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A Model for SCM Analysis and Its Application

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Abstract

During the last decade supply chains have become a new arena for business competition, and Supply Chain Management (SCM) has emerged as a new forefront for pursuing competitive advantage in many industrial segments. Consequently, an adequate approach for managing the supply chain has become imperative for business success in many marketplaces worldwide. One useful and fast way to achieve this purpose is through the use of models that can support an effective SCM analysis. This article fulfills this objective. It provides a model that systematizes the analysis of SCM configurations and presents its application to the automotive industry. The proposed model should function as a guide to help its users to understand (1) how supply chains of manufacturing products generate competitive advantage and (2) if the actual SCM configurations meet and support companies' corporate interests. The model has been applied to four supply chains of an European Auto maker. Results have indicated that although these selected supply chains target the production of the same vehicle model, they have distinctive SCM configurations. Most of these configurations yielded a high developmental stage of SCM in the immediate supply chain of the auto maker, mainly in the case of highly valued suppliers (for instance, the one responsible for modules). The SCM developmental stage beyond this link is still incipient and limited to just one of the analyzed supply chains. These results indicate that the theory behind SCM is still far from outreaching the complete supply chain, mostly if the target is the total integration of the supply chain.

Keywords: Supply Chain Management, Supply Chain Analysis, Automotive Industry.

Introduction

The 90's have often been viewed as the decade of market globalization, shorter product life cycles, and the disintegration of many industries, facts that increased competition among companies and that resulted in a race to improve supply chains (Lee, 2001). Such a race established a new competition logic where the potential to generate competitive advantages is no longer limited to a single company or business unit, but is extended to many other companies that take part in the same supply chain (Pires, 1998).

To be successful in the supply chain competition logic, the integration and optimization of the main processes across a chain should be achieved under a Supply Chain Management (SCM) perspective. Many companies have been discovering that effective SCM is the next step they need to take to increase profits and market share (Simchi-Levi et al., 2000).

Taking these facts in consideration, this paper aims to present a model for SCM analysis and to apply it to the automotive industry. Within a SCM perspective, the model systematizes the analysis of relevant elements involved in supply chains, called here SCM configurations. To apply it to the automotive industry, first, the study analyzes the automotive industry as an industrial segment and, then, it selects the supply chains responsible for the creation, production, and distribution of an European Auto maker to apply the model.

The paper is organized in six main sections, being the present introduction the first. The second section describes the scientific methodology adopted in the paper. The third presents a literature review of the relevant elements for a SCM analysis. The model for SCM analysis with its eight steps is presented in the fourth section, while its application is developed in the fifth. The last section closes the paper and addresses the main conclusions.

Methodology

Methodologically, this research has been inspired by the Discovery Oriented Approach adopted by Menon et al. (1999). The Discovery Oriented Approach consists of three dimensions: (1) an academic one, based on secondary data, whose main goal is to identify and analyze the theoretical concepts related to the theme; (2) an industrial dimension, based on primary data, whose main goal is to identify and analyze the practical concepts related to the theme; and (3) an authoritative dimension based on the authors' own knowledge, which has been construed by the analysis of the first two dimensions and the data collected.

A preliminary version of the model for SCM analysis has been developed in the light of an academic dimension. Specifically, the academic dimension emerged from a survey of the available literature on SCM and its related research areas in international journals and books. To refine the preliminary framework, non-structured interviews with SCM practitioners and experts were conducted. All the respondents were interviewed at least three times in different phases of the model's development and improvement processes.

The first interviews took place just after the establishment of the preliminary model. Some of the interviews were conducted individually, while others were carried out during meetings with at least two respondents. The results of the interviews and their influence on the SCM analytical model were shared with all respondents involved in the research. Each new interview started from the most recent version of the model. This interactive process was conducted during a period of three months, when a final version for the model emerged and was validated by all the SCM practitioners and experts involved in the research.

We selected the automotive industry as our focal segment due to the following facts: it has pioneered the development and implementation of many new management concepts and philosophies (e.g. SCM, Total Quality Management, and Lean Manufacturing); it has complex and global supply chains; and it has high impact on the world's economy. The model was applied to the four supply chains of the same vehicle model (here labeled ß Model) produced by a European Vehicle Manufacturer (here labeled XYZ).

The methodological approach adopted for the case study involved four supply chains of the ß Model and conjugated the academic and industrial dimensions. To gather primary and secondary data, we used XYZ's internal documents; journals, papers and reports about XYZ and its ß Model; direct and indirect observations of XYZ plants and their supplier parks; and non-structured, semi-structured, and structured interviews with XYZ employees and SCM consultants involved in XYZ projects. These procedures allowed us to prepare, validate, and apply the model to the case study, involving all the supply chains of the ß Model.

Because most data were collected by non-structured and semi-structured interviews, a qualitative analysis was undertaken for the XYZ case study. The data collected by structured interviews were quantified, but the sample was not significant for a statistic analysis. We chose these data analysis procedures because we preferred to conduct a few interviews with lengthy, deep, interactive, and more reliable answers than many with superficial information. The total number of respondents was twelve (n=12): five of them were consultants who were acting in XYZ projects; and seven were high-ranked managers and directors who have been working for XYZ for many years, in many different assignments (logistics, production planning, control and quality, and marketing).

Literature Review

The introduction or consolidation of a SCM philosophy is essential for the achievement of supply chain competitive advantage. Though there are many definitions for SCM in the literature, we do not intent to exhaust all the main existing ones. Instead, we would like to list the main definitions that reflect our comprehension of SCM.

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The term "supply chain" refers to the sequence of activities conducted within the organization itself, to the group of suppliers that deliver goods and services to the organization, and to both of them, coupled with the organization's customers (Lamming, 2000).

The supply chain can be classified as internal, immediate (or direct), and total (Slack, 1992). The internal supply chain consists of departments, cells or operation sectors that are internal to a firm or a business unit, that is, a single organization. The immediate supply chain consists of suppliers and customers who are in direct contact with the operation of a single organization. The total supply chain consists of all the organizations that are involved with the creation, production, and distribution of a specific product.

There are also other classifications in the literature that are similar to the one described in Slack (1992). Simchi-Levi et al. (2000), for instance, classify supply chains as basic, extended, and ultimate. A basic supply chain consists of a company, an immediate supplier, and an immediate customer. An extended supply chain includes suppliers of the immediate supplier and customers of the immediate customer. The ultimate supply chain is defined exactly as Slack (1992) defined the total supply chain.

Lambert and Cooper (2000), for their turn, stated that the supply chain structure is the set of firms that participate in a total supply chain, from raw material suppliers to ultimate consumers, as well as the links between these firms.

Simchi-Levi et al. (2000) defined SCM as "a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements".

