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CAPABILITIES FOR INCLUSION IN GLOBAL SUPPLY CHAIN

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Thesis submitted to the Ph.D. Program in Business Administration of the Universidade do Vale do Rio dos Sinos – UNISINOS as partial fulfillment of the requirements for the degree of Doctoral in Business Administration.

Advisor: Ph.D. Luciana Marques Vieira

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I dedicate this work to my family. Special feeling of gratitude to my lovely wife, Daniela, who has motivated and supported me in every single moment of this journey. To my mother, Jandira, that really believes that education makes difference. My sons, Bento and Dante, you are my inspiration.

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“The empires of the future are the empires of the mind.”

Winston Churchill

ABSTRACT

To operate in global supply chains, there is need for development of capabilities to integrate different companies, from different countries with diverse cultures, economic and technological level. The semiconductor industry fits into a scenario of global production with a supply chain spread worldwide, seeking cost efficiency, mass production and flexibility. Brazil stands out in the global economy as an emerging country and has promoted public policies and incentives for the competitiveness of semiconductor chain in the country. The guidelines are made by public policies for the development of national production and tax incentives in order to attract foreign companies that are able to produce and develop the capabilities needed to create competitiveness. Considering that Brazil intends to move from a high consumer of microelectronics items to a competitive player in the semiconductor industry, this research aims to analyze what capabilities are needed by companies to become players in a global supply chain. The theoretical framework proposed for this investigation is designed to evaluate capabilities in a global supply chain. It proposes that the upgrading level results from capabilities developed by the companies and also influenced by political and economic factors. Productive, relational and innovative elements compose the set of global supply chain capabilities of this study. The method is descriptive-exploratory, using multiple case studies carried out in four Brazilian design centers. Data were collected through semi-structured interviews and document analysis. NVivo® supported data coding and analyses. The results demonstrate that Brazilian industrial policy affects the development of global supply chain capabilities of the national design houses, especially in terms of organizational and R&D processes. As consequence, the companies developed productive and relational capabilities and most of them are still in a process upgrading level. The development of global market and strengthening of innovative capabilities can lead companies to other upgrading levels and move the design houses up in the semiconductor global chain.

Keywords: Global supply chain; Capability; Public policy; Upgrading.

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LIST OF ABREVIATIONS

ABDI: Agência Brasileira de Desenvolvimento Industrial

ABINEE: Associação Brasileira da Indústria Elétrica e Eletrônica

ASEAN: Association of Southeast Asian Nations

ASIC: Application Specific Integrated Circuits

BNDES: Banco Nacional de Desenvolvimento Econômico e Social

CEITEC: Centro Nacional em Tecnologia Eletrônica Avançada

CNPQ: Conselho Nacional de Desenvolvimento Científico e Tecnológico

COFINS: Contribuição para o Financiamento da Seguridade Social

CRM: Customer Relationship Management

CTO: Chief Technology Officer

DH: Design Houses

EDA: Electronic Design Automation

EDI: Electronic Data Interchange

EU: European Union

FDI: Foreign Direct Investment

Finep: Financiadora de Estudos e Projetos

GPS: Global Positioning System

GSCC: Global Supply Chain Capability

GSCM: Global Supply Chain Management

IDM: Integrated Device Manufacturers

IC: integrated circuit

ICT: Information and Communication Technology

IP: intellectual property

ISO: International Organization for Standardization

MCT: Ministério da Ciência e Tecnologia

NAFTA: North America Free Trade Agreement

NIS: National innovation systems

OBM: Own brand manufacturing

OEA: Original Equipment Assembling

OEM: Original equipment manufacturer

PADIS: Programa de Apoio ao Desenvolvimento Tecnológico da Indústria de Semicondutores

PACTI: Plano de Ação em Ciência, Tecnologia & Inovação

PASEP: Programa de Formação do Patrimônio do Servidor Público

PNM: Programa Nacional de Microeletrônica

PPB: Processo produtivo básico

R&D: Research and Development

RBV: Resource based view

RFID: Radio-Frequency Identification

SCM: Supply Chain Management

SIA: Semiconductor Industry Association

Sibratec: Sistema Brasileiro de Tecnologia

SIP: Silicon Intellectual Property

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1 INTRODUCTION

In the current global competitive market, the management evolution is featured on agility in operations and value added orientation. This scenario, along with the constant advances in communication technologies and transportation, motivates the continuing evolution of supply chain management and different techniques for managerial efficiency and demand orientation (SIMCHI-LEVI et al., 2010). Thus, supply chain management (SCM) has been an important approach of operations management area, and it is at the core of success of most leading companies (SANDERS, 2012). Different factors can be considered to represent this new scenario, such as the necessity of mass customization, the presence of global consumers segments, time and quality competition, advances in communication and information technology and a strong dependence on government policies (MENTZER et al., 2007b). In this business environment, competition is no longer between organizations, but between supply chains (WU et al., 2014). It involves management of technology and innovation, streamlining processes, insourcing and outsourcing and managing complex relationships (ELLRAM; COUSINS, 2007), with the need to align different firms and interorganizational processes in order to bring products and services to the market.

The strategic supply chain management is a phenomenon characterized by broad and complex interactions involving multiple elements, such as strategic purchasing orientation for long-term relationships, inter-firm communication, interorganizational teams and buyer-supplier integration (PAULRAJ; CHEN, 2007). As the flow of products crossing country borders is increasing at a rapid pace (HAUSMAN et al., 2010), all these concepts are understood through strategic management theories in order to seek collaborative advantage in a global environment. Nowadays, companies source globally, sell globally, or compete with some companies that also do that. For these reasons, global supply chain management (GSCM) represents a major focus for many businesses and business schools today (MENTZER et al., 2007a). Supply chain management deserves further attention because it has been transformed in recent years by the influence of globalization, and the conceptual fundamentals of global supply chain management remain underdeveloped (CONNELLY et al., 2013).

Global supply chain research focuses explicitly on the nature of the relationships among the various actors involved in the chain, stressing the role that global buyers and producers may play while supporting developing countries producers' learning and innovation

activities, and explores their implications for development of capabilities to seek competitive advantage (MORRISON et al., 2008). Alliances are formed with foreign partners for business purpose and risk sharing, but also encourage learning about new ways of doing things (ALAM; BAGCHI, 2011). For being part of these global chains, companies must identify the key factors that would enable their operations as players as well as the important elements behind forming interorganizational relations across borders to upgrade and move up in the supply chain. One important issue that must be pursued by companies, especially in developing countries, is how to gain access to the skills and capabilities required to participate and to upgrade in global chains (BAIR, 2005). It is also critical because, for companies in developing countries, their inclusion in global chains not only provides new markets for their products but also plays a growing and crucial role in access to knowledge and enhanced learning and innovation (PIETROBELLI; RABELLOTTI, 2011).

Upgrading can be defined as the process by which nations, companies or workers move from low-value to relatively higher-value activities in global production networks (GEREFFI, 2005). Companies may upgrade in various ways, for example: by entering higher unit value market niches, by entering into new sectors, or by undertaking new productive or service functions (PIETROBELLI; RABELLOTTI, 2004). It is necessary to view the upgrading challenge in a wider perspective, capturing the central idea that it may involve changes in the nature and mix of activities, both within each agent in the chain and in the distribution of intra-chain activities. This relates to the achievement of new product and process development as well as to the functional reconfiguration of who does what in the chain as a whole (KAPLINSKY; MORRIS, 2001).

Considering global chain operations, the complexities are related to the fact that most of the organizations are embedded in very different national cultures, regional business norms, economic situations, and regulatory environments (FLINT, 2004). According to Schuler et al. (2011), when firms cross national boundaries with imports and exports of goods and services, or extend their organizational boundaries across borders through foreign direct investments, their transactions necessarily conform simultaneously within a variety of public policy regimes. Considering this scenario, public policies represent an important environmental factor (SANDERS, 2010) able to foster productive capabilities, attracting new businesses and investments to advance in global chains. Schmitz (2005) poses that, if policy-makers expect local companies to learn from participating in the global economy, they need to know whether these firms engage merely in transaction (buying or selling) or interaction

(which also involves intensive exchange of information and transfer of ideas). They need to be aware of power and inequality in the chain. In this way, it is important to evaluate in a macroeconomic perspective how policymakers should change the environment facing business to promote international trade and economic growth, whereas the microeconomic perspective of supply-chain logistics considers how a business should organize its operations given the policy environment (MANN, 2012).

The semiconductor industry fits into this scenario of global production as it has a supply chain that is spread all over the world (LEE et al., 2006), with the presence of leading technology-based companies which need cost efficiency, mass production and flexibility. The semiconductor industry is a capital intensive industry, with sophisticated processes of R&D, composed of a small number of competitive companies. The management models in this global industry require the implementation of outsourcing/offshoring and supply chain management (JIANG et al., 2010).

Brazil stands out in the global economy as an emerging country and has developed policies and incentives for the development of semiconductor chain. The guidelines are made by public funding for the development of national production and tax incentives aiming to attract foreign companies in order to cooperate and develop the capabilities needed to create competitiveness (GUTIERREZ; MENDES, 2009). Currently, the semiconductor supply chain involves technological leaders coming from countries such as the United States, Japan, China and South Korea. If compared to these countries, Brazil has a low level of investment in innovation and technology as well as a lack of skilled labor (GUTIERREZ; LEAL, 2004).

Brazil already operates in some activities of the semiconductor value chain, such as the back-end and project, and also has some laboratories and design houses. Semiconductor production is one of the priorities of Brazilian economic planning and technological development. The Federal Government aims to move from being a high consumer of microelectronics items to a competitive player in the semiconductor chain. Since 2005, the Microelectronics National Program has been inducing project services activities as priority with the creation and implementation of the microelectronics design in the country (GUTIERREZ; MENDES, 2009). According to ABDI (2011), currently there are 22 design houses (DH) distributed throughout the national territory. It is recognized that the levels of technological and productive maturity of the national DHs are still far below if compared with leading countries, and the capability of prospecting international market represents the main barrier to increase their productivity. The identification and improvement of key processes,

aligned with the pressures and opportunities established by the global market, can allow the DHs to upgrade in the semiconductor chain. Even considering that the development of microelectronics in Brazil is on the agenda of the Brazilian Ministry of Science and Technology, it is known that the results are still very incipient if compared with leading players.

Based on the global supply chain management approach, this thesis aims to evaluate the development of capabilities in Brazilian companies to operate as players in the semiconductor industry. The influence of the public policies that are fostering the promotion of this industry is emphasized, identifying the barriers and opportunities for the growth and upgrading of Brazilian companies' participation in the global semiconductor chain.

1.1 RESEARCH PROBLEM

The semiconductor industry has been one of the most important industries for the past three decades. Because of its critical position in modern industry, the research on the semiconductor industry is plentiful (LI et al., 2010). It has a supply chain that is distributed worldwide, and its manufacturing process has the particular characteristics that should be considered in the supply chain structure (LEE et al., 2006).

Macher and Mowery (2003) stand out for how critical it is to obtain competitive performance in the semiconductor industry: i) the introduction of a new semiconductor product typically needs significant changes and innovations in the underlying manufacturing process; ii) the ability to increase output of a new semiconductor chip rapidly before imitators enter is crucial to profitability; and iii) the high fixed costs associated with semiconductor manufacturing mean that low manufacturing yields and long cycle times reduce profitability and threaten firm survival.

According to Li et al. (2010), the semiconductor production process is dominated by a group of high tech leading companies (such as Intel, Samsung, and IBM) known as Integrated Device Manufacturers (IDM), that operate as the semiconductor industry integrators. The producers of integrated circuits (IC) operate in different ways in this supply chain that is fundamentally composed of three main value activities (GUTIERREZ; MENDES, 2009): i) the product design: it makes an assessment of market demands and it designs the products; ii) manufacturing: it is performed by means of physical-chemical processes to produce the wafer. This phase is called front-end; and iii) packaging and test of the IC, denominated back-end.

Global supply chain management strategies have helped the semiconductor companies to gain competitive advantage, with high investments in international operations with successive stages of outsourcing and offshore activities in these different chain activities (JIANG et al., 2010). Lee et al. (2006) pose that semiconductor companies run global business through multiple manufacturing sites, warehouses or distribution centers, subcontractors and suppliers. Manufacturing sites may consist of multiple fabrication sites, probe sites, assembly sites, and final test and packaging sites throughout the world. Also, it is necessary for the supply chain model of the semiconductor industry to include coordination and cooperation in the entire chain stream starting from suppliers of raw materials to customers of the final products.

Semiconductor production is one of the priorities of Brazilian economic planning and technological development. The country aims to move from a strong consumer of microelectronics items to a strong player in the semiconductor chain. The difficulties of creating a microelectronic ecosystem characterize a great challenge that should be overcome to reduce the trade deficit in electrical and electronic equipments that, in 2013, corresponded to US$ 36.2 billion, 11% more if compared to 2012 that was US$ 32,5 billion (ABINEE, 2014). The incentives promoted by the Brazilian industrial policy have already developed operations in the three main stages of the semiconductor chain, but the levels of technological and productive maturity of the national companies are still far below if compared with leading countries ones. The Microelectronics National Program faces many barriers to move Brazilian companies up as players in the semiconductor global chain; however, there are also lots of opportunities of growth, such as the lack of a national infrastructure, experienced labor, and a proper industrial policy to leverage this economic sector, motivating new ventures, developing national production and attracting foreign companies (BORGES; VIEIRA, 2014).

Since the beginning of the national project, over 50 million dollars were already invested to structure the national semiconductor industry (ABDI, 2011). As part of the Microelectronic National Program promoted by the Ministry of Science and Technology, the CI-Brasil program was created to leverage the industry through the implementation of the design houses in the country. This strategy aims to promote the economic activity in the project area of integrated circuits, to develop an ecosystem in microelectronics and to leverage the country in the international arena of semiconductors (ABDI, 2011). Currently, there are 22 design houses and two training centers in Brazil, what represents good opportunities for researching and development. They are partially supported by the CI-Brasil

program, and 13 of these are non-profit organizations. Most of them are spin-offs that have arisen or are connected to universities or public research institutions (CI-BRASIL, 2014). This value activity has been chosen as a priority for two reasons: design is fundamental and decisive for generating innovation and it involves less investment if compared to manufacturing activities (ABDI, 2011).

The penetration in global supply chain presents great opportunities, but, on the other hand, it simultaneously presents great complexities and high risks resulting from turbulent environmental conditions (MYERS et al., 2007), differences in labor productivity and access to labor skills, access to transportation and infrastructural support (SANDERS, 2012). There is also the cultural distance between the buyer's country and the supplier's country, which measures informational and communication complexity and geographic complexity (KAUFMANN; CARTER, 2006). These elements represent the challenges for a traditional producer of commodities like Brazil, considered latecomer in terms of technological development. Brazil is an emerging economy, a large consumer market and has plenty of resources, what represents good elements for national companies to operate as players in the semiconductor value chain activities. It is still necessary to distinguish the main constraints and potentiality for the development of a semiconductor national industry, determine what factor can foster capabilities, and define the role of public polices to leverage companies from an emerging economy, like Brazil, as a player in this typically global chain. These considerations compose the basis for the formation of the research question of this study:

"What are the capabilities needed by companies to become players in a global supply chain?"

