparing investment and performance differences with static industries. International Journal of Production Economics, No. 135, Vol. 2, pp. 541–551.

Wilson, M.C. (2007). The impact of transportation disruptions on supply chain performance. Transportation Research Part E: Logistics and Transportation, Vol. 43, pp. 295–320.

Wu, T., Blackhurst, J., and O'Grady, P. (2007). Methodology for supply chain disruption analysis. International Journal of Production Research, 45 (7), pp. 1665–1682.