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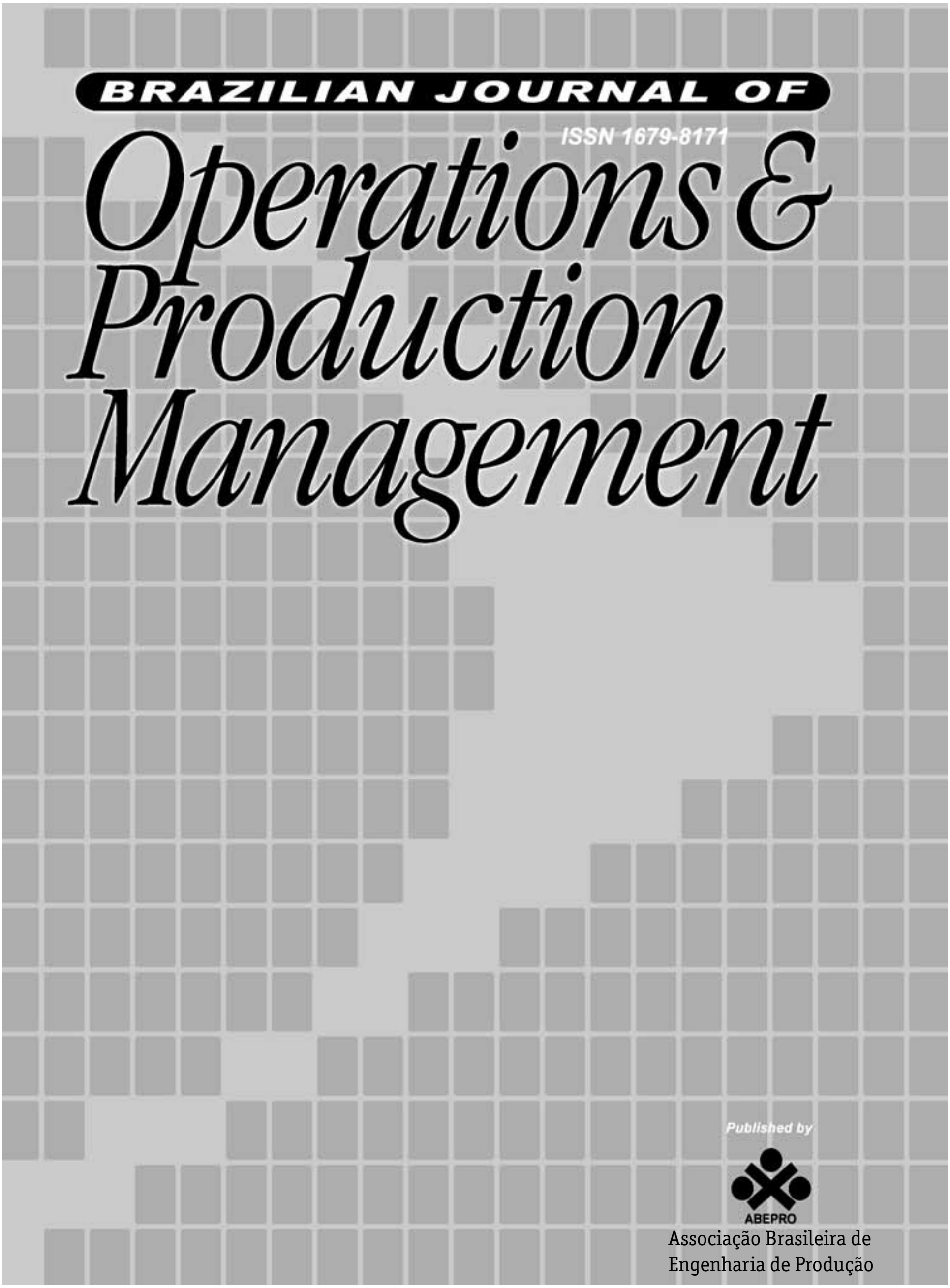

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Editorial Introduction

On behalf of the Editorial Board, I am happy to deliver the second issue of volume 4 (2007) of the Brazilian Journal of Operations & Production Management. We appreciate all the academicians who support and contribute to the editorship. The accomplishment of this issue would not be possible without the work of our editorial review board. We would like to take this opportunity to acknowledge their contribution to the journal referral process.

We hope the readers find the articles in this issue a useful source within the scope of production engineering and operations management.

In this Issue

The present issue has five competitive and up-to-date papers from some researchers from Brazil and abroad. Most articles consider qualitative methods as the methodological research approach, but also includes a quantitative data analysis. The first paper by Istefani de Paula and José Luiz D. Ribeiro proposes a reference model for pharmaceutical Product Development Process, which consists of three macro stages and seven phases, embracing from business opportunity recognition to product market launching. The authors concludes that their proposal represents an improvement compared to the general product development models presented in the literature. This paper is followed by the study of Giancarlo Pereira and Albert Geiger. It focuses on an exploratory study concerning the analysis of business-to-business relationships between big and small or medium-sized enterprises in the automotive sector in Brazil. It aims to tentatively identify the challenges that hinder the insertion of small and medium-sized enterprises in this supply chain by a multiple case study methodological approach.

The third article by Valério Salomon and Rozann Whitaker consider as a requirement that alternatives and criteria be independent of one another when applying traditional decision-making methods. In this sense, the paper show how a Brazilian company can consider dependencies among the alternatives and among the criteria in solving production management problems. The paper demonstrates that the proposal enables to improve the quality of the process of decision-making. A qualitative data analysis is considered in the fourth article by Cláudia de Mattos and Fernando Laurindo. They aim at analysing how companies are exploring web (Internet) technology for developing new products, based on the concepts of interactivity and connectivity. The authors investigate two service companies by identifying enablers and tools for supporting the development of a new product as well as components that are used during the innovation cycle of creation of a product based on the web. Finally, another article that studies the automotive sector is offered by Luiz Scarvada and Sílvio Hamacher. The authors analyse the role these SCM capabilities play in automotive industry supply chains. They present an empirical research through a case study in a European vehicle manufacturer including three supply chains embracing three vehicle plants and two supplier parks located in Western Europe and in South Africa. The analysis concludes that the SCM capabilities identified by the study constitute a response to support trends in the automotive industry, as they intend to bring advantages that obey a new logic in competition based on chains.

The journal expects to count on the research community by considering the journal as the outlet for publication of their research work mostly related but not limited to the research areas defined by ABEPRO[1].

This issue closes with ABEPRO's executive and ABEPRO's Editorial Board (NEA).

Paulo A. Cauchick Miguel, Marcelo Márcio Soares and Sérgio E. Gouvêa da Costa

[1] Production Management; Quality Operations; Economic Management; Ergonomics and Work Safety; Product Development; Operational Research; Strategy and Organizations; Technology Management; Information Systems; Environmental Management; Education issues in Operations Management.

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A Proposal of a Reference Model for the Pharmaceutical PDP Management

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Abstract
This paper presents a reference model for pharmaceutical Product Development Process. The model was created founded on renowned methods as Concurrent Engineering, Stage Gates and Product Based Business. It was developed using legislation and information from interviews with professionals of Brazilian pharmaceutical companies. The developed model contemplates three macro stages and seven phases, embracing from business opportunity recognition to product market launching. The purpose of this article is to introduce the reference model for the pharmaceutical body, since it represents an improvement compared to the general product development models presented in the literature. The reference model is also important in the pharmaceutical academic field, as a didactic tool.

Keywords: pharmaceutical product development process, reference model, product development management

Introduction

Since the 1990's product development has been considered under a broader standpoint, in which the idea of development centered in technical activities was substituted by the concept of business supported by product development. This new concept has been called, afterwards, Product Development Process (PDP) (Clark and Fujimoto, 1991; Cooper, 1994; Cooper et al., 1999; Patterson and Fenoglio, 1999; Corso and Pavesi, 2000; Crawford and Benedetto, 2000).

The main reason for this change was the important role played by products and services innovation in companies' outcome concerning competitiveness. To survive in the market, companies had to increase the pace at which they developed their products, launching them before their competitors. Therefore, along the last twenty-five years several product development approaches were proposed, supported by methods and tools (Clark and Wheelwright, 1992; Clark and Wheelwright, 1993; Cooper, 1994; Pahl and Beitz, 1996). Each of them has particularly contributed to the evolution of this knowledge area. Among the development approaches, outstands those that are considered under the expression *Integrated Product Development* (IPD) as *Concurrent Engineering* (CE) (Prasad, 1997; Hartley, 1998); *Stage Gates methodology* (SG) (Cooper, 1994; O'Connor, 1994; Cooper, Edgett, Kleinschmidt, 1999); *Product Based Business* (PBB) (Crawford and Benedetto, 2000; Koufteros et al., 2002); and more recently the *Lean* (L); *Design for Six Sigma* (DfSS) and *Maturity Models* (MM) considered as new approaches for IPD (Rozenfeld et al., 2006). Andreasen and Hein (1987), Kormos (1998) and Lovejoy and Srinivasan (2002) discuss IPD as a separate methodology, but Rozenfeld, Forcellini, Toledo, Amaral, Alliprandini, Scalice and Silva (2006) group CE, SG and PBB as being Integrated Product Development expressions.

In the same decade 1960, NASA (National Aeronautics and Space Administration) and the US Department of Defense (DoD) have developed tools to improve Project Management (PM) activities and to enhance project success. They were compiled, afterwards, by PMI (Project Management Institute) in the renowned PMBoK (Project Management Base of Knowledge) (Casarotto Filho et al., 1999; Dinsmore, 1999; Verzuh, 2000; Gasnier, 2001; Kerzner, 2002; Heldman, 2003; Vieira, 2003; Xavier, 2005). Accordingly to Kerzner (2002), the tools mentioned in PMBoK have influenced the Product Development area and, inversely, the Product Development methodologies have influenced and supported the PM subject growth.

Global pharmaceutical corporations, even dominating large markets and presenting a typical very long lasting product development process, have adhered, in the 1990's decade, to the product speed development concept and have reduced their development cycles significantly, as it is mentioned in related literature. The two approaches adopted by them include new PDP management practices (Boogs et al., 1999; Getz and Bruin, 2000; Hunt et al., 1998) and special technology development, directed to new drug discovery, identification and test (Gobburu and Chen, 1996; Wermuth, 1996; Gieschke et al., 1997; Cavalla, 1998; Hall, 1998; Gordon and Kerwin, 1998; Moos, 1998; Balant and Gex-Fabry, 2000; Weinstein, 2000; Wechsler, 2001). The changes in the pharmaceutical field may be attributed to the expiration of many drug patents in the 1980's what boosted the 'generic product' development by competitors, a medicine that presents the same properties of the reference product, and therefore may be interchanged with it, but which presents lower prices.

The generic medicine production in Brazil has been encouraged by the government in year 2000, mainly viewing the AIDS drug cocktail price reduction. Nevertheless, the Brazilian pharmaceutical industry scenario is dominated by few large multinational pharmaceutical companies, that produce most of the medicine consumed in the country, and a large number of national companies, that attend a smaller market slice, mainly producing copies of medicines developed previously by the larger companies ('me too' or 'similar' products which may not be interchanged with reference products). The government incentive to generic medicine has been decisive to some Brazilian pharmaceutical companies, which have considerably grown in the last seven years. More precisely, in 2005 the generic sales were stable, but increased considerably from 2006 to 2007, what made Brazil to become the most important market in South America, and the 8th medicine sales market in the world (Nascimento, 2007).

In this context, the development and launching of generic products in a fast pace is decisive for competition. Some companies observed that the existence of a formal product development process might reinforce product development success. To formalize companies' PDP practices is a global tendency and product development reference models, in addition to PDP methodologies and PM tools, play an important role in such formalization.

For this reason, the main objective of this paper is to introduce and discuss a reference model for the pharmaceutical product development process, focused in generic products.

Reference Models

The difficulty in describing how a product development process proceeds has significant reflects in the way this process is managed. How can a manager preview, plan and control the work of a team if the components do not have a common language; a minimum global vision of the project development or a perception of the expected contribution that project will bring to the company? In this sense it is very important to model the company business processes and register them as documents, including the product development process. Such product development documentation permits that a large number of people access the reality described in it and will be useful to structure new product development projects. Therefore it is called reference model (Rozenfeld et al., 2006).

Reference models have evolved from mere representations of the problem solution cycle (analysis, synthesis, simulation, evaluation and decision), also named as 'basic project cycle', to the four phases engineering project representation, from Pahl and Beitz, in 1960 decade (that includes design specification, conceptual design, embodiment project and detail design), up to the third type, the PDP phase model. The last type is a broader representation, since it includes: the product development relationship with the corporate strategic planning (CSP); the marketing practices (from pre-development phase), which are necessary for client demand assessment; the product strategic planning; apart of the descriptions of 'product and process projects', that are part of the 'basic project cycle', mentioned previously in Pahl and Beitz model (Roozenburg and Eekels, 1995).

A reference model may assume several formats. Some of them represent only the activities that must be performed in product development; other models detail what

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procedures and methods are supposed to be adopted; they may include the evaluation criteria and mention what literature has to be consulted in order to accomplish a specific activity. The model may be a manuscript, manual or even a graphical representation available in intranet (Rozenfeld et al., 2006). They may be classified in generic models which may be adopted by different production companies or specific models, which describe a particular type of product development, as the model proposed in this paper.

Research Method

This proposal consists in the development of a specific reference model for pharmaceutical product development whose architecture was supported by three sources: (i) the Brazilian pharmaceutical companies' professionals experience acquisition and legislation review; (ii) the selection of 'best product development practices' from literature, and (iii) information from project management gathering. The following items present the description of how these sources were investigated and how they contributed to the reference model development.

The Brazilian pharmaceutical companies' professionals experience and legislation

The Case Study in a multi-case analysis was the research method adopted in this paper (Eisenhard, 1989) for the model development and the Delphi Method (Baxter, 2000) adaptation for the model validation. The qualitative approach was used for data collection and it was performed in two interview blocks. The objective in the first interview block was gathering information for construction of the reference model. The objective in the second interview block was the validation of the reference model. The latest was performed with the purpose of submitting the reference model to pharmaceutical professional analysis in relation to performance and applicability in the field. Table 1 resumes the information from companies and interviewed professionals' characteristics.

Table 1 – Companies' sizes and interviewed professionals areas.

First block interview characteristics Reference model construction			Second block interview characteristics Reference model validation		
Company Size	Medium	Large	Company size	Medium	Large
Interviewed professional area			Interviewed professional area		
Marketing and sales, R&D, Quality, Production, Medicine Registration	Company 1 Company 2 Company 3	Company 4 Company 5	Marketing and sales, R&D, Quality, Production, Administration, Costs, IT, Medicine Registration , Logistics, Production Planning and Control	Company A Company B Company C Company D	Company E* Company F Company G*
ANVISA professional	Generic product referee				

IT (Information Technology); R&D (Research and Development); and *Multinational companies.

As described in Table 1, five national companies' professionals were interviewed in first block, from two large and two medium size companies, from the medicine and cosmetic fields. The selection criterion was the size of the companies, since small Brazilian pharmaceutical companies do not present, in general, a formal PDP nor develop generic medicines. The interviewed professional areas were those considered important for product development and it was respected the company development team or professional interview availability. A referee for generic product registration from ANVISA (*Agência Nacional de Vigilância Sanitária*), the Brazilian medicine registration body from the Government Health Ministry, was also interviewed for the reference model construction. Only one referee was interviewed in ANVISA, since the legislation information is of objective nature. The reference model was analyzed by professionals from seven companies, three large and four medium sizes (medicine, veterinary and cosmetic fields), concerning the model validation. The analysis was conducted in a collective approach inside each company, in which the interviewed group exchanged ideas and impressions about the model. The interviews lengths were two hours in average, in both blocks, and semi-structured questionnaires were used; their contents are presented in Table 2.

All interviews were recorded and, afterwards, submitted to transcription. The First block interviews were analyzed through internal comparison: between companies' information, and between the latest and the ANVISA referee information. The data gathered were important for construction of the reference model macro-phases and activities. The Second block interviews were analyzed through consensus ordination and importance ordination. Thus, the elements mentioned by the interviewed professionals about whom they agreed or disagreed were identified; as well as the model elements considered by them as interesting or object of concern. The elements mentioned by interviewed professionals from one company were compared with the opinion of interviewed professionals from

Table 2 – Questionnaires used in first block and second block interviews.

Reference model construction questionnaire	Reference model validation questionnaire
Company questionnaire /interview steps	Company questionnaire /interview steps
(i) General information (company size, administrative structure, kind of product developed, market focus); (ii) Information from the development process (macro stages, phases, average development time, team, financial aspects); and (iii) Product registration difficulties and easiness, ANVISA x company relationship.	(i) General information (company size, administrative structure, kind of product developed, interviewed professionals skills and experience in product development); (ii) Reference model presentation (explanation about its characteristics, construction architecture and value); and (iii) Questions about resemblance between the reference model and the interviewed company's PDP (estimated similarity); opinion about observed failures or restrictions from the model.
ANVISA questionnaire	
(i) General information about the referee (experience time in ANVISA, experience as a referee for generic products dossiers); (ii) Information from generic products rules in pre-registration; registration and post registration stages; and (iii) Information from difficulties and easiness in ANVISA x companies relationship.	

other companies, characterizing the internal comparison in Second block either. The data gathered in validation block interviews were important for changing, excluding or including activities in the reference model, or for reinforcing its value as a reference for generic product development in pharmaceutical companies.

The best product development practices from literature

The product development methods that support the reference model are Concurrent Engineering (CE), Stage Gates (SG) and Product Based Business (PBB). These theories, which are of the Integrated Product Development (IPD) methodologies type, have been adopted by companies and considered responsible for successful product development along the last years. The aspects of each approach that were integrated in the reference model will be presented.

Concurrent Engineering (CE) focuses in multidisciplinary teams, co-localized and simultaneous activities performance, mainly those that are independent. The physical co-localization of teams and multidisciplinarity will depend on companies' culture, but the latest element is mandatory to development efficiency. Much rework may take place if the project of a new product is not simultaneously but, sequentially performed by organizational sector specialists. The application of tools and methods is important as IT (Information Technology); DfM (Design for Manufacturability); TQM (Total Quality Management); SPC (Statistical Process Control); DOE (Design of Experiments); QFD (Quality Function Deployment), among other methods and tool (Goldense, 1992; Hartley, 1998; Moffat, 1998; Kormos, 1998; Toni et al., 1999; Rozenfeld et al., 2006). Therefore, such tools were suggested in the reference model and may be observed in the detailed pictures of it (Paula, 2004).

Stage Gates (SG) is a methodology, which focuses in two aspects: business character of product development and product development process managerial control. The first aspect is guaranteed by the 'portfolio management methodology' that analyses what business-products the company is investing in. It is normally performed along Corporate Strategic Planning (CSP) implementation. Therefore the SWOT analysis tool (Strength, Weakness, Opportunity and Threats) may be present in this process phase. The process control aspect of SG is the phase transition evaluation/control which is systematically performed via process interruptions named 'gates'. The gates are generally located between important transition phases and they present a decision nature of process abortion; process modification or process maintenance. The gates may include control check lists that confirm the conclusion of the most important activities of that phase; although the document central managerial question is 'will the product development be continued in the next phase, changed or aborted?' The number of gates is a function of the risk level implicated in the product development process, but Cooper suggests six gates in his paper (Cooper, 1994; O'Connor, 1994; Cooper et al., 1999; Rozenfeld et al., 2006) that were incorporated in this reference model.

Product Based Business (PBB) is a methodology which reinforces the innovation mechanism, represented by two elements: the pair 'portfolio analysis-Corporate Strategic Planning' (from the strategic level) and by the activities of 'identification, selection and development of opportunities that were identified in the market' (from the tactical level). The business/company growth is a result of innovation in products or services since they must provide both, income and profit. The incomes from mature and new products maintain the innovation mechanism, since they may finance new market evaluation and technology acquisition. In this sense, a feedback mechanism is generated in terms of cash and information. The products must be followed after launch for all their lives (product life cycle management), and their performance in market must be measured. The information gathered from products feedbacks the development process for a new 'portfolio analysis-Corporate Strategic Planning' and the improvement cycle is maintained. In general, a Product Manager is the professional responsible for a specific class of product in the company (Paterson and Fenoglio, 1999; Crawford and Benedetto, 2000).

Summarizing, the IPD methodologies have in common the following best practices incorporated in the model: (i) a strong market orientation, based in the knowledge of clients demand; (ii) the practice of business opportunities screening, competitors benchmarking and portfolio management as support for decision in 'what projects to invest'; (iii) the practice of former technical, financial and economical analysis of projects, before product development; and (iv) the continuous analysis of products after launching, providing the feedback character of the PDP. The grouped practices (i) to (iii) form the Pre-Development Stage from product development process and the practice number (iv) outlines the Post Development Stage from this reference model. More details from the practices are presented in detailed version of the model (Paula, 2004).

Information from project management

The main contribution of Project Management (PM) methodology is its focus in project completeness. Some practices from PM have been proved to guarantee the completion and success of a project and they have been incorporated to the PDP, since product development is characterized as a project in an organization. In fact, a project is distinct from a routine activity, since it describes the performance of a group of activities which generate a unique product whose process presents start and conclusion proceedings, clearly executed in a period of time; i.e., a project is a temporary effort (PMBoK, 2004).

The first effort in organizing a project is the thoroughly description of its scope. Most authors in PM indicate the use of WBS (Work Breakdown Structure) as an efficient tool for scope definition (Casarotto Filho et al., 1999; Dinsmore, 1999; Verzuh, 2000; Gasnier, 2001; Kerzner, 2002; Heldman, 2003; Vieira, 2003; PMBoK, 2004; Xavier, 2005). WBS is a hierarchical decomposition (top down flow chart) oriented to the project deliverables, including internal and external project products, aiming to reach project goals. This tool organizes the project global scope by its division in work packages that are decomposed in activities. At the activity decomposition level it is finally possible to designate a person to execute it; to estimate performance duration for that activity; to calculate related costs and resources necessary for executing it and, as well, it is possible to define the activity control specification or the specification for its deliverable(s). Therefore, WBS is the first step of project planning, since it provides the base from which the project scope, time, human resources, cost, quality, risk and other plans derive. WBS may be presented as an indented list or in a graphic manner as it may be seen in Figure 1, which presents the first hierarchical level with nine resume tasks and task number 1 decomposed into work packages. These nine resume tasks and their decompositions are the information gathered from pharmaceutical professionals interviewed (their experience in Brazilian Pharmaceutical Companies) in addition to the best Product Development Practices, both mentioned in the items before. The nine resume tasks were decomposed in work packages that are represented in detailed pictures of the reference model in Paula (2004).