1.2 Objectives

In order to answer the research question, this section presents the general and the specific objectives of this study.

1.2.1 Main Objective

The main objective of this study is to evaluate the capabilities developed by Brazilian design houses to participate in the semiconductor global supply chain.

1.2.2 Specific Objectives

The specific objectives of this study are:

- to describe the public policies promoting the national semiconductor industry and attracting foreign direct investment;
- to describe the semiconductor global chain;
- to analyze the current operations of Brazilian DHs and their participation in the global chain;
- to identify the supply chain processes that are impacting on global capabilities;
- to present the impact of public policies on capabilities generation;
- to identify the upgrading level achieved through the global supply chain capabilities.

1.3 Structure

The structure of this research is composed as follow: chapter 1 presents an introduction, which describes the focus and the research question, followed by the main and specific objectives of the study. The theoretical review, presented in chapter 2, is composed by supply chain concepts and its elements, followed by the main factors that must be considered for a global chain operation. In the sequence, we present the impact of public policies to foster a new industry and the national companies operations in a global chain and the capabilities for going global in a supply chain. The last part of the theoretical review presents the main elements to evaluate the upgrading process to move up in a global chain. Chapter 2 also includes the theoretical framework. Chapter 3, in its turn, describes the method used for this research. Chapter 4 is dedicated to describe the semiconductor global supply chain and the Brazilian initiative to promote an industrial policy to foster national players in the semiconductor global chain. Chapter 5 presents the cases descriptions and analysis, followed by chapter 6, which is composed by the propositions analysis and the results of this study. Finally, in chapter 7, the final considerations and recommendations for future studies are described.

2 LITERATURE BACKGROUND

Rising international cooperation, vertical disintegration and focus on core activities have led to the notion that companies are linked in a supply chain. This perspective has created the challenge of designing and managing a structure of interdependent relationships developed and fostered through strategic collaboration (CHEN; PAULRAJ, 2004). This was accelerated mainly by rapid changes in information technology and the new competitive globalized environment created by economic, demographic, and political developments (GIANNAKIS; CROOM, 2004), where inter-company relationship management, integration and coordination take place in a global perspective (KOTZAB et al., 2011). These cross-border issues lead to the need for an understanding of the supply chain configuration in a global context. This growing strategic importance of global supply chain management has also motivated the need for managers to keep more detailed attention to external factors (SANDERS, 2012) in order to clearly understand the links among products, the supply chain processes used to produce and deliver them, and the strategy used to manage the supply chain activities (STAVRULAKI; DAVIS, 2010). It means that a proper management of key processes, aligned with the conditions of external factors, is the basis for a company's strategy to achieve capabilities for upgrading in global chains.

For the purposes of this study, this chapter defines in the first section the concepts and the elements that compose supply chain management and also the characteristics that make up its global operations, involving relationships between different companies from different countries and different technological and economic levels. The second section discusses the importance of public policies to foster new industries and their impact in the development of companies' capabilities to advance in global operations. The third section presents a discussion of what are the capabilities needed to advance globally in a supply chain. The fourth section presents the concepts and elements that allow the evaluation of the upgrading process to move up in a global supply chain. At the end of each subsection, a theoretical proposition is elaborated. These propositions compose the basis for the theoretical framework designed for this research that is presented in the last section of this section.

2.1 GLOBAL SUPPLY CHAIN MANAGEMENT (GSCM)

Companies are pursuing collaborative operations based on inter-organizational models because of issues such as the complexity of the global market, the demand for greater flexibility and lean operations and the necessity to offer more added value for customers. There are many efforts of practitioners and scholars to understand this research area and its main elements as well as to develop models in order to map and interconnect concepts. Thomas and Griffin (1996), for example, propose a model to reduce operating costs by integrating the activities of procurement, production and distribution, based specially on the advances in communications and information technology, as well as a rapidly growing array of logistics options. Harland (1996) discusses the term supply chain management and how it can be used to represent a variety of different meanings, some related to management processes, others to structural organization of businesses. Cooper et al. (1997a) present a conceptual scheme identifying the main logistics flows, considering different supply chain business processes and components. Mentzer et al. (2001) extend the scheme presenting elements of inter-functional coordination and indicators in a global environment. Chen and Paulraj (2004) propose a model in which buyer-supplier relationship is the central operation accomplished in an environment of uncertainties and leveraged by strategic purpose to seek higher performance. Charvet et al. (2008) focus on the term supply chain management and its use in the academic literature. Therefore, while definitions of supply chain management (SCM) vary significantly, an understanding of the range of its use and the structure of related concepts is worthwhile. These studies help the understanding of the chain configuration and allow practical applications. From these studies, we can detach that: i) SCM requires strategic operations in a global and uncertain context; ii) the dyad buyer-supplier is an important element to accomplish procurement, production and distribution activities; iii) cooperation, coordination and long-term relationship increase the flow of knowledge along the chain; iv) key processes must be managed with adequate infrastructure and technology to achieve higher performance, especially in terms of customer satisfaction, profitability and competitive advantage; and v) managing a supply chain in a global context brings different concerns if compared to the domestic ones.

The combination of a world population that is shifting toward emerging markets and fierce competition has precipitated the globalization of demand and supply sources (CONNELLY et al., 2013). This globalization infers the cross-border movements of goods

and the emergence of global competitors and opportunities across competing supply chains within industries (SANDERS, 2012). This scenario has forced companies to look for more effective ways to coordinate the flow of materials into and out of the company (MENTZER et al., 2001). The complexities of cross-border operations are exponentially greater than in a single country, and the ability to compete in the global environment often depends on understanding the subtleties that emerge only in cross-border trade (MENTZER et al., 2007a). Thus, many other factors need to be considered for the evaluation of the supply chain in a global perspective, such as cultural differences, geographic distances, language barriers, political uncertainty, currency exchanges and multiple time zones in their supply chain (CONNELLY et al., 2013).

All these fundamental changes in the industrial competition have caused an increasing level of uncertainty and turbulence in the global economy, leading to the emergence of new theories which largely emphasize the importance of considering interrelationships, interactions, and networking while developing a strategy (SHARIFI et al., 2013). The global environment provides many organizations with an incentive to establish a value-added network, where complex inter-company relationship management, collaboration and coordination take place in the areas of product design, production, supplier selection and marketing (KOTZAB et al., 2011). These characteristics and challenges of the integrated market have been creating new rules for the achievement and maintenance of competitiveness advantage. Many companies serve multiple global markets with products sourced and produced across many continents. Even the smallest rural farms are affected by the global influx of foreign goods and trade regulations (SANDERS, 2012). It is possible to identify the same elements present in a supply chain focused on coordination, collaboration, supply processes and performance, but with the flows of information and resources in a cross-border context. So, the understanding of global supply chain management (GSCM) concepts is based on the supply chain management approach embedded into a global perspective. Thus, the next two subsections present the main concepts and elements involved in this perspective.

2.1.1 Supply Chain Management (SCM)

The supply chain concept originated in the logistics literature, and logistics has continued to have a significant impact on this concept (BETCHEL; JAYARAN, 1997). Supply chain appears as logistics taken across inter-organizational boundaries (COOPER et

al., 1997a). The field is generally considered to involve integration, coordination, and collaboration across organizations. A typical supply chain, also known as logistic network, includes activities such as purchasing, manufacturing, transportation, warehousing, retailing, and delivery, focusing on the transportation of goods through these facilities (SIMCHI-LEVI et al., 2010).

The management of a supply chain will include a broad array of activities needed to plan, implement, and control sourcing, manufacturing, and delivery processes from the point of raw material origin to the point of ultimate consumption. Thus, leading logistical practice has shifted from an exclusively internal focus to collaboration across the full range of supply chain participants (STANK et al., 2001).

Supply chain management has been a melting pot of various disciplines, with influences from logistics and transportation, operations management and materials, and distribution management, marketing, as well as purchasing and information technology (GIUNIPERO et al., 2008). With recent advances in communications and information technology, companies have had an opportunity for significant savings in logistics and transactions costs by coordinating these ranges of different areas and planning the various stages of SCM (THOMAS; GRIFFIN, 1996).

So, what exactly is supply chain management? Gibson et al. (2005, p. 22) present the following definition:

> Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, demand creation and fulfillment, and all Logistics Management activities. Thus, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies.

Hence, supply chain management involves multiple companies, multiple business activities, and the coordination of those activities across functions and across companies in market. The literature presents different definitions and categories to represent the term and the practices of supply chain management. As a result, it creates a source of confusion for those involved in researching the phenomena, as well as those attempting to establish a supply chain approach to management (MENTZER et al., 2001). However, even with distinguished definitions and confusions in the current literature, several key points emerge in commonality,

and most of the definitions agree that the supply chain covers material flow from channel members or suppliers through end users (BETCHEL; JAYARAN, 1997).

Cooper et al. (1997a) propose a list of these key points:

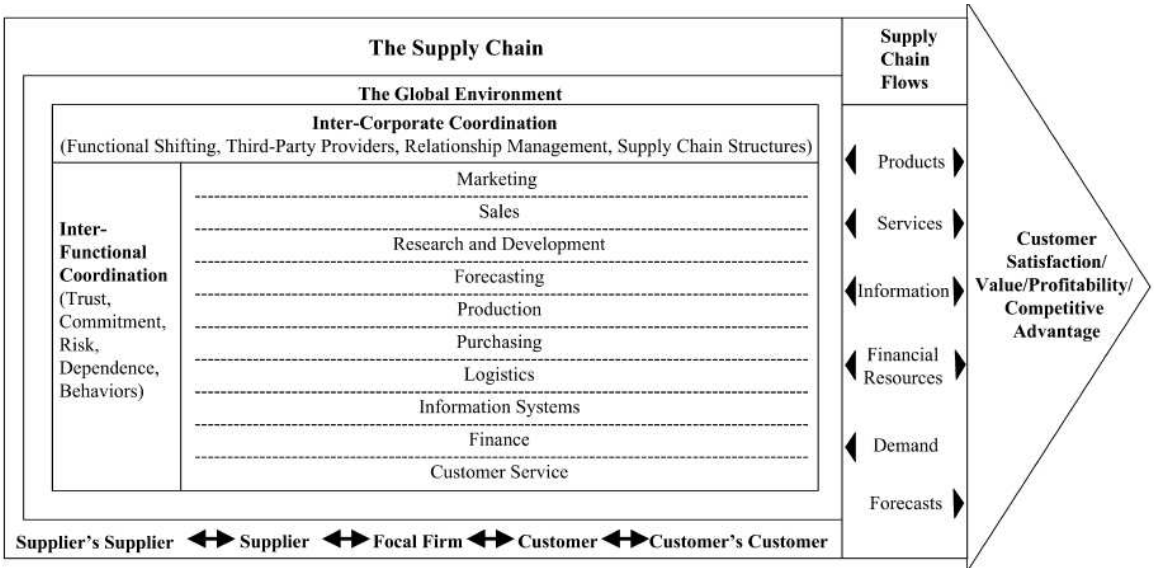
- It evolves through several stages of increasing intra and inter-organizational integrations and coordination; and, in its broadest sense and implementation, it spans the entire chain from initial source (supplier's supplier, etc.) to ultimate consumer (customer's customer, etc.).
- It potentially involves many independent organizations. Thus, managing intra and inter-organizational relationships is of essential importance.
- It includes the bidirectional flow of products (material and services) and information, the associated managerial, and operational activities.
- It seeks to fulfill the goal of providing high customer value with appropriate use of resources and to build competitive chain advantages.

The nature of SCM is generally considered to involve integration, coordination, and collaboration across organizations and throughout the supply chain. It includes the broad array of activities needed to plan, implement, and control sourcing, manufacturing, and delivery processes from the point of raw material origin to the point of ultimate consumption. The focus should be on creating as much value for the end customer as profitable, and doing this requires coordinated effort among all companies in the entire supply chain (STANK et al., 2001). The role of individual business functions, and how they are coordinated across functions and across companies, should be examined through inter-functional and inter-corporate perspective. Inter-functional coordination includes an examination of the roles of trust, commitment, risk, and dependence on the viability of internal functional sharing and coordination. Inter-corporate coordination includes functional shifting within the supply chain, the role of various types of third party providers, how relationships between companies should be managed, and the viability of different supply chain structures (MENTZER et al., 2001).

Supply chain management has been examined from different perspectives, encompassing a multidimensional field. The diversity of the supply chain management literature does not imply that it is infeasible to attempt to map a common problem domain, and the established management disciplines evolve very strong research themes within them (GIANNAKIS; CROOM, 2004). Mentzer et al. (2001) propose a scheme (Figure 2) showing directional supply chain flows (products, services, financial resources, the information

associated with these flows, and the informational flows of demand and forecasts). The traditional business functions of marketing, sales, research and development, forecasting, production, procurement, logistics, information technology, finance, and customer service manage and accomplish these flows from the supplier's suppliers through the customer's customers to ultimately provide value and satisfy the customer. The scheme also shows the critical role of customer value and satisfaction to achieve competitive advantage and profitability for the individual companies in the supply chain, and the supply chain as a whole. Inter-corporate coordination includes functional shifting within the supply chain, the role of various types of third party providers, how relationships between companies should be managed, and the viability of different supply chain structures.

Figure 1 - A scheme for supply chain management



Source: Mentzer et al. (2001)

It is important to consider in a supply chain configuration the outcomes expected to be achieved. Improving customer satisfaction in a global economy frequently requires companies to reengineer a supply chain for cost reduction and performance improvement (MABERT; VENKATARAMANAN, 1998). Considering supply chain, it is important to find metric solutions capable of: i) capturing performance across the entire supply chain; ii) determining the interrelationship between corporate and supply chain performance; and iii) supporting information to implement strategies and obtain competitive advantage (LAMBERT; POHLEN, 2001). The integrated measures help to avoid optimization at one point in the

supply chain without considering the problems that may occur at other points. Integrated measures offer more control over the supply chain since key managers have measures reflecting actions across a number of functional areas (BECHTEL; JAYARAM, 1997). The supply chain outcomes proposed to be evaluated are: i) customer satisfaction; ii) value; iii) profitability; and iv) competitive advantage. It is important that the implementation of SCM enhances customer value and satisfaction, which in turn leads to enhanced competitive advantage for the supply chain, as well as each member company. This, ultimately, improves the profitability of the supply chain and its members (MENTZER et al., 2001).

The scheme proposed in figure 1 already considers the need for a global context evaluation while managing a supply chain. Thus, the next section presents the main elements that compose this global scenario.