Handfield and Nichols (1999) defined SCM as "the integration of all activities associated with the flow and transformation of goods from raw material to the end user, as well as associated with information flows, by means of improved supply chain relations, to achieve a sustainable competitive advantage".

Another definition for SCM is one developed by the Global Supply Chain Forum, a group of non-competing firms that joined a team of academic researchers to improve the theory and practice of SCM. This Forum defines SCM as "the integration of key business processes from end user through original suppliers that provide products, services and information that add value for customers and other stakeholders (Lambert and Cooper, 2000).

We believe that behind all these definitions there are commonalties. All of them highlight that SCM aims at maximizing the benefits obtained by adopting a single entity view of the supply chain rather than a fragmented-in-parts view. They also see SCM's main purpose as to serve end customers more effectively and efficiently, either by reducing costs across the whole supply chain or by enhancing customer value, satisfaction, and profitability, in order words, by providing the whole supply chain with a differential competitive advantage.

The integrated and optimized approach to SCM starts in the internal supply chain. It is impossible to integrate and optimize key business processes beyond the four walls of a business unit (firm), if this business unit has not integrated and optimized its processes inside its own single organization. Internal integration has already been largely achieved by many firms worldwide. Handfield and Nichols (1999) argued that now these firms should not only manage their own single organizations but also be involved in the management of the upstream and downstream connections of their supply chains. Such a broader approach is a response to the need to increase the level of performance of these business units, adapting them to the supply chain logic. Frohlich and Westbrook (2001) demonstrated empirically that a greater degree of supply chain integration is strongly associated with higher levels of performance. Frohlich and Westbrook defined five supply chain strategies under the perspective of the arc of integration between upstream suppliers and downstream customers: inward-facing, periphery-facing, supplier facing, customer-facing, customer-facing, and outward facing. In the inward-facing supply chain strategy, the integration level is very low and companies work as isolated business units, while in the periphery-facing strategy this integration is a little bit broader, but still too low for SCM goals. In the outward-facing strategy the companies develop their activities intensely integrated with the rest of the chain, adopting a complete SCM view, while in the customer facing strategy this integration focuses only on the companies' downstream connections. In the suppliers facing strategy the integration focuses on the companies' upstream connections.

One of the critical issues in SCM is the development of SCM capabilities that allow activities and processes to be integrated throughout the supply chain. To develop them, we need to adapt them to the new logic in competition, providing competitive advantage (Rice and Hoppe, 2001; Lummus et al., 1998). Here, capability is defined as a set of actions that the assets of an organization or business use to create, produce, and commercialize a product (Sanchez et al., 1996). Scavarda and Hamacher (2003) extended this definition to a SCM perspective, defining SCM capability as a set of actions that use the assets of a supply chain to create, produce, and commercialize a product, providing final customers with an essential benefit. It derives from four elements: the coordination and integration of activities and processes in a supply chain; the conjugation of information technologies adopted by the supply chain; the management of its human resources and of external relations among members of the supply chain. These four elements enable the SCM capabilities and are called SCM enablers (Marien, 2000). According to Scavarda and Hamacher (2003), the main SCM capabilities identified in the automotive industry are: co-design, e-commerce, e-procurement, Early Supplier Involvement (ESI), follow design, follow sourcing, global sourcing, In Plant Representatives (IPR), Just in Time (JIT), Just in Sequence (JIS), milk-run, modu-

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larization, supplier parks (industrial condominium and modular consortium), postponement, Quick Response (QR), and Vendor Managed Inventory (VMI).

A second critical factor in SCM management is the set of parameters that influence the development of SCM, such as the main trends in an industrial segment and the development of strategies related to the supply chain of different products. In the supply chain competition logic, companies should move their efforts away from conventional business paradigms, which focus on transaction management and parochial performance metrics, toward strategies that recognize the need to work together across enterprise boundaries to achieve competitive advantage (Ross, 1998). They should also optimize and integrate the processes of the supply chain business and the innovative capabilities that anticipate potential competition and open whole new areas for competition (Ross, 1998).

The literature also provides some models for SCM. Their objective is to help practitioners and researchers to apply and understand SCM. Giannoccaro and Pontrandolgo (2001) and Min and Zhou (2002) provided a literature review of the different existing models for SCM. Among the different models, we can highlight Simchi-Levi et al. (2000) and Lambert and Cooper´s (2000) models. Simchi-Levi et al. (2000) provided an integrative model for SCM to help practitioners as well as researchers to understand what SCM is as well as what its prerequisites and potential effects on business and chain performance are. Lambert and Cooper´s (2000) model for SCM consisted of three interrelated elements: the supply chain structure, the supply chain business processes, and the supply chain managerial variables, by means of which the business processes are managed across the supply chain.

Given the broad spectrum of a supply chain, no model can capture all of its aspects and processes. To shorten the distance between model complexity and reality, authors should define the scope of their supply chain model in such a way that it reflects key real-world dimensions that are not too complicated to be represented (Min and Zhou, 2002). To help practitioners to do so, in the next heading we introduce a model for SCM analysis that incorporates the relevant elements involved in supply chains within a SCM perspective.

A Model for SCM Analysis

This section introduces the model that systematizes the analysis of relevant elements in SCM configurations. After introducing the elements, we describe the steps practitioners should take to apply the model.

The relevant elements in SCM configurations are organized according to the key-questions illustrated in Table 1:

Table 1 – Key-questions of the model for SCM analysis.

Key-question	Comments
I – What *influences the SCM development?*	This influence is normally guided by trends that act in an industrial segment and by corporate strategies/goals in regards to the supply chain.
II – Who *are the relevant actors (supply chain members) that should be involved in the development and implementation of a SCM?*	These members form the supply chain structure (Lambert and Cooper, 2000, and Min and Zhou, 2002).
III – Which *SCM capabilities are developed?*	These capabilities are the group of actions necessary to create, produce and commercialize a product, generating competencies for a chain as a whole under the perspective of the SCM.
IV – How *are the SCM capabilities enabled?*	According to Marien (2000), the SCM enablers are: information technology; process integration; external relationship level; and management of human resources.
V – Where *are the SCM capabilities developed and the SCM enablers present in the supply chain structure?*	This location is focused in links between the firms that form the supply chain structure.
VI – Why *does the supply chain have a given SCM configuration?*	This reason justifies, for instance, the development of certain SCM capabilities in some supply chain links and absence in others.
VII – When *is a given SCM configuration established?*	This question addresses the developmental stage of SCM of a chain (e.g. initial, intermediate, or advance).

It is in order to note that all key-questions are extremely dependent on each other and their answers are strongly connected.