Besides WBS, project management methodologies recommend the use of matrices for human resources planning, in which the responsibilities for the project activities are established. Thus the team components have a clear vision of their and the others duties. Both WBS and an activity x responsibility matrix were used as elements for this pharmaceutical reference model construction and more details are available in Paula (2004). Aiming to control the PDP process, check lists were created for phase transition as recommended in Stage Gates and in PM. The gates in PM are called 'milestones', and differ from de first only by the fact that the milestones exist to call attention to an important fact inside project phase or between phases, not necessarily being a stop point for strategic decision, as to continue-or-abort the project, for instance. Therefore, the gates were adopted in this reference model, instead of milestones. Other tools from PM will not be discussed in this paper, although they may facilitate PDP implementation and management.

The Pharmaceutical Reference Model Presentation

The pharmaceutical reference model architecture developed from the sources mentioned before, presents three macro stages and seven phases, embracing from business opportunity recognition to product market launching. Figure 2 presents a general view of it.

Macro-stages, phases and organizational function structure

Figure 2 is an overview and its focus is the general aspects of the reference model, not the specific detailed work packages, presented in Paula (2004). The figure presents the three macro stages, seven phases, seven typical pharmaceutical organization functional sectors involved in PDP (grey flags on the left), six gates and phase work packages represented by internal boxes. The model is oriented from left to right, frontally fed by the Corporate Strategic Planning information, as recommended by IPD methodologies.

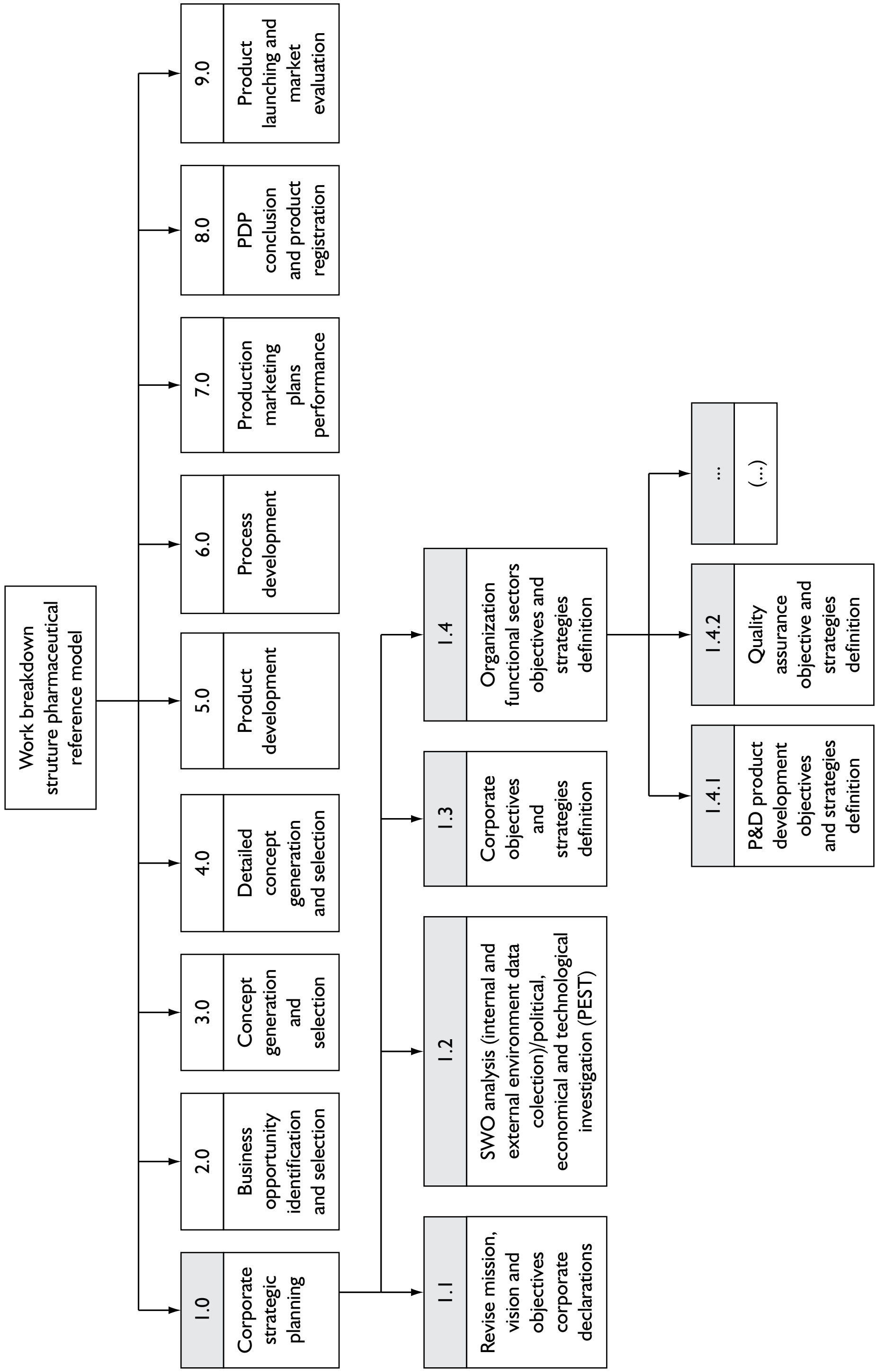
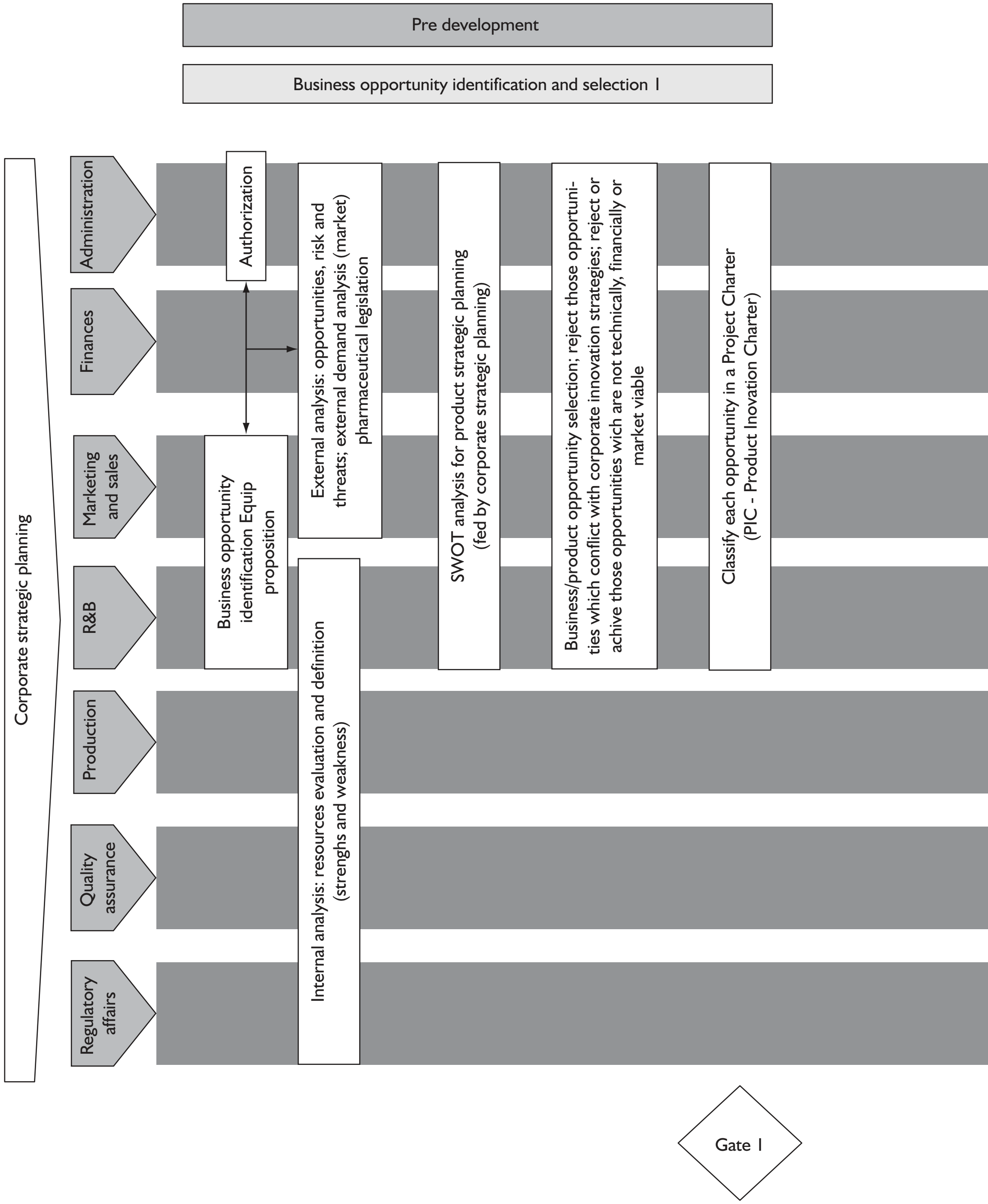


Figure 1 - Part of WBS from the pharmaceutical PDP reference model.


Pre development
Business opportunity identification and selection 1
Corporate strategic planning
Administration
Finances
Marketing and sales
R&B
Production
Quality assurance
Regulatory affairs
Authorization
Business opportunity identification Equip proposition
External analysis: opportunities, risk and threats; external demand analysis (market) pharmaceutical legislation
Internal analysis: resources evaluation and definition (strenghs and weakness)
SWOT analysis for product strategic planning (fed by corporate strategic planning)
Business/product opportunity selection; reject those opportunities which conflict with corporate innovation strategies; reject or achive those opportunities wich are not technically, financially or market viable
Classify each opportunity in a Project Charter (PIC - Product Inovation Charter)
Gate 1

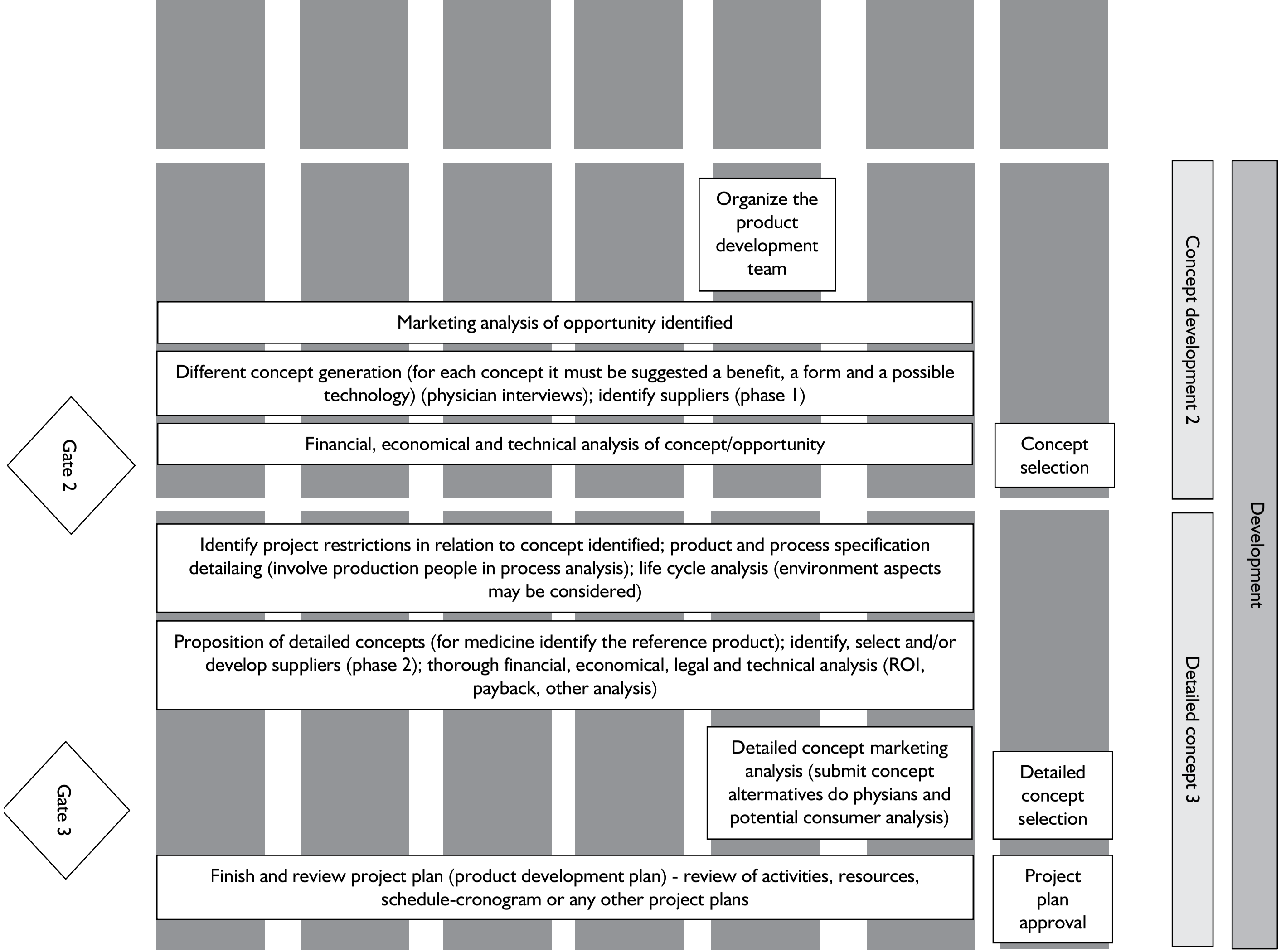


Figure 2 - Emphasis in general aspects: three macro stages (Pre-Development, Development and Post Development); seven phases (From Business opportunity identification and selection to Product Launching and market evaluation); team (horizontal dashed stripes under the white blocks) (white blocks represent work packages); and six gates between phases. Work packages are not emphasized in this figure (Source: adapted from Paula, 2004).

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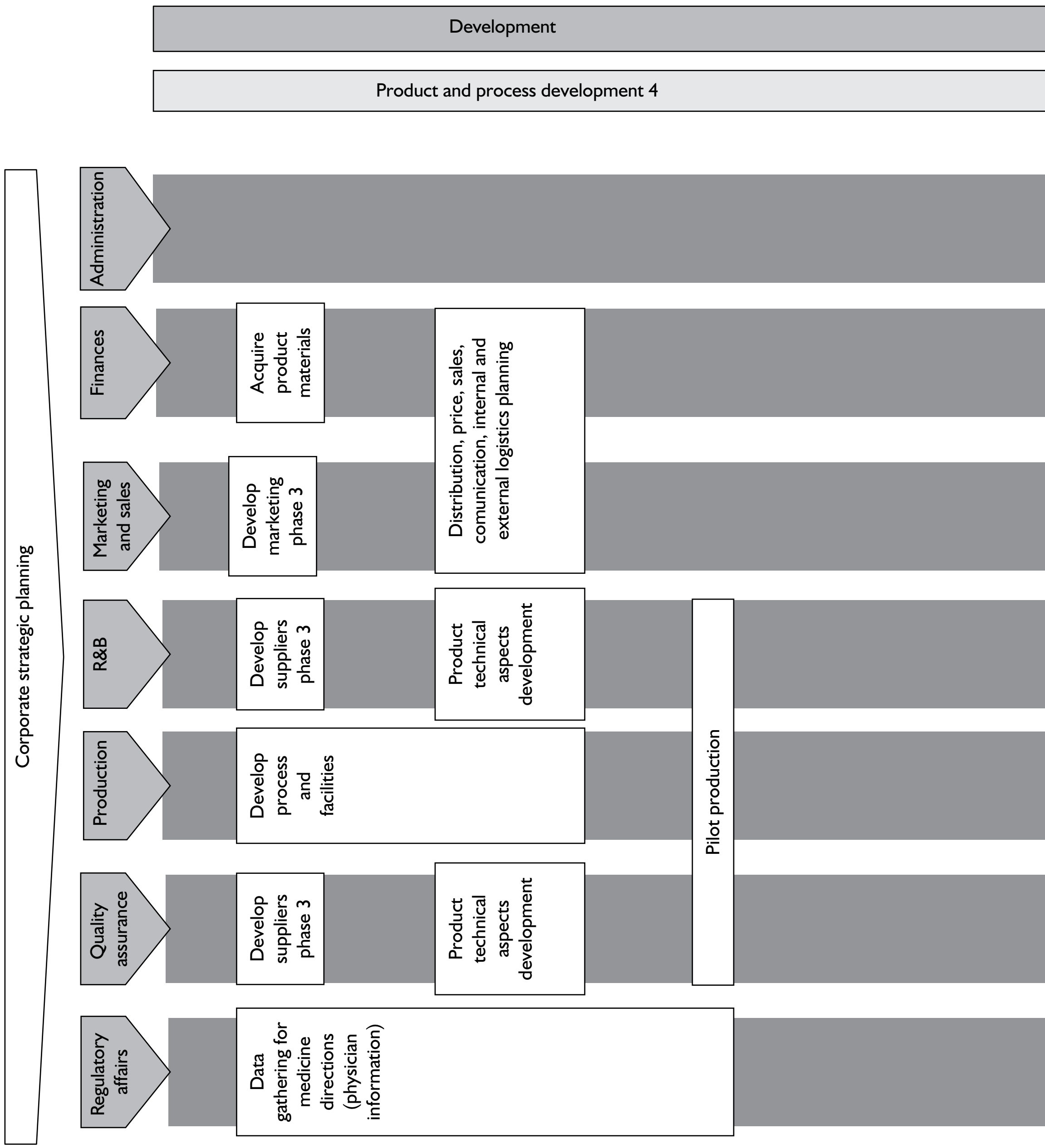

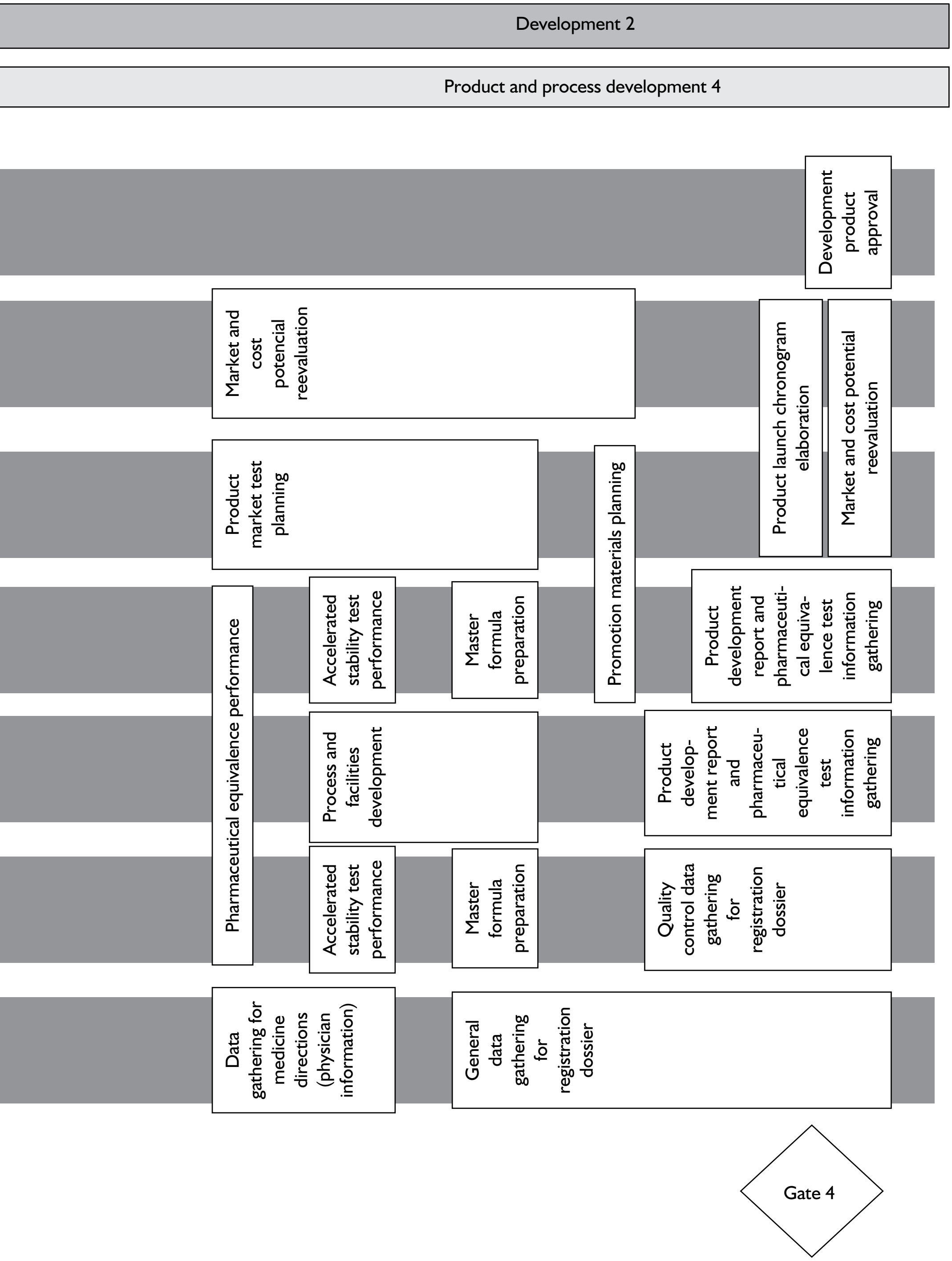

Figure 2 – Continued...