2.1.2 Supply Chain Management in a Global Perspective

The strategy of the supply chain is a global issue. Slack and Lewis (2011) pose that a global supply means the identification, evaluation, negotiation and configuration across multiple geographies. Companies are increasingly looking for suppliers in some remote locations. According to these authors, many companies have accomplished to save from 10% up to 35% in costs by working with suppliers from low-cost countries. Considering this scenario, GSCM represents a central area of focus for many businesses and business schools today (MENTZER et al., 2007a).

Managers seeking to leverage supply chain processes in order to enhance performance need to understand the relative importance of the various competencies in each particular operating arena. The needs of key customers may vary across international borders, and the means for developing an effective fulfillment and replenishment process may also vary across international locations (CLOSS; MOLLENKOPF, 2004). According to Mentzer et al. (2007a), the complexities of cross-border operations are exponentially greater than in a single country, and the ability to compete in the global environment often depends on understanding the subtleties that emerge only in cross-border trade, that is, in GSCM. The operation in a global supply chain is based on the development of capabilities to integrate different companies, from different countries, languages and cultures, and different economic and technological level. Thun (2010) states that the supply chain integration necessary to compete in the global market is defined as the improvement of cooperative relationships with

customers and suppliers. The challenge is to develop the buyer-supplier cooperation in an environmental uncertainty with multidimensional constructs consisted of dynamism and complexity, such as: i) the dynamism regarding an internationally purchased item which measures the frequency, extent, and unpredictability of changes; ii) the complexity of that purchased item which measures technical complexity; iii) the cultural distance between the buyer's country and the supplier's country which measures informational and communication complexity; and iv) the geographic complexity between the two countries which measures the complexity of the flow of goods or logistical complexity (KAUFMANN; CARTER, 2006).

Without going global, companies would be limited to have just goods and services produced within their own borders. Being global provides opportunities to tap into huge and growing markets, capitalize on new economic trends, and utilize natural resources available in other geographic areas (SANDERS, 2012). The larger the portfolio of markets in which the supply chain operates, the greater the opportunities and, simultaneously, the greater the complexities and risks resulting from turbulent environmental conditions (MYERS et al., 2007). Trading on a global or international market scale is considerably more complicated than on a domestic one. There are time costs due to longer transit time and there are also operational costs involved in conducting business in a different part of the world. These include differences in labor productivity and access to labor skills, access to transportation and infrastructural support, as well as availability of technology. Besides, there are significant risks that include political instability, as well as currency fluctuation (SANDERS, 2012). A proper evaluation of these opportunities and barriers, considering the different trade off involved, is what best characterizes the management of a supply chain in a global level.

Studies on global supply chain management, such as the ones carried out by Sanders (2012), Mentzer et al. (2007a), Mentzer et al. (2007b), Myers et al. (2007), Caniato et al. (2013), and Skjøtt-Larsen et al. (2007), discuss that the complexities of this field is related to a diverse set of environmental issues and conditions of the global market. So, the concept of global supply chain management can be described by this study as follows:

> Global supply chain management integrates supply and demand management within and across companies (suppliers, intermediaries, third party service providers or customers), belonging to different countries and presenting distinction in their economic and technological level. The planning of activities involving sourcing, outsourcing, and supplying are subject to environmental conditions that compose the global market.

This concept considers the fundamentals of supply chain management, aligned with the characteristics and complexities of global operations. The global environment embraces a long list of possible topics that express this complexity (SKJØTT-LARSEN et al., 2007). Sanders (2012) resumes these environment issues in six significant factors that companies must monitor throughout the process of managing their global supply chain. They are: market and competition, cost, infrastructure, technology, political and economic environment and culture which are going to be discussed as follows.

2.1.2.1 Market and Competition

The international market is not only a sum of different national markets. Traditionally, international business strategy is based upon these individual markets and sets up objectives and policies separately to satisfy the specific requirements of different countries (SHI; GREGORY, 1998). Outsourcing manufacturing to offshore supplier locations, for example, has been a common practice in recent years. In this way, supplier selection decisions have been changing the global supply chain design problem in fundamental ways, in part because they are based on more broadly complex criteria (MEIXELL; GARGEYA, 2005). Market and competition are all factors involved in marketing and selling to global markets, including customer preferences and competition. Customer preferences and expectations are often unique in different global regions (SANDERS, 2012). To gain competitive advantage in this scenario, a company needs to examine its activities in relation to the comparative advantages offered by various nations. Matching these activities and the sourcing decisions with the appropriate country conditions can lead companies to gain costs, quality, lead times and, perhaps, innovation (PRASAD; SOUNDERPADIAN, 2003).

Globalization of markets interacts with globalization of companies, which act as buyers and sellers of goods and services (MATTSSON, 2003). This global market is based on the shared and common demands of different countries. It integrates different national preferences into a core entity and presents this as a fundamental and non-differentiable market requirement. To satisfy the growing global market as well as companies' internationalization, the traditional products and related development strategies are clearly not enough (SHI; GREGORY, 1998).

The challenge to today's global business is, firstly, to identify the appropriate supply chain solutions to meet the different needs of the different product/market characteristics and

then, secondly, to manage what are likely to be multiple supply chains (CHRISTOPHER et al., 2006). On a global scale, companies will need to decide upon the degree to which the supply chain can be rationalized (PRASAD; SOUNDERPADIAN, 2003). Many critical issues, such as properties of international manufacturing network systems in terms of structural architecture, dynamic mechanisms, and related strategic capabilities and strategy processes (SHI; GREGORY, 1998), must achieve a higher maturity level in global markets.

2.1.2.2 Cost

Today's market place is characterized by heightened global competition often against a backdrop of an excess of supply over demand (CHRISTOPHER et al., 2006). Considering this scenario, the global competition is forcing corporations to periodically look at their supply chain map to reduce costs and time involved in the process. Innovations in this area are helping corporations gain significant advantages over their global competitors (MOTWANI et al., 1998). In order to reduce their production costs, especially labor costs, many companies have relocated segments (sometimes the entire process) of their industrial production systems to new locations; a process commonly known as offshoring (RODRIGUE, 2012).

Cost is often the most cited reason by companies for going global. Frequently, companies only consider individual costs, such as low directed labor cost, marketing cost or, perhaps, local supplier cost. However, it is important for companies to consider total supply chain costs when going global. These include costs of quality, differential productivity and design costs, as well as added logistical and transportation costs (SANDERS, 2012). Cost management must focus on the functional and integrated logistics and supply chain cost components (CLOSS; MOLLENKOPF, 2004). Cost components include fixed and variable production charges, inventory charges, distribution expenses via multiple modes, taxes, duties, and duty drawback (ARNTZEN et al., 1995).

2.1.2.3 Infrastructure

Flexibility is important in global supply chains because it plays a facilitating role in the coordination process and provides a unique ability to help companies manage the high levels of environmental and operating uncertainty inherent in global operations (MANUJ; MENTZER, 2008). Infrastructure availability enables the development and functioning of the supply chain network flexibility. This includes access to roads and transportation, equipment

and communication network, distribution systems, and skilled labor. This is typically one of the biggest global challenges. The ability to penetrate global markets depends on having global facilities and distribution and supply networks to respond to consumer demands (SANDERS, 2012). Infrastructural deficiencies in developing countries in transportation and telecommunications, as well as inadequate worker skills, supplier availability, supplier quality, equipment and technology provide challenges normally not experienced in developed countries. These difficulties inhibit the degree to which a global supply chain provides a competitive advantage (MEIXELL; GARGEYA, 2005).

The infrastructural challenges, in order to have a global chain capable of meeting the demands, involve the management of three main factors (SANDER, 2012):

- Labor: access to low-cost and/or high quality labor.
- Transportation: access to roadways and transportation.
- Supplier: designing a global supply chain requires important decisions regarding the number of suppliers and their geographic locations.

2.1.2.4 Technology

The emergence of the global market and the intensification of global competition are matched by major developments in technology. New generations of communication and transportation technologies are creating the possibility for transnational companies to organize their worldwide operations more effectively and efficiently (SHI; GREGORY, 1998). An important aspect of global supply chain cooperation is the communication between partners from different nations. So, the more integrated the flow of information between customers and suppliers, the easier it becomes to balance supply and demand across the global network (THUN, 2010).

Technology enables manufacturing innovation that, in its turn, allows more efficient means of changing the product mix and the ability to serve different markets. The global planning process must include competencies of technology and planning integration resulting in information systems capable of supporting the wide variety of operational configurations needed to serve diverse market segments (CLOSS; MOLLENKOPF, 2004).

Information technology, in particular, enables information sharing and collaboration across the globe. Examples of this are availability of bar code technology, GPS, EDI and RFID, since all of them enable global product tracking and communication (SANDERS,

2012). By making collaboration easier and cheaper, the new technology means companies can integrate aspects of their operations more swiftly and collaborate more closely than before (FROHLICH; WESTBROOK, 2001).

2.1.2.5 Politics and Economy

In a global context, the ability of managers to serve specific segments effectively can be limited by regulations and political economies that restrict the standardization of the offerings and processes needed to do so. These often dichotomous environmental conditions alone account for the often exponentially more difficult management conditions faced by global, rather than single market supply chain managers (MENTZER et al., 2007b). Politics and economy can include government regulation, political stability, formation of trade agreements, and currency fluctuations (SANDERS, 2012). Proper assessment of the political economy scenario often facilitates considerable savings in tariffs, as well as market opportunities. It is essential to evaluate political risk, credit risk, social risk, and market risk as well as to minimize their effects through awareness of their impact and cost across global supply chains (MAYERS et al., 2007).

According to Mann (2008), trade facilitation must be pursued by policymakers. It is the rubric that covers the research and policy analysis on impediments to global sourcing and multinational supply chains that are not the traditional border barriers, such as tariffs or quotas. Trade facilitation offers a macroeconomic perspective on how policymakers should change the environment facing business to promote international trade and economic growth, whereas the microeconomic perspective of supply chain logistics considers how a business should organize its operations given the policy environment. The view is that policies that, for example, increase port efficiency, or use of information technology, or adherence to international standards, will improve the environment for business to buy, sell and invest across borders and, thus, drive more efficient and effective trans-border supply chains (MANN, 2012).

Another economic factor that global operations face is the exchange rate fluctuations. Actually, the financial and accounting complexities of foreign exchange rates go beyond the understanding, or responsibility, of global supply chain management. Instead, it is the task of managers to reduce foreign exchange in global supply chain transactions (MAYERS et al., 2007). Small fluctuations are expected and do not have a large impact. However, large

fluctuations can have huge implications for global operations. It means that the ability to purchase in the currency you possess is suddenly diminished with no fault of your own. Therefore, supply chain managers have to include these fluctuations in their management strategies (SANDERS, 2012).

2.1.2.6 Culture

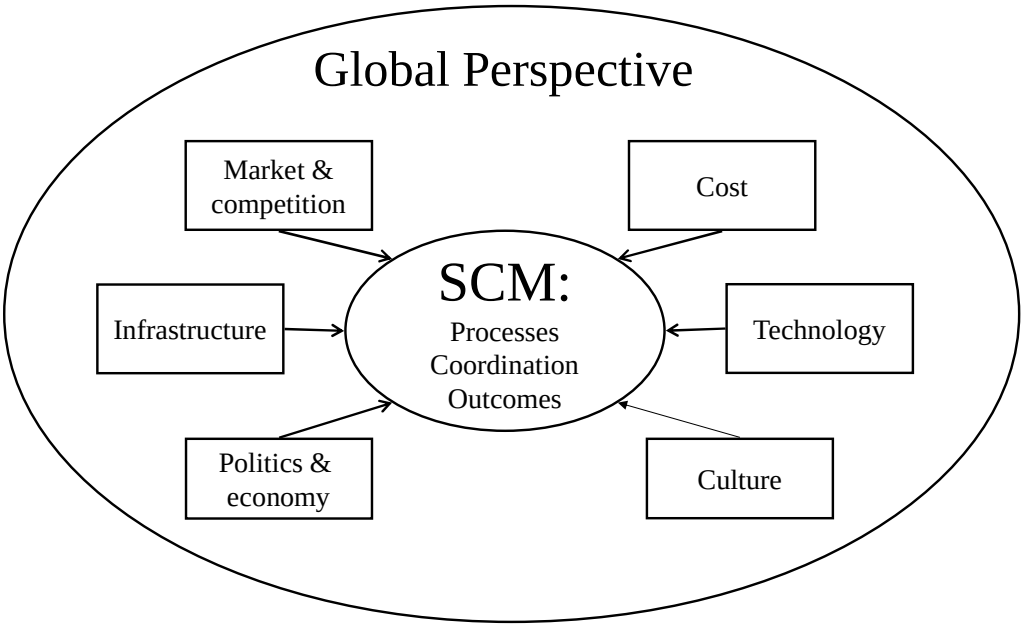
Culture refers to acceptable behaviors, beliefs and norms characteristic of a particular global region. This includes social structures and acceptable interactions, work ethic, observances and manners, gender roles, and adherence to formal chains of authority (Sanders, 2012). A market is embedded in an institutional setting, which is comprised of a society's norms and culture (MATTSSON, 2003), where different languages, beliefs and practices have a close relationship with the effectiveness of business processes (MEIXELL; GARGEYA, 2005).

Globalizing the supply chain is often ineluctable and requires the development of good relationship across multiple cultures (MAYERS et al., 2007). Each country has its specific elements of originality and peculiarity, and matching supply chain strategies with the different cultural imperatives is a challenge for every organization that decides to go abroad to do business (MAYERS et al., 2007). Globalization of companies and markets involves confrontation between these different cultural issues, both at the organizational and national level. The challenge is that national culture is deeper and less adaptable than organizational culture where the latter is influenced by the former (MATTSSON, 2003).

It is critical that managers understand these different dimensions related to culture issues and keep them in mind as they conduct negotiations, collaborate, and build rapport with members of their supply chain across the globe (SANDERS, 2012).

The relevance of developing a proper model for managing a supply chain in a global perspective is justified precisely by the complexity of the international market. The international market needs greater flexibility and lean operations, and it requires more added value for customers from different geographies and specific needs. Global supply chains operate in a distinct geography, where the dimensions of production, distribution and consumption may be established at a different location on the globe (RODRIGUE, 2012).

Figure 2 - Factors impacting global supply chain management



Source: Adapted from Sanders (2012)

By exploring the six factors proposed by Sanders (2012) - market and competition, cost, infrastructure, technology, political and economic environment, and culture -, this study discusses how managing international supply chain is more complex than managing a domestic supply chain (DRAKE, 2012). All the six factors represent external forces that must be carefully evaluated while developing a strategy for global transactions. The scheme represented in Figure 2 shows that, from a global perspective, it is not just enough to acquire new resources, equipment and to hire specialized people. Managers need to access critical aspects related to these factors jointly with the internal companies characteristics to determine the proper global supply chain strategy their organization should seed to align operations with global partners (MENTZER et al., 2007b). The scope of international chains is more complex in terms of mission, structure, infrastructure, capability, and design process (SHI; GREGORY, 1998), which needs more detailed attention to external factors. Because of these factors, the achievement of the outcomes expected in a chain operation—customer satisfaction, value, profitability and competitive advantage (MENTZER et al., 2001)—is more dependent of an effective coordination model and collaboration between the global partners.