The SCM critical factors bring forth implications that are common to different supply chains in a same industrial segment and implications that are specific to the chains of different products in the same segment. For these reasons, the SCM analysis was first conducted in an industrial segment (IS) and later in selected supply chains of the same industrial segment. Thus, the first four steps of the analytical framework take the case of one industrial segment and the next three steps specifically look at selected supply chains that belong to the same industrial segment. These first seven steps provide the necessary input to generate the SCM configuration for the selected supply chains and to execute the last stage of the framework successfully, the one responsible for the analysis of the SCM itself. Figure 1 illustrates the model for SCM analysis associating its eight steps with the key-questions for SCM relevant elements.

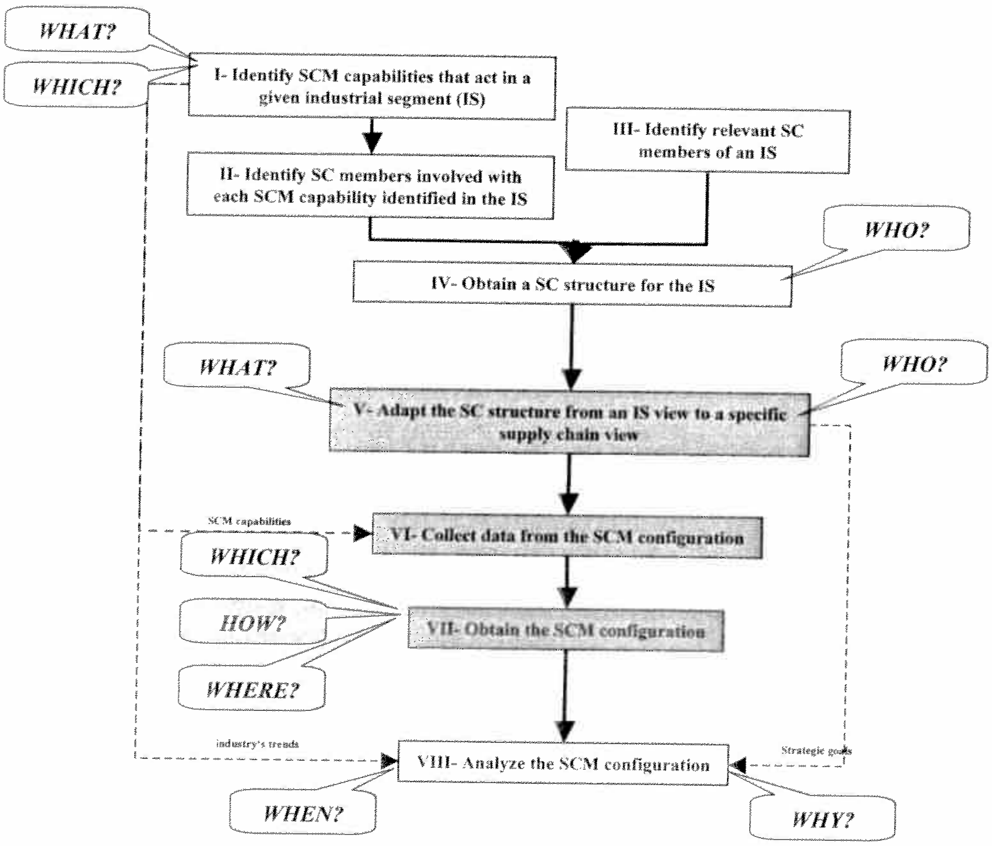

Figure 1 – A model for SCM analysis.

Next, a brief description of each of these steps is provided.

Step I: To identify SCM capabilities that act in a given industrial segment (IS)

First, the trends that impact the supply chain of the industrial segment are identified and then they are analyzed. These procedures allow practitioners to extract related SCM capabilities from the trends. Step one answers key-questions I (what influences SCM development) and III (which SCM capabilities are developed) for a given industrial segment.

Step II: To identify supply chain (SC) members involved with each SCM capability identified in Step I.

The SCM capabilities identified in Step I should be individually analyzed to allow the identification of supply chain members involved in each of these capabilities. These identified members should be considered in the supply chain structure, which is the base for implementing and developing SCM.

Step III: To identify relevant supply chain (SC) members of an industrial segment (IS).

This step consists of a sequence of sub-steps: to define *criteria* to select supply chain members according to their relevance in the supply chain; to define *criteria* that should be

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adopted; and to implement the adopted *criteria* to select the members of a chain. This step can be done simultaneously with steps I and II and is another way of identifying relevant members in the supply chain. The development of this step allows practitioners to compare its results with the ones obtained in Step II, generating data to feed Step IV, the next one.

Step IV: To obtain a supply chain (SC) structure for the industry segment (IS).

The supply chain structure which is valid for an industrial segment emerges from the comparison of members obtained in Step II and III. If there are members that are not coincident, steps I, II and III should be revisited.

All members that belong to this structure should be considered in the development of SCM, procedure that answers Key-question II (who are the relevant actors of a supply chain in a given industrial segment).

Figure 2 is based on Lambert and Cooper (2000) and on Slack (1992). It illustrates a possible structure for the supply chain obtained in Step IV.

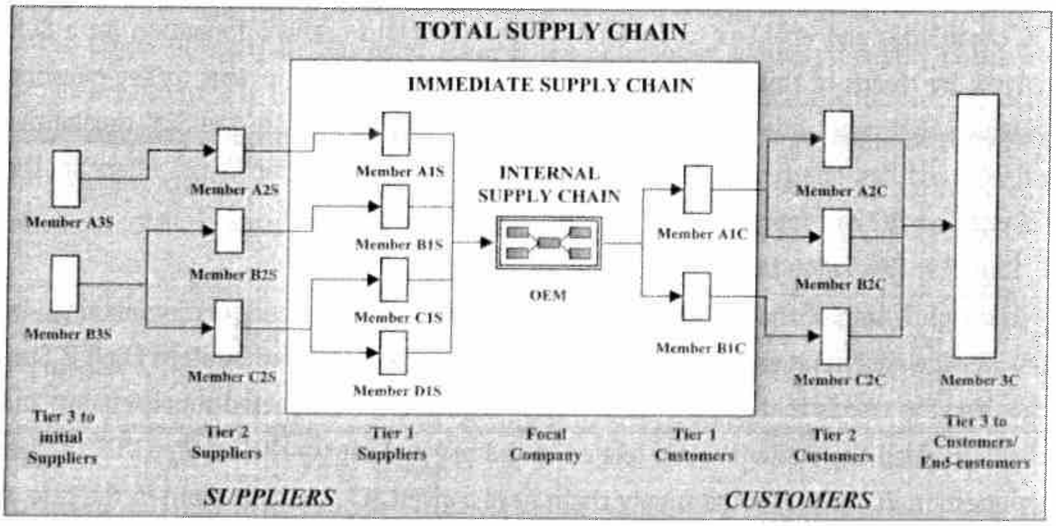

Figure 2 – Supply chain structure for a given industrial segment.