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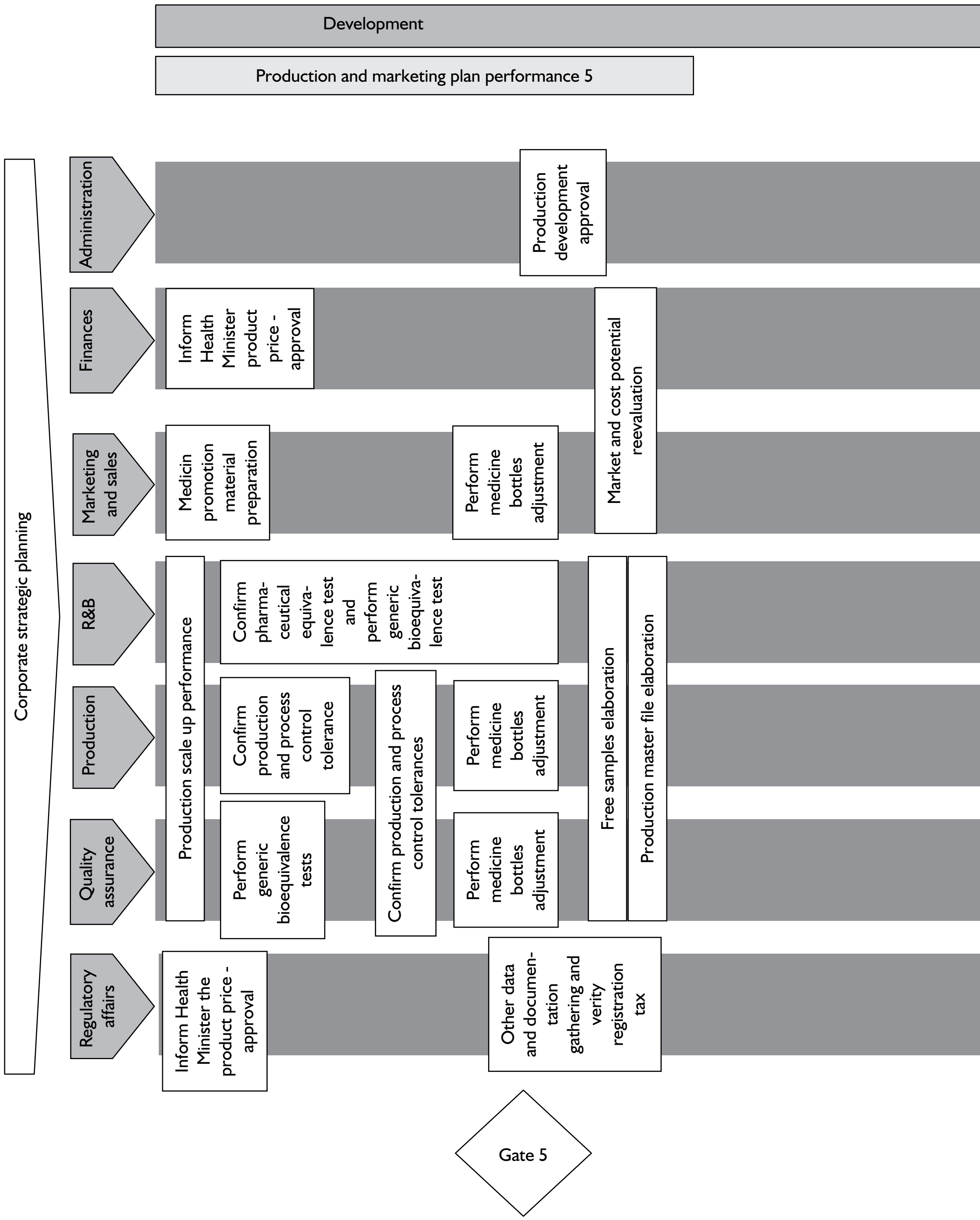


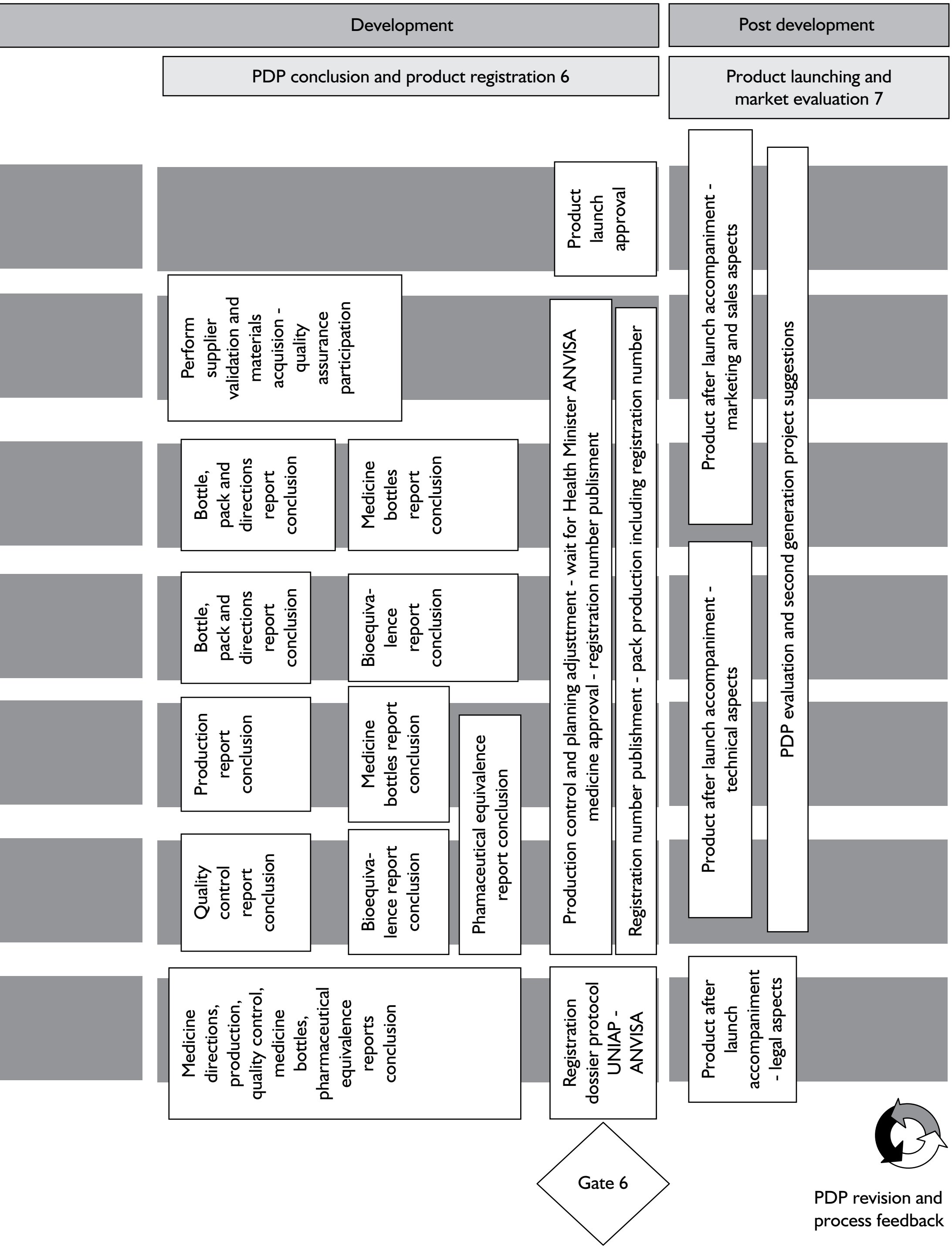


Figure 2 – Continued...

The three macro-phases are named pre-development, development and post development. Pre-Development complies the business opportunity identification and selection, as well the definition of a project manager and a team to perform the other subsequent PDP phases. The Development macro-phase embraces five phases: (i) concept development; (ii) detailed concept; (iii) product and process development; (iv) production and marketing plan performance; and (v) PDP conclusion and product registration. The Post-Development macro stage consists of only one phase (product launching and marketing evaluation). Underneath the internal boxes (the boxes represent the work packages from WBS) there are seven grey shaded horizontal stripes, which reflect the functional sector involvement along the entire PDP. Sometimes a single box covers six shaded lines, indicating that this specific work package is under the responsibility of all the six organization functional sectors beneath it. As it shows, the IPD recommended multifunctional team is included in the reference model, augmenting the chances of 'doing right for the first time'.

The organization functional sectors typical in Brazilian pharmaceutical companies are: administration, finances, marketing and sales, R&D, production, quality assurance and regulatory affairs. The interviews showed that the functional organization structure still predominates in medium and large Brazilian pharmaceutical companies, although there are multifunctional product development teams. In smaller companies, the number of team components is most of the time restricted, since the same professional may assume more than one function in the company. In general the product development management is responsibility of R&D or marketing and sales professionals, depending on the typical level orientation to market in the company's PDP and depending on its culture.

The pharmaceutical PDP reference model control

The reference model presents six gates, similar to those of the Stage Gates methodology. They are located between phase transitions, in which a decision of abortion, phase modification or process maintenance may occur. A check list and specific control documents were created for each gate, as it is observed in Table 3. Along the first three gates of the model (between the three respective phases), it is possible to notice the increase of financial risk. At the first gate the financial investments are relatively low, since no physical product development has occurred yet (product opportunity identification phase). Further, in the second gate, product prototypes may be constructed (concept phase), augmenting phase two expenses; but the third gate of this macro-stage, the transition between 'detailed concept identification and selection' and 'product and process development', is the most risky and delicate. The product and process development phase involves the physical development of the product and the process (Figure 2), generally performed at high expenses. Such gate is an important transition and strategic point in the reference model. Therefore, the control documents used in this gate are three: (i) the check list (used to control the phase activities completion); (ii) detailed product protocol (including financial and technical information for administrators strategic analysis); and (iii) project plan (that presents project specifications for the product development team). The other four gates are controlled by the documents listed in Table 3 (more document details are published in Paula, 2004).

Table 3 - Pharmaceutical reference model macro-stage, phases, gates, and main documents.

Macro stage	Phase	Gate	Control documents	Document description
Pre development	Business opportunity identification and selection	1	Check list	List of phase activities completion control and authorization for process maintenance
			Product Innovation Charter (PIC)	Description of business/product opportunity
			PIC archive	Archive for PIC files classification
Development	Concept development	2	Check list	List of phase activities completion control and authorization for process maintenance
			Product Protocol	Description of product benefit, form and technology, i.e, product concept
	Detailed concept	3	Check list	List of phase activities completion control and authorization for process maintenance
			Detailed Product Protocol	Detailed description of product, including market information, product-process specifications and tolerances, financial, technological data
			Project Plan	File with project specifications for the product development team from different organizational functions
			Project chronogram	Chronogram with PDP activities distributed in a line time
			Activity x responsibility matrix	Matrix with activities and Human resources responsibilities
	Product and process development	4	Check list	List of phase activities completion control and authorization for process maintenance
			Phase Register Dossier reports	Reports from product and process development demanded for registration by ANVISA
	Production and marketing plan performance	5	Check list	List of phase activities completion control and authorization for process maintenance
			Phase Register Dossier reports	Reports from product and process development, demanded for registration by ANVISA
			Product/process master file	Document with all product and process control specification for quality control and assurance
	PDP conclusion and product registration	6	Check list	List of phase activities completion control
			Register Dossier	Document with product/process information submitted for registration by ANVISA
Post development	Product launching and marketing evaluation	PDP feedback	Check list	List of phase activities completion control
			PDP history and project lessons	Summary of documents used for project control, as check lists, approvals, reports and learned lessons
			Marketing and technical information	Data from post approval tests; data from stability tests and from marketing analysis of the product

The last gate, named 'PDP feedback', guarantees the process character of the model, since the information generated along the process will provide feedback for the initial phases of future developments. In this sense the information may be classified in strategic data and data from the product/process properly speaking, including the lessons learned (good and bad results from PDP). Information management requires special routines and will not be part of the scope of this paper. Authors from Project Management area recommend the formal conclusion of a project, in the form of a meeting where these lessons may be commented and the knowledge reinforced in the team. This practice is, therefore, suggested in this reference model.

Finally, it is important to mention that inside each phase it may be defined several milestones or project marks, for example: materials entering the process, important team meetings, chronogram disbursement and other events considered relevant by the team.

Reference model detailed representations: work packages and activities

Details in the reference model are represented by: (i) work packages from the overview model (distributed in all the seven phases) from Figure 2 and by (ii) the work packages decomposed in activities that are shown in graphic representations of each phase, as exemplified in Figure 3.

Figure 3 shows larger boxes (the work packages) covering the organizational function sector involved, the parallel activities, represented by smaller boxes inside the larger ones, and gate 1. Figure 3 is the exploded graphic representation of the first phase shown in Figure 2. As observed, concurrent development from CE is provided by the parallelism of independent activities described in the smaller boxes of this figure. It means that the organizational function sectors work in parallel, performing independent activities not sequentially, thus reducing development cycle. The detailed pattern of this reference model is a differential in the product development literature and it is an advantage for those pharmaceutical companies, which do not have a formal PDP yet. The model helps the generic product development team to remember all tasks necessary to successfully develop this kind of medicine. On the other hand, it is an inspiring model for companies that intend to structure PDP, even for new product development, since the model comprises the best development practices.

The interviews with Brazilian professionals showed that the pre-development stage and the first two phases from Development stage are the least structured in their companies. In contrast, PBB literature and other IPD methodologies devote most of the product success to the innovation pattern from pre-development, concept generation and detailing activities performance. Therefore, the pre-development is considered a foremost contribution of this reference model to the pharmaceutical area. Table 4 resumes the important work packages suggested in this macro-stage, as well the other macro-stages work packages from the model, since it is not possible to present all graphic representations in this paper. The detailed graphic representation of work packages and activities for all phases is available in Paula (2004).

Special attention may be given to the italicized words in Table 4, since they describe the important work packages for generic medicine development and, therefore, are specially performed in pharmaceutical processes. These work packages were decomposed in activities in the graphic phase representations available in Paula (2004). The other work packages not italicized in Table 4 reflect the best practices from IPD methodologies and they are also performed in development processes of other product types. The graphic representation also indicates the organization function sector, which is responsible for the work package and its respective activities.

Further Discussion

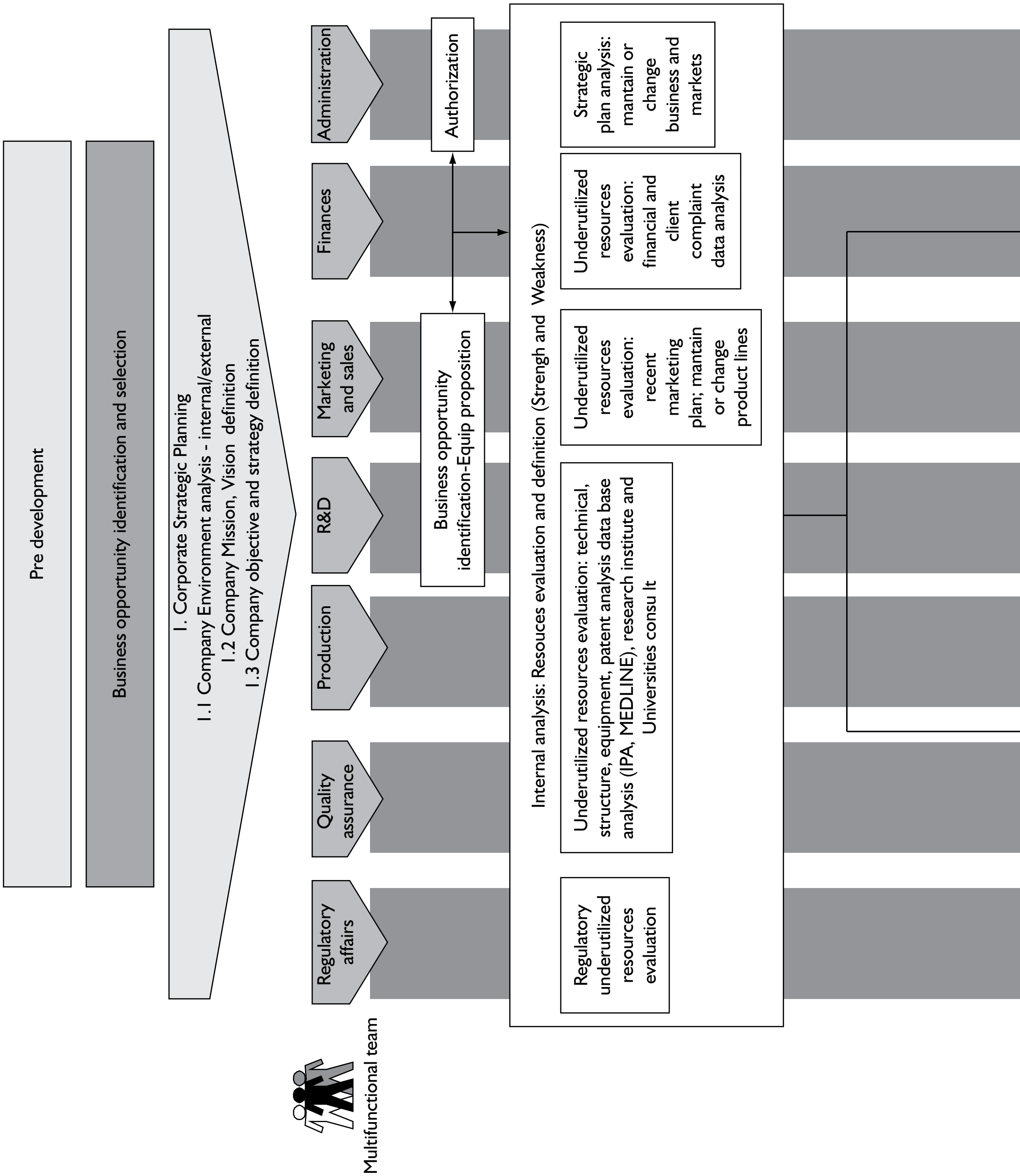
Conclusions

The qualitative approach adopted in the construction of the reference model proved to be efficient, since it permitted to gather information from professionals in a deeper manner, generating the model work packages. The choice of companies from medium and large sizes was adequate, since their development processes and relationship with ANVISA presented particularities, and the different types of business these companies develop brought more robustness to the final reference model. The same differences would not be so clear if the interviews included small companies; moreover the smaller companies hardly ever produce generic medicines.

The interview with the ANVISA referee was important for the delineation of legislation related workpackages in all macro-stages and phases. Furthermore, it was possible to notice the distance that still existed, at the time of the interviews, between the Registration Agency and the professionals, mainly those from medium pharmaceutical companies. Fortunately from 2004 on, some changes have occurred in direction to faster dossiers analysis and generic medicine registration in ANVISA. In spite of this fact, more efforts have to be made in order to improve the communication between the Agency and the regulatory functional sectors of companies. Actually the future goal is to create a partnership between companies and the Agency.

The interviews in the construction phase were important for the reference model configuration, since each company PDP was modeled in block 1 interviews and the final graphic reference model format was consequence of them. The second block interviews were important for validation and adjustments made in the final model. The adapted Delphi method proved to be efficient for the validation phase.

As mentioned before, professionals from seven pharmaceutical companies, totalizing 40 people with large experience in pharmaceutical product development expressed their



Pre development
Business opportunity identification and selection
I. Corporate Strategic Planning
I.1 Company Environment analysis - internal/external
I.2 Company Mission, Vision definition
I.3 Company objective and strategy definition
Multifunctional team
Regulatory affairs
Quality assurance
Production
R&D
Marketing and sales
Finances
Administration
Business opportunity identification-Equip proposition
Authorization
Internal analysis: Resouces evaluation and definition (Strengh and Weakness)
Regulatory underutilized resources evaluation
Underutilized resources evaluation: technical, structure, equipment, patent analysis data base analysis (IPA, MEDLINE), research institute and Universities consu lt
Underutilized resources evaluation: recent marketing plan; mantain or change product lines
Underutilized resources evaluation: financial and client complaint data analysis
Strategic plan analysis: mantain or change business and markets

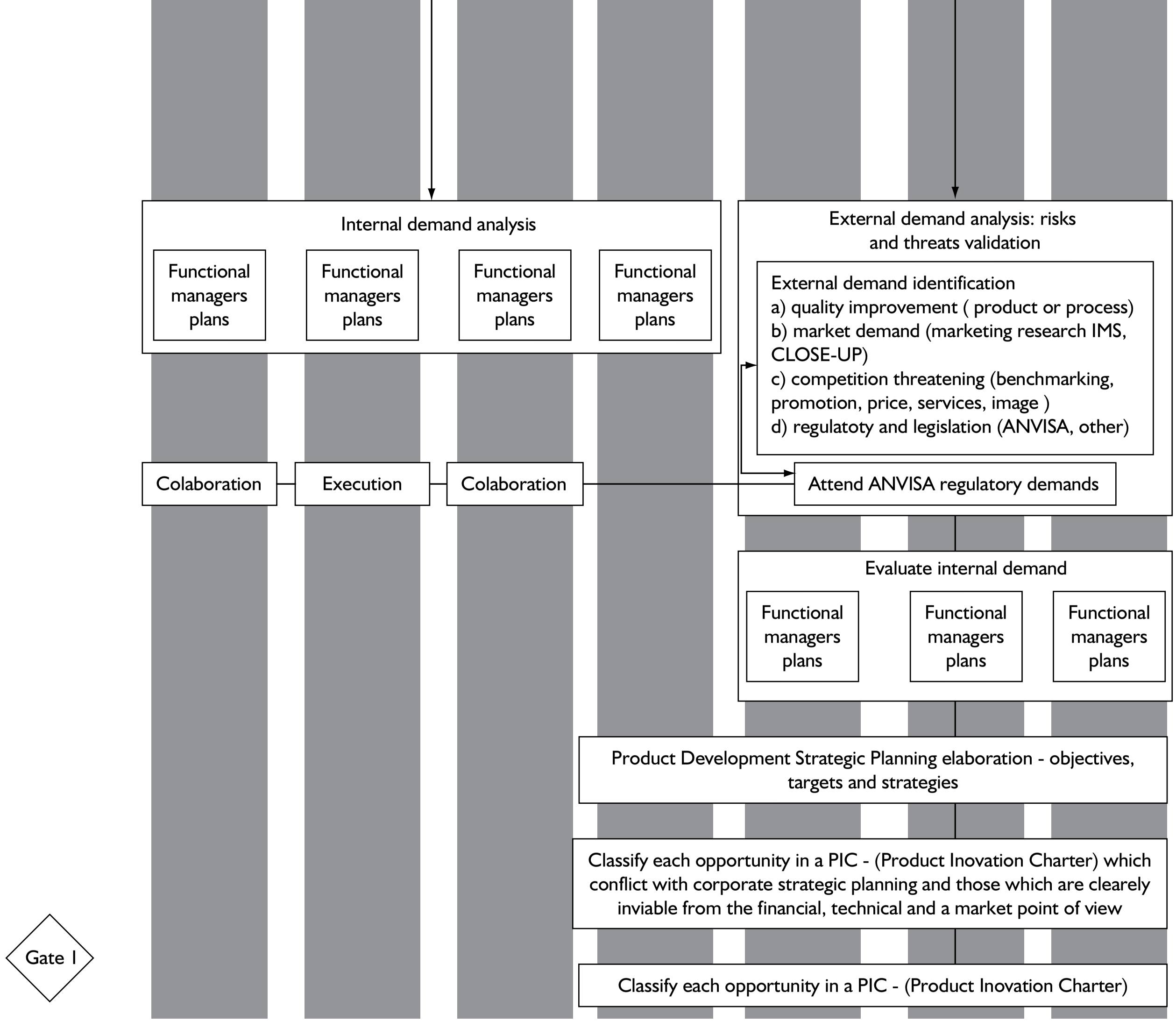


Figure 3 - Detailed graphic view from the Business opportunities identification and selection phase from the PDP reference model (Pre Development macro-stage) (IMS, CLOSE UP marketing research companies contracted).