The literature presents that the joint of a global chain and sourcing for international suppliers, partners or customers represents opportunities to improve performance, but, at the same time, it requires different infrastructural and managerial capabilities to deal with the

complexities of the external elements and turbulent environmental conditions of global market. There is a pressure to go global, especially if companies want to grow up and be more competitive. Since globalization is reducing trade barriers, the achievement of competitive efficiency demands the search for new technologies, knowledge, raw materials, services or customers globally. Therefore, the conceptual elements for global supply chain management presented above allow the definition of the first proposition of this research:

Proposition 1: Going global in a supply chain may be an option of the companies, but, most of the time, it is demanded by the characteristics of the industry and the market.

2.2 PUBLIC POLICIES DEVELOPING COMPANIES' CAPABILITIES

The global environment embraces a long list of issues that affects the configuration and managerial demands of a supply chain. Skjøtt-Larsen et al. (2007) pose that this list may include political and cultural issues, information and communication technology, legal systems and labor markets. Regulatory developments and national policies have been critical in the choice and prioritization of these elements for the industry upgrading. In this global context, the ability of managers to perform specific segments effectively can be affected by regulations and political economies that can influence both positively or negatively the ability to standardize the offerings and processes needed to do so. Global supply chain designs must take into account these changing political economy infrastructures to remain competitive (MYERS et al., 2007). These often-dichotomous environmental conditions turn more difficult the management conditions faced by global rather than single market supply chain managers (MENTZER et al., 2007b).

The governments' industrial strategy implementation capabilities largely rest on the specificity and credibility of the economic policy instruments that influence the international economic strategies that government can implement (MURTHA; LENWAY, 1994). Schmitz (2005) points out that the approach of global chain can help the policymaker to find out where the opportunities and bottlenecks are, which part of the chain holds up progress in the others, which bottlenecks deserve priority attention of government, which can be expected to be resolved by the private sector and which require public-private partnership. At the same time, companies can defeat stronger rivals in goods or services markets through actions in the political nonmarket arena, finding opportunities to be more efficient, more innovative, or

more capable of appealing to customers through differentiation, holding political strategy constant (SCHULER et al., 2011). It requires establishing relationships with organizations operating under completely different political, economic and physical environments (SKJØTT-LARSEN et al., 2007). Considering this scenario, companies can use political strategies to enhance their competitive positions against weaker rivals as well (SCHULER et al., 2011).

It is important to have an alignment between the interests of public institutions and the corporate sector for the development of public policies that are able to promote opportunities for the companies' capabilities development and, consequently, the upgrading of the national industrial. According to Sahoo (2010), companies must be able to decide the organizational structure of the chain, to identify intermediary players and add value to the product, to serve product to the end consumer to his best satisfaction, to provide effective linkages such as infrastructure, extension, R&D support and credit facilities to the players and to build trust among partners. Sahoo (2010) also argues that, at the same time, government needs to play the role of a facilitator, to frame suitable policy for the development of the sector, to encourage public-private partnership in development of the sector, to undertake investments in infrastructure development, to encourage development in innovation and technology, to put forth suitable insurance policy for risk mitigation, to promote exportation and to make periodic assessment and evaluation of various risks, i.e., supply risk, operational risk and demand risk. What is important to keep in mind is that there are different kinds of supply chains, and different chains may require different responses from policymakers and local companies (SCHMITZ, 2005).

It is also important to see industry evolution as a process, and that involves the promotion of technology development by institutions via repeated interactions among a range of industry participants (Spencer et al., 2005). The technological capability development does not evolve in a vacuum. Domestic institutions through policy instruments and intermediation between companies and companies and institutions have been critical in stimulating learning and innovation (RASIAH, 2004). Rasiah (2004) also affirms that national innovation systems (NISs) and industrial policy (IP) can promote the policy and institutional environment necessary to stimulate upgrading, innovations and company-level performance. According to Lenway and Murtha (1994), the government is the main responsible for the international economic strategy that composes the government plans to allocate resources with intent to

reach long-term national political and economic objectives, including growth and competitiveness.

If policymakers expect local firms to learn from participating in the global economy, they need to know whether these companies engage merely in transaction (buying or selling) or interaction (which also involves intensive exchange of information and transfer of ideas) (SCHMITZ, 2005). In global chains, these relationships cover management of dynamic interactions between suppliers, customers, investors, government, media, community and industry groups (MENTZER et al., 2007b). It involves issues that include trust, agreements, negotiations, joint ventures, contracting, and even conflict resolutions (SANDERS, 2012). This can allow the recognition of the opportunities to compose strategic planning able to identify the nature of the external environment, including domestic and global market, government and regulatory conditions, characteristics related to global supply chain and industry, the nature of competition, and company-related characteristics such as management style, shared values, and culture (MENTZER et al., 2007b).

Historically, successful bilateral and multilateral negotiations have reduced average tariff rates of protection, thus reducing that price component of procurement costs. On the other hand, trade negotiations are increasingly contentious and lengthy with little progress on tariff rates or quotas (MANN, 2012). According to Lee and Wilhelm (2010), some attributes of a country (e.g., sound fiscal and monetary policies, a trusted and efficient legal system, a stable set of democratic institutions) contribute to a healthy economy, providing the opportunity to create wealth. Besides, these authors argue that wealth is also created at the microeconomic level, based on the sophistication of the operating practices and strategies of companies and the quality of the microeconomic business environments in which international companies are sited (LEE; WILHELM, 2010). Therefore, this issue brings the necessity of a broader approach of the public policies.

Mann (2012) discusses the political and economic environment through two different perspectives: a macroeconomic perspective on how policymakers should change the environment facing business to promote international trade and economic growth; and a microeconomic perspective of supply chain logistics that considers how a business should organize its operations given the policy environment. In light of this broadening definition, it incorporates relatively “concrete border” elements, such as port efficiency and customs administration, and “inside the border” elements, such as domestic regulatory environment and the services infrastructure (WILSON et al., 2005). This broader vision is important to deal

with a global economy in transition from national autonomy to an integrated system of production, trading and consuming, driven by technology, operating under completely different political, economic and physical environments (SKJØTT-LARSEN et al., 2007).

Wilson et al. (2005) present that are distinct areas of focus that meet policymakers' needs for specificity on how to approach trade facilitation reforms. According to these authors, port efficiency needs to be designed to measure the quality of infrastructure of maritime and air ports. Customs' infrastructure needs to be designed to measure direct customs costs as well as administrative transparency of customs and border crossings. Regulatory environment needs to measure the economy's approach to regulations. Service sector infrastructure needs to be designed to measure the extent to which an economy has the necessary domestic infrastructure (such as telecommunications, financial intermediaries and logistics companies).

The macro and microeconomic perspectives of the public policies compose a wider scenario where government's strategic choices affect companies' international strategies and operational decisions. It covers how policymakers should change the environment to promote global sourcing and international trade and to support supply chain demands, as well as how a business should organize its operations given the environment (MANN, 2012). It includes the environment in which trade transactions take place, including the transparency and professionalism of customs and regulatory environments, as well as harmonization of standards and conformance to international or regional regulations (WILSON et al., 2005).

2.2.1 Macroeconomic Perspective of Public Policies

Under this perspective, public policies are formulated on the basis of regional economic integration, promoting agreements among countries, reducing and removing barrier to improve the flow of goods, services and factor of production (MYERS et al., 2007). The government policies lead to inducements, regulations, trade barriers, foreign ownership restrictions, presence of demanding regulatory standards, government support of land usage, ease of remittance to home country, clarity and stability of regulations, and stringency of environmental regulations significantly influencing national companies' strategy (LEE; WILHELM, 2010).

The taxes and duties that international companies must remit to foreign countries depend on other related to government policies and regulations. Some competitiveness actions

include incentives for FDI, efficiency of government bureaucracy, prevalence of trade barriers, and degree of protectionism (LEE; WILHELM, 2010). Regional agreements, trade protections mechanisms and currency fluctuation resulted from political instability influence the decisions to globalize operations and can significantly ease global operations or create large barriers, thus, must be carefully considered (SANDERS, 2012). According to Myers et al. (2007), this exposure to both risk and return opportunities leads companies to face environmental challenges outside the realm of previously developed capabilities in supply chain management.

Often, the political economy forces companies to alter supply chain design (MYERS et al., 2007) and there are different aspects that foster global supply chain operations. One is protectionism, a second is trade liberalization, a third is the development of regional trade and unification, for example ASEAN, EU, Mercosur, NAFTA (SKJØTT-LARSEN et al., 2007). Trade agreements are pacts between countries that encourage trade in a region by eliminating or lowering tariffs, quotas, and other trade barriers, whose purpose is to protect trade in the region and increase regional growth by given preferences to members of the pact (Sanders, 2012). The liberalization potentially provides a basis for eliminating discrimination and other barriers in trade (SKJØTT-LARSEN et al., 2007). Emerging market economies often use protectionism through high tariffs barriers and direct controls to limit internal competition and encourage locally base technology. They may also seek to attract industry through direct subsidies and special financing arrangements (SKJØTT-LARSEN et al., 2007).

There is also the existence of non-tariffs barrier that need to be considered by policymakers. They are various forms of indirect, non-price trade protection, that have become far more significant as obstacles to global exports and imports, such as import quotas (restriction on volumes), trigger price mechanism (minimum price for sales), local content requirements (a portion of the added value must be produced inside the country), technical standards and health regulations (SANDERS, 2012).

Proper assessment of the political economy scenario often facilitates considerable savings in tariffs, as well as market opportunities. It is essential to evaluate political risk, credit risk, social risk, and market risk and minimize their effects thorough awareness of their impact and cost across global supply chain (MYERS et al., 2007). This has serious implications for the way companies structure their global supply chain since they have to be aware of the opportunities, as well as restrictions, such trade agreement provides (SANDERS, 2012). Supply chain optimization mandates that companies take advantage of these political

issues to meet multiple market needs, or benefit from multiple market offerings, while reducing the overall costs associated with taxes, tariffs, and other trade barriers (MYERS et al., 2007).

2.2.2 Microeconomic Perspective of Public Policies

The global chain perspective highlights the importance of facilitating linkages with the global economy, what includes improvements in infrastructure, customs and visa procedures, which enable companies to move goods and people quickly into and out of the country (SCHMITZ, 2005). These move the focus of trade facilitation efforts “inside the border” to domestic policies and institutional and governance structures. In addition, with the rapid integration of networked information technology, including telecommunications for data flows and financial infrastructure to support the fragmentation of the global chain, modern definitions of trade facilitation include these services infrastructure as well (WILSON et al., 2005). To participate in just-in-time and fragmented international supply chains, companies must be able to communicate and engage in cross-border financial transactions with supply chain partners in a timely manner, usually via the Internet. Mann (2012) argues that information and communications technology (ICT) networks and globally linked financial institutions are integral to today’s trade-facilitation research and policy analysis (MANN, 2012).

This perspective view is that policies, for example, improve logistics infrastructure, or use of information technology, or adherence to international standards to improve the environment for business to buy, sell and invest across borders and, thus, drive more efficient and effective transborder supply chains (MANN, 2012). The implication for policymakers is that linkages deserve more attention, both domestic and global, and the quality of domestic linkages and domestic support systems plays a critical role in creating international competitiveness (SCHMITZ, 2005). According to Lee and Wilhelm (2010), there is a significant relationship between factors such as labor (education and skill level, impact of union), infrastructure, business environment, proximity to markets, proximity to suppliers, locations of key competitors, and the competitiveness over the supply chains configuration within a nation.

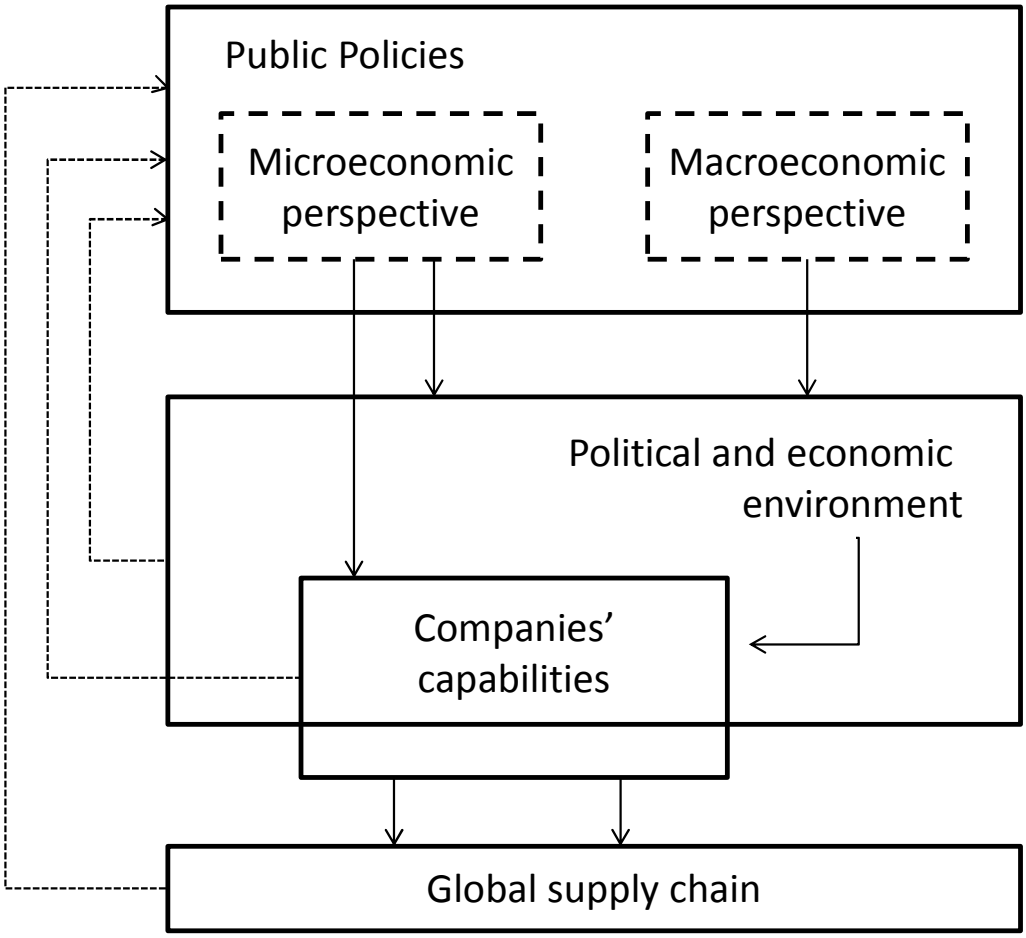
Another important point is how the government encourages the research and development in technology and innovation. Regulatory states may have a strategic advantage

in transitions from investment to innovation driven growth (LENWAY; MURTHA, 1994). Government support can take the form of financial incentives or subsidies, launching of training and R&D organizations, and special programs to build companies' training and R&D relationships (RASIAH, 2004). Optimal policies to support high technology fund workforce education, infrastructural development and basic research, while keeping markets competitive so that they reward entrepreneurship and innovation (LENWAY; MURTHA, 1994). National innovation systems and industrial policies need government intervention to overcome market failures associated with companies' participation, especially in R&D activities, and the range of related activities, such as human resource training beyond schooling and process technology acquisition and development. Hence, the national innovation systems and industrial policies advocate interventions for building the high-tech infrastructure necessary to stimulate innovations in companies (RASIAH, 2004).