Step V: To adapt the SC structure from an IS view to a specific supply chain view

The fifth step adapts the supply chain structure, valid for a specific industrial segment, to a structure that considers the particularities of selected supply chains, such as the object of this study--the supply chains of the ß Model. In spite of having the same generic structure, different supply chains that belong to the same industrial segment have particularities that should be considered because they influence their own structure.

Step V answers Key-question III (who are the relevant actors in the supply chain) in the case of the selected supply chains. To move away from an industrial segment dimension to a selected supply chain approach, parameters such as the strategic goals of the members

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involved, the location of the relevant members, the market they attend upon, among other information that vary from supply chain to supply chain, should be considered, in the development of SCM. These parameters address Key-question I (what influences the development of SCM) in the case of the selected supply chains. They are important input for Step VIII (SCM configuration analysis).

Step VI: To collect data from the SCM configuration.

The sixth step explains how data related to the SCM configuration should be collected. It is recommended that practitioners observe the following set of procedures: define a data collection method (e.g. non-structured/structured interviews, direct/indirect observation, document analysis); include ways to validate and to confirm information obtained in previous research steps in the research methodology (e.g. the supply chain structure--result of Step V--and the identified SCM capabilities--result of Step I).

Step VII: To obtain the SCM configuration.

The seventh step defines how the different data collected should be associated with the SCM capabilities and enablers to transform rough data into useful information for a SCM analysis. By means of this association, we could provide possible answers to Key-question III (which SCM capabilities are developed), Key-question IV (how are the SCM capabilities enabled), and Key-question V (where are the SCM capabilities developed and where are the SCM enablers in the supply chain structure).

Step VIII: To analyze the SCM configuration.

The eighth step of the framework analyzes the supply chain configuration obtained by Step VII. The analysis is enhanced by additional information obtained by steps I and V. Step I provided the trends that impact the industrial segment of the selected supply chains, and Step V provided the strategic goals related to the selected supply chains. Step VIII answers Key-question VI (why does the supply chain have a given SCM configuration) in the case of the selected supply chains. This key-question justifies, for instance, the development of certain SCM capabilities in some links of the supply chain and their absence in others. Step VIII also allows practitioners to figure out the SCM developmental stage of the selected chains (SCM implemented in the internal, immediate or total supply chain), answering Key-question VII (when is a given SCM configuration established).

The Application of the Model

The present section aims to apply the model for SCM analysis, first in the automotive industry (first four steps of the model) and next in the four supply chains of the ß Model (last four steps of the model). The application used the plants of this vehicle manufacturer as the focal member of their respective supply chains.

The first supply chain analyzed has as its focal member a plant located in Europe (Plant A), which has been producing completely build up (CBU) vehicles since the 1960's. The second supply chain analyzed has also as its focal member a CBU plant located in Europe (Plant B). Plant B has been producing since the mid 80's and was designed to be more flexible than Plant A. The third supply chain analyzed has as its focal member a plant located in an emerging country (Plant C) that has recently moved from the assembly of completely knocked down (CKD) vehicles to the production of CBU vehicles. The focal member of the fourth supply chain is a new plant in Europe (Plant D) that will start its production in 2005. The objective of these four supply chains is to produce the same vehicle model (the ß Model), but they have different characteristics and needs. This particularity constitutes an interesting arena for the analysis of the impacts of the different characteristics and needs on the SCM configurations of each of the four supply chains.

The application of the model was based on the eight steps described earlier in this paper, namely:

Step I: To identify SCM capabilities that act in an industrial segment (IS)

The object of study in this application is the automotive industry's supply chain. An auto maker has usually three kinds of suppliers: the module (or system) suppliers, the component suppliers, and the raw material suppliers. To simplify the application of the model to the supply chains of the ß Model, this study clustered the suppliers, taking them as a unit. Figure 3 illustrates how these different kinds of suppliers can fit in a supply chain.

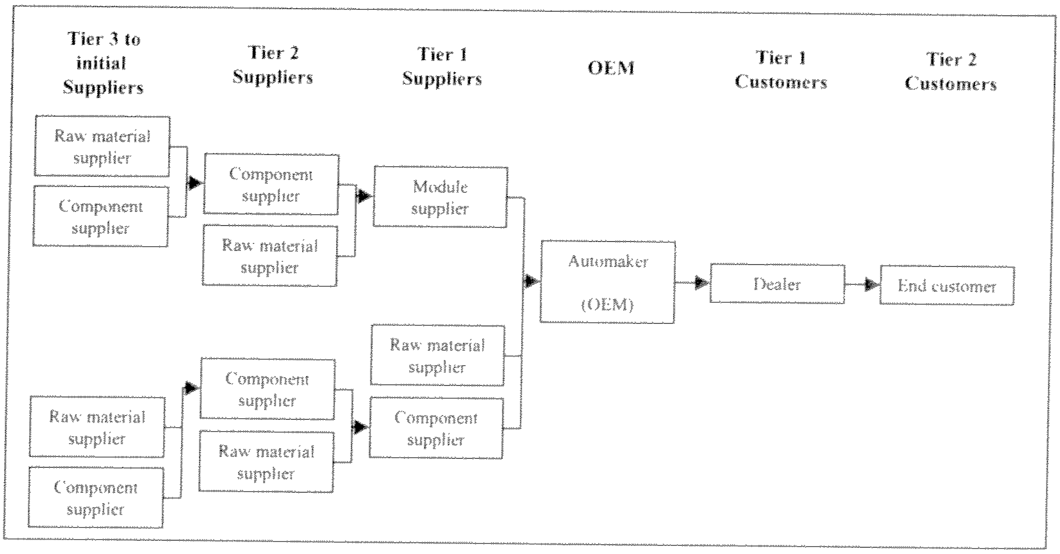

Figure 3 – Tiers of suppliers and customers in the automotive industry's supply chain.

In order to complete Step I, the researchers conducted an explanatory study of the automotive trends to identify the relations between these trends and the SCM capabilities,

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as well as the relations between these capabilities and the members of the supply chain. The trends were classified into the following groups: change of business orientation in the supply chain from push to pull, globalization, outsourcing, reduction in the number of suppliers, and other trends (development of new materials, reduction in the life cycle of the vehicle models, global platforms). Scavarda and Hamacher (2003) connected these trends to each of the respective SCM capabilities and took them as reference to identify the main SCM capabilities developed in the supply chains of the automotive industry.

Step II: To identify members of the supply chain (SC) involved with each SCM capability.

The second step of the model aims at identifying the supply chain members that were involved in the development of each SCM capability identified by Step 1. Step 2 of the framework was based on the literature review and its results are displayed in Table 2. The last line of Table 2 indicates the number of SCM capabilities that are developed by each supply chain member.