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Table 4 – Pharmaceutical reference model macro-stage, phases and work packages.

Macro stage	Phase	Work packages from WBS - short description
Pre development	Business opportunity identification and selection	Internal and external data gathering (includes pharmaceutical legislation information)
		SWOT analysis for Product Strategic Planning (fed by Corporate Strategic Planning)
		Business/product opportunity identification, selection and PIC classification
Development	Concept development	Marketing analysis of opportunities identified
		Different concept generation (for each concept it must be suggested a benefit, a form and a possible technology (it is important do conduce interviews with physicians at this phase) (its time to identify suppliers – Phase 1)
		Financial, economical and technical analysis of concept/opportunity
	Detailed concept	Proposition of detailed concepts (For generic medicine it's time to identify and analyze the reference product; its time to select and/or develop suppliers – Phase 2)
		Detailed concept marketing analysis (submit concept alternative to physicians and potential consumers analysis)
		Thorough financial, economical, legal and technical analysis (Return on Investment, payback, other analysis)
		Product and process specification detailing (involve the production people in processes analysis); Life Cycle Analysis (environment aspects may be considered)
		Detailed product protocol analyzes and development approval (create project plan)
	Product and process development	Generic medicine bench development; generic equivalence and accelerated stability studies; process control, validation and specifications development
		Marketing plan development
	Production and marketing plan performance	Generic medicine scale up
		Production execution; marketing plan execution
		Perform generic medicine bioavailability studies and stability studies
	PDP conclusion and product registration	Submit registration dossier to ANVISA; organize Process Control Planning; finalize Product Master File ; Publish Product registration number; produce generic free samples; submit price to ANVISA
		Prepare promotional material and sales training; conclude project and save development historical
Post development	Product launching and marketing evaluation	Product launching and sales; finalize stability studies;
		Make marketing, technical, sales, and suppliers analysis; follow product performance; continuous gathering of product information

impressions about the reference model in block 2 interviews. All the interviewed experts recognized the importance of PDP management, although some of the companies still present a product development not fully formalized. Companies A, B and C, of medium sizes for example, possess PDP phase similarities with some development phases and with the post development macro-stage of the reference model. In relation to the pre-development stage and to the first two phases from Development macro-stage (concept identification and detailing) it is less structured. The larger companies D, E, F and G present a more structured pre-development macro-stage, and company G practically execute all the phase activities mentioned in the model. It is important to mention that E and G are multinational companies that develop innovative products, being therefore, more structured.

The professionals in general appreciated the Pre-Development, concept identification and detailing descriptions in the model, since there is no parallel in pharmaceutical literature. They also valued the control documents suggested in the model. Some activities dependencies were discussed mainly by professionals from company G, what imposed changes in the model. Changes or criticism in work packages were not frequent and the interviewed professionals appreciated the graphical characteristic of the model. They commented that such format is easily understood by the team components and the overview provided by Figure 2 facilitates the identification of a particular task in the global process. This fact permits a team component to establish a relation between his work and the work of other components and to valorize his participation in the overall product development.

The generality of the model was considered large, since it was analyzed and approved by experts from companies that produce human/veterinary medicines and cosmetics. The macro-stages and phases are independent on the product under development, but the work packages and activities, specially the latest, have to be defined product to product, when adopting the model.

Some other aspects must be considered. Although the model is supported by development methodologies, CE tools for example, were not widely commented in it. The tools mentioned before in literature review have been proved to bring efficiency and efficacy to product development. The Design for Six Sigma development approach, for instance, is a current successful evidence of this. It is a limitation of this reference model to present these tools, since the tools applicability has to be analyzed at each development case.

On the other hand, tools as corporate Strategic Planning and Product Strategic Planning are recommended. The marketing methodologies are mentioned in all macro-stages, reinforcing the market orientation of the model. The practice of business opportunities screening, competitors benchmarking and portfolio management as support for decision in 'what projects to invest'; the practice of former technical, financial and economical analysis of projects, before product development; the continuous analysis of products after launching, providing the feedback character of the PDP, are essential parts of the model.

The managerial aspects of the reference model are attributed to: the broad scope description guaranteed by the WBS or the hierarchical indented activity list, which were transformed in a graphic representation of the process; the process segmentation, that facilitates risk management, process execution and control, since its complexity is crescent from the begin to the end; the clear indication of organizational function sector activities and work packages in the graphic representation; the decision making and quality control gates, with their check lists and process documentation; the model feedback activity which stimulates the process cyclic quality improvement.

This reference model adoption may be easily performed by the following steps: (i) to perform the company PDP analysis/description followed by comparison with the reference model; (ii) team definition and further adjustment of the activities that will be necessary for generic product development, using WBS representation (the activities chosen from the reference model will depend on the company culture and the available structure); (iii) WBS activities decomposition in other management plans (time or chronogram; infrastructure, materials and equipment; acquisitions; human resources; risk; communication and quality plans, as prescribed in Project Management subject); (iv) process implementation and control of reference model documents and plans; (v) product development conclusion and feedback; and (vi) market product accompaniment.

Finally, some advantages of the reference model, mentioned by the interviewed professionals, include: the possibility of speeding product development; the possibility of using it to support training activities of recently contracted people and trainees; to be used for convincing administrators of investments in new resources, since the model provides a wide vision of development process; to facilitate process simulations, information management and rationalization; focus in waste minimization (time, resources, rework); the standardization of development practices, among others. The reference model is also important in the pharmaceutical academic field as a didactic tool. Some of its limitations comprise: the necessity of further activity detailing and tools definition; to perform a deeper analysis of activity dependency when the model is adopted. Possibly the company culture and infrastructure may difficult model implementation, mainly in small or medium companies that still work under an organizational function approach, instead of the process approach, and at last, the necessity of model revision if the registration legislation is changed. More significant changes must be done in the reference model activities for its application in innovative products development.

This reference model contributed to the product development state of the art evolution in the pharmacy field and it is introduced by this paper. It represents an improvement compared to general product development models presented in the literature and may be useful to guide or adjust the PDP of pharmaceutical companies.

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Biography

Istefani Carísio de Paula is pharmacist. She accomplished her Engineering Doctorate in 2004 at UFRGS and her Post Doctorate at the same University in 2007. She is an assistant professor in Rio Grande do Sul Federal University (UFRGS) since 2007 and her research interest areas are Product Development Process Management, Sustainable Product Development and Project Management.

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An Exploratory Investigation on the Challenges to the New Brazilian Automotive Suppliers

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Abstract
This paper analyzes the B2B (business-to-business) relationships between big and small or medium-sized enterprises in the automotive sector in Brazil to tentatively identify the challenges that hinder the insertion of SMEs (small and medium-sized nterprises) in this supply chain. This multiple case study analyzed the largest car part manufacturers and the largest car assembly plants located in the state of Rio Grande do Sul, Brazil. This was followed by studies of small and medium-sized businesses that had been indicated by the executives of the large companies studied. The objective was to answer the question: why are very few SMEs successful in their attempts at inserting themselves in the automotive supply chain. As identified, the main challenges faced by SMEs that do not operate in the auto chain are: the differences in the organizational objectives and the little know-how about the reality of B2B transactions in this sector.

Keywords: supply chain management, automotive industry, SMEs

Introduction
The decentralization process that is taking place in the automotive industry has been studied by several researchers, such as Collins et al. (1997); Pires (1998); Zilbovicius, Marx, and Salerno (2002); Alves Filho et al. (2002); Alves Filho et al. (2004), and Grisi and Ribeiro (2004). They argue that the strategy of large car manufacturers relies chiefly on shifting part of their production processes to the first- and second-tier suppliers (large organizations that produce parts for cars). These part producers also outsource a share of their production activities to smaller organizations, usually low-cost customized items of

a part, with low technical requirements (simple brackets, shafts, frameworks and others). As a result, many SMEs (small- and medium- sized enterprises) previously inactive in this productive chain have become responsible for the production of non-strategic items.

Usually neglected by researchers, non-strategic items represent around 40% of the total items assembled in a car, but only 8% of the cost of the vehicle (Pereira and Geiger, 2005). Considering that there are over 15,000 components in an "average" automobile (Pérez and Sanchez, 2001) and the low impact on the cost of those items, it is reasonable to say that SMEs have an important role in enabling the new productive strategies of first- and second-tier suppliers (Krause, 1997; Humphrey et al., 2000; Tan and Wisner, 2003).

However, the actual majority of buyer-supplier relationships concerning non-strategic items is not marked by a cooperative attitude. On the contrary, it has been considered, by authors such as Cousins and Crone (2003); and Kozan et al. (2006), as "unilateral", and marked by the power of the "contractor".

Considering that this situation may be influenced by other elements not yet thoroughly investigated, this article presents the results of an exploratory case study developed aiming to identify: Which other constraints hinder the inclusion of SMEs in this productive chain? Answering this question will shed new light in the challenges that the new entrants in the chain have to face.

Theoretical Framework

The high level of complexity, dynamism and uncertainty that large companies have been facing in the last years has forced firms to review their competitive priorities, triggering a transition process in which they are giving up traditional manufacturing models, adopting new organizational forms, new management practices and new strategies on all levels (Vázquez-Bustelo and Avella, 2006). In the automotive industry, companies have "organized" their suppliers into structured tiered networks, as reported by Takeuchi and Nonaka (1986) and Imai et al. (1985), namely: "primary" (or first tier) and "secondary" (or second tier) subcontractors. The second tier group is supposed to supply the first tier, which is supposed to supply an auto assembler, which plays the role of a focal company of the array. Based on cost–benefit analysis (between in-house and contracted-out production), many manufacturing functions have been transferred to the independent operators and subcontractors (Kotabe and Murray, 2004; Alves Filho et. al., 2002; Rachid et al., 2001).

The delegation process orchestrated by car assemblers allow these companies to lower total costs, to improve quality, to save space and to reduce development time (Henke Jr., 2000; and Freytag and Mikkelsen, 2007). This approach can also be observed among first- and second-tier suppliers in this sector, since the increase in the number of models and makes of vehicles manufactured and the small/medium production volumes of some models has also forced them to outsource a share of their activities to smaller organizations (Mudambi and Helper, 1998).

This outsourcing process eliminates the need for specific investments in the first- and second-tier part suppliers (Canez et al., 2001), while reducing the risks of obsolescence of a specific technology. Actually, production technology obsolescence is a potential problem in low-cost, customized items, with small or medium production volumes, and low technical requirements (such as simple brackets, shafts, frameworks and others). In this context, those "simple" items are classified as non-strategic and are delegated by the large part manufacturers to SMEs, most of them selling their surplus capacity to large organizations in different supply chains.

Considering the facts about non-strategic items assembled in a vehicle it is possible to identify the importance of the role played by SMEs in enabling the new productive strategies of large part manufacturers in the automotive sector (Krause, 1997; Humphrey et al., 2000; Tan and Wisner, 2003). On the other hand, Tuten and Urban (2001) have pointed out that SMEs benefit from this process, as this relationship provides a better use for their productive capacity, while Hondai (1992), Hayashi (2000) and Hayashi (2002) claim that such interaction leads to greater technological and managerial development in SMEs, as a result of the paradigms required by large global corporations.

Analyzing the elements described, it is possible to identify another level of the automotive supply chain that is usually ignored by researchers of this sector, namely a level made up of a large number of small- and medium-sized enterprises that are also active in other business fields, and which sell their excess capacity to large manufacturers of car parts. These SMEs are an essential constituent of the decentralization strategy of the large part producers, particularly during periods of uncertainty.

Relationship between companies in the auto chain

Although many researches suggested that close partnerships among companies are always desirable, several authors like Gadde and Snehota (2000) and Daly and Nath (2005) have pointed out that partnerships with suppliers are resource-intensive and can be justified only when the costs of extended involvement are exceeded by the relationship benefits. In fact, this is exactly what happens in the relationship developed among large part producers and SMEs, since these companies may not always be interested in a long term relationship, but only in interactions that are highly profitable or interesting for a certain amount of time. These elements have led Rese (2006) to propose a normative guideline to decide whether or not a partnership is the right coordinative form for OEM-supplier relations within a value-creating network. The guideline states: if the outsourced part does not require specific investment by the supplier, and if there is no difference in quality between the envisaged supplier and its competitors, then seeking the cheapest supplier and using the conventional market price mechanism is the best option for the buying company (large part manufacturers). Rese (2006) has also pointed out that, despite

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declarations of friendship and faithfulness, the fundamental rules of economics cannot be ignored or broken.

The interaction of elements described above has led to a situation that Kamp (2005) called the "instability of B2B relationships", which in turn resulted in a lack of confidence by the suppliers and the buyers in the longevity of standing business relationships. The author also recognizes that the instability in the network composition may generate new costs, whereas substituting suppliers offering insufficient added value improves a network's overall competitiveness.

Another problem in the relationship developed among large part producers and SMEs is the imbalance of power, which in turn may enhance the SMEs' fear of unilateral dependence, thus reducing its autonomy and power (St-John and Heriot, 1993). This perception is supported by the fact that a supplier of non-strategic items, even when their quality is considered as outstanding, may find it strategically unattractive to be a dependent partner in an arrangement owned by the buying company (Freytag and Mikkelsen, 2007). In this situation, the SME owner-manager is likely to adopt a defensive attitude toward integrated logistics into the auto chain, because of the risk of losing freedom and being imposed standards.

Outline of the scientific opportunity of this research

Reflecting on the topics described above, it is possible to conclude that the imbalance of power described may be insufficient to explain the rejection by some SMEs of the large companies' proposals, especially if we consider the strategic importance of those small units to their operational strategies. Aiming to identify elements that are influencing the decision of SMEs not to take part in automotive supply-chains, we have performed a full revision of the articles published through the last ten years in the Journal of Business and Industrial Marketing and the Industrial Marketing Management. This analysis has revealed articles focused on issues such as value creation, value measurement, B2B relationships, CRM, trust, commitment, relationship quality, power, conflict management, channel management, reverse auctions, governance, and others.

In spite of the invaluable work revised, little research has been found to deeply investigate the barriers that hinder increasing relationships among large companies and SMEs in the auto chain. Considering the fact that SMEs are the major economic agents for industrialized countries (Light, 1993; Acs, 1992) and that companies such as Toyota Motors, General Motors and Ford are now at the top of large networks of suppliers — mostly SMEs, this article attempts to fill the gap found in the literature by analyzing the characteristics and content of each challenge to SME inclusion. Identifying these challenges will shed new light on some issues related to industrial marketing approaches for SMEs in the auto chain.

Research Method

The question that had guided this study was: Why are very few SMEs successful in their attempts at inserting themselves in the automotive supply chain, in spite of all good perspectives identified? In order to answer this question, and bearing in mind the importance of the direct involvement of the researcher in the data collection process, this study was designed as an investigation based on the method of multiple holistic case study as proposed by Yin (2001) and Miguel (2007). The study will have an exploratory character, since a theory about the challenges has not been consolidated yet.

Internal validity

Observations made over a period of three years, during which the researchers took part in the Automotive Marketing Committee of the Federation of Industries, have been coupled with an analysis of documents, which made up the additional source of evidence used to collect information for the research, as instructed by Yin (2001) and Miguel (2007).

Construct validity

As proposed by Strauss and Corbin (1990), the information gathered at all stages has been cross-checked in order to consolidate the adopted constructs, before data analysis, which followed Eisenhardt's model (1989). First, the data collected from each of the cases is analyzed. This is followed by an analysis along the range of cases investigated. The final analysis was based on the dynamic matrix proposed by Miles and Huberman (1994). The final result obtained by this process has also been carried out in accordance with the research guidelines for case study research proposed by Voss et al. (2002) and Miguel (2007).

External validity and generalizability

The results of this study are limited to companies and the surrounding conditions described. In this case, the results presented can not be generalized beyond these domains. In fact, generalizability can only be claimed through a large number of replications in different contexts and industries, at different times, which is not the case.

Data collection

Interviews were conducted with the executives of purchases or logistics departments of six global parts manufacturers located in Brazil, as well as people from one truck, one bus and two tractor manufacturers. The choice of the large companies was made according to their volume of purchases described in the statistics of the Federation of Industries. Another criterion was the profile of the company. In fact, selecting companies that are different on important dimensions aimed at helping establish if the same phenomenon exists at some sites rather than at others. This approach increases the internal validity of the study.

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Table 1 presents a description of the large companies interviewed.

The interviews followed a common protocol: people from the large companies were first asked to answer some introductory questions. After that, more specific questions were asked about the problems in the supply chain and the relationship with SMEs. The results of the interviews were then sent back to the respondents in order to give them the opportunity for factual corrections.

The second stage of the research was performed before processing data from the interviews and involved 20 SMEs recommended by the executives of the large companies. The first ten SMEs have already been active in the chain and had been shortlisted by the large companies as reference suppliers, while the remaining ten were considered as potential suppliers, which for a number of reasons had been rejected in the qualification processes. In all SMEs, the interviews were conducted directly with the owners or general managers.

Table 2 presents a description of the SMEs interviewed.

Reliability

In order to ensure the reliability of this study, a written document describing the constructs to be measured was developed and tested with the managers. However, the replications verified through the process did not require a revision of this document. All information gathered during the study was saved on a database.

Constructs and propositions

The analysis of the references presented in the theoretical framework leads to the conclusion that two groups of constructs emerge from the literature, namely: "context" and "challenges".

Table 1 - The large companies interviewed.

Company	Number of companies interviewed	Product
Manufacturers of the First and Second tier of suppliers of the automotive industry	6	Pumps, shafts, engine components or drive trains
Truck manufacturer	1	Trucks for special purposes
Bus manufacturer	1	Customized units
Tractor manufacturers	2	Tractors for general and special purposes

Table 2 - The SMEs interviewed.

Product or service	Companies active in chain	Companies not active in chain
Machining	3	2
Forging	1	2
Die cast mould	2	1
Rubber	2	3
Plastic	2	2

The construct "context" is related to the mutual benefits presented in the literature, which could suggest that both groups of companies are investing their own resources aiming to optimize the relationship in focus. In this context, is reasonable to make the following propositions:

- Large companies are supporting SMEs aiming to enable their own productive strategies; and
- SMEs have been investing in order to create conditions to operate in the auto chain. These investments will leads to a better use for their productive capacity and greater technological/managerial development.

Besides that, the construct "challenges" emerge of the references that relate several problems in the relationship between large companies and SMEs. Since these problems may act as a barrier to the SMEs in the auto chain, it is reasonable to propose:

- Large companies and SMEs perceive that the instability and the imbalance of power are not the only elements that explain the problems related in the relationship.

The references that lead to the constructs and propositions described are presented in Table 3.

In order to investigate the propositions yet described, an investigation protocol was organized. The introductory questions of this protocol are presented in the Appendix.

The next section presents a summary of the information gathered.

Data Gathering

Data gathered was grouped by the authors in constructs (context and challenges) as presented in the Tables 4 and 5. As may be seen in these tables, both groups of companies have different visions regarding the questions proposed. Actually, this was already expected by the researchers. Nevertheless, the most surprising aspect identified is the difference in perceptions between SMEs that are active in the auto chain and the SMEs that are not active. As showed in the analysis presented in the next chapter, this difference in perception may also represent a challenge to the SMEs that are not active in the chain. Table 4 presents a summary of the data gathered.

Table 3 - References, constructs and propositions.

References	Constructs	Propositions
Henke Jr. (2000), Freytag and Mikkelsen (2007), Mudambi and Helper (1998), Canez, Platts, and Probert (2000), Krause (1997), Humphrey, Lecler and Salerno (2000), Tan and Wisner (2003), Tuten and Urban (2001), Hondai (1992), Hayashi (2000) and Hayashi (2002).	Context	1. Large companies are supporting SMEs aiming to enable their own productive strategies. 2. SMEs have been investing in order to create conditions to operate in the auto chain. These investments will leads to a better use for their productive capacity and greater technological/managerial development.
Gadde and Snehota (2000). Daly and Nath (2005), Rese (2006) and Kamp (2005).	Challenges	3. Large companies and SMEs perceive that the instability and the imbalance of power is not the only element that explains the problems related in the relationship.

Table 4 - Data gathered – construct context.

Introductory questions	Large companies	SMEs active in the auto chain	SMEs not active in the auto chain
What is the main objective that guides the actions of your company when interacting with your partners?	To identify new cheap SME suppliers for low-cost customized items with small or medium production volumes and low technical requirements.	To reduce the production idleness with an attractive profit margin.	To have a profit margin and a standard of service similar to those practiced in other productive chains.
How do you see the perspectives of this relationship?	The large companies will keep pressing SMEs for better indexes on low-cost, customized items with small or medium production volumes, and low technical requirements, until the imports become attractive for those items.	Good, if the SMEs do not allocate the full production capacity of their units to the large companies.	Unattractive since SMEs can find other business opportunities that offer better returns.

Table 5 - Data gathered – construct challenges.