Public policy aimed at the private sector typically tries to influence decisions of entrepreneurs so that they can grow and improve their performance (SCHMITZ, 2005). Infrastructure and competition policy all contribute to variation in the extent to which consumers and industrial or service market players might enjoy opportunities to implement structural change—inducing political strategies (SCHULER et al., 2011). This perspective has the potential to improve global supply chain efficiency and effectiveness considering that national infrastructure like ports, roads, human resources, technology and innovation programs are leverage to global standards.

Figure 3 represents the configuration of the public policies composed by micro and macro perspectives. Both impact the national political and economic environment and the development of companies' capabilities to move up in a global supply chain. The impact of the micro perspective is more direct because it deals with more infrastructural issues. The figure also detaches that the companies demands, the global chain characteristics and the results achieved by the policies must be used by policymakers as important feedbacks to redesign the national public policies.

Figure 3 - Public policies fostering companies' capabilities to go global



Source: The author

Morrissey (1995) states that, historically, many countries had been inclined to adopt an inward-oriented trade policy: tariffs and quantitative restrictions protected the import competing sectors while protectionism and exchange rate policy tended to reduce the return to exports (relative to domestic production of importable). This author also argues that there is growing evidence that outward-oriented trade policies, in which exports are encouraged or at least not discriminated against, promote more rapid (export-led) economic growth. Also, trade liberalization, the removal of restrictions on imports and reduction of discrimination against exports have become an increasingly common policy reform. This scenario is leading many companies, especially from developing countries, to seek a position in a global chain.

According to Mann (2012), the focus on trade facilitation can help policymakers within a country prioritize the reform efforts so as to maximize the potential for its own businesses to compete in global supply chains. The author also argues that a focus on the trade, particularly on the relationship between foreign aid and international trade, can help aid

agencies prioritize funding to projects and countries. The process of globalization has brought far-reaching impacts on the structure, sourcing, production, distribution and sale of goods and services, as well as the nature of market opportunities and competitive pressures for producers, around the world (SCHMITZ, 2005). Policymakers and aid agencies might generate the greatest increase in international trade flows for individual countries, within regions and for the global trading system as a whole (MANN, 2012).

So, policy instruments range in specificity from macroeconomic tools of monetary and fiscal policy that affect entire economies to microeconomic tools such as loans or subsidies that may target a particular transaction among companies (MURTHA; LENWAY, 1994). These elements compose the whole of an economic development agenda. As country's policymakers cannot address all aspects of all at once (MANN, 2012), governments need to make strategic choices and compose public policies capable to affect positively companies' international strategies. It is the governments' ability to implement industrial strategies (MURTHA; LENWAY, 1994), linking countries' political institutional structures, promoting innovators' approaches to technological entrepreneurship and governments' technology policy orientations (MURTHA et al., 2001).

All the theoretical elements presented above showing different perspectives of the public policies and their impact in company's capabilities development lead to the formulation of the second theoretical proposition of this research.

Proposition 2: Companies are subject to the national public policies that influence the development of capabilities to join a global supply chain.

2.3 Global Supply Chain Capabilities

The development of strategic capabilities can influence companies' success factors competition directly in their operations in a global supply chain, i.e., capabilities are potential behavior modes of a plant with which it can support and shape corporate strategy and which help it to succeed in the marketplace. The development, nurturing and abandonment of strategic capabilities are major tasks of manufacturing strategy (GRÖßLER; GRÜBNER, 2006).

The studies of capabilities can be found in the management literature. However, in this study, we briefly present the different approaches and theories in order to identify how

capabilities can be linked to global supply chain management. The current discussion on capabilities is divided into topics, such as: i) the core competences of the corporations, defined by Prahalad and Hamel (1990 p. 4) as the collective learning in the organization, specially how to coordinate diverse production skills and integrate multiple streams of technologies; ii) the company's absorptive capacity, defined by Cohen and Levinthal (1990, p. 128) as the ability to recognize the value of new information, assimilate it, and apply it to commercial ends; iii) the company resources, discussed by Barney (1991) as sources of sustained competitive advantage; iv) the technological capabilities, presented by Lall (1992 p. 168) as the ability to identify a company's scope for efficient specialization in technological activities, to extend and deepen these with experience and effort, and to draw selectively on others to complement its own capabilities; v) competitive priorities, identified by Wheelwright (1984 p. 79) as a composition of driven forces in manufacturing to establish the context in which the competitive advantage is defined and pursued; vi) organizational capabilities, defined by Collis (1994 p. 145) as the socially complex routines that determine the efficiency with which companies physically transform inputs into outputs; vii) innovative capabilities, defined by Ariffin and Figueiredo (2006 p. 198) as the capability to create, change or improve products, processes and production organization, or equipment; and viii) dynamic capabilities, presented by Teece et al. (1997 p. 510) as internal and external company specific competencies to address changing environment.

All these different approaches have in common the view of the resources and capabilities of the company as the source to reach competitive advantage. According to Grant (1991), these resources and capabilities are the primary constants upon which the company can establish its identity and frame its strategy, and they are the primary sources of the company's profitability. The study of Penrose (1959) presented the company as a collection of resources, and her investigation composed the foundation for the development of the resource-based theory (BARNEY, 1991; GRANT, 1991; WERNERFELT, 1984). The resource-based view suggests that companies can achieve sustainable competitive advantage through the acquisition and control over resources and capabilities as long as the resources are valuable, rare to come by, imperfectly mobile, not imitable by competitors and not substitutable (BARNEY, 1991; GRANT, 1991).

These different labels refer to specific capabilities that the company creates and uses strategically in order to identify market gaps to be filled with new offerings of value (ZAWISLAK et al., 2012). To leverage competitive advantage in a supply chain operation, it

is also necessary to develop and explore capabilities for multiple forms of inter-company cooperation such as dyadic buyer-supplier relationships, alliances, marketing and distribution chains, competitive coalitions, partnership to develop new products, etc.

2.3.1 Capabilities to Go Global in a Supply Chain

Although capabilities are widely used in strategic management literature, there are important links between capabilities in a supply chain and aspects of relationship management. Zacharia et al. (2011) discuss that capabilities for the relational activities in the supply chain need to allow organizations to: i) recognize, select, and negotiate with potential partners; ii) manage interactions such that roles and responsibilities are clear; iii) work with their partner to combine and synthesize complementary knowledge and resources; iv) resolve conflicts that arise as part of the interaction; and v) monitor the process and make adjustments if things are not moving in a positive direction. For a supply chain to be competitive, it is important that the required capabilities of each constituent company are closely related to the competitive priorities of the dominant company in the supply chain (AHN et al., 1999). In order to follow standards and rules established by leader companies and leading countries, considering a global chain is even more critical. According to Fawcett et al., (1997), cross-border production-sharing operations offer a nice balance between the complexity of international operations and the manageability of relatively proximate business activity. There is also the need of key customers, that may vary across international borders, and the means for developing an effective fulfillment and replenishment process may also vary across international locations (CLOSS; MOLLENKOPF, 2004).

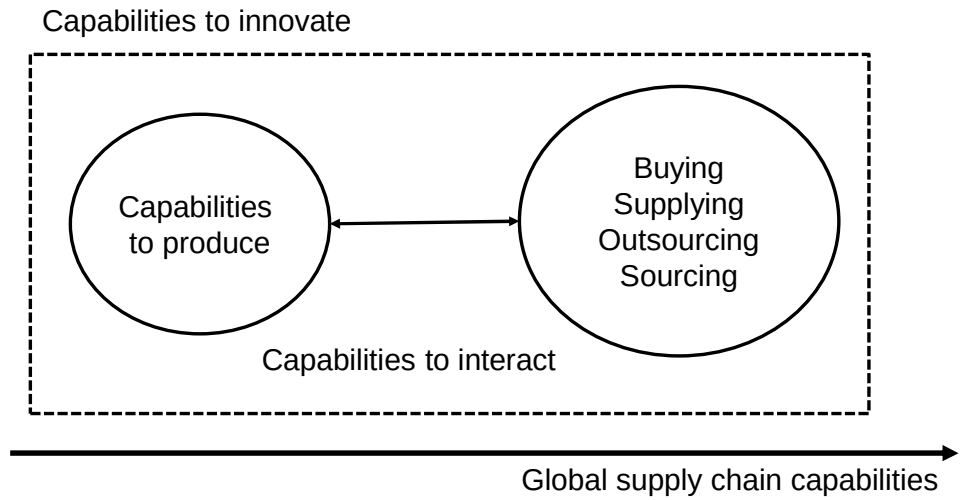
The capabilities to produce and innovate are two sub-sets of what Bell (2007) establishes as technological capabilities. Technological capabilities are defined as the specialized resources, i.e., skills, knowledge and experiences, as well as the institutional structures and linkages which are needed to generate and manage technological changes (BELL; PAVITT, 1995). According to Panda and Ramanathan (1996), technological capability needs to be explored as a set of functional abilities that reflects in the company's performance through various technological activities and whose ultimate purpose is company-level value management by developing difficult-to-copy organizational abilities.

Technological knowledge is not shared equally among companies, nor is it easily imitated by or transferred across companies. The extent to which company-level differences

in technological effort and mastery occur may vary by industry, by size of company or market, by level of development or by trade/industrial strategies pursued (LALL, 1992). In assessing a company's technological capability, it is necessary not only to examine its ability to produce an output but also its ability to bring about technological change. This ability to bring about change is crucial since production conditions as well as competing products are constantly altering (FRANSMAN, 1984). In sum, technological capability development can be seen as the outcome of investments undertaken by the company in response to external and internal stimuli and in interaction with other economic agents, both private and public, local and foreign (LALL, 1992).

The elements presented above emphasize mainly the need for the establishment of an infrastructure for production and innovation, capable to meet the diversities and contingencies of the market. It is important as well as to establish relationship management to the supply chain competitiveness. The combination of these three items composes important capabilities to allow a company to operate as a player in a global supply chain (Figure 4).

Figure 4 - Capabilities for going global in a supply chain



Source: The author

Figure 4 highlights three categories of capabilities that must be developed for the upgrading process of a company in a global chain: capabilities to produce, interact and innovate. Those three critical capabilities demonstrate that, in a global chain, it is not just enough to acquire new resources, equipment and to hire specialized people. It is important to develop the necessary capabilities to turn the access to technologies into competitive

advantage, to possess productive capabilities and also capabilities to interact, collaborate and cooperate as a buyer or a supplier in the chain. These three sets of capabilities and their main elements are described below.

2.3.1.1 Productive Capabilities

Productive capabilities are necessary to use and operate given forms of technology in specific configurations (BELL, 2007). It is the capability to produce goods at determined levels of efficiency and input requirements. It may be described as technology-using skills, knowledge and organizational arrangements (FIGUEIREDO, 2008). According to Morrison et al. (2008), production capabilities include the skills necessary for the efficient operation of a plant with a given technology and its improvement over time. Process, product and industrial engineering capabilities are part of this subset. They involve activities such as: i) the search for viable alternative technologies; ii) selecting the most appropriate technologies; iii) dominating the technology, iv) adapting the technology to suit the specific production conditions; and v) the process and product innovations related to basic research activity (FRANSMAN; KING, 1987).

For the appropriation of the technologies to have an efficient operation of a plant, and its improvement over time, capabilities are leveraged from manufacturing strategy and are related to: i) production with low cost; ii) achieve conformance or higher quality; iii) reliable and fast delivery; and iv) flexibility in production processes and mix and volume of products (WHEELWRIGHT, 1984). In operation management, these four dimensions cost, quality, delivery and flexibility compose the operational skills that are turned into capabilities that lead companies to higher operational performance. These four capabilities make a rich picture for the development evaluation of operational performance that allows the achievement of higher competitive advantage.

2.3.1.2 Innovative capabilities

The innovative capabilities are those needed to create new knowledge or to transform knowledge into new specifications and concrete forms required for operational use (BELL, 2007). It is defined as the capability to create, change or improve products, processes and production organization or equipment. It may be described as change-generating capability, consisting of technology-changing skills, knowledge, experiences, and organizational

arrangements (FIGUEIREDO, 2008). The innovation capability is understood as both the technological learning process from the company translated into the technology development and operations capabilities as well as the managerial and transactional routines represented by the management and transaction capabilities (ZAWISLAK et al., 2012).

These capabilities normally involve activities such as: i) development of technology by small innovations; ii) institutionalized search for the most important innovations by the research and development department (R&D); and iii) conducting basic research (FRANSMAN; KING, 1987). All of these activities are related to different maturity level of technological development, what Bell (2007) refers to Design and Engineering and R&D capabilities.

Related to these topics, Wang et al. (2008) propose criteria for their evaluation, dismembering them into three different capabilities:

- R&D capabilities: percentage of researchers to overall employees, success rate of R&D products, self-generated innovative products, number of patents and R&D intensity.
- Innovation decision capabilities: the degree of innovativeness of R&D ideas, intensity of collaboration with other companies or R&D centers, R&D knowledge sharing ability, forecasting and evaluating technological innovation and entrepreneurial innovation initiatives.
- Marketing capabilities: marketing share, degree of new product competitiveness, monitoring the market forces, specialized marketing unit and export percentage.

2.3.1.3 Relational capabilities

Companies in supply chains are compelled to restructure and re-engineer in order to increase their effectiveness and satisfy customers. This requires companies to look beyond their organizational boundaries and evaluate how the resources and capabilities of suppliers and customers can be utilized to create exceptional value. It implies cooperation and some form of alliance between two or more organizations. These are formed for sharing the costs of large investments, pooling and spreading risk and access to complementary resources (SOOSAY et al., 2008). According to Dyer and Hatch (2006), a company that is able to participate in a chain with established routines for efficient knowledge transfer among members would be expected to have advantages over companies without access to those chain knowledge resources.