Table 3 – Relations between the identified SCM capabilities and supply chain members

	Tier 3 Supplier		Tier 2 Supplier		Tier 1 Supplier			OEM		
	Raw material supplier	Component supplier	Raw material supplier	Component supplier	Raw material supplier	Component supplier	Module supplier	Vehicle assembler	dealer	End Customer
Co-design				x	x	x	x	x		
Esi				x	x	x	x	x		
E-commerce								x	x	x
E-procurement				x		x	x	x		
Follow design						x	x	x		
Follow sourcing						x	x	x		
Global sourcing				x		x	x	x		
JIT						x	x	x		
JIS							x	x		
Milk-run						x		x		
Modularization							x	x		
Supplier park				x		x	x	x		
Quick response								x	x	x
VMI								x	x	
Number of SCM capabilities developed	-	-	-	5	2	9	10	14	3	2

Results in Table 2 indicate that most SCM capabilities have been developed in the immediate chain of the auto makers and that none of them were developed in the 3rd tier of suppliers. This demonstrates that the theory of SCM is still far from reaching the total chain, being in practice still a philosophy limited to some parts of the chain, normally the immediate chain of a focal company.

Step III: To identify relevant members in a supply chain of an industrial segment.

The third step identifies relevant members of a supply chain to compare these members with the ones obtained in Step II and to obtain the supply chain structure for a given industrial segment. To select members according to their relevance in the supply chain, the researchers considered the following criteria, based on the existing literature:

- Cost composition in the supply chain (Dittler and Heidingsfelder, 2000);
- Impact of product/activities on end customers (Lambert et al., 1998);
- Bargain power (Porter, 1980);
- Complexity of supply chain sub-products (Croxton et al., 2001).

From these four criteria, this study adopted just the first two: cost composition in the supply chain and impact of product/activities on end customers. The other criteria were not adopted because their application to the automotive segment is very difficult to measure.

The cost composition criterion of a vehicle can vary much according to its type, for instance, the cost composition of an urban bus is very different from that of a truck or car. As the object of this study is the supply chain of auto-vehicles, we considered the cost composition for a medium sized car, following Dittler and Heidingsfelder (2000), as Table 3 summarizes.

Table 3 – Cost distribution in the supply chain of a medium sized vehicle (cf. Dittler & Heidingsfelder, 2000).

Supply Chain Member	Cost
Tier 1 Customer – Dealers	6,4%
OEM – Vehicle Manufacturers	45,4%
Tier 1 Suppliers – Auto-parts (components + modules)	20,1%
Tier 1 Suppliers – Raw material	7,2%
Tier 2 Suppliers – Auto-parts (components + modules)	7,4%
Tier 2 Suppliers – Raw material	3,7%
Tier 3 Suppliers – Auto-parts (components + modules)	3,4%
Tier 3 Suppliers – Raw material	6,5%
Total	100,0%

The cost distribution criterion allowed us to understand why most SCM capabilities have been developed in the link between the vehicle manufacturer (OEM) and its tier 1 suppliers. According to Table 1, the most relevant members should be vehicle manufacturers; auto parts suppliers (module and component producers) from the first and second tiers; and raw material suppliers from the first tier. Together they are responsible for 79,8% of the total costs in the supply chain. In addition, the product/activities impact on the end customer

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criterion led us to choose the dealers in place of the raw material suppliers of Tier 3, because dealers strongly influence vehicle sales and after sales services.

Step IV: To obtain a supply chain structure for the industrial segment.

To obtain a general supply chain structure for the automotive industry, with its relevant supply chain members, the fourth step of the SCM analytical framework compared the supply chain members selected by the second step with those identified by the third step. As a result of Step IV, the members that take part in the general supply chain and should be considered in the implementation and development of SCM are: Tier 2 and Tier 1 auto-part suppliers, Tier 1 raw-material suppliers, the automaker, the dealers, and the end customer.

Step V: To adapt the SC structure from an IS view to a specific supply chain view.

Once again the association of an academic dimension and an industrial dimension has been undertaken as methodology, combining primary and secondary data. This procedure supported the preparation, validation and application of the case studies that involved four supply chains for the ß Model.

The analysis of the XYZ case indicates the following strategic goals as the most important for the supply chains: to increase the frequency of introduction of new models and the quality of recently launched vehicles; to expand production activities worldwide; and to develop and implement customer-oriented sales and production processes. It is important to emphasize that the supply chain strategic goals relate to traditional strategic goals such as return on investment (ROI) and satisfaction of the stakeholders, among others.

Figure 4 illustrates the first move toward obtaining the supply chains for the ß Model. Interviews with XYZ employees and with consultants who are in and/or joined XYZ projects mentioned that the component suppliers of tier two and the raw material suppliers of tier one are not still considered relevant for the ß Model's supply chain when the target is SCM. The same happens to first tier suppliers of low valued components. The respondents also added the existence of three supplier parks in these supply chains and of one engine plant.

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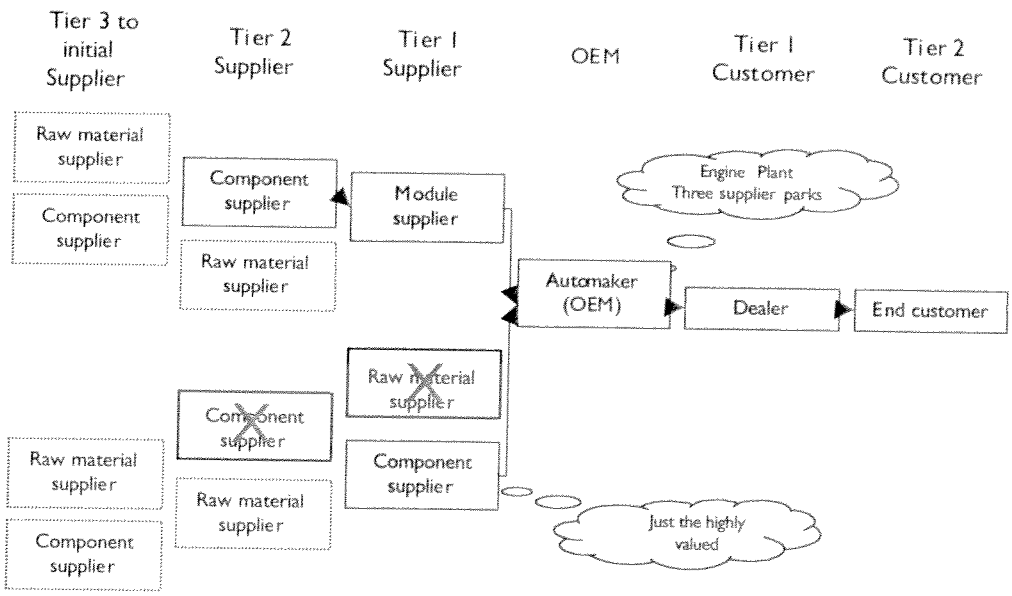

Figure 4 – First version of the supply chain structure for the ß Model.