Introductory question	Large companies	SMEs active in the auto chain	SMEs not active in the auto chain
Which are the major weaknesses of your partners?	Low levels of technical and managerial expertise of some SMEs make it difficult to understand the complex calculations to determine price adjustments. The tendency to concentrate power on the SMEs owner.	Large companies do not know the real costs of non-strategic items. This allows SMEs to make a huge profit in the chain.	Little knowledge about the reality of an SME.
Do you see any points of conflict?	Pricing, quality and delivery requirements.	The reluctance shown by large companies in accepting automatic cost hike transfers.	Requests for free samples and lack of support in the acquisition of expensive tools.
Which are the major problems in the relationship?	SMEs find it difficult to understand that the low margins offered by the large companies can be compensated by a high volume of sales or a steady flow of orders.	Large companies place a high demand on SMEs without compensation in the prices paid.	No support from the large companies during the prototyping phase. Prices paid are not attractive.
Which other elements hinder the inclusion of SMEs in the auto chain?	SMEs can not deliver international price, quality and performance benchmarks.	The international benchmarks imposed are a result of specific advantages of some regions of the world, which are not available in Brazil.	Prices paid and absence of financial support by the large companies to SMEs during the prototyping phase.

Data Analysis

The analysis of the data gathered suggested that the important challenges result from the differences in the objectives of each group of companies and the little know-how of inactive SMEs about the reality of B2B transactions in the chain. Considering the number of "non-strategic" items assembled in a car and its impact on the vehicle's cost (see the Theoretical Framework chapter), it is reasonable to admit that the SMEs active in the chain are correct when they say that some large companies do not know the true costs of all "non-strategic" items assembled in their auto parts. In this context, only the SMEs active in the chain can capitalize in the profitable items to subsidize the non-profitable ones and keep the relationship going.

With time, the SMEs that are active in the chain will try to convince large companies to offer those items to SMEs that are not active in the chain. Faced with non-profitable items, the SMEs that are not active will prefer to refuse the offer, reinforcing and even consolidating their false perception about the low attractiveness of the chain, in circular thinking. In fact, these obstacles are responsible for many small indigenous firms viewing the inclusion into the auto chain with great skepticism, as well as neophyte entrants developing a negative attitude toward the practices in the sector. At the same time, this context also reinforces the position and price policies of SMEs active in the chain, since the refusals force the large companies to buy those items from their traditional SME suppliers.

The expectation for financial support expressed by SMEs that are not active in the chain is also another important challenge. Indeed, the prices, the request for free samples and the lack of financial support from large companies for the purchase of expensive tools clashes with the desire for "quick profits" voiced by owners of this group of SMEs.

Besides that, the global presence of large part manufacturers exposes local SMEs to international price benchmarks. This pressure does not take into account that the benchmarks considered are a result of the very specific competitive advantages of some regions of the world, which might not apply to the situation in Brazil. The lack of technical and managerial expertise of some SMEs, associated with high performance demands regarding pricing, dictated by global benchmarks, can drive away many local organizations.

However, this challenge is in some cases merely a result of the lack of information by SMEs, which may be unaware of the real intentions of large companies. Actually, some large corporations resort to these approaches with the sole objective of pressing local SMEs for lower costs not having intention of importing items, because of the requirements made by foreign suppliers (especially in terms of quantities and accuracy of forecasts). In fact, these requirements are sometimes in direct opposition to the need for flexibility dictated by the oscillating Brazilian market. Accordingly, a procurement manager states that what large organizations wish for is a local SME that can handle the production of a given item according to "favorable" price conditions. Again, this situation generates a challenge to the SMEs not active in the chain, since those companies do not know the rules of the game.

Proposition's Analysis

The analysis of the first proposition reveals that the large companies are not supporting SMEs, in spite of the importance of these small companies to their operational strategies.

Regarding the second proposition, only the SMEs that are active in the chain will invest to develop new business in the sector. SMEs that are not active in the chain do not plan to invest, since this group of enterprises does not know the unwritten rules of the game in the auto sector. The proposition focused on instability and imbalance of power was confirmed.

Conclusions

Aiming to answer the question "Why are very few SMEs successful in their attempts at inserting themselves in the automotive supply chain, in spite of all good perspectives identified?" this investigation analyzed large buyers of the auto industry and small and medium-sized suppliers that are active or inactive in this chain.

As identified, SMEs that do not operate in the auto chain may face some difficulties to find a point of insertion in the automotive chain as a result of the following challenges: differences in the organizational objectives and little know-how about the reality of B2B transactions in this sector. The non-profitable items offered by large companies to SMEs that are not active in the chain, the lack of financial support from large companies, the high performance demands regarding prices imposed by the big buyers and the lack of technical and managerial expertise of SMEs are some of the elements associated to these challenges that were identified in this study.

Indeed, these challenges unveil some pending questions that must be solved in order to create a more attractive scenario to small and medium-sized companies in this chain.

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Biography

Giancarlo Medeiros Pereira is a professor at Universidade do Vale do Rio dos Sinos (UNISINOS). He received his master degree from the Universidade Federal do Rio Grande do Sul (UFRGS) and his Ph.D. from the Universidade de São Paulo (USP). His researches are focused on Operations Management, Industrial Marketing and Supply Chain Management and Innovation.

Albert Geiger is a Metallurgical Engineer and a Master in Engineering from the Universidade Federal do Rio Grande do Sul (UFRGS). He is currently completing his doctorate in production engineering (at UFRGS) when he has discussed the competitiveness of clusters within the context of global value chains. He has dedicated his research in the study of the global automotive value chain, its movements, and supplier characteristics and requisites.

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Appendix

Table I – Introductory questions.

Constructs	Propositions	Introductory Questions
Context	1. Large companies are supporting SMEs aiming to enable their own productive strategies. 2. SMEs have been investing in order to create conditions to operate in the auto chain. These investments will leads to a better use for their productive capacity and greater technological/managerial development.	What is the main objective that guides the actions of your company when interacting with your partners? How do you see the perspectives of this relationship?
Challenges	3. Large companies and SMEs perceive that the instability and the imbalance of power is not the only element that explains the problems related in the relationship.	Which are the major weaknesses of your partners? Do you see any points of conflict? Which challenges hinder SME inclusion into the auto chain? Which are the mechanisms used for hindering the inclusion of SMEs in the auto chain?

The concept of the challenge adopted by the authors and proposed to the participants was: constraint that hinders the firm's ability to initiate, to develop, or to sustain business relationships in the auto chain.

All questions listed were proposed to both groups of companies. The following questions were also proposed to the executives of the large companies at the end of the meetings:

- Can you provide a list of your best SME suppliers?
- Can you provide a list of potential SME suppliers that for any number of reasons have been rejected in the qualification process?

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Decision-Making Considering Dependence Relations for the Improvement of Production Management

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Abstract
Traditional Multiple Criteria Decision-Making methods have been effectively applied by Brazilian industries. An intrinsic requirement of applying these methods is that the alternatives and criteria be independent of one another. In this paper we show how a Brazilian company can consider dependencies among the alternatives and among the criteria in solving Production Management problems. The need to consider dependence among alternatives was detected in the course of a study applying traditional decision-making methods. The main benefit from considering dependence was the notably higher satisfaction of the decision-makers. That is, it made the decision-making model closer to the real problem, as perceived by the decision-makers. A main conclusion of this article is that considering dependence in decision making can improve the quality of the process.

Keywords: AHP, ANP, BSC, MCDM, production management

Introduction
In production management, managers must keep the operation flowing and balance their activities. The issue is how to decide where to devote attention and resources to achieve that objective. In this article we will show how a Production Management team in a company used Multiple Criteria Decision Making (MCDM) methods to prioritize its activities for improvement.

A Brazilian company, part of a worldwide group, approached the first author of this study asking for help with waste due to excessive overtime hours, idle workstations and excess inventory levels. The company manufactures equipment for the mining and construction industries and its production process involves assembling standardized products. A team

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was assembled with the first author serving as a consultant and facilitator and managers from production management serving as the experts and providing the judgments.

The Production Management team decided that the goal of their study should be to use the company's performance indicators to prioritize the list of key activities for Production Management from Silver (1998). The Analytic Hierarchy Process (AHP) developed by Saaty (2001) was chosen as the MCDM method. The Analytic Network Process (ANP) for decision making with dependence and feedback is a generalization of the AHP due to Saaty (2005). The team made the necessary additional assessments. A prioritized list of activities that seemed more realistic than those derived using the AHP was the result. The members of the team were more satisfied with the results from the second model.

We then show how the multiple-criteria decision was structured. A brief comparison of the results from the AHP versus those from the ANP is given in the Conclusions section.

Research Methodology

The Brazilian company is part of a worldwide industrial group and as the study got under way it was learned that the board of the parent company had already implemented the Balanced Scorecard (BSC) proposed by Kaplan and Norton (1992) to identify indicators they wanted to use to measure performance. According to the Production Decision Making Framework proposed by Silver et al. (1998) some of the key activities of production management are: capacity planning; distribution planning and scheduling; materials planning; sale forecasting; and short-range scheduling.

In this way, the Production Management team could determine the key production management activities they should improve. The hierarchy was structured with the goal at the top, the board's performance indicators as established using BSC in the first level (the criteria), and the key activities of production planning in the second level (the alternatives). The weights for the performance indicators had already been determined using the BSC process. The next step would be to use the AHP to prioritize the production management activities with respect to each indicator to get an overall prioritized list of activities for improvement.

After obtaining a list of activities with their priorities from the first AHP model, the team recognized that they had not considered dependence among the factors so they expanded their original AHP model into an ANP model.

Background

For more than ten years, MCDM has been effectively applied by Brazilian industries. Salomon and Shimizu (2006) reported that research in Brazil has been concentrated in applications of the AHP, the *Élimination et Choix Traduisant la Réalité* (ELECTRE) method and the Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH). In Brazil, these three methods have been considered to be the traditional MCDM methods. An intrinsic feature of traditional MCDM methods is that the elements must be independent. So to apply any of these methods, the alternatives must be independent of each other.

The same consideration applies to the criteria. Keeney (1992) stated that independence among criteria is required, because each criterion must allow the analysis of a fundamental aspect, in an independent way. If two or more criteria are mutually dependent then these criteria must be aggregated before applying a traditional MCDM method. Otherwise, the same effect might be counted twice or more.

Traditional MCDM methods also require independence among the alternatives. That is, the performance of an alternative should have no effect on the performance of other alternatives. This consideration may sound strange, nowadays, when companies practice Benchmarking (Camp, 2006). With Benchmarking, also known as Best Practice Benchmarking, companies evaluate various aspects of their processes in relation to best practice, usually within their own sector. This way, how well a company performs a business process can depend on or even influence the performance of other companies. One must, however, remember that AHP, ELECTRE, and most of the other MCDM methods, were developed in the 1970's before Benchmarking became a commonly accepted practice.

The ANP is a newer MCDM method, a generalization of the AHP that does not require independence among alternatives or criteria. As can be seen, the ANP application started out as an AHP application, but when some dependence relations were detected, the method was changed to ANP to accommodate the dependencies.

AHP can be used to make decisions in a complex multi-objective setting that includes both tangibles and intangibles using judgments supplied by key players or experts (Saaty, 1980, 1996). The AHP methodology is based on three principles: (1) identify the elements in the problem and arrange them into hierarchical levels with parent elements in a given level connected to their children elements in a level below; (2) make all possible pairwise comparison judgments on the children of each parent with respect to the common property it represents; and (3) synthesize all the judgments throughout the structure to determine the priorities of the alternatives. In the AHP, the Fundamental Scale, a linear 1 to 9 scale presented in Table 1, is used to make the judgments.

The criteria are pairwise compared with respect to the goal, the sub-criteria with respect to their parent criterion, and the decision alternatives with respect to the last

Table 1 – AHP's Fundamental Scale.

Judgment	Description
1	A and B are equal
3	A is moderately dominant over B
5	A is strongly dominant over B
7	A is very strongly dominant over B
9	A is absolutely dominant over B

The values 2, 4, 6, and 8 are used for judgments in between. The judgments are relative absolute numbers; consider the dominated element to be the unit and enter the judgment that expresses how many times more the dominant element is. Enter the reciprocal in the inverse position in the matrix. Decimals are allowed, i.e., 5.6 is a permissible judgment. If A and B are close, use 1.1, 1.2, …1.9.

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level of sub-criteria above them. Let us consider the criteria (or alternatives) A_1, A_2,..., A_n. The purpose in the AHP is to prioritize them with respect to a parent element (the goal) to find the weights of influence w_1, w_2,..., w_n. The vector $w = [w_1\ w_2\ \ldots\ w_n]^T$ is called a priority vector. For (A_i, A_i) set the judgment to $a_{ii} = 1$ (along the diagonal). For the ordered pair (A_i, A_j) if A_i is dominant over A_j enter the judgment $a_{ij} > 1$ in the (i, j) position in the matrix and enter the reciprocal, $1/a_{ij} < 1$ in the (j, i) position, otherwise enter $a_{ij} > 1$ in the (j, i) position and $a_{ij} = 1/a_{ij} < 1$ in the (i, j) position. If A_i is equal in dominance to A_j, then $a_{ij} = a_{ji} = 1$. One thus forms a reciprocal n × n comparison matrix $A = (a_{ij})$.

A priority vector $w = [w_1\ w_2\ \ldots\ w_n]^T$ is derived from each comparison matrix $A = \{a_{ij}\}$ and its elements w_i, i = 1, 2, ..., n, are referred to as the priorities or simply the weights of the elements A_i. The set of n relative priorities is often normalized to sum to one, $\sum_{i=1}^{n} w_i = 1$, wi >, i = 1, 2,...n. If $a_{ij}a_{jk} = a_{ik}$, for all i, j, k, then the elicited judgments are consistent, and the matrix is also called consistent. When the matrix A is consistent, it is easy to find w by summing each row and normalizing the resulting vector or by normalizing any column of A. When A is consistent, $a_{ij} = w_i/w_j$, i, j = 1, 2, ..., n.

When A is not consistent, and in practice it is usually not consistent because it is based on subjective judgments, Saaty (2005) proves that the principal eigenvector of the matrix should be used for the priority vector w because it uniquely captures transitivity of dominance along all possible paths in the case of an inconsistent matrix.

All the priorities throughout the network are synthesized by a process of weighting and adding that yields the overall priorities for the alternatives.

Structuring an MCDM Decision in Production Management

The worldwide industrial group that owned the Brazilian company with the production management problem had earlier implemented a management strategy using the Balanced Scorecard (BSC) theory, proposed by Kaplan and Norton (1992), to measure the performance of their companies. The group's board, located in Europe, identified the indicators to be used. As suggested by the BSC theory, the importance values were equally distributed among the main BSC perspectives, and were also equally distributed to the indicators for each perspective resulting in the overall importance percentages for the indicators shown in Table 2.

Table 2 - Relative importance of the indicators.

BSC perspective	Indicator	Importance (%)
Financial	Profitability	25
Customer	Customer satisfaction	25
Internal	Effectiveness	8.3
	Efficiency	8.3
	Productivity	8.3
Innovation	Creativity	25

Among other problems, the Production Management team in Brazil reported that there were too many hours of overtime for employees at workstations that were idle later in the same week. They also reported they had been working with high levels of inventories (raw-materials and work-in-process) in order to deliver their products by the promised dates. The overtime work and high levels of inventory were causing the company to waste money. Because of this the company recognized that Production Management performance must be improved and established a team to work on it.

From the Production Decision Making Framework proposed by Silver et al. (1998), five key activities emerge: capacity planning; distribution planning and scheduling; materials planning; sale forecasting; and short-range scheduling. These are the activities where improvement should be sought and they can be considered to be the alternatives of the decision. The objective of the decision-making is not only to select the best activity to improve, but to determine which activity to improve first.

The team decided to apply a traditional MCDM method to this decision using the indicators presented in Table 2 as criteria and improvements in the Production Management activities as alternatives. The AHP was the MCDM method selected because of its widespread use (Steiguer et al., 2003).

The Analytic Hierarchy Process Application – the First Model

Figure 1 presents the AHP model for the MCDM problem. This model is a three level hierarchical structure. In the first level we have the objective or goal of the decision; in the second level we have the criteria; and in the lowest level are the alternatives. The goal of the model is to prioritize the Production Management activities (in the bottom level) for their potential as candidates for improvement. The arrows from the goal to the criteria,

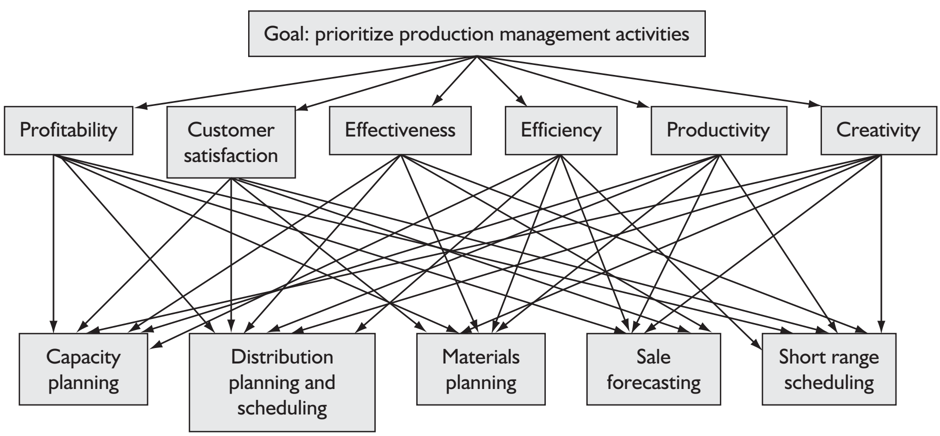

Figure 1 – Hierarchical model for improving Production Management activities.

the indicators which were selected using BSC, show that they must be pairwise compared to prioritize them with respect to the goal. The initial values are shown in Table 2. The arrows from the criteria to the alternatives indicate that the alternatives must be pairwise compared with respect to each criterion.

Pairwise comparisons are made using judgments based on the Fundamental Scale (Saaty, 2001), resulting in a judgment matrix A. The priorities are obtained by determining the principal eigenvector, w, of the judgment matrix, A. There are different software packages that can be used to obtain w. There are also several academic or commercial versions of software which make this computation. However, some developers or vendors set limitations for using the free versions of their software. Examples of these limitations are no printing or saving of files and sometimes there are limitations on the number of criteria and alternatives.

In this paper a version of the SuperDecisions software for the ANP (Whitaker and Adams, 2005) was used. The SuperDecisions software was chosen, among other reasons, because there is a free version (to educators and researchers) that can be downloaded from www.superdecisions.com with no limitation on its features. Another great advantage of the SuperDecisions software when comparing it to other AHP capable software is that it can be used for both AHP and ANP applications.

The Production Management team made the judgments to prioritize the activities with respect to the indicators. Table 3 shows their judgments on the activities with respect to the Profitability indicator. For instance, improving distribution planning and scheduling was considered moderately more important than improving capacity planning, so a 3 was placed in the (DIS, CAP) cell. The values in the Priority column are the components of w, obtained with the SuperDecisions software.

A similar judgment matrix was completed for each of the other indicators. Table 4 presents the resulting priorities. To obtain the overall priority, a weighting and adding process was used. For each activity its priority with respect to an indicator was multiplied by the relative importance of the indicator (taken from Table 2 and indicated in bold), and these products summed across the row to yield the overall priority. Note that the sum of the priorities of the indicators is 1, and as each column also sums to 1 the Overall priorities in the final column will sum to 1.

Table 3 – Judgments and resulting priorities to improve Profitability activities.

Profitability	CAP	DIS	MAT	FOR	SCH	Priority (%)
Capacity planning (CAP)	1	1/3	3	1	1	18.5
Distribution planning and scheduling (DIS)	3	1	1	3	1	28.0
Materials planning (MAT)	1/3	1	1	1	1/5	11.0
Sale forecasting (FOR)	1	1/3	1	1	1/5	9.8
Short-range scheduling (SCH)	1	1	5	5	1	32.7

It can be seen from Table 4, that short-range scheduling (SCH) had the greatest overall priority with distribution planning and scheduling (DIS) second for improvement. After performing sensitivity analysis, this result was further reinforced. As can be seen in Table 3, DIS and SCH are the two highest priority alternatives for all the criteria except under Efficiency. Sensitivity analysis shows that only if the importance of Efficiency is increased from 8.3% to more than 30%, will the overall priority of capacity planning (CAP) be higher than that of distribution planning and scheduling (DIS). And only if the importance of Efficiency is higher than about 55%, will the improvement of capacity planning (CAP) have the highest priority. Figure 2 shows how the overall priorities change as the priority of Efficiency changes.

The judges reported that they had some difficulty in making the judgments in Table 2 because of the fact that in Production Management the activities are not independent – they influence each other; for example, consider capacity planning and materials planning, Even so, it was possible to obtain consistent judgments so that the Consistency Ratio was never more than 0.1, as shown by Saaty (2001) for 5 by 5 judgment matrices. Due to this difficulty, however, and due to the feelings the judges expressed that there was some

Table 4 – Overall priorities for improving activities.

Activity	Profitability (%)	Customer satisfaction (%)	Effectiveness (%)	Efficiency (%)	Productivity (%)	Creativity (%)	Overall (%)
	25	25	8.3	8.3	8.3	25	
CAP	18.5	12.1	7.4	46.3	4.9	9.6	14.9
DIS	28.0	41.6	29.5	3.7	16.7	26.3	28.2
MAT	11.0	5.6	18.5	14.4	13.1	12.3	11.0
FOR	9.8	15.3	22.3	6.2	14.0	18.7	14.5
SCH	32.7	25.4	22.3	29.4	51.3	33.1	31.4

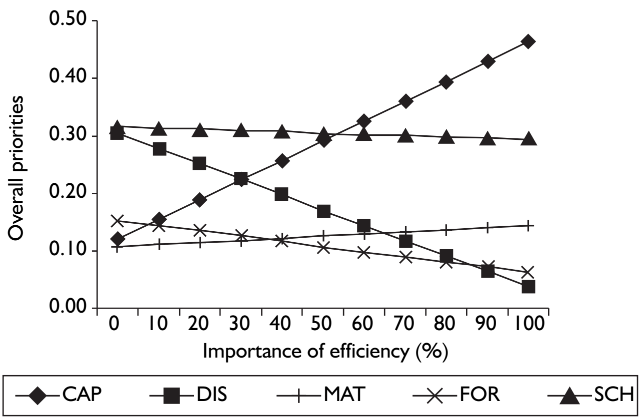

Figure 2 – Variation of overall priorities according to the importance of efficiency.

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dependence among the activities, the team decided to formulate the decision again as an ANP model that would be able to handle these dependencies.

The Decision Revisited with the Analytic Network Process – the Second Model

The Analytic Network Process (ANP) is a generalization of the AHP that can take feedback and dependencies among the elements into consideration. The first step in an ANP application is to group the elements in clusters. According to Saaty (2005), a cluster is a collection of elements whose function derives from the synergy of their interaction. In this case, the criteria of the AHP application were grouped in a cluster and the alternatives in a second cluster. Figure 3 shows the resulting structure of clusters, nodes and links in a screenshot from the SuperDecisions software.