Considering this dynamic, companies must develop relationship on agile basis, integrated by collaborative business processes. Some key elements are important to enhance the relationship performance and build proper supply chain capabilities: the quality of supplier relationships; a high level of shared information; and a high level of connectivity between companies in the supply chain (CHRISTOPHER, 2000).

According to Wu et al. (2006), the capabilities to interact in a supply chain encompass four dimensions of analysis: i) information exchange (capability of a company to share knowledge with its supply chain partners in an effective and efficient manner); ii) coordination (capability of a company to coordinate transaction-related activities with supply chain partners); iii) inter-company activity integration (capability of a company to integrate their activities both internally and across channel partners); and iv) supply chain responsiveness (capability of a company to respond cooperatively to environmental changes). These four dimensions represent all the important activities involved in the supply chain process. Each of the four dimensions reflects an ability to perform cross-functional as well as inter-organizational activities, which are required in supply chain management. The drivers of these relationships include advances in information technology, complex customer requirements, intense global competition, and the desire to be the first to market with innovative products (YUSUF et al., 2004).

These capabilities can include the development of a long-term relationship, a collaborative communication, the design and use of cross-functional teams, the reduction of the supplier base, and the involvement of supply chain partners in order to create and deliver strategic value to customers and other stakeholders (CHEN; PAULRAJ, 2004). The knowledge transferred from these intimate business relationships are able to increase the quality and efficiency of the dyadic operations resulting in greater competitive advantage to the global chain.

2.3.2 Supply Chain Processes as Key Capabilities

The way we think about supply chain management has developed during the last years, and the unit of analysis has changed in its complexity and its nature (COUSINS et al., 2008). Every business acquires many capabilities that enable it to carry out the activities necessary to move its products or services through the supply chain (DAY, 1994). Creating capabilities is not simply a matter of assembling a team of resources, capabilities involve

complex patterns of coordination between people and between people and other resources (GRANT, 1991). These issues regarding resources, flows and coordination compose precisely the fundamentals of process management. The diversity of the supply chain management literature does not imply that it is infeasible to attempt a common problem domain, and the established management disciplines evolve very strong research themes within them (GIANNAKIS; CROOM, 2004). The breadth and power of supply chain management comes across in the process view of supply chain management. When the multi-company nature of the supply chain diagram is combined with a process flow diagram, one can see that supply chain management is not just about order fulfillment (KOPCZAK; JOHNSON, 2003). Mentzer et al. (2001) point out that the complexity of a supply chain model is characterized by the different flows involved in the inter-companies relationships (flows of products, services, financial resources, the information associated with these flows and the informational flows of demand and forecasts). To manage these flows, the authors propose the need of a clear definition of the processes that compose the chain structure, a model for outcomes evaluations and a model for coordinating the inter-companies relationship.

Most of the definitions of supply chain management are characterized by phrases such as “a chain of processes”, “a network of processes”, “a set of management processes”, or “integrating and managing processes across the supply chain” (LARSSON; LJUNGBERG, 2007). All the functions within a supply chain are reorganized as key processes, which aim to meet the customer’s requirements, and the company is organized around these processes (MENTZER et al., 2001). It means that the results expected through the supply chain operations is achieved by the processes. It is also argued that, in many major corporations, management has reached the conclusion that optimizing the product flows cannot be accomplished without implementing a process approach to the business (LAMBERT; COOPER, 2000). Thus, successful supply chain management (SCM) requires a change from managing individual functions to integrating activities into key supply chain processes. Operating an integrated supply chain requires continuous information flows, which, in turn, help to create the best product flows (LAMBERT; COOPER, 2000).

The competitive advantage possible to be achieved by managing SCM processes can be evaluated by the perspective of the resource-based view (BARNEY, 2012) or resource advantage theory (HUNT; DAVIS, 2012). The supply chain orientation results in emergent supply chain logistics capabilities that lead to supply chain agility (GLIGOR; HOLCOMB, 2012). According to Day (1994), this operational level is exercised through organizational

processes that ensure superior coordination of functional activities. The selection process associated with the supply chain perspective is management's ability to develop stable, low cost supply relations and to govern those relationships as efficiently as possible. The core of business processes and structures is distinctive capabilities that consist of attributes, abilities, organizational processes, knowledge, and skills that allow a company to achieve superior performance (BARNEY, 1995). Those processes are considered an important differentiator between competing organizations and they are hard to copy in their entirety (LARSSON; LJUNGBERG, 2007). Considering that capabilities are those resources which are not easily replicated (GRANT, 1991), it is necessary, therefore, to evaluate the role of supply chain process as a source of key capabilities that allow the achievement of higher performance and competitiveness. Hence, managers need to be aware of how supply chain capabilities can be used to react and respond to market turbulence (GLIGOR; HOLCOMB, 2012).

Companies that do not insure their supply chain processes are executed in a manner conducive to satisfying clients desire in time experience deterioration in its competitive position relative to those competitors who emphasize supply chain proficiency (TRACEY et al., 2005). Managers need to realize that the different dimensions of supply chain capabilities are interrelated (WU et al., 2006), since SCM capabilities impact on perceived product value, customer loyalty, market performance, and financial performance. Thus, the key to market success is to develop these SCM capabilities that will allow management to develop appropriate strategies to take advantage of opportunities that are present in global markets. This mode requires the capability to adjust to rapid changes, and capabilities related to joint knowledge and business innovation development (SVAHN; WESTERLUND, 2007).

SCM systems can facilitate the synchronization of the entire supply chain because they can assist a company in integrating internal business processes within the corporate boundary so that all internal functional areas can operate in synchronization. This is mainly due to the power enjoyed from the integration of business processes internally and externally. Further, SCM systems allow an individual organization to integrate its business processes with those of its business partners (TARN et al., 2002).

2.3.3 Supply Chain Processes

The business will have as many processes as necessary to carry out the natural business activities defined by the stage in the supply chain and the key success factors in the

market (DAY, 1994). Lambert et al. (1998) and Mentzer et al. (2001) propose a framework for SCM composed by several business processes. So, based on the literature and comparing these propositions, we propose the following supply chain processes, which represent key supply chain capabilities: manufacturing flow management, demand management, R&D, supplier relationship management, order fulfillment, commercialization and marketing, customer relationship management, and reward management.

The manufacturing flow management process is, according to Goldsby and García-Dastugue (2003), the conversion of materials and components into finished goods demanded by the market. It is the coordination of the main resources and flows (material and information) to provide products and services with high quality and productivity. It performs the transformational role of the organization and has evolved from being a strictly production function to having a strategic organizational role (SANDERS, 2012). The process involves much more than the production function within the company and spans beyond the manufacturer in a supply chain. In fact, it is up to the entire supply to make the product flow as smooth as possible and to ensure that the desired flexibility is achieved (GOLDSBY; GARCÍA-DASTUGUE, 2003).

Second, the demand management is the process that balances de customer demands with the company's capacity, proving more efficiency and flexibility to the supply chain. Mentzer et al. (2007c) detach that, in the supply chain, only the company that serves the end-use customer directly experiences an independent demand. All subsequent companies experience a demand that is tempered by purchasing policies of other companies in the supply chain. So, an integral part of any demand management process is an implementation of an iterative process of sales forecasting and planning. Sanders (2012) points out that, when members of a supply chain made their forecasts independent of one another, they are looking at the demand of their immediate buyer, not at the end customer in the chain. Multiple sourcing and routing options are considered at the time of order receipt, which allows market requirements and production plans to be coordinated on an organization-wide basis. In very advanced applications, customer demand and production rates are synchronized to manage inventories globally (LAMBERT; COOPER, 2000).

The third process is R&D (research and development) that involves resources, knowledge and technology to innovate and develop valuable new products, processes, and services. Lambert and Cooper (2000) stand out that customers and suppliers must be integrated into the product development process in order to reduce time to market. As product

life cycles shorten, the right products must be developed and successfully launched in ever shorter timeframes in order to remain competitive. According to Rogers et al. (2004), supply chain considerations might drive innovative customer-focused solutions which differentiate the product from competitors' offerings, particularly in saturated markets. Physical products might include intangible services, which means that many solutions now include varying proportions of products or services.

Supplier relationship management is the fourth process and it represents the structure to establish relationship with different suppliers for sourcing and outsourcing activities. In order to maintain competitiveness, companies must design their supply chain to be aligned with their business strategy, to satisfy the needs of the customers, take advantage of the company's strength, and remain adaptive (SANDERS, 2012). According to Ellram and Cousins (2007), supply management needs to develop professionalism as well as rigorous processes, such as strategic sourcing, to guide its actions. It needs to be viewed as much more than simply a source or price savings with real contributions to the company's strategic success.

The fifth process is order fulfillment that means the customers' orders pull the supply chain in operation, and filling them efficiently and effectively is the first step in providing customer needs. According to Lambert and Cooper (2000), the objective is to develop a seamless process from the supplier to the organization and then on to its various customer segments. Alliances should be developed with key supply chain members and carriers to meet customer requirements and reduce total delivered cost to the customer. To accomplish these tasks, management must design a fulfillment process that allows that to happen. This requires integration of logistics, marketing, finance, purchasing, R&D and production with the company, as well as coordination with key suppliers and customers (CROXTON, 2002).

Commercialization and marketing is the next process and it involves sales processes, identifications of customers' need, communication of the companies' values and the creation of the channels for products as services distribution. According to DeCarlo and Cron (2007), effective marketing programs necessitate a customer focus that requires companies to segment and target selected markets to maximize the returns on their marketing efforts. The authors also detach that these marketing decisions have important implications for how salespeople should set priorities and allocate their time among different customers. Lambert and Cooper (2000) stand out that the traditional roles of marketing and sales people are changing. Team efforts are becoming more common for developing and marketing new products, as well as

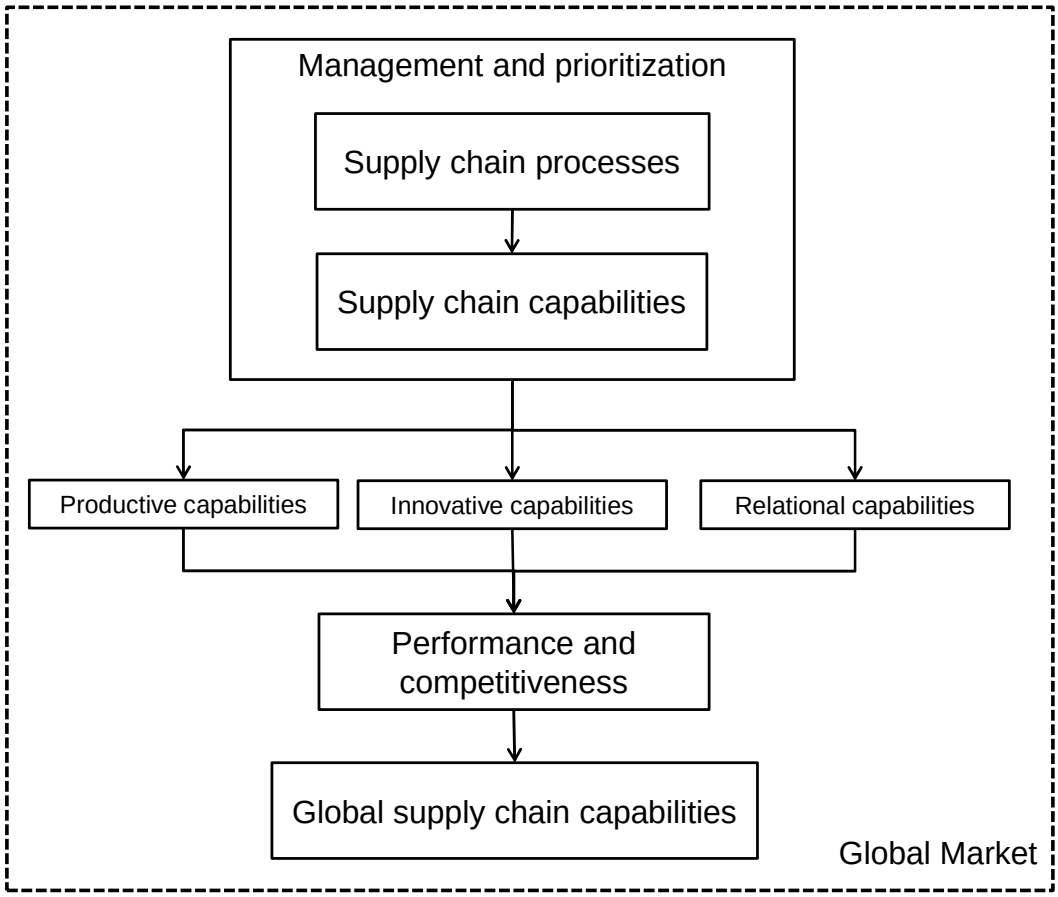
managing current ones. The role of the company's sales force is changing to one of relationship management in which measuring and selling the value proposition for the customer is critical.

The seventh process is customer relationship management (CRM). In a business-to-business environment, customer relationship management is the process that provides the structure for developing and maintaining relationships with customers (LAMBERT, 2014). It involves relationships with customers, key account management, segmentation, service agreements, cross-functional teams, etc. According to Lambert and Cooper (2000), an important step toward integrated SCM is to identify key customers or customer groups, which the organization targets as critical to its business mission. Product and service agreements specifying the levels of performance are established with these key customer groups. The advantage of CRM, states Sanders (2012), is that it provides information that helps market segmentation as it can better create clusters of customers based on profitability and others factors. Besides, she argues that it also helps to predict customer behavior and create customized customer communication.

The next process is the customer service management, which involves the balancing between the customers' needs and the companies' capacity, providing assurances of products and services quality. According to Bolumole et al. (2003), the goal is to provide a single source of customer information, such as product availability, shipping dates and order status. Customer service management requires a real-time system to respond to customer inquiries and facilitate order placement. Customer service objectives are also accomplished through a customer-enriching supply system focused on developing innovative solutions and synchronizing the flow of products, services, and information to create unique, individualized sources of customer service value (MENTZER et al., 2001).

Finally, return management is the process by which activities associated with returns, reverse logistics, gatekeeping, and avoidance are managed within the company and across key members of the supply chain. In many countries, this may be an environmental issue, but not always (LAMBERT; COOPER, 2000). According to Rogers et al. (2002), it is a critical process that requires planning and effective execution throughout the supply chain, and the effective implementation of returns management enables executives to identify productivity improvement opportunities. Biodegradable product packaging, responsible product disposal, control of manufacturing and transportation emissions, and sustainable sourcing practices are activities that impact in a supply chain management (SANDERS, 2012, p. 375).