Figure 5 presents the results for the supply chain of Plant A. Basically, these results follow the structure showed in Figure 4 with the inclusion of an engine plant for XYZ.

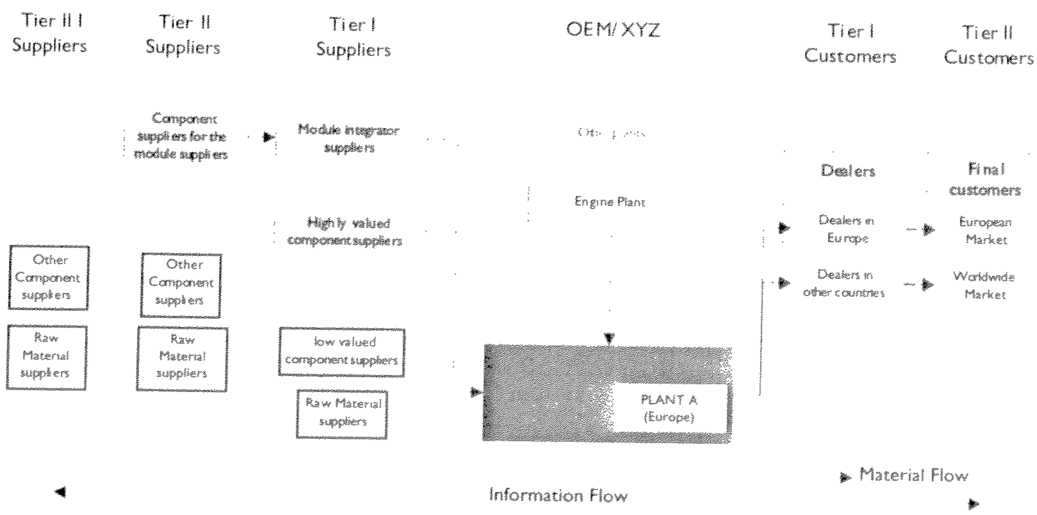

Figure 5 – The supply chain structure for the ß Model (focus: Plant A).

The supply chain of Plant B and the one illustrated by Figure 5 are practically the same except for the inclusion of Supplier Park I as an additional member of the supply chain of Plant B. Supplier Park I is located in Europe and near Plant B.

The supply chain of Plant C is located in an emerging Country. The European auto-part plants do not supply Plant C directly, making the consolidation of their products in Supplier Park I necessary.

Plant D is still being constructed and its supply chain will count with a new supplier park that will supply modules Just-In-Sequence (JIS). This supplier park will host six module suppliers.

Step VI: To collect data from the SCM configuration.

The sixth step consists of obtaining primary data from each supply chain through interviews and direct observation for later comparison with data collected for the automotive industry and with the SCM capabilities obtained in Step I. An important part of the case study was the conduction of interviews with XYZ managers and directors. These interviews were based on a questionnaire that was divided into three parts:

Part I (closed questions) – Main Goal: to check key information obtained by the pre-interviews (primary data) and the literature review (secondary data). The questions verify if the supply chain structure for the ß model, obtained by Step V, and the SCM capabilities, obtained by Step I, are suitable for the second part of the questionnaire; they also seek to identify the relevance of the main SCM capabilities.

Part II (closed questions) – Main Goal: to identify how the SCM is being developed and supported in the ß Model supply chains. Part II provided the backbone for the identification of SCM capabilities and enablers. The sequence of questions is organized according to the XYZ business processes. The main business processes for XYZ were manufacturing, logistics, procurement, marketing, and research & development. The answers to this section indicated the intensity of the relation between XYZ and each relevant supply chain member of the four ß Model supply chains.

Part III (open questions) – Main Goal: Obtain general input concerning XYZ strategies for the ß Model supply chains. Part III provides important input for the SCM analysis, conducted in Step VIII.

Once the data of Step VI are collected, Step VII unfolds, transforming these data into information for SCM analysis.

Step VII: To obtain the SCM configuration.

Because a significant part of the data was collected by non-structured and semi-structured interviews, the results of the XYZ case studies were analyzed qualitatively. The answers of the second part of the questionnaire were classified / tabulated according to their relation to the SCM capabilities and SCM enablers. This procedure allowed us to identify their development in the links of the supply chain. The application of the model considers three SCM enablers: information technology, process integration, and level of relationship with external members.

This step answers Key-question III (which SCM capabilities have been developed in the ß Models supply chains), Key-question IV (how are these capabilities enabled), and Key-question V (where are the SCM capabilities developed and where are the SCM enablers located).

Based on the four supply chain structures presented in the previous section of this paper, Table 4 displays the results of the application of the framework to the supply chain links that develop the SCM capabilities. The first column of Table 4 indicates the SCM capabilities that have been identified by Step 1 of the framework. The subsequent columns display the relevant members of the four ß Model supply chains identified by Step V, represented in Table 4 by Table 4a, Table 4b, Table 4c, and Table 4d.

Table 4 classifies the supply chain members in *Member I*: module suppliers (tier 1); *Member II*: highly valued component suppliers (tier 1); *Member III*: suppliers of Member I (tier 2); *Member IV*: all the supply chain members who are not considered critic for the implementation of SCM; *Member V*: in the supply chain of Plant A, this member is XYZ's engine plant; in the supply chain of Plant B, this member encompasses the engine plant and the Supplier Park I; in the supply chain of Plant C, this member is Supplier Park I; and in the supply chain of Plant D, this member is Supplier Park III; *Member VI*: Dealers; and *Member VII*: End-customers.

The values displayed in Table 4 represent how intensively the SCM capabilities are developed within the supply chain links of plants A, B, C, and D. A scale ranging from one to five represents the intensity, where five indicates that the SCM capability is largely developed within the related link and one represents that this SCM capability is not developed at all.

The SCM capabilities developed in the supply chains are highlighted in dark gray in Tables 4. The SCM capabilities that are modestly developed are highlighted in light gray. The SCM capabilities that are not developed are not highlighted. This table uses the term "ANP" (answer not possible) for the links where it was not possible to obtain the value of the development intensity for a SCM capability. The supply chain links that do not have a direct relation with a SCM capability are represented in Table 4 by a hyphen.