In the SuperDecisions software, to avoid the visual confusion of too many arrows, the convention is that an arrow from one cluster to another cluster means that a node in the source cluster has a link to at least one node in the destination cluster.

All the links are shown in the Reachability Matrix. For the network exhibited in Figure 3 the Reachability Matrix consists of four blocks: (Alternatives, Alternatives), (Alternatives, Criteria), (Criteria, Alternatives), and (Criteria, Criteria). When there is a 1 in a Reachability Matrix cell, the column element is linked to the row element. It means that the row element influences the column element or, to put it another way, the column elements depends on the row element. If there is only one 1 in a column of a block, this means that the column element is totally dependent on the row element. If there is more than one 1 in a column of a block, then, the next step will be to determinate the priorities

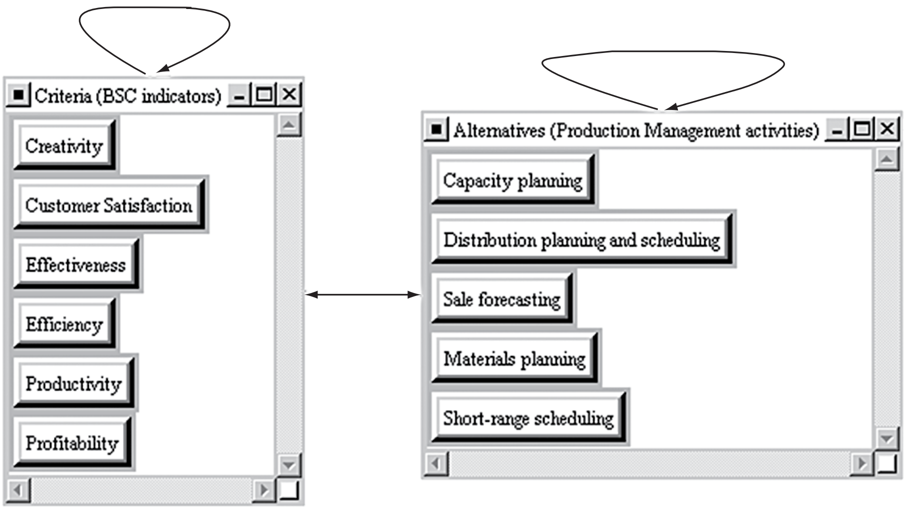

Figure 3 – Network model for improving Production Management activities.

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of the influence from the row elements on the column element. So row elements will be pairwise compared as to which influences more the column element.

When the Reachability Matrix presented in Table 5 was completed it was shown to the judges and approved by them.

The inner dependencies in the (Alternatives, Alternatives) block of the Reachability Matrix were based on the Production Decision Making Framework proposed by Silver et al (1998). For example, CAP is connected to CAP, FOR, MAT and SCH. This way, the Production Management team has provided pairwise comparison about the influence of CAP, FOR, MAT and SCH on CAP. These judgments, based on the Fundamental Scale, were input in the SuperDecisions software resulting in the priorities in Table 6.

Table 5 – Reachability Matrix.

		Alternatives					Criteria					
		CAP	DIS	FOR	MAT	SCH	CRT	CST	EFC	EFT	PRF	PRO
Alternatives	Capacity planning (CAP)	1	1	0	1	0	1	1	1	1	1	1
	Dist. plan. and sch. (DIS)	0	1	0	0	0	1	1	1	1	1	1
	Sale forecasting (FOR)	1	1	1	0	1	1	1	1	1	1	1
	Materials planning (MAT)	1	1	0	1	1	1	1	1	1	1	1
	Short-range sch. (SCH)	1	1	0	1	1	1	1	1	1	1	1
Criteria	Creativity (CRT)	1	1	1	1	1	0	1	1	0	0	0
	Customer Sat. (CST)	1	1	1	1	1	0	0	0	0	1	0
	Efficiency (EFC)	1	1	1	1	1	0	0	0	0	0	1
	Effectiveness (EFT)	1	1	1	1	1	0	1	0	0	0	1
	Profitability (PRF)	1	1	1	1	1	0	0	0	0	0	0
	Productivity (PRO)	1	1	1	1	1	0	0	0	0	1	0

Table 6 – Supermatrix of resulting priorities.

		Alternatives					Criteria					
		CAP (%)	DIS (%)	FOR (%)	MAT (%)	SCH (%)	CRT (%)	CST (%)	EFC (%)	EFT (%)	PRF (%)	PRO (%)
Alternatives	CAP	64.9	15.5	0	14.9	0	9.6	12.1	46.4	7.4	18.5	4.8
	DIS	0	47.1	0	0	0	26.3	41.6	3.7	29.5	28.0	16.7
	FOR	15.9	4.0	100	0	5.9	18.7	15.3	6.2	22.3	9.9	14.0
	MAT	11.2	6.9	0	78.5	24.0	12.3	5.6	14.4	18.5	11.0	13.1
	SCH	8.0	26.5	0	6.6	70.1	33.2	25.4	29.5	22.3	32.7	51.3
Criteria	CRT	25.0	25.0	25.0	25.0	25.0	0	16.7	0	100	0	0
	CST	25.0	25.0	25.0	25.0	25.0	0	0	0	0	83.3	0
	EFC	8.3	8.3	8.3	8.3	8.3	0	0	0	0	0	25.0
	EFT	8.3	8.3	8.3	8.3	8.3	0	83.3	0	0	0	75.0
	PRF	25.0	25.0	25.0	25.0	25.0	0	0	0	0	0	0
	PRO	8.3	8.3	8.3	8.3	8.3	0	0	0	0	16.7	0

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The elements from the criteria cluster also have some dependence among themselves. The dependence relations among the BSC indicators had been established independently by the company board in Europe as shown in an actual graphic from the company, presented in Figure 4.

It is interesting to note that in Figure 4, a graphic from the company based on the BSC theory, the convention used for the direction of the arrows is opposite to that used in the ANP. For example, the link is from Customer Satisfaction to Creativity and Effectiveness in ANP as shown in Table 5, meaning Customer Satisfaction depends on Creativity and Effectiveness, but it goes the opposite direction in Figure 4.

The next step in the ANP application is to establish the priorities. This is done by making pairwise comparisons in the same way as in the AHP by making judgments using the Fundamental Scale, and deriving priorities as the eigenvector of the judgment matrices. The Supermatrix has the same structure as the Reachability Matrix with priorities replacing the link indicators as shown in Table 6.

The priorities from the AHP application for improving the activities with respect to each of the indicators (Table 4) were inserted in Table 6 in the (Alternatives, Criteria) block. That is, the same priorities from the AHP model were re-used in the ANP model.

The priorities of the criteria, that is, the BSC indicators importance as specified by the European board in Table 2 were used as the priorities of the influence of the criteria on the alternative. The same priorities were used for all the alternatives in the (Criteria, Alternatives) block. Usually in an ANP model (Saaty, 2005) these feedback priorities are also derived by making pairwise comparisons, and would be different for each alternative.

The overall priorities of the elements in the ANP come from the Limit Supermatrix. But, at first, a Weighted Supermatrix is obtained from the initial Supermatrix in Table 6. In this

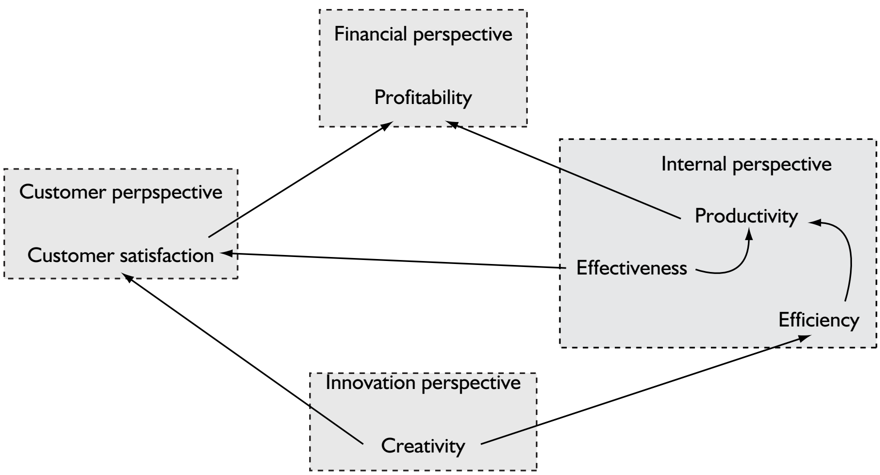

Figure 4 – Dependence among the criteria.

simple case that has only two clusters, it can be achieved by multiplying the blocks of the Supermatrix by ½. The Limit Supermatrix is then obtained from the Weighted Supermatrix by raising this matrix to powers until it converges. The Weighted Supermatrix here has converged by the 16^{th} power and is given in Table 7. Note that all the columns are the same in this instance.

The new overall priority vector for the alternatives is obtained by normalizing the priorities in the alternatives component in the Limit Supermatrix. They are given in Table 8 along with the original priorities obtained using AHP.

We observe that improving short-range scheduling has the highest priority when applying either AHP or ANP. The overall priority value is almost the same with both methods (32.0% for AHP and 29.2% for AHP).

With the AHP the improvement of distribution planning and scheduling has the next highest priority (28.5%); while with the ANP application it is markedly less (18.6%), coming after improving sales forecasting (21.6%). The reason for the difference can be explained this way: improving sales forecasting would have an impact on the improvement of capacity planning, distribution planning and scheduling and short-range scheduling, but improving distribution planning and scheduling has only expected impacts on itself.

Table 7 – Limit supermatrix.

		Alternatives					Criteria					
		CAP (%)	DIS (%)	FOR (%)	MAT (%)	SCH (%)	CRT (%)	CST (%)	EFC (%)	EFT (%)	PRF (%)	PRO (%)
Alternatives	CAP	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
	DIS	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9
	FOR	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
	MAT	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
	SCH	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
Criteria	CRT	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
	CST	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
	EFC	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	EFT	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
	PRF	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
	PRO	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1

Table 8 – Priorities for improving activities with AHP versus ANP.

Activity	Overall priority (AHP) (%)	Overall priority (ANP) (%)
Capacity planning	14.5	13.1
Distribution planning and scheduling	28.5	18.6
Materials planning	10.9	18.4
Sale forecasting	14.1	21.6
Short-range scheduling	32.0	28.3

Limitations and Thrust of the Research

The Production Management activities were evaluated against the indicators developed by the parent company, but additional indicators could be added. The judgments were done through consensus but the AHP also has the capability to use individuals' judgments. Finally, the problem areas of excessive overtime hours, idle workstations and excess inventory levels that inspired the study in the first place were not specifically addressed in the model. A cluster containing these elements could be added into the ANP model. Some initiatives, such as the use of *kanbans* and optimized production technology, are beginning to be studied. However, these are subjects for future research.

This is a multicriteria problem where the influence of many factors is brought to bear on the outcome and one needs to know the priorities of these factors to take the necessary measures to improve the highest priority activities. It is clear that expert judgment is essential because a large number of intangible factors are involved and there is no way to made sense of raw data apart from expert judgment in this case. Multicriteria decision methods make the role of human judgment central in any undertaking, either directly or by using it to interpret numerical data. These methods have introduced a shift in paradigm in scientific research by making the judgment process explicit by structuring it mathematically. So one of the main contributions of this study is to show how such a method can be used to bring human judgment into an important practical business problem.

Conclusions

An application using first the Analytic Hierarchy Process (AHP) then the Analytic Network Processes (ANP) to prioritize improvements of Production Management activities for a Brazilian company is presented in this article. The result for both approaches is that the highest priority area for improvement is short-range scheduling in the factory. However, the results for improving the other activities were different for the ANP than for the AHP. After some reflection and analysis, the ANP results for the secondary improvements seemed to be more realistic.

The example presented in this article was a real world application of MCDM. The Brazilian company, part of a worldwide industrial group, had five different alternatives to reduce some problems. With the AHP and ANP applications it was possible to determinate which alternative to do first, that is, which alternative ranked highest for improvement. In this decision-making exercise, some previous information, such as the BSC indicators determined by the company board, was incorporated.

The first observation learned from this article is that considering dependence among the elements of an MCDM application did not change the result much for the top priority alternative, but it did change the order of the lower ranked alternatives and it did clarify the results. The judges concurred that the order obtained in the ANP result made more sense to them and was more what they expected. The main benefit from the ANP application was the notably higher satisfaction of the decision-makers. With dependence the model was more able to capture the real problem and the results were easier to explain and better matched the intuitive understanding of the judges. The judges were more satisfied with the process when they could include their feelings about the dependencies. This cannot be done with traditional MCDM methods. Perhaps the main contribution of this article is that considering dependence in decision-making can improve the quality of the process.

Acknowledgments

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Biography

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New Product Development based on Web Technology – Case Studies in Brazilian Companies

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Abstract

The advent of new information and rapid-communication technologies such as extremely powerful desktop computers, the Internet, and the World Wide Web (web) are leading to new and exciting methods of concept evaluation. This paper aims to analyze how companies are exploring Web (Internet) technology for developing new products, based on the concepts of interactivity and connectivity. The adopted methodological approach was case study. Two service companies were studied, selected according to their previous (and preliminary) classification in the Strategic Grid. A plan was developed based on the theoretical background in order to carry out this research. Interviews were made with at least three different professionals (from different areas and hierarchical positions) of each company. Information was collected through semi-structured interviews. The choice of companies of different classification in the Grid is important to analyze the differences and similarities in the new product development process and to allow a comparison among these enterprises. The preliminary results allowed the identification of enablers and tools for supporting the development of a new product as well as the identification of the components that are used during the innovation cycle of creation of a product based on the web.

Keywords: services, new product development, internet

Introduction

In the 21st century, operations management will continue to emphasize the creation of value through innovation and improvement of products and processes. New challenges and opportunities are arising driven by global markets, global competition and the global dispersion of engineering talents. In that scenario, communication and information technologies are adding new capabilities for products development (PD) and customer input to all stages of the product development process.

Nowadays, the economic scenario, sometimes identified as “The Digital Economy” (Tapscott et al., 1996) or “Digital State” (Martin, 1997), is well known the increasingly critical role played by Information Technology (IT). In special, the Internet (or the Web) has been considered the most ubiquitous application of IT (Porter, 2001; Zwass, 1998).

Laurindo (2002) discussed the relationship between IT and business strategy and enterprises operations through the Strategic Grid (McFarlan, 1984), the Information Intensity Matrix (Porter and Millar, 1985) and the Strategic Alignment Model (Henderson and Venkatraman, 1993).

According to Smithson and Hirschheim (1998), due to pressures to implement costs reduction and improve the quality of products and customer services, the organizations have faced the need to review their processes and to transform their business models. Therefore, information technology (IT) has assumed an important role within the organizations, in terms of creating the conditions for the viability of these requisites so that the organization can strive to and maintain its competitiveness. Thus, it has been observed that organizations make high investments in IT, and these investments have increased mainly due to need of Internet based applications.

This paper aims to analyse if the companies are exploring Web (Internet) technology for developing new products in organization, based on the concepts of interactivity and connectivity.

The adopted methodological approach was case study (Yin, 1991; Claver et al., 2000). Two service companies were studied, selected according to their previous (and preliminary) classification in the Strategic Grid. Another criterion was the existence of important IT projects based on Internet.

The selected companies can be classified in the Strategic and Turnaround boxes of the Strategic Grid (McFarlan, 1984). The choice of companies of different classification in the Grid is important to analyse the differences and similarities in the new product development process and to allow a comparison among these enterprises.

A plan was developed based on the theoretical background in order to carry out this research. Interviews were made with at least three different professionals (from different areas and hierarchical positions) of each company.

The preliminary results allowed the identification of enablers and tools for supporting the development of a new product as well as the identification of the components that are used during the innovation cycle of creation of a product based on the web.

Literature Review

IT can assume different roles in the organizations, varying from simple support until a strategic position, regarding present and future IT impacts on business strategies (Nolan and McFarlan, 2005; McFarlan, 1984). McFarlan (1984) mentions that the Strategic Grid (Figure 1) allows to analyze the impact of current and future IT applications on the company's business. The grid is divided into four quadrants, each one representing a situation to the organization: Factory, Support, Turnaround and Strategic.

Nolan and McFarlan (2005) discussed that the impacts of existing IT applications is related to the need for reliable IT and that the impacts of future IT applications is related to the need for new IT. They also pointed out that companies classified in the Factory and Support quadrants show a defensive approach regarding IT use. Meanwhile, companies classified in the Turnaround and Strategic quadrants adopts an offensive behavior about IT utilization.

Among the enterprises investments in IT applications, it must be highlighted those based on the Internet. According to Porter (2001), Internet it is the most important IT ever available in order to allow enterprises to establish differentiated strategic positioning, since these enterprises follow the principles of "good strategy".

In the vision of Tapscott (2001), Internet brought a revolution in the economy and in the way companies develop their business, which should be based on network approach, instead of the traditional way based on single enterprises. He called this new form of business as the "business-web" or simply "b-web".

According to Zillur (2004) various authors have described benefits from web for individual functional areas such as marketing (Mckenna, 1997), purchasing (Ellinger and Daugherty, 1998) and logistics. In particular, the flow of goods is expected to become more transparent (Bowersox and Daugherty, 1995) and to allow to the integrated management

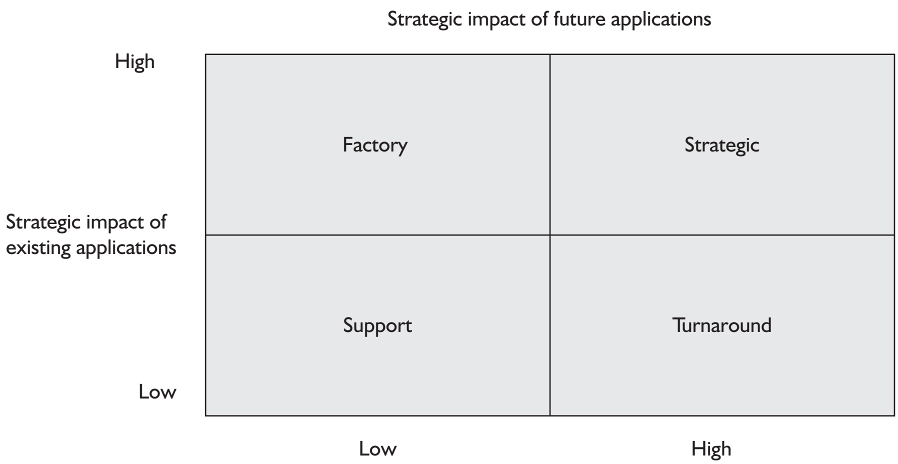

Figure 1 – Strategic grid of impacts of IT applications (McFarlan, 1984).

of a physically dis-integrated unit (LaLonde and Powers, 1993). Besides, it would enable decentralization and centralization within one operating system (Bowersox et al., 1992), and the increase of relevance of information exchange by avoiding one of the best known problems in the supply chain: the Forrester's bullwhip effect (Lee et al., 1997).

Dutta and Segev (1999) mention that enterprises are increasingly more dedicated to explore the potentialities and capabilities provided by the Internet. These authors detail this affirmation based in a proposed model, called "The Marketspace Model", which presents two basic dimensions: interactivity and connectivity. These two aspects, interactivity and connectivity, are transforming business models in the organizations. Interactivity allows a greater richness in the relationship with customers and creates new paradigms for designing products and services, meanwhile connectivity allows new mechanisms of coordination among organization and its customers.

Venkatraman and Henderson (1998) consider that virtuality is a characteristic that can be applied to any organization. However, this emerging architecture of virtual organizations is not possible or cannot be constituted without the significant power of IT. Considering that virtuality can be used by any organization, these authors developed a framework in which virtuality is defined as a strategy that reflects three distinct but interdependent vectors:

- Customer interaction vector;
- Asset configuration vector; and
- Knowledge leverage vector.

The first vector, organizational virtuality, represents interaction with the customer (virtual encounter). This first indicator of organizational virtuality reveals the organization's relationship with the customer. This vector deals with challenges and opportunities for the interaction between companies and customers. IT enables customers to try products and services in a remote way, besides participating actively in the dynamic customization process and creating communities of customers.

This architecture represents, in Venkatraman and Henderson's (1998) opinion, the structure to conduct the business, the guide that provides a context for the organization (Table 1).

In that context, the Web can transform product engineering, market research, prototyping, and revision of new products. Web-enabled product development will allow companies not only to drastically reduce costs and time expended in developing new products, but also to design what customers really want.

Several fields of research accentuate the increasing importance of customer orientation and customer integration. For the success of new products, customer integration is seen as an important factor (Cooper and Kleinschmidt, 1995; Griffin and Hauser, 1993).

Dahan and Hauser (2001a) mention that, while information technology transforms internal PD processes within firms, it also impacts firms' external interactions with

Table 1 – Virtual Organization: Three Vectors and Three stages (adapted from Venkatraman and Henderson, 1998).

Vectors	Stage 1	Stage 2	Stage 3
Customer interaction	Remote experience with products and services	Dynamic customization	Communities of customers
Asset configuration	Modules	Interdependent process	Coalition of resources
Knowledge leverage	Work unit	Corporate asset	Professional community
Characteristics	Stage 1	Stage 2	Stage 3
Focus	Tasks	Organization	Inter-organization
Performance objective	Efficiency (ROI)	To add economic value (EVA)	Innovation and sustainable development (MVA)

potential consumers of new products. Customers' broadband connections at home and work, combined with emerging Internet panels of willing respondents and prospects, mean that PD teams can reach customers more quickly and, ultimately, less expensively. Media rich computing and communication mean that product stimuli can include more realistic virtual prototypes and more realistic product features. And powerful, server-based software and downloadable applets mean that web-based methods can be more adaptive to customer input and change questioning procedures on the fly.

New Vision for Developing Products - i4PD - Dahan and Hauser (2001a)

According to Dahan and Hauser (2001a), by the end of the 1990s, the challenges of product development began to change as markets and competition became more global, as engineering and design talent became more dispersed, as internal product development efforts migrated into the extended enterprise, and as information and communication technologies changed the way people worked. According to Holmes (1999) the new vision of product development is that of a highly disaggregated process with people and organizations spread throughout the world. The new challenges call for a product development process that should be integrated, information intensive, almost instantaneous, and that makes strong use of new technologies such as the Internet. These authors call this new vision i4PD: integrated, information, instantaneous, and Internet. The characteristics of each of these four factors will be discussed in the following paragraphs.