Figure 5 - Supply chain processes as key capabilities



Source: The author

Based on the literature discussed above that considers the characteristics of the global market and the main elements for companies to go global in a supply chain, figure 5 proposes the supply chain processes as the source of key capabilities in a supply chain operation. Companies involved in the supply chain should mutually share information, risks and rewards, as well as cooperate on activities performed within the chain. Furthermore, it suggests that effective SCM includes the same goals throughout the chain, along with a consistent customer focus and complete integration of processes (GIUNIPERO et al., 2008). The basis for this integration is related to the establishment of an appropriate prioritization and management of those supply chain processes according to the characteristics of the market. The drivers of supply chain integration can include advances in information technology, complex customer requirements, intense global competition, and the desire to be the first to market with innovative products (YUSUF et al., 2004). Integrating all these business processes is a best practice in supply chain management that involves coordinating

decisions across multiple facilities and tiers (MEIXELL; GARGEYA, 2005). A more comprehensive view suggests that the accomplishment of each of these processes is not just a sequential handoff of materials, information or finances from player to player in the supply chain but involves a collaborative effort among all the players in the supply chain (KOPCZAK; JOHNSON, 2003). The main supply chain capabilities will compose the companies' strengths to produce, innovate, interact, and achieve the appropriate performance to be competitive in a global supply chain. The identification and prioritization of the key processes to leverage companies' capabilities will depend on the characteristics of the local industry and its level of competitiveness and attractiveness in the global market. All these elements present the principles that need to be considered to strengthen companies' global supply chain capabilities.

The identification and prioritization of key processes, such as supply chain capabilities in a globalized environment that requires advances in technologies to produce and innovate, and also skills to establish cooperative and collaborative relationship allow the definition of the third theoretical proposition of this research:

Proposition 3: To become included in global supply chain, companies need to prioritize and manage their key supply chain processes to develop global supply chain capabilities.

2.4 Upgrading to Go Global

The evolution of global-scale industrial organization affects not only the structure of industries, but also how and why countries advance or fail to advance in the global chain (GEREFFI, 2005). In all countries, excellence can be found in some individual companies, and discussion on improving competitiveness often concentrates on how to achieve more of such individual excellence (SCHMITZ, 2005). Proponents of the resource-based view of the company (BARNEY, 1991; PENROSE, 1959; PRAHALAD; HAMEL, 1990; TEECE et al., 1997) see companies with superior systems and structures being profitable because they have superior resources, and those resources are sources of sustained competitive advantage supra-normal returns. They argue that acquiring capabilities can be a resource for the company if these new resources are not easily systematized and, therefore, are hard to replicate. Kaplinsky and Morris (2001) affirm that companies should concentrate on those resources

that they possessed which were relatively unique, which provided valuable products and services to customers and which were difficult to copy, outsourcing the remaining competences to other companies. This will be the base for the upgrading process in the global chain.

Participating in global markets which allows for sustained income growth requires the capacity to learn and upgrade (KAPLINSKY; MORRIS, 2001). Upgrading is often seen in the literature as one of the main ways through which developing country companies or industries can respond to the challenges of globalization and increased competition. According to Gereffi (2005, p. 171), upgrading can be defined as “the process by which economic actors - nations, companies and workers - move from low-value to relatively high-value activities in global production networks”. To follow these demand rules, and to be part of a global chain and compete according to international standards, companies should change the way they evaluate the competitive parameters of the market. Giuliani et al. (2005) state this may be defined as the “high road” to competitiveness, contrasting with the “low road”, typical of companies from developing countries, which often compete by squeezing wages and profit margins rather than by improving productivity, wages, and profits. The key difference between the high and the low road to competitiveness is often explained by the different capabilities of companies to upgrade. The term upgrading has also been often used to highlight paths for developing country producers to move up the supply chain. The upgrading process is examined through the lenses of how knowledge and information flow within supply chains from suppliers or buyers with different technological and economic levels (GEREFFI, 1999).

The concept of upgrading is important to the global chain analysis because it helps to understand and to highlight paths for companies to move up in the supply chain. Companies may achieve upgrading in different ways, for instance, by entering into higher unit value market niches, by moving into new sectors or by undertaking new productive functions with new goods or services (TEJADA et al. 2011). The sources of upgrading may come from innovation in products, processes, by different managerial models, different end markets, and increased demands placed by retailers on time-to-market, packaging materials, and/or food safety standards. It may also arise as a result of abandoning innovations developed within a company or cluster to accommodate buyer demands and/or changing consumption trends (PONTE; EWERT, 2009). Kaplinsky and Morris (2001) pose that two schools of thought have focused in the way companies had managed to upgrade their activities. The first one

focuses on core competences of the company (HAMEL; PRALAHAD, 1994), while the second school of thought focuses on dynamic capabilities (TEECE; PISANO, 1994).

According to Hamel and Prahalad (1990), the core competence results from a specific set of skills that deliver additional value to the customer, enabling an organization to access a wide variety of markets. For this school, Kaplinsky and Morris (2001) argue that companies need to examine their capabilities to determine those of its attributes which: provide value to the final customer; are relatively unique in the sense that few competitors possess them; and are difficult to copy, that is, where there are barriers to entry. So, it is important to identify the sources of capabilities that lead to accessing new markets and to increasing competences, a long-standing contention between those privileging locational and institutional knowledge transmission and those focusing on transmission via buyer-supplier relations (PONTE; EWERT, 2009).

Closely related to this is a school of thought focusing on dynamic capabilities. Teece and Pisano (1997) refer dynamic capabilities approach as a mean to exploit existing internal and external company specific competences to address changing environments, understanding why certain companies build competitive advantage in environments of rapid technological change. Kaplinsky and Morris (2001) argue that corporate profitability in the long run cannot be sustained by control over the market (for example, through using quasi-monopolistic practices), but through the development of dynamic capabilities which arise as a result of: i) its internal processes which facilitate learning, including the capacity to reconfigure what the company has done in the past; ii) its position, that is, its access to specific competences either within its own activities or those which are drawn from the regional or national system of innovation; and iii) its path, that is, its trajectory, because change is always path-dependent. Ponte and Ewert (2009) pose that, in this perspective, upgrading is about acquiring capabilities and accessing new market segments through participating in particular chains. The main global supply chain argument is that upgrading in various forms can be effectively stimulated through learning from lead companies rather than through interactions between companies in the same functional position or within the frameworks of common business systems or national systems of innovation.

Upgrading is usually associated with competitiveness and it can be defined as all actions which involve a shifting into activities, products or sectors that have a higher added value and higher barriers to market entry (TEJADA et al. 2011). Organizational learning is the primary means and, thereby, a fundamental precedent for upgrading, through which

processes that are developed by a company can enhance and complement one another (AZADEGAN; WAGNER, 2011). Humphrey and Schmitz (2000) consider upgrading as the acquisition of capabilities that will allow companies to enter higher margin. They propose four types of companies upgrading working in global chains: process, product, functional, and inter-sectoral (or inter-chain) upgrading, presented below.

2.4.1 Process Upgrading

Process upgrading means transforming inputs into outputs more efficiently by reorganizing the production system or introducing superior technology (HUMPHREY; SCHMITZ, 2000). According to Kaplinsky and Morris (2001), it means the increasing of efficiency of internal processes such that these are significantly better than those of rivals, both within individual links in the chain (for example, increased inventory turns, lower scrap) and between the links in the chain (for example, more frequent, smaller and on-time deliveries). Gereffi et al. (2005) pose that, for many late entrants, the evolutionary process of catching up with incumbents begins with delineating the production of easy-to-produce items. So, late entrants may sequentially add higher value-adding activities, such as assembly of more complex parts, design of components, and the manufacture of complete product lines into their portfolio of operations. Ponte and Ewert (2009) reinforce that, to achieve process upgrading, it is also important to explicitly recognize the importance of matching standards that are set by buyers and/or are embedded in import country regulations, for example, conforming to food safety standards (e.g., to comply with EU regulation or ISO 22000 certification) or applying environmental management procedures (for ISO 14000 certification). It implies improving production procedures, but not necessarily in more efficient (or cost effective/profit maximizing) ways. In sum, it requires a multifaceted process of accumulating, internally disseminating and applying new knowledge to achieve a more efficient transformation of inputs into outputs through the reorganization of productive activities and meeting international standards and regulations.

2.4.2 Product Upgrading

The growing integration of the global economy as an opportunity for entering into a new era of economic and industrial growth reflects not only in the possibility of reaping higher incomes but also in the improved availability of better quality and increasingly

differentiated final products (KAPLINSKY; MORRIS, 2001). Product upgrading is achieved by introducing new products, changing designs, improving quality, and producing a more sophisticated final output (HUMPHREY; SCHMITZ, 2000). It means moving into more sophisticated product lines in terms of increased unit values (PIETROBELLI; RABELLOTTI, 2011). It is important to introduce new products or improving old products faster than rivals. This involves changing new product development processes both within individual activities in the supply chain and in the relationship between different chain activities (KAPLINSKY; MORRIS, 2001). A lot of knowledge is transferred along the supply chain from the buyer to the producer. Such specific knowledge is critical for upgrading products (SCHMITZ, 2005). Schmitz and Knorringa (2000) pose that producers from developing countries tend to quickly improve their manufacturing skills when they operate in global chains, but find it difficult to upgrade to the higher functions, such as design, marketing, and branding. According to Ponte and Ewert (2009), it is not necessarily more numerous value added products that must be included in these portfolios, but a large range of products with different specifications that cover the whole range of quality and/or origins; sometimes higher quality can actually be the entry window for creating profitable portfolios that include lower quality/ higher volume offerings. It is possible to notice that upgrading is implemented through a sequential and paced approach to developing operational processes, which allow for effective organizational learning. In manufacturing plants, upgrading involves moving from cheap to expensive items and from simple to complex products (GEREFFI, 1999).

2.4.3 Functional Upgrading

There is a broad agreement about how the advantages of being part of a global chain can lead to increase local companies' upgrading opportunities (such as through the access to information about required skills and standards that need to be met). Nevertheless, this consensus is only reached easily on process and product upgrading (HUMPHREY; SCHMITZ, 2002). The challenge begins when companies seek positions in activities with higher added value in the chain. Functional upgrading is acquiring new, superior functions in the chain, such as design or marketing, or abandoning existing low-value added functions to focus on higher value added activities (PIETROBELLI; RABELLOTTI, 2011). It involves to seek for functions (or abandoning old ones) that increase the skill content of activities (HUMPHREY; SCHMITZ, 2002). It means increasing value added by changing the mix of

activities conducted within the company (for example, taking responsibility for or outsourcing accounting, logistics and quality functions) or moving the locus of activities to different activities in the supply chain (for example, from manufacturing to design) (KAPLINSKY; MORRIS, 2001). Upgrading the stepwise development of manufacturing skills from simple to more complicated tasks can be a highly effective approach for late entrants, what means relying on a sequential and paced approach to develop progressively more complicated industry-established practices (AZADEGAN; WAGNER, 2011). It involves pursuing subsequently more valuable capabilities in order to improve one's relative competitive position within the supply chain. In this case, upgrading will involve developing more value added processes, creating more value added products or performing higher value added activities (PIETROBELLI; RABELLOTTI, 2011). The implicit normative expectation is that developing country companies follow a "high road" to upgrading, one eventually leading to performing functions in a supply chain that have more skill and knowledge content (GEREFFI, 1999).

2.4.4 Inter-sectoral (or Inter-chain) Upgrading

Inter-sectoral upgrading means applying competences acquired in one activity of a chain and using them in a different sector/chain (HUMPHREY; SCHMITZ, 2002). It is a moving to a new supply chain (for example, Taiwanese companies moved from the manufacture of transistor radios to calculators, to TVs, to computer monitors, to laptops and now to WAP phones) (KAPLINSKY; MORRIS, 2001). The challenge is not always about moving into more advanced functions along the supply chain, but is often about deepening the specific capabilities required to explore new opportunities (MORRISON et al., 2008). The status of inter-sectoral upgrading is more difficult to be achieved and also understood, as it relates to a trajectory of upgrading, while the other three categories describe what aspect of a given business is being upgraded. Furthermore, the literature sometimes refers to inter-chain upgrading when it actually means learning that is taking place in one strand of a supply chain (e.g., the strand of a supply chain oriented toward domestic consumption) that is applied to another (e.g., the strand of a supply chain oriented toward export) (PONTE; EWERT, 2009). Consequently, we need to view the upgrading challenge in a wider perspective, capturing the central idea that it may involve changes in the nature of resources and mix of activities.

According to Kaplinsky and Morris (2001), invariably, this is a trajectory which involves a progressively higher content of disembodied activities.

Table 1 - Comparative views of global chain upgrade

Type of upgrade	New technology required?	New process required?	New market necessary?	Degree of control
Process	Yes	Yes	No	Great
Product	Yes	Yes	No/Maybe	Great
Functional	Yes	Yes	Yes	Small
Inter-sectorial	Yes	Yes	Yes	Small

Source: Wong (2012)

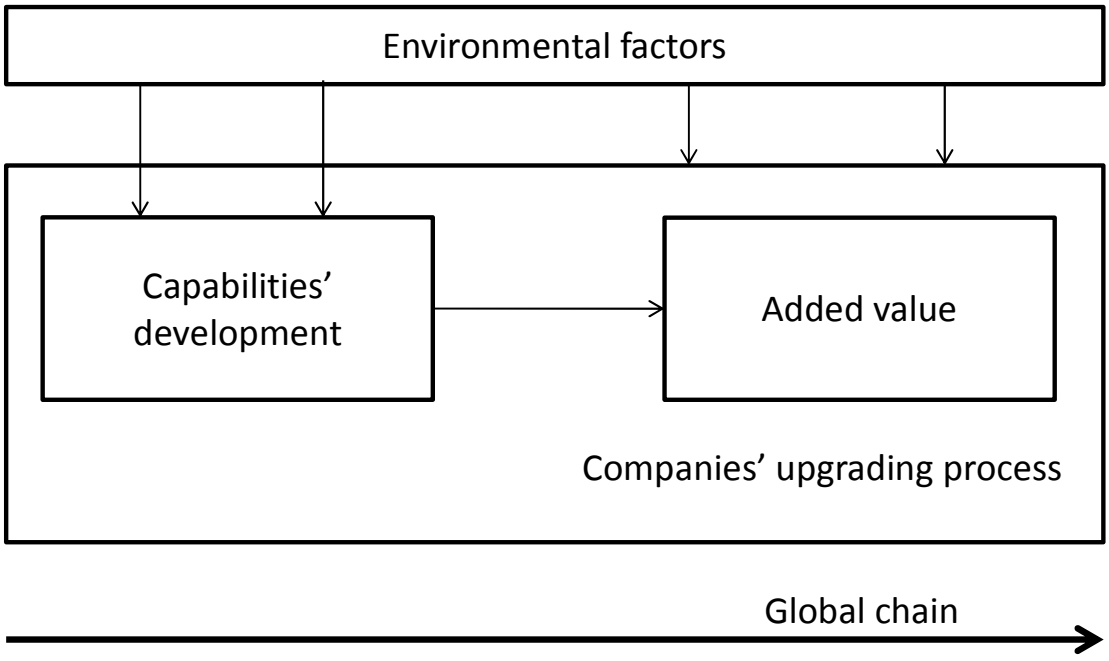
So, in the global chain, upgrading is linked to a combination of making better products, improving processes to make these products, and/or taking over new functions. Upgrading requires the continued development of new skills in order to find new opportunities in the market, as well as to identify internal resource to achieve competitiveness in a global chain. Wong (2014) propose a comparative view with the requirements of the different types of upgrade for new technology, process, and market access, as well as the degree of control a company may exert over the upgrade (Table 1). Differentiating between these types of upgrading is useful not only to offer a framework that is relevant to the analysis of companies but also to understand the complexity demanded by higher added value activities.