Table 4 – SCM capabilities developed in supply chains links

SCM Capabilities	Table 4ª – Members of Supply Chain A							Table 4b – Members of Supply Chain B						
	I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII
Modularization	5.0	3.5	1.7	1.7	5.0	-	-	5.0	3.5	1.7	1.7	5.0	-	-
Just in Time	5.0	4.0	1.7	2.3	5.0	-	-	4.3	4.0	-	2.3	5.0	-	-
Just in Sequence	4.5	4.0	-	1.8	4.5	-	-	5.0	4.0	-	1.8	5.0	-	-
Milk Run	1.0	3.0	-	2.0	-	-	-	1.0	3.0	-	2.0	-	-	-
Supplier Park	1.0	1.0	1.5	1.5	-	-	-	3.5	3.0	1.5	1.5	-	-	-
Global Sourcing	2.5	2.5			-	-	-	2.5	2.5			-	-	-
Follow Sourcing			2.0	2.0	-	-	-			2.0	2.0	-	-	-
Postponement	-	-	-	-	-	1.0	-	-	-	-	-	-	1.0	-
e-Commerce	-	-	-	-	-	5.0	4.3	-	-	-	-	-	5.0	4.3
e-Procurement	4.0	3.0	1.5	2.5	-	-	-	4.0	3.0	1.5	2.5	-	-	-
Co-design	5.0	4.0	2.0	2.2	-	-	-	5.0	4.0	2.0	2.2	-	-	-
Early Supplier Involvement	5.0	4.0	2.0	2.2	-	-	-	5.0	4.0	2.0	2.2	-	-	-
Quick Response	-	-	-	-	-	3.0	-	-	-	-	-	-	3.0	-
Vendor Managed Inventory	2.0	1.0	-	1.0	5.0	2.0	-	2.0	1.0	-	1.0	5.0	2.0	-

SCM Capabilities	Table 4c – Members of Supply Chain C							Table 4d – Members of Supply Chain D						
	I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII
Modularization	3.0	2.0	1.0	1.0	3.0	-	-	5.0	3.5	2.0	1.7	5.0	-	-
Just in Time	2.5	2.2	-	1.0	-	-	-	5.0	4.0	-	2.0	5.0	-	-
Just in Sequence	1.8	1.8	-	1.0	-	-	-	5.0	4.0	-	1.8	5.0	-	-
Milk Run	2.0	2.0	-	1.0	-	-	-	1.0	3.0	-	2.0	-	-	-
Supplier Park	1.0	1.0	1.0	1.0	-	-	-	5.0	2.5	1.0	1.5	-	-	-
Global Sourcing	ANP	ANP	ANP	ANP	-	-	-	2.5	2.5	2.0		-	-	-
Follow Sourcing	4.0	4.0	1.5	1.5	-	-	-	4.0	2.0	1.0	2.0	-	-	-
Postponement	-	-	-	-	-	1.0	-	-	-	-	-	-	1.0	-
e-Commerce	-	-	-	-	-	3.0	2.3	-	-	-	-	-	5.0	4.7
e-Procurement	1.8	1.5	1.0	1.0	-	-	-	4.0	3.0	1.0	2.5	-	-	-
Co-design	ANP	ANP	ANP	ANP	-	-	-	5.0	4.0	3.0	2.2	-	-	-
Early Supplier Involvement	ANP	ANP	ANP	ANP	-	-	-	5.0	5.0	3.0	2.2	-	-	-
Quick Response	-	-	-	-	-	1.0	-	-	-	-	-	-	4.0	-
Vendor Managed Inventory	1.0	1.0	-	1.0	3.5	1.0	-	2.0	1.0	-	1.0	5.0	3.0	-

The results presented in Table 4 allowed us to answer the Key-question III (which SCM capabilities have been developed) and the Key-question V (where have they been developed) regarding the supply chains of the ß Model.

Based on the same four supply chain structures presented in Subsection 4.2.2, Table 5 displays the results of the framework application to supply chain links in which SCM enablers are present. The first column displays the SCM enablers grouped by the business processes adopted by XYZ (Logistics & Manufacturing, Procurement, Marketing, and Research & Development). The subsequent columns illustrate the relevant members of the four ß Model supply chains. They are represented in Table 5 by Table 5a, Table 5b, Table 5c, and Table 5d. The values displayed in Table 5 should be interpreted as the ones in Table 4.

Table 5 – SCM enablers in supply chains links

	Table 5[a]							Table 5b							Table 5c							Table 5d						
SCM enablers	**Members of Supply Chain A**							**Members of Supply Chain B**							**Members of Supply Chain C**							**Members of Supply Chain D**						
	I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII	I	II	III	IV	V	VI	VII
Business Process: Manufacturing / Logistics																												
Process integration	4.9	4.2	2.0	2.0	4.9	-	-	5.0	4.2	2.0	2.0	5.0	-	-	3.0	2.3	1.0	1.0	4.0	-	-	5.0	4.3	3.0	2.0	5.0	-	-
Information Technology	5.0	4.5	2.0	2.0	5.0	-	-	5.0	4.5	2.0	2.0	5.0	-	-	3.0	2.5	1.0	1.0	3.8	-	-	5.0	4.8	3.0	2.0	5.0	-	-
Intercompany relationship	4.9	4.4	2.0	2.0	4.9	-	-	5.0	4.4	2.0	2.0	5.0	-	-	3.0	2.5	1.0	1.0	3.8	-	-	5.0	4.6	3.0	2.0	5.0	-	-
Business Process: Procurement																												
Process integration	4.8	4.5	1.5	2.0	5.0	-	-	4.8	4.5	2.0	2.0	5.0	-	-	3.5	3.0	1.0	1.0	4.0	-	-	4.8	4.5	2.5	2.0	5.0	-	-
Information Technology	4.7	4.5	2.0	2.0	5.0	-	-	4.7	4.5	2.0	2.0	5.0	-	-	3.3	3.0	1.0	1.0	4.0	-	-	4.7	4.5	3.0	2.0	5.0	-	-
Intercompany relationship	4.8	4.6	1.7	2.0	5.0	-	-	4.7	4.8	2.0	2.0	5.0	-	-	3.4	3.2	1.8	1.8	4.0	-	-	4.7	4.8	2.7	2.0	5.0	-	-
Business Process: Marketing																												
Process integration	-	-	-	-	-	4.6	4.0	-	-	-	-	-	4.6	4.0	-	-	-	-	-	3.1	2.2	-	-	-	-	-	4.6	4.0
Information Technology	-	-	-	-	-	4.6	4.3	-	-	-	-	-	4.6	4.3	-	-	-	-	-	3.3	2.5	-	-	-	-	-	4.6	4.5
Level of relationship	-	-	-	-	-	4.7	3.7	-	-	-	-	-	4.7	3.7	-	-	-	-	-	3.5	2.2	-	-	-	-	-	4.7	4.3
Business Process: research & Development (R&D)																												
Process integration	5.0	4.0	2.0	2.0	-	-	-	5.0	4.0	2.0	2.0	-	-	-	A NP	A NP	A NP	A NP	-	-	-	5.0	4.6	3.0	2.0	-	-	-
Information Technology	5.0	4.0	2.0	2.0	-	-	-	5.0	4.0	2.0	2.0	-	-	-	A NP	A NP	A NP	A NP	-	-	-	5.0	4.6	3.0	2.0	-	-	-
Intercompany relationship	5.0	4.0	2.0	2.0	-	-	-	5.0	4.0	2.0	2.0	-	-	-	A NP	A NP	A NP	A NP	-	-	-	5.0	4.5	3.0	2.0	-	-	-

Results in Table 5 answer key-questions IV (how are the SCM capabilities enabled) and V (where have they been present), for the case of the ß Model supply chains.