Integrated

In relation to "Integrated", Holmes (1999) mention that research challenges of the next decade are those that address product development as an integrated, end-to-end process that requires a detailed understanding and coordination of customers, competition, and

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internal capabilities. The design now means the design of the product, the assembly and manufacturing process, the service delivery process, the entire value chain, and the marketing materials – all integrated to provide high value to the customer.

Information

The demands for information have grown since PD teams must integrate information from the customer, the assembly process, the manufacturing process, the channel delivery process, and the marketing process. In some cases, some firms now use "marketing engineers" - this means the appearance of new professional roles – who help design a product that would be easy to market. Methods such as services exchanges are just the beginning of integrated information systems that could lead to greater product development competitiveness.

Instantaneous

In the new context, speed-to-market has been proposed as a competitive advantage – at least if it can be obtained without sacrificing cost or customer satisfaction. (Dahan and Hauser, 2001a). Greis and Kasarda, (1997) also emphasize that the speed and agility are important factors for gaining competitive advantage.

New methods such as virtual prototypes, web-based voice-of-the-customer methods, web-based conjoint analysis, the Information Pump, listening in, Securities Trading of Concepts, and user design all have the potential to provide information to the PD team almost instantaneously.

New web-based methods have the potential to reduce that to two days, opening up the potential for the PD team to have its customer preference questions answered almost instantaneously. In fact, it might soon be possible to get statistical information about customer wants and needs almost as fast as it used to take to debate them. Virtual prototypes mean that products can be "created" in days, and Internet connectivity means that these prototypes can be tested with customers in hours. Service integration methods mean that many engineering design decisions can be reduced from months to days. Interestingly, in the future we might be in a situation where the decision on how fast to introduce products might be more of a strategic decision on product positioning rather than constrained by the firm's ability to design and test products.

Internet

The i4PD paradigm is one perspective on the future of product development; a perspective that describes how the process will look. The internet represents the technology that are enabling the process to be integrated, information intensive, and instantaneous. (Dahan and Hauser, 2001a).

Dahan and Hauser (2001a) said in that article that end-to-end processes should be robust, knowledge-based, people-based, and market-based.

- "robust" means a process that can adapt to changes in the environment, market conditions, and organization.
- "knowledge-based" means that it is recognized that the firms that will be most competitive will be those that can train their PD teams to design and build products most effectively.
- by "people-based", it can be understood that the process respects the teams' needs and that the metrics and incentives (explicit and implicit) are designed so that team members, acting in their own best interests, make decisions and take actions aligned with the best interests of the firm.
- "market-based" means two things: first that the process will be responsive to customers and competitors, and second, that it empowers teams to make their own choices in the context of their own specific expertise and knowledge.

Ogawa (2006) mentions that new products suffer from notoriously high failure rates. Many new products fail, not because of technical shortcomings, but because they simply have no market. Not surprisingly, then, studies have found that timely and reliable knowledge about customer preferences and requirements is the single most important area of information necessary for product development. To obtain such data, many organizations have made heavy — but often unsuccessful — investments in traditional market researches (Bartl et al., 2004).

According to Urban (2000), the Internet can represent an indirect method of capturing unmet customer needs by observing customer interactions with an Internet-based sales recommendation system. Virtual engineering aim to organize the web site based on features related to customers needs. In order to do this, virtual engineers should observe and understand how customers process attributes and, in particular, when they search for attributes, features, or needs that cannot be satisfied by any existent product.

The Internet also provides the means to identify customer needs by passively observing interactive customer behavior on a web site.

Paustian (2001) in the paper describes promising pilot tests of all six methods proposed by Dahan and Hauser (2001a) and suggests a more than 90% correlation between web-based conjoint-analysis measures and consumers' preferences for a camera's features. The six methods for gathering customer input are:

- Web-based conjoint analysis: Conjoint analysis is the most widely used method to understand customer trade-offs; McArdle (2000) reports on the application of conjoint analysis to the design of a new camera. The advantages of such web-based applications are that rich, contextual, yet virtual media can be used to illustrate products.

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- Fast polyhedral-adaptive-conjoint estimation. By exploiting new computational algorithms to select questions rapidly, a tool called fastpace gathers considerable information on preferences using far fewer questions than existing methods. This is extremely important for hurried web-based respondents.
- User design: Customer can design a product using a drag-and-drop application. costs and engineering constraints are computed automatically — the prices and the entire virtual product change as the customer makes choices.
- Virtual concept testing: Rather than waiting for physical prototypes, product-development teams can test virtual prototypes with customers in a media-rich presentation.
- Securities trading of concepts: Product concepts are represented by "securities", which respondents buy and sell in a stock-market-like environment. Research suggests that the security price is a good predictor of how the market will accept the product.
- Information pump: a web-based interactive game, with fine-tuned incentives for truth telling, elicits information from customers about their needs and shows how they describe those needs.

Hauser (2001) states that:

"you want to be able to design products that will sell and be profitable: that's what these techniques enable you to do" .

He predicts the move to adopt the techniques will be led by the large, consumer packaged-goods companies, but he says the methods can be used by any type of company.

Kwak (2001) said that Web sites could use the individual-based approach to construct pseudo-users, and combine them with real customers in a collaborative-filtering system. Using a variety of bots to rate different items, he explains, provides a way to enrich sparse databases and quickly feed in information on new products.

Web-enabled product development can also improve the fit of a product to a market by allowing potential customers to "experience" virtual product prototypes several times during the product's development, and give detailed on-line reactions to its appearance, functionality, and features. In additional, companies can monitor how customers actually use products to uncover unconventional uses and to determine failure modes.

Companies can continuously monitor how customers actually use products to assess usage patterns, uncover unconventional uses, and determine failure modes. For example, several large machinery manufacturers are integrating wireless sensors into products to report performance and use such information that will allow companies to create new products that better meet customers' needs, fulfil unmet needs, and last longer. They may even reduce costs by allowing developers to remove from later models features they discover are largely unused.

Web-based rapid concept testing provides the means to gather customer input about virtual concepts, and service exchanges provide the means to design quickly these virtual concepts.

Dahan and Srinivasan (2000) developed and tested a web-based method of parallel concept testing using visual depictions and animations. Respondents viewed eleven new product concepts, and expressed their preferences by "buying" their most preferred concepts at varying prices.

Case Study and Results

The problem of the present study was investigated through a Qualitative Research approach and the method used was Case Study (Yin, 1991; Claver et al., 2000).

The case selection criteria were: the existence of an expressive IT projects based on the Internet for developing new services and products and different classification based on the Strategic Grid (Nolan and McFarlan, 2005; McFarlan, 1984).

Based on these criteria, two companies were selected, one that can be classified in the strategic box and another that can be classified in the turnaround box of the Strategic Grid (McFarlan, 1984). The choice of companies of different classification in the Grid is important to analyse the differences and similarities in the new product development process and to allow a comparison among the processes of these enterprises.

In order to analyze how companies are exploring Web (Internet) technology to develop new products, this study was based on the points below:

- The availability of product related information on –line;
- The customization of products for individual or groups of customers;
- The participation of customer s in the specification and design of products;
- The provision of on-line communications to customers; and
- The participation of suppliers in the specification and design of products or services.

Interviews were carried out with at least three professionals from the company (CIO, project managers and executives from the business area), based on the established script. However, during the interviews, there were attempts to obtain, through the conversation, more subsidies for the qualitative analysis of the case.

The main aspects of the gathered information can be found in the following items.

Case background – Case A

The first studied case is as a commercial bank that is part of a diversified group and that have been obtaining important results in their operation segments: Asset Management, Insurance, Pension Funds, Capitalization. The company has 800 employees and 300 offices.

The IT area became independent of the Bank in 2002. Nowadays, it provides services for the bank, other companies of the group and for the market.

One of the main investments in IT in the last years has been the Internet. These investments in the Internet started in 1997 and a special group was appointed to work in this project. The main objectives were the development of infrastructure focusing on the electronic commerce market, ASPs (application server provider) and the creation of the corporate portal. The bank's Corporate Portal begun its operations in 1999 and since then has been significantly improved. The Portal has been considered the most important for competitive advantage.

The main decision criteria pointed by the Projects Manager (e-business) to investments in projects, mainly to WEB projects, are:

- Flexibility and low cost in the implementation of branches;
- Reduction in back-office;
- Re-utilization of workflow in the creation of new businesses; and
- Base for developing news products.

The focus for that organization it is on using the power of the Internet to enhance customer relations. The case study showed that new services have been developed based on WEB.

All "logs" of the Internet and everything what it is made during the previous day is stored and transmitted for the central office, with all the types of transaction that had been carried through. This allows the emission of reports that offer a detailed knowledge of the use that customers make of the Portal. It was observed that the analyzed company effected some customization of its services in function of the relationship allowed by the Internet what demonstrates alignment with the theoretical reference previously presented.

It was observed in the case that the company virtually monitors how customers are using the products of the bank, searching for detecting imperfections earlier and truing to find ways how to solve them, in order both to anticipate and to detect the necessities of the customer. This was one of the benefits that appeared with the use of web in the products development process.

Case background – Case B

Established in 1977, company B was created with the objective to supply tickets to the employees of the companies. This activity is regulated by the Federal Government in Brazil. The companies that provide this kind of service occupies important position in the services sector in Brazil, with about 18 thousand companies as its customers. The analyzed company offers a variety of products. Beyond traditional tickets, it also offers products as personal credit, life insurances and others. The company created an internet portal that is a channel for electronic commerce for products of the company, besides supplying information of human resources, as training programs, wages and legal research, among other types of information. The description of products that are based on web can be seen below:

- Order receipt and entry;
- Human resources Portal;
- Internet Banking : the objective to facilitate the access to the information on the product and to speed the taking of loans, what it can be made by the proper employee in the Portal; and
- Also it was created Plan for funds to be commercialized and to all have its relationship for the Internet. The differential is that it had one of the lesser taxes of administration, minimum limits of application of the market.

Currently, more than 55% of the orders generated by the customers are made by the Portal of the company, as informed by the executive regarding the transactional site lead by the company, considering both the distribution of tickets, and the access of the information for the employees of the customers.

The portal is offering more flexible services, so that customers might customize them according to their preferences. By adding user-friendliness, reliability and additional services to the Website, company B found that this is the best way to have customers to improve the company's products.

Specific application of the web (portal) for developing products new is limited. Actual situation show that the company is using Human resources Portal as way to create new products, for example, recruiting on-line. This product is one is that was developed considering many inputs from customers and was based on web capabilities.

Case Analysis (A and B)

Analyzing the role of IT in case A, it is possible to verify that IT applications are critical for present operations, and planned IS uses are critical for future success, which allows to classify the organization in the Strategic quadrant in the strategic grid (McFarlan, 1984). The case B can be classified in the Turnaround quadrant in the strategic grid, since it is possible to verify that planned IS uses are critical for future success, meanwhile present applications are not essential for current operations.

In case A it is also possible to observe that IT investments are directed to achieve organizational goals, searching for innovations in products and services.

Company A uses internet according to Dutta and Segev (1999) mentioned in their article, since it is exploring both interactivity and connectivity. As mentioned before, Interactivity enriches the relationship with customers and enables new paradigms for designing products and services. Connectivity, at same time, allows coordinating the organization with its customers. The interactivity of the Web also allows user-specific feedback. In company A, when a user completes the assessment form online, he is immediately provided with a score in a pop-up window on their computer. More than just a rating, the score includes specific written explanations and suggestions for improvements, as well as references to other sources of information. As data are collected, the tool would

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provide users with comparative benchmarking with others who have completed the assessment.

In Company B, it was not observed the aspect related to interactivity on the use of internet. Company B initially created a portal with objective to pass some processes for the Internet environment and to sell some services only by web. For instance, organization B launched services as order entry by the internet. After that, company B searched for innovations in services, starting by offering Internet banking facilities.

Company B created the Resource Human Portal that provides integration services to the community in order to bring the power of free information exchange among users, encompassing:

- Newsletters and electronic alerts distribution based on user profile; and
- A wide range of resource human discussion forums

In Table 2, it is possible to see a summary of the comparative analysis of the two cases, considering the main aspects previously pointed out in the literature review.

By the analysis of these two cases presented, it seems that Company A used the idea of the Internet to conceive new products, meanwhile company B used the Internet was a way to facilitate the development and the use of previously conceived products. Therefore, Company A is using more intensively the potential provided by the Internet.

Conclusions

The advent of Internet has transformed industries and redefined rules of competition in many markets and changed the nature of relationships between businesses and between

Table 2 – Comparative of Cases A and B, considering the main points highlighted in the theor.

Description	Case A	Case B
Strategic grid (McFarlan, 1984)	Strategic; IT affects current and future strategic situation.	Turnaround; IT affects only future strategic situation.
Portal (site)	To establish a relationship with customer.	Only to establish transactions for offering news services.
Duta and Segev (1999) – "MarketSpace" model	Interactivity and Connectivity provide a way to enrich sparse databases and quickly feed in information on new products.	No provide a way to understand customers in more detail; The organization is using the portal only for Connectivity.
Urban (2000)	Method of capturing unmet customer needs by observing customer interactions.	Observed that is beginning to explore the portal as way to capture customer needs;
Kwak (2001)	Using a variety of bots to rate different items provides a way to enrich sparse databases and quickly feed in information on new products.	It still does not use as a way to enrich sparse databases.
Venkatraman and Henderson (1998)	Vector Interaction Customer; Stage 2.	Vector Interaction Customer; Remote experience with products and services; Stage 1.

businesses and their customers. Old rules still exist, but they have also given way to new channels and infomediaries. Given current trends, the Internet's influence will continue to grow into the foreseeable future as businesses will collaborate with suppliers and partners. With the support of the Internet, they will source, produce and distribute products and services globally. Web offers an even greater and lasting advantage: a powerful, low-cost means of integrating customer feedback into all phases of product development. The speed, convenience, interactivity, and worldwide coverage of the Internet match the requirements of the different activities in the new product development process, which involves uncertainties and risks and requires firms to take into account the views of customers and to introduce their new products to the market fast.

The findings from this study tend to agree on the potential benefits of applying web tolls in product development. However, disappointments have also been expressed by academics that related situations of web tools that have not yet been practiced to an extent to maximize their potentials. Company A is applying the web tool for user-specific feedback, but in company B the web have not yet been used to maximize its potential. In both cases the tool is based on a Portal.

Web-based interaction between customers and producers offer new promising ways of bringing customers into the company right to where the value creation begins – in new product development. Despite the high potential of virtual customer integration practical application is limited. In a sum, Web can help to reduce uncertainties and costs of new product developments and implementations by allowing more ideas to be conceptually tested in parallel.

Future studies should deepen the main conclusions of the present paper. As a continuation of this study, further and refined empirical research will help reveal deeper insights into the potential of web as way to improve interaction customer for developing products process.

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Biography

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The Role of SCM Capabilities to Support Automotive Industry Trends

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Abstract

As Supply Chain Management (SCM) becomes essential to generate competitive advantage, the development of capabilities in cooperation with other supply chain members is a premise for success. The goal of this paper is to analyze the role these SCM capabilities play in automotive industry supply chains. The paper offers first a study based in the literature and in interviews regarding trends in the automotive industry, SCM capabilities and their co-relation, which resulted in a formal definition for SCM capability. Then a case study in a European Vehicle Manufacturer is presented and discussed. The case study was conducted with three supply chains embracing, among other significant members, 3 vehicle plants and 2 supplier parks located in Western Europe and in South Africa. Within the case study, we analyze how the SCM capabilities are related to the vehicle manufacturer strategic goals and correlate the trends with the capabilities developed within the three supply chains. The analysis allowed us to conclude that the SCM capabilities identified by the study constitute a response to support trends in the automotive industry, as they intend to bring advantages that obey a new logic in competition based on chains. As a spin off of the research, it was also possible to identify that SCM is still limited to the immediate chain of vehicle manufacturers.

Keywords: supply chain management, capabilities, automotive industry, trends

Introduction

It is widely argued in the literature that competition is no longer between organizations, but among these organizations' supply chains (for instance: Lambert et al., 1998; Rice and

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Hoppe, 2001; Pires, 2004; Li et al., 2005). Increasing competition has forced manufacturers to go beyond their own factory gates and search for improvements in the interaction with their suppliers and customers along their supply chains. This new logic in competition, based on supply chains, has inspired the appearance of Supply Chain Management (SCM).

SCM is defined by the Global Supply Chain Forum 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 et al., 1998). SCM encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities and it includes coordination and collaboration with channel partners (CSCMP, 2006).

One of the critical issues concerning SCM is the development of SCM capabilities that allow activities and processes to be integrated, throughout the supply chain, adapting suppliers and customers to the new logic in competition and providing competitive advantage (Lummus et al., 1998; Rice and Hoppe, 2001). Differently from a capability developed within a single company, the SCM capability is developed in cooperation between different supply chain members to build up together an integrated approach to design, organize, and execute supply chain activities. This does not mean ownership or even direct control, but it does imply mechanisms that influence decision-making and impact system-wide performance (Vonderembse et al., 2006).

In spite of the importance of the topic, the literature lacks a precise and standard definition for the notion of capability (Duysters and Hagedoorn, 2000; Hafeez et al., 2002). Therefore, one of the contributions of our paper is the analysis of existing definitions for capability and to use them as the springboard toward a precise and standard definition for SCM capability.

The main goal of the paper is to analyze the role of SCM capabilities in the automotive industry as a result of the major trends that impact this industry's supply chains. The automotive industry was chosen as it has been very active in the development and introduction of new production systems and management concepts worldwide. Therefore, it is presently developing and introducing capabilities in its supply chains stimulating other industries to do the same.

The rest of the paper is organized as follows. The next section describes the methodology adopted in this research. The third section presents the main trends that have been impacting the management of supply chains in the automotive industry. The fourth section introduces SCM capabilities and correlates them to the automotive trends. The fifth section presents the case study results and the last section offers our final thoughts and main conclusions on the subject.

Research Methodology

The methodology approach consists of two main parts. The first part is a study regarding trends and SCM capabilities in the automotive study and second is a case study.

In the first part we conducted initially non-structured interviews with six specialists and consultants who have been working in the automotive industry for many years, each interview lasting between two and three hours. The results allowed us to unravel and group this industry's main trends and SCM capabilities. These results were corroborated by an exploratory study based in the existing literature. This exploratory study identified the relation between these trends and SCM capabilities and was validated in a second round of interviews with the same group of specialists and consultants mentioned before.

In the second part of the research, we adopted an exploratory case study (Yin, 1994) to investigate the association between the identified trends and the strategic goals of an OEM (Original Equipment Manufacturer) regarding its supply chains to analyze how SCM capabilities are related to the goals. The case study embraced three supply chains of a same vehicle model. To gather secondary data we used internal documents from the OEM, European Automotive Associations reports, and press releases. To collect primary data from each supply chain we conducted:

- Direct observations at three vehicle manufacturer plants (two in Europe and one in Africa) and at two supplier parks (one in Europe and one in Africa); and
- Semi-structured and structured interviews with twelve respondents: five were SCM consultants involved in the OEM's projects; and seven were high-ranked managers and directors who have been working for the OEM for many years in different assignments (logistics, production planning, control and quality, and marketing).

The case study interviews were based on a questionnaire divided into three parts. The first part embraced closed questions and identified the supply chains structure and the SCM capabilities. The second part quantified the intensity of the SCM capabilities developed between the OEM and each of its relevant supply chain members in the three analyzed chains. The third and last part obtained general input concerning the OEM strategies regarding at the chosen supply chains.

Trends in the Automotive Industry

This section presents the major trends that have been impacting the management of supply chains in the automotive industry. The main trends identified in our research were: business orientation change in the supply chain; globalization; outsourcing; rationalization and the reduction in the number of suppliers; development of new materials; shortening of life span of vehicle models; increase of product variety; and adoption of world platforms. Each trend is briefly presented next.

Business orientation change in the supply chain

The automotive industry has been undergoing major changes in business orientation as far as the supply chains are concerned. It is now becoming apparent that the current 'stock-push' vehicle supply orientation in the automotive industry by fulfilling the large

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majority of orders from existing stock is no longer a viable proposition (Holweg and Miemczyk, 2003). With the trend of mass customization and personalization, more and more cars are being made through build-to-order (BTO) supply chains, which allows each customer to configure a final product from a personalized subset of components which may be ordered (Krajewski et al., 2005).

Globalization

We share Hill's (1998) understanding of globalization, according to which the term refers to changes toward a more integrated and interdependent world, where commerce, finance, markets, and production are not locally outlined anymore. The automotive industry is nowadays widely regarded as one of the 'most global' industries (Schlie and Yip, 2000). In the automotive industry, globalization has been strongly influenced by the saturation of markets in the triad region (Western Europe, Japan, and North America) and by the potential of growth of markets in developing countries (Humphrey et al., 2000). Hong and Holweg (2005) present the relative growth of the car production in emerging countries compared to the Triad region (Europe; Japan; U.S.A. and Canada). While the global production enlarged from 26.5 million units in 1971 to 41.8 million in 2003 (approximately 63.4%), more than half of this growth was accounted for by emerging countries, which production increased by a factor of seven over the period analysed.

Outsourcing

Outsourcing is a practice in which part of the set of products and services used by a business organization is executed by another business organization, in a cooperative and interdependent relationship. Outsourcing means an option for a relationship that involves partnership and complicity with one or more suppliers in the supply chain, which is comprehensive and difficult to be reversed (Pires, 1998). Such a trend directly influences the sharing of responsibilities executed by members of the supply chain in the automotive industry, where OEMs have been transferring several activities that were traditionally their own to some of their first tier suppliers (Collins et al., 1997; Arbix and Zilbovicius, 1997; Pfaffmann and Stephan, 2001; Smock, 2001). This outsourcing is justified by lower costs and higher quality, and at the same time every company can use its resources in the areas it has technical expertise (Gao et al., 2000).

According to the European Association of Automotive Suppliers (CLEPA), the added value of suppliers in the automotive business went from US$ 496 billion in 1988 to US$ 958 billion in 1998, an increase that reflects the practice of outsourcing in its majority (Gormezano, 2000). The percentage of value creation at the suppliers will continue to rise. The Fraunhofer/Mercer study (2004) estimates the growth to continue from 65% of the total vehicle value built at the suppliers in 2002 towards a 77% in 2015. The suppliers' share in product development is estimated to grow even faster from 30% in 2000 to 50% in 2010 (Dudenhöffer and Büttner, 2003).