The different characteristics of each chain reflected distinct SCM configurations. This could be seen by the development of specific SCM capabilities in some chains and not in others. The same happened with the presence or absence of SCM enablers in different links of each chain of business processes. The resulting SCM configuration indicates that the supply chains of plants A and B have developed SCM capabilities in several of their links that belong to the immediate chain of XYZ plants (module suppliers, highly valued suppliers, and dealers). The main capabilities developed in these links were the following: Modularization, JIT, JIS, e-procurement, e-commerce, co-design, and early supplier involvement (ESI). The resulting SCM configuration also reveals that these SCM capabilities are supported by the SCM enablers which were taken (information technology, processes integration, and external-relationship level) in consideration in each business process and their respective

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related capability. If the focus is the immediate chain of XYZ plants, the supply chain of Plant D holds a SCM configuration that is similar to the ones for plant A and B. In spite of this, there are some SCM capabilities that have been developed in the chain of Plant D that are not developed in the chains of plants A and B (e.g. quick response). The SCM configuration for Plant D also presents an incipient presence of SCM enablers and of SCM capabilities (e.g. co-design and ESI) in the link that connects Plant D to the suppliers of the module suppliers (second tier). This link does not show in the SCM configurations of plants A and B. The SCM enablers are still too timidly present in the business processes of the supply chain of Plant C. This timid presence precludes the development of SCM capabilities considered very important by XYZ (e.g. Modularization, JIT and JIS). Follow sourcing has been the most well developed SCM capability in the supply chain of Plant C, as a result of its initial CBU production.

Step VIII: To analyze the SCM configuration.

Therefore, the SCM analysis indicate that the different characteristics and SCM configurations result in distinct developmental stages of SCM for each of the four ß Model supply chains.

The supply chains of plants A and B have been established for more than 20 years and most of their activities and supply chain members (both auto-part suppliers and end customers) are located in Europe. This results in a well-developed stage of SCM in the immediate chains of plants A and B, which allows XYZ to achieve its strategic goals concerning the supply chain of these plants.

The supply chain of Plant D is still not producing ß Model vehicles, which will only happen in 2005. It is being designed for SCM. In other words, it should be state of the art and benchmark not only for the other XYZ supply chains, but also for the automotive industry. The SCM analysis of the XYZ plants for this chain supports this last affirmation. The supply chain of Plant D demonstrates a SCM developmental stage slightly more advanced than the ones presented by the chains of plants A and B. The advanced developmental stage of SCM in Plant D is also corroborated by the expansion (even though still shy) of SCM beyond the limits of the immediate chain of XYZ plants.

The supply chain of Plant C is still being adapted to meet the requirements of its new activities, that is, the production of CBU vehicles. This chain shows good integration level within the internal supply chain of XYZ, but a very incipient level if we go beyond the XYZ frontier (e.g. in its immediate supply chain). In other words, the supply chain of Plant C is in the initial developmental stage of SCM, which makes the achievement of XYZ strategic goals difficult. The development of a supplier park in the emerging country where Plant C is located is important to the establishment of a SCM configuration that will allow this chain to compete globally. This supplier park should support the development of SCM capabilities that will help the supply chain of Plant C to achieve a better and more advanced developmental stage of SCM.

Conclusions

This article argues that one useful and fast way to improve the competitiveness of SCM is through the use of adequate models that can support an effective analysis of SCM. For this purpose, it presents a model to help manufacturing companies to obtain and to analyze the SCM configurations of their products. Overall, the model guides practitioners about how chains generate competitive advantage and signals if the actual SCM configurations satisfy and support their cooperative interests. To do this, it incorporates the elements that are relevant to the comprehension and analysis of a SCM configuration. These elements are organized according to seven *Wh-questions* (what influences the development of SCM; who are the relevant actors in a supply chain; which SCM capabilities are developed in a chain; how are these capabilities enabled; where are the SCM capabilities developed; where are the SCM enablers located in the supply chain; why does the supply chain have a given configuration; and when is a given configuration established). It is important to highlight that these relevant elements should be analyzed together, because a SCM analysis based on just one or a few elements can mask or misguide practitioners about the real SCM configuration. Therefore, one major contribution of this paper is to offer a model for SCM analysis that systematizes these elements.

Another contribution is the application of the model to the supply chains of four plants of an European auto maker to illustrate the use of the model in one special case. The results of such an application have indicated that the two supply chains that have been established many years ago in Europe show a higher developmental stage of SCM than the supply chain that is under development for the establishment of a new CBU plant in an emerging country. On the other hand, the results have also indicated that these two European supply chains show a lower SCM developmental stage than the future supply chain that is still under planning. The application underlines the use of the model for the analysis and comparison not only of existing and established SCM configurations, but also of supply chains that are still being established or planned.

In addition, in the case of the SCM relevant elements, the study reveals that the implementation of the SCM philosophy occurred mainly in the immediate chain of the auto maker. Even in the immediate chain, the link between the first tier suppliers (mainly the module suppliers) had more developed SCM capabilities than the link that connected the auto maker with its dealers. The same effect applies to the presence of SCM enablers in the immediate chain. This result corroborates Rice and Hoppe (2001) and the assertion that although the theory of SCM considers the whole supply chain, it is still far from being actu-

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ally put into practice, at least if the integration of the total supply chain is the target. In the case of the automotive industry, the cradle of many advances in SCM, the major concern still is the links among auto-makers and their first tier suppliers, links where the greatest added value to the product takes place. The SCM developmental stage beyond this link is still incipient and limited to just one of the analyzed supply chains.

Finally, we would like to note that, although the Brazilian auto industry has received a notorious amount of new investments during half of the 1990's (which positioned some of its plants as state-of-the-art in various aspects of SCM), our research did not embrace the Brazilian auto industry. We focused on four distinctive supply chains of a same vehicle model, and none of them are in Brazil. However, a logical follow-up of this research would be the application of the model here introduced to the analysis of one or more of the upgraded Brazilian automotive supply chains. For this purpose, we suggest researchers to consult studies that have investigated the Brazilian automotive industry, such as the one that describes and analyzes the new supply chain configuration of the Brazilian industry (see www.poli.usp.br/pro/cadeia-automotiva) and the one that studies the competitiveness of integrated chains in Brazil (see www.desenvolvimento.gov.br/cadeiasprodutivas).

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