Rationalization and reduction in the number of suppliers

The trend to rationalize and reduce the number of suppliers is also present in the automotive industry (Collins et al., 1997). It has been driven by the reduction in the number of suppliers in the first tier of OEMs, leading to the establishment of partnerships and a high level of cooperation between these chain members (Bidault and Butler, 1995; Gao et al., 2000; Corrêa, 2001) and adding value to the extra functions and activities assigned to the suppliers (Pilorusso, 1997; Pires, 1998). Another reason for the mentioned rationalization and reduction is the opening of world markets, making local companies with few technological and financial resources face competition with big multinationals and cease to be independently viable in developing countries.

Other trends

There are also other trends that have been impacting supply chains in the automotive industry. The development of new materials has emerged as a trend to meet rowing environmental, safety and cost constraints, which are stricter each day (Davies, 2003). The use of world platforms has been largely adopted by OEMs to capitalize on the benefits of large scale purchases of common parts and on time and cost reductions that are correlated with vehicle design. Several models share a single project design, instead of having one project for each model of each make (Muffato, 1999). This strategy has allowed OEMs to separate the industrial variety of auto-parts and components from the commercial variety of models offered to the final customers. Another trend that has highly impacted the supply chain in the automotive industry variety is the shortening of life span of vehicle models (Holweg and Greednwood, 2001). BMW, for instance, is planning to introduce an average of 3.7 new models per year until 2010. In the seventies the average was 0.7 new models a year. The product life cycle was constantly shortening from a 9-year cycle in 1990 to less than 7 years today. Most other OEMs have a similar increase in products and shortening life cycles (Software Forum Bayern, 2003). Another key trend in the automotive industry is the increase in offer by OEMs in variant numbers and options for individual models (Seidel et al., 2005). Pil and Holweg (2004), for instance, identified a group formed by BMW and Mercedes models whose total variations factory fitted surpassed the order of 10E16, reaching the order of 10E24 for Mercedes' Class E model.

SCM Capabilities

The existing literature offers different definitions and interpretations for the notion of capability. This section aims toward offering a precise and standard definition for SCM capability.

Capability is a set of actions that the assets of an organization or business use to create, produce, and commercialize a product (Sanchez et al., 1996). According to Day (1994), capability is a complex set of abilities and co-shared learning experiences that guarantee strategic relevance to the coordination of functional activities whenever it involves maintenance of competitive advantages within an organization. Hafeez et al. (2002), however, define capability as the ability to use resources to perform a task or activity. For these authors, capability derives from the coordination and integration of activities and processes and is the product of a co-shared learning experience in the uses of a business' assets. Hayes et al. (1996) make a difference between ability and capability. The first is simply an indication that a person or organization is capable of doing something, regardless of how efficiently or perfectly, aspects embraced by capabilities. Klein et al. (1998) and Hafeez et al. (2002) highlight the subtle difference between capability and competence. In their point of view, competencies are formed by a set of capabilities, not restraining themselves to a single capability.

Based on the literature, this study advances the following definition for the notion of capability as being a set of actions that use the assets of an organization to create, produce, and commercialise a product (Sanchez et al., 1996), providing customers with an essential benefit. It derives from the coordination and integration of the organization's activities (Haffez et al., 2002; Stalk et al., 1992; Day, 1994), the conjugation of the technologies adopted by this organization (Mazzilli and Wilk, 1997), and the management of its human resources (Day, 1994).

The definition of SCM capabilities that this study adopts takes the aforementioned definition of capability and adapts it to the new logic in competition. Consequently, the term "organization" gives place to "supply chain" and the term "customer" gives place to "final customer," to emphasize that we mean the customer of the chain and not the direct customer of an organization. Thus, management of relationship among members of the chain becomes one more element in the construal of these capabilities. As a result, to face this new paradigm organizations need to intensify their relationship. This study adds these understandings to the definition of SCM capability, which thereafter reads as being a set of actions that use the assets of a supply chain to create, produce, and commercialise a product, providing final customers with an essential benefit. It derives from the coordination and integration of activities and processes in a supply chain, the conjugation of technologies adopted by the chain, the management of its human resources and of relations among members of the chain.

The SCM capability should be developed at least by two entities that establish a supply chain link. Not all links throughout the supply chain should be closely coordinated and integrated (Lambert and Cooper, 2000), what means that there should be different capabilities being developed among the different links. Determining which parts of the supply chain deserve management attention must be weighed against capabilities and the importance to the firm (Lambert and Cooper, 2000).

The literature offers many ways to categorize SCM capabilities, for instance see Evans and Danks (1998) and Min and Keebler (2001). We follow Rice and Hoppe (2001), categorizing SCM capabilities as techniques, practices, policies, and systems. Examples of SCM capabilities that they identified include ESI (Early Supplier Involvement), JIT (Just in Time), postponement, supplier park, and VMI (Vendor Managed Inventory). Lummus et al. (1998) and Howard et al. (2006) also adopt this form of categorization to refer to JIT as a SCM capability.

Based on the definition we put forward, on the interviews conducted with specialists and on the literature review, the main SCM capabilities that have been developed in the automotive industry considered in our research were: Concurrent Engineering, Co-Design[1], Early Supplier Involvement (ESI)[2], e-Business (e-Commerce and e-Procurement), Follow Design (or Carry Over)[3], Follow Sourcing[4], Global Sourcing, In Plant Representatives (IPR)[5], Just-in-time (JIT), Just-in-Sequence (JIS), Milk Run, Modularisation, Supplier Park[6], Postponement, Quick Response[7], and Vender Managed Inventory (VMI). Table 1 summarizes the correlation among theses capabilities and the main trends acting in the automotive industry.

Case Study

The vehicle manufacturer chosen for the case study is European and produces cars for the luxurious market segment. The current strategies for this OEM supply chains originated from automotive market changes at the end of the 80's, when newcomers joined the luxurious market segment. In this period of time, Honda, Toyota and Nissan introduced their sophisticated and highly valued brands, respectively Acura, Lexus and Infiniti. In the beginning of the 90's, the vehicle manufacturer of this case study noticed that it was not immune to the competition from the Japanese newcomers. The Japanese highly valued brands were already with a significant market share in the luxurious vehicle segment of the American market. This fact, associated with the market share decrease of the OEM, influenced the establishment of the following strategic goals:

- develop and implement a BTO program;
- expand the production activities worldwide;
- increase the frequency of introduction of new models; and
- increase the quality of recently launched vehicles.

[1] Joint design and execution of plans for a product or component by means of a partnership between the manufacturer and its suppliers (De Toni and Nassimbeni, 2001).
[2] This implies in choosing a supplier before or during the design of a project for a specific product, as well as its involvement in the phases of product development (Dowlatshahi, 1998).
[3] It demands that suppliers, when manufacturing parts, follow the same specifications and attributes in the original project in several countries where the vehicle manufacturer operates (Salerno et al., 1998).
[4] Suppliers move with manufacturers to the new region where vehicles will be produced, building new plants in the region or supplying with its plants already established in the area (Salerno et al., 1998).
[5] When there are representative of a business organization who perform in the facilities of another business.
[6] Parks that concentrate suppliers in one location adjacent to assembly plants (Wright et al., 1998).
[7] A system used to replenish inventory based on real sales information passed on to suppliers (Mentzer, 2001).

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Table 1 – Correlating trends with SCM capabilities in the automotive industry.

SCM capabilities	Trends				
	Push => pull	Globalization	Outsourcing	Reduction in the number of suppliers	Other trends
Co-design	Agrawal et al. (2001)	Dias and Salerno (1998)			Medina and Naveiro, (2000)
Early supplier involvement (ESI)	Agrawal et al. (2001)	Gormezano (2000)		Bidault and Butler (1995)	Bidault and Bulter, (1995), Hayes and Pisano (1996), Freyssenet and Lung (2000), Medina and Naveiro (2000), Wynstra et al. (2001)
E-business	Helper and MacDuffie (2000), Agrawal et al.(2001), Gunasekaran and Nagai (2005)	Pires and Musetti (2000) , Smock (2001)			Ratnasingam (2003)
Follow design		Gormezano (2000), Humphrey and Salerno (2000)			
Follow sourcing		Dias and Salerno (1998), Amato Neto and D´Angelo (2000), Lung (2000), Humphrey and Salerno (2000)	Lung (2000)		
Global sourcing		Dias and Salerno (1998), Lung (2000), Freyssenet and Lung (2000), Pfaffmann and Stephan (2001)			
In plant representatives				Pires (2004)	
Just-in-time	Agrawal et al. (2001), Alford et al. (2000), Gunasekaran and Nagai (2005), Howard et al. (2006)	Dias and Salerno (1998)			
Just-in-sequence		Dias and Salerno (1998)	Morris et al. (2004)		
Milk-run	Corrêa and Nogueira (2001)				

Table I – Continued...

SCM capabilities	Trends				
	Push => pull	Globalization	Outsourcing	Reduction in the number of suppliers	Other trends
Modularisation	Helper and MacDuffie (2000), Agrawal et al (2001), Alford et al. (2000)	Dias and Salerno (1998), Humphrey and Salerno (2000)	Collins et al. (1997), Arbix and Zilbovicius (1997), Corrêa (2001), Pfaffmann and Stephan (2001), Morris et al. (2004)	Pilorusso (1997), Salerno et al. (1998)	Hayes and Pisano (1996), Pricewaterhouse-Coopers (2002), Seidel et al. (2005)
Supplier park	Alford et al. (2000), Howard et al. (2006)	Wright et al. (1998), Dias and Salerno (1998), Amato Neto and D´Angelo (2000), Humphrey et al. (2000)	Collins et al.(1997), Arbix and Zilbovicius (1997), Dias and Salerno (1998), Lung (2000), Corrêa (2001), Cullen (2002), Morris et al. (2004), Howard et al. (2006)	Collins et al. (1997), Corrêa (2001)	Howard et al. (2006)
Postponement	Gunasekaran and Nagai (2005), Howard et al. (2006)				van Hoek et al. (1999)
Quick Response (QR)	Corrêa and Nogueira (2001)				
Vendor managed invetory (VMI)	Cohen et al. (2000), Corrêa and Nogueira (2001)				

The case study associates the trends presented before to these strategic goals regarding three supply chains that produce a same vehicle module. Within this association, we analyzed how the SCM capabilities are related to each strategic goal.

The first supply chain has as its focal member a Completely Build Up (CBU) plant located in Western Europe (Plant A). Plant A is the OEM's oldest plant and is located inside a big urban center, which brings many restrictions to the management of its supply chain. This plant produces two body type[8] variations of the chosen vehicle Model.

The second supply chain has as its focal member another CBU plant also located in Western Europe (Plant B). Plant B was designed to be more flexible than Plant A, consequently it produces five body type variations of the vehicle model. This supply chain embraces a supplier park nearby Plant B (here called Supplier Park I) that assembles auto parts in sequence for Plant B. Supplier Park I was established in the late 80's and hosts many auto-part companies that belong to the OEM first tier of suppliers. Supplier Park I

[8] The main body types are: sedan/saloon, hatchback, convertible, coupe, and station wagon.

also serves as the European consolidation and distribution center that provides auto parts to the OEM's vehicles assembly plants worldwide.

The third supply chain has as its focal member a plant located in South Africa (Plant C). Plant C assembled, in the past, many different vehicle models, but in a reduced scale. To increase its production scale and to become an important exporter for non-European Markets, Plant C has moved away from assembling Completely Knocked Down (CKD) vehicles models to produce CBU vehicle based on just one model. Supplier Park I also takes part in this supply chain and serves as a consolidation and distribution center for auto parts produced in Europe that will be exported to South Africa. There is also a brand new supplier park in this supply chain (labeled Supplier Park II). This park is located nearby Plant C and should host many first tier and second tier suppliers.

Results

Table 2 displays the results obtained for the case study. The first column displays the main SCM capabilities developed in the automotive industry. The subsequent columns display the relevant supply chain members of the three supply chains analyzed. The case study grouped the supply chain members according to plants A, B and C as follows:

- Upstream members: Member I: module suppliers (tier 1); Member II: highly valued component suppliers (tier 1); Member III: main suppliers of Member I (tier 2); Member IV: supply chain members not considered critic; Member V: in the supply chain of Plant A, this member encompasses an OEM's engine plant, in the supply chain of Plant B, this member encompasses the engine plant and Supplier Park I; in the supply chain of Plant C, this member is Supplier Park I; and
- Downstream members: Member VI: Dealers; and Member VII: End-customers.

The values displayed in Table 2 represent how intensively the SCM capabilities are developed within the supply chain links of plants B and C. 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 highly developed in the supply chains are highlighted in dark gray. The SCM capabilities that are modestly developed are highlighted in light gray. The SCM capabilities that are not developed are not highlighted. The supply chain links that do not have a direct relation with a SCM capability are represented in Table 2 by a hyphen.

The results presented in Table 2 allowed us to know which SCM capabilities have been present, how intense and in which supply chain links they have been developed. The main links are the ones that embrace the OEM's plants and their supply chain members from the first tier (downstream and upstream).

Table 2 – SCM capabilities developed in supply chains.

SCM capabilities	Supply chain relevant members of plant A							Supply chain relevant members of plant B							Supply chain relevant members of plant C						
	I	II	III	IV	V	VI	VII	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	-	-	3.0	2.0	1.0	1.0	3.0	-	-
Just in time	5.0	4.0	1.7	2.3	5.0	-	-	4.3	4.0	-	2.3	5.0	-	-	2.5	2.2	-	1.0	-	-	-
Just in sequence	4.5	4.0	-	1.8	4.5	-	-	5.0	4.0	-	1.8	5.0	-	-	1.8	1.8	-	1.0	-	-	-
Milk run	1.0	3.0	-	2.0	-	-	-	1.0	3.0	-	2.0	-	-	-	2.0	2.0	-	1.0	-	-	-
Supplier park	1.0	1.0	1.5	1.5	-	-	-	3.5	3.0	1.5	1.5	-	-	-	1.0	1.0	1.0	1.0	-	-	-
Global sourcing	2.5	2.5			-	-	-	2.5	2.5			-	-	-	-	-	-	-	-	-	-
Follow sourcing			2.0	2.0	-	-	-			2.0	2.0	-	-	-	4.0	4.0	1.5	1.5	-	-	-
Postponement	-	-	-	-	-	1.0	-	-	-	-	-	-	1.0	-	-	-	-	-	-	1.0	-
e-Business	4.0	3.0	1.5	2.5	-	5.0	4.3	4.0	3.0	1.5	2.5	-	5.0	4.3	1.8	1.5	1.0	1.0	-	3.0	2.3
Co-design	5.0	4.0	2.0	2.2	-	-	-	5.0	4.0	2.0	2.2	-	-	-	-	-	-	-	-	-	-
ESI	5.0	4.0	2.0	2.2	-	-	-	5.0	4.0	2.0	2.2	-	-	-	-	-	-	-	-	-	-
Quick response	-	-	-	-	-	3.0	-	-	-	-	-	-	3.0	-	-	-	-	-	-	1.0	-
VMI	2.0	1.0	-	1.0	5.0	2.0	-	2.0	1.0	-	1.0	5.0	2.0	-	1.0	1.0	-	1.0	3.5	1.0	-
IPR	2.0	1.0	-	1.0	-	-	-	1.0	1.0	-	1.0	-	-	-	1.0	1.0	-	1.0	-	-	-

SCM Analysis for the Supply Chains

The analysis is organized according to the following strategic goals: develop and implement a BTO program; expand the production activities worldwide; increase the frequency of introduction of new models; and increase the quality of recently launched vehicles. These goals respond to different trends that impact the automotive industry supply chains and to achieve the goals, SCM capabilities have been developed in different supply chain links, as discussed next.

BTO approach

The strategic goal of developing a BTO program responds to the new business orientation in the supply chain and to the product variety increase trends. The program consists of offering a wide option of choices to end customers to allow them to have customized BTO vehicles. According to the OEM, it is impossible to develop this program without considering other supply chain members. Therefore, the OEM aims to get closer to its upstream and downstream supply chain links.

The OEM has been developing SCM capabilities in the upstream links of its assembly plants, which makes its supply chains flexible to meet a customized order within a pre-established short timing and to allow changes in the purchase order only a few days before the vehicle is delivered to the end customer.

The OEM emphasized the importance of continuously increasing the modules in its vehicles final assembly line for the achievement of the necessary flexibility to execute the BTO program. The responsibility of assembling the modules is given to their suppliers, with very few exceptions, for instance the supply of engines, whose responsibility belongs to OEM. Modularization is a capability well developed in the supply chains of plants A and B.

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To make the OEM's final assembly lines more flexible, the modules should feed these assembly lines according to the order of needs for customized vehicles. As the modules are generally highly voluminous, valued and customized, they are not usually stocked in the OEM's plants. Therefore, the development of the Just-in-Sequence (JIS) capability is necessary. Table 2 indicates that this SCM capability is well developed in the module suppliers (member I) for the supply chains of plant A and B. As modularization and JIS, JIT and e-business are also present in the link formed by module suppliers and the OEM.

The modularization, JIS, JIT and e-business SCM capabilities have also been developed in the supply chain links that contain highly valued component suppliers of the first tier (member II) for plants A and B. However, as displayed in Table 2, the development of these capabilities in these links is not as intense as it is for the link that embraces the module suppliers (member I) and the OEM.

E-business has been well developed in all downstream links of plant A and B, both with the dealers and with the end-customers and is not well developed in the supply chain of Plant C, where the developmental stage of SCM is still incipient.

SCM analysis within a worldwide expansion approach to production activities

The goal of expanding production activities worldwide is associated to the globalization trend in the automotive industry. This influenced the production of CBU vehicles in South Africa at Plant C. The change in Plant C from being a CKD assembly plant to a CBU production plant has brought deep transformations to its supply chain, now in an initial developmental stage of SCM. The poor development of SCM capabilities makes the development of SCM in the supply chain of Plant C difficult. Supplier Park II responds to the necessity to improve the SCM of Plant C in such a way that it will become possible for this supply chain to compete globally supporting the vehicle production expansion goal. Such improvement reflects on the need to establish SCM capabilities, mainly ones that concern logistics, for instance JIT and JIS, capabilities that are weakly developed in this chain (see Table 2). To do so, Supplier Park II should host first and second tier suppliers.

Follow sourcing was pointed out as being very relevant for OEM in the links that connect Plant C with their module suppliers (member I) and with highly valued component suppliers of Tier 1 (member II).

Other strategic goals

The other two strategic goals are quality improvement of recently launched vehicles and increase of new models introduction frequency. These goals are related to trends such as outsourcing, reduction in the number of suppliers and reduction in the life cycle of vehicle models. These goals depend on the management of OEM upstream connections, as Hayes and Pisano (1996) have highlighted in their work, suggesting a great proximity with supply chain members, mainly the ones involved with the Research and Development (R&D) process. This proximity was verified in the supply chains of plants A and B by means of a huge participation of suppliers in vehicle projects that involve the development of SCM capabilities with these plants, such as Early Supplier Involvement (ESI) and co-design. This is highlighted in Table 2, table that indicates that the ESI and co-design SCM capabilities are strongly developed in the supply chain links that connect plants A and B with its module suppliers (member I) and with its highly valued component suppliers (member II). The answers to the questionnaire corroborate this conclusion by providing evidence for the development of these capabilities, as follows: the selection of the supplier occurs in the early stages of the new product development; the information about new products and their respective processes development (e.g. module, technical implications, costs, time periods, etc) is shared with the suppliers, the information systems of the suppliers are compatible and connected with the ones of the OEM; when the OEM transfers activities to its suppliers, it also transfers its respective activity know-how; the OEM has established formal long-term partnerships within with these suppliers.

Not much can be said about the presence of SCM capabilities in the R&D process of the supply chain of Plant C. Co-design and ESI are not developed in this Supply Chain, as the South African branch of the OEM and its local suppliers (in general subsidiaries of multinational companies) do not play important roles in this process. R&D activities are developed and managed by the companies' headquarters.

The capabilities Milk Run, Postponement, Quick Response, VMI, and IPR were not identified in any of the three analyzed supply chains.

Conclusions

Although the development of SCM capabilities in supply chain links has been considered relevant in the academic literature, there is still a lack of definitions regarding this concept. Therefore, this paper's first contribution was to offer a definition for SCM capability that could be appropriate for the SCM literature and could be used to analyze supply chains of the automotive industry. Based on the offered definition, many SCM capabilities were identified by analyzing the main trends that act upon the supply chains of the automotive industry and their relation with the strategic goals of a European Vehicle Manufacturer. To achieve its goals, this OEM has increased its collaboration with its immediate supply chain members. The supply chains of plants A and B presented many SCM capabilities that are well developed in the links that connect the two assembly plant with the relevant members of their immediate chain, mainly module and highly valued component suppliers. With these capabilities the OEM seeks to achieve three of its four goals. The fourth goal, expanding production activities worldwide, was fundamental for the development of the supply chain structure of Plant C, an assembly plant that is located in an emergent country. Its SCM configuration reflects the transition of Plant C from a CKD manufacturing system to a CBU system in the late 90's and the many restrictions yielded by the incipient level of the automotive industry in this country. There are very few existing signs of SCM capabilities

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between the relevant supply chain members of Plant C, with the exception of the links that belong to the OEM internal chain.

The analysis allowed us to conclude that the SCM capabilities identified by the study constitute a response to trends in the automotive industry, as they try to bring about competitive advantages that obey a new logic in competition based on supply chains. The results of the case study lead us to the conclusion that although the three analyzed supply chains target the production of the same vehicle model, they present different SCM capabilities.

The results could also indicate that most SCM capabilities have been developed in the immediate chain of the vehicle manufacturer plants. This demonstrates that the theory of SCM is still far from reaching the total supply chain, being in practice still a philosophy limited to some parts of the chain, normally in the main links established with an OEM (in our research a Vehicle Manufacturer). But today's 1st-tier suppliers will face tomorrow the same problems that the OEMs are facing today. They will be forced to interact closer with their suppliers (2nd-tier under an OEM perspective) in supply chain processes, like logistics, manufacturing, research and development, and supplier and customer relationship management, therefore enhancing the management scope of the supply chain beyond the immediate chain.

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