Wong (2014) proposes a progressive challenge in terms of managerial capabilities when a company identifies opportunity to upgrade in the chain. Process and product upgrading require the development of new technologies, and both present a high degree of company control. Ponte and Ewert (2009) pose that it is sometimes difficult to distinguish product and process upgrading because they compose the minimum standard conditions for companies to operate as player in a global chain. One important characteristic of product upgrading, according to Wong (2012), is the fact that new products may involve the source for new markets, what represents an important step for continuing upgrading. According to Humphrey and Schmitz (2002), upgrading opportunities vary with the chain coordination, and it is not hard to promote fast process and product upgrading for local companies, but it is very difficult to move into higher value activities and to achieve functional upgrading. Functional and inter-sectorial upgrading are more likely to take place, together with the transfer of new

capabilities to different global chains (KAPLINSKY; MORRIS, 2001; HUMPHREY; SCHMITZ, 2002), since they are more susceptible to external variables of the company.

Kaplinsky and Morris (2001) argue that, due to companies' maturity, they begin with process upgrading, then move to product upgrading, to functional upgrading and, last of all, to chain upgrading. In order to upgrade, companies need to constantly improve their knowledge and also developing and retaining skilled human resources (ERNST; KIM, 2002). Kaplinsky and Morris (2001) illustrate this scenario using the example of East Asian companies that have made the transition from OEA production (original equipment assembling, that is, thin value added assembling under contract to a global buyer) to OEM (original equipment manufacturer, that is, manufacturing a product which will bear the buyer's badge), to ODM (own design manufacturer), and to OBM (own brand manufacturing). Invariably, this is a trajectory which involves a progressively higher content of disembodied activities (KAPLINSKY; MORRIS, 2001).

Figure 6 - Companies process upgrading



Source: The author

Figure 6 presents the main elements involved in the companies upgrading to move up in a global chain. To upgrade, it is necessary to develop capabilities in terms of processes, products and services to deliver more added value to customers. Especially in the global context, this process is influenced by environmental factors that compose the political,

economic and infrastructural scenario where companies are operating. The upgrading opportunities of local companies differ according to the type of global chain they feed into, what means that the way trade is organized matters (SCHMITZ, 2005). There is a broad agreement about how the advantages of being part of a global chain can lead to increase local companies' upgrading opportunities. Only, exporting through global chains does not guarantee an automatic upgrading pathway nor does it provide access to the whole range of activities needed to compete in the global economy (NAVAS-ALEMÁN, 2011). Companies need to make efforts to seek and also innovate in terms of global products and processes, following global standards. In sum, the logic goes from innovation, to upgrading, to the acquisition of company-level competitiveness (GIULIANI et al., 2005). According Kaplinsky and Morris (2001), at the same time, it is necessary to focus on the institutions which drive international specialization and normative levers which can be used to alter or achieve those patterns. In this way, external factors that compose the global market also influence the upgrading process, especially because of: i) the existence of forms of imperfect competition in domestic and international markets; and ii) the presence of different degrees of (dynamic) externalities in different subsectors and stages of the supply chain (GIULIANI et al., 2005). When companies face these external pressures, they need either to perform the same activities, but more efficiently, or change the activities they undertake (HUMPHREY; SCHMITZ, 2000). For all these reasons, the concept of production efficiency is encompassed within the broader concept of competitiveness, and the efforts to upgrade functionally and intersectorally (and the policies to support these processes) are justified to reap larger rents and externalities emerging in specific stages of the supply chain, market niches or sectors (GIULIANI et al., 2005). Wong (2012) refers to it as the company's micro perspective influenced by the macro environment created by government policy and supply chain relations. Figure 7 presents the influence of the environmental factors is on companies' capabilities and on the upgrading process.

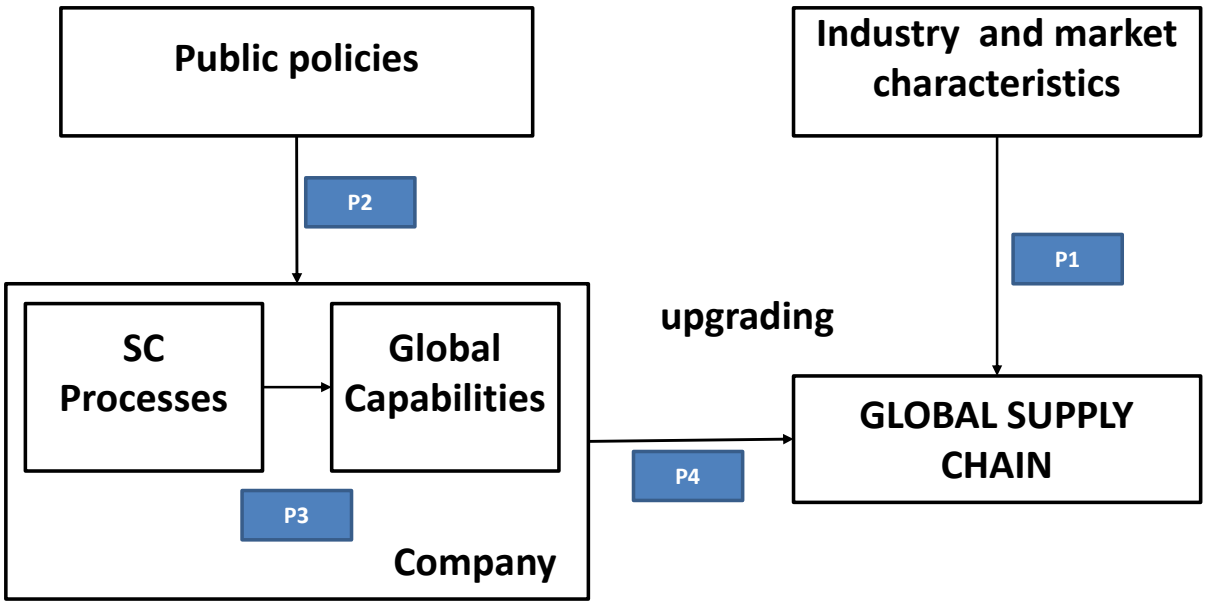
All the theoretical elements presented above show different perspectives of the upgrading process to generate value, detaching that it is simultaneously affected by company-specific efforts and actions, and also influenced by the environment issues in which companies operate. This leads to the formulation the fourth theoretical proposition of this research.

Proposition 4: The upgrading process to move up in a global chain depends on both the capabilities of the companies and the environmental factors.

2.5 THEORETICAL FRAMEWORK

The main purpose of this study is related to companies' capabilities for upgrading in global supply chain. The four theoretical propositions that emerged from the literature compose the basis for the theoretical framework construction of this research. The last sections discussed the characteristics of the global supply chain and factors that underpin the field (section 2.1), the impact of public policies on global supply chain configuration (2.2), the development of global supply chain capabilities (2.3), and upgrading in global chain (2.4). Figure 7 represents the relationships proposed for the investigation, integrating those four propositions.

Figure 7 - Theoretical framework



Source: The author

The first proposition highlights that, in a global chain, companies must manage its production capacity considering external factors that are critical and are not directly controllable by them. Being part of a global chain is not necessarily a decision of the companies. It is related to the characteristics of the industry where companies are operating and it requires different infrastructural and managerial capabilities to deal with the

complexities of the external elements and turbulent environmental conditions of global market.

Considering this demand to go global, expressed by the first proposition, the second proposition brings the discussion of the influence of public policies to foster a new industry and affecting companies' supply chain capabilities. Government, supported by its national institutions, is responsible for promoting public programs with incentives to create favorable conditions for the companies' capabilities development. The policies need to formulate the basis of regional economic integration, offering tax incentives, funding, promoting agreements among countries, reducing and removing barrier to improve the flow of goods, services and factor of production, as well as to improve national infrastructures and services to promote the trade.

The third proposition argues that the source of global supply chain capabilities are the supply chain processes. The supply chain processes' list cover productive, relational, innovative and market issues. The identification and prioritization of those key processes can result in the necessary capabilities to advance in the global chain, where companies have to be able to produce, innovate and interact with global supplier, customers or partners.

Finally, the fourth proposition brings a discussion of how companies can upgrade in the global chain. This proposition argues that the four upgrading stages (process, product, functional, and inter-chain) result from the global supply chain capabilities. The companies' characteristics and the context where they are embedded make up the determining factors for the development of global capabilities to achieve specific levels of upgrading.

3 METHOD

A descriptive-exploratory research using a qualitative approach and supported by the application of multiple case studies comprises the method applied in this investigation. A qualitative research gives the researcher its own trademark understanding of everyday life and its context (SILVERMAN, 2013) and allows the use of a flexible research design providing a reflexive process during the data analysis (MAXWELL, 2013). An important strength of qualitative research is that it can use naturally occurring data to locate the interactional (how) in which participants' meaning (what) are deployed (SILVERMAN, 2013). According to Maxwell (2013), qualitative research focuses on specific situations or people and its emphasis is on descriptions rather than numbers, suiting for:

- understanding the meaning of events, situations, experiences and actions they are involved;
- understanding the particular contexts within which the participants act and the influence that this context has on their actions;
- understanding the process by which events and actions take place;
- identifying unanticipated phenomena and influences and generating new grounded theories about the latter;
- developing causal explanations.

In this way, a qualitative exploratory approach can help this research to better understand the social and cultural context within which decisions and action take place (MAYERS, 2009) in the Brazilian semiconductor industry scenario. For this research, it can provide greater familiarity with the research problem in order to improve ideas to make more explicit the main elements involved in the upgrading process of Brazilian companies in the semiconductor global chain.

This research is also descriptive because it aims to establish relationships between variables or to describe the characteristics of a given contemporary phenomenon (GIL, 2006). The theoretical foundations established previously in section 2 guided the construction of a framework (Figure 7) that serves as the basis for the variables definition and the organization of the field investigation. The framework proposes elements for the relationships' analysis, specially the environment affecting the supply chain processes, the supply chain processes affecting the global capabilities and the global capabilities affecting upgrading.

According to Barratt, Choi and Li (2011), the qualitative approaches have become more representative in researches of operation management, complementing the quantitative traditional studies. In this proposal, the focus is to evaluate the capabilities developed by Brazilian design houses to achieve competitiveness in order to be part of a high technological global chain. Considering that there is still a small number of companies operating in the value chain activities of this global industry, these companies strategy and productive basis require in-depth investigations, what justifies the use of a qualitative approach.

The case study represents a good opportunity to comprehend a new phenomenon, combining different data collection methods, such as archives, interviews, questionnaires and observations (EISENHARDT, 1989). An exploratory case study is appropriate when there is a problem and it is necessary to know more about it (what is happening and why), i.e., there is little preliminary knowledge of it (THOMAS, 2011). It is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (MYERS, 2009). Unconstrained by the borders of questionnaires or models, the case study can lead to new and creative insights and have high validity with practitioners (VOSS et al., 2002).

Case study allows the analyses of persons, events, decisions, periods, projects, policies, institutions or other systems, which are studied holistically by one or more methods (THOMAS, 2011). It is very difficult in a case study to separate the phenomenon of interest from the context because the context itself is part and parcel of the story (MYERS, 2009). According to Thomas (2011), a case study: i) is a set of circumstances in its completeness and the case is described by those circumstances; ii) is the circumstances of the instance that are being studied (Where did it happen? When? What had happened before? Who was around? What was in the news? How did all of this affect what was going on? and how events turned out); iii) involves analysis about the relationships between the elements of the study; and iv) involves justifying the conclusions, using evidence drawn from the empirical work.

The effort of Brazilian companies to become new players in the semiconductor global chain can be considered a contemporary phenomenon, what justifies this methodology choice (YIN, 2008). Due to that, this research is based on four different cases, composed by design houses in the semiconductor global chain. The choice of multiple case studies is because there are several companies in Brazil, and each individual case is less important in itself than the comparison with one another (THOMAS, 2011).

In order to answer the research question, four main activities were accomplished during the investigation: exploratory phase; case selection; data collection; and data analysis. The subsections below present details of these activities.

3.1 Exploratory Phase

An exploratory study was accomplished before the definition of the research question and objectives of this research. This study was necessary to understand the empirical field and identify the opportunities of study in accordance to the theoretical lens of the research. It was divided in two different steps in order to comprehend, firstly, the Brazilian semiconductor chain and, secondly, the Brazilian design houses operations.

3.1.1 Step 1: The Brazilian Semiconductor Chain

This first exploratory investigation aimed to understand the national industrial policy and how Brazilian companies are operating in the semiconductor supply chain. The primary source came from semi-structured questionnaire and interview procedure (Appendix A). The interview protocols were developed on the basis of the literature review and highlighted elements to understand and analyze the participation of Brazilian companies in the semiconductor global chain and the main gaps and barriers involved. These different narratives brought a rich picture of the current reality. Industrial reports and empirical studies were used as secondary data in order to complement this first exploratory investigation.

The interviews were conducted with six experts who were selected for their knowledge and experience on different stages and activities of Brazilian operation in the semiconductor chain. Table 2 presents the interviewee's profiles.

Table 2 - Interviewee's profiles – step 1

Interviewee focus	Interviewee position	Education level	Years of experience	Interview time	How
Brazilian semiconductor company	CEO	MBA	20	00:54:25	In person
Brazilian public policies	CFO	Msc	4	00:35:00	In person
National semiconductor industry	Head of a research institute	BsC	10	00:50:00	In person
Global semicoductor industry	CEO international affairs	Msc	6	00:55:30	In person
Researcher	Professor	PhD	22	01:25:00	In person
Process engineer	Manager	PhD	12	00:46:00	In person

Source: The author

On this phase, the configuration of the semiconductor global chain was described, identifying the participation of Brazilian companies in each activity of the value chain, the infrastructure involved and the influence of the industrial policies that are fostering the composition of this chain. The barriers and opportunities for the growth of Brazilian companies' participation in the global semiconductor chain were also emphasized. The preliminary results were presented and discussed with experts in two international conferences: the 22nd International Conference on Management of Technology (BORGES; VIEIRA, 2013a) and the 20th EUROMA Conference (BORGES; VIEIRA, 2013b), besides a publication at Journal of Operations and Supply Chain Management (BORGES; VIEIRA, 2014). This phase was concluded with the definition of the design as the value chain activity to be studied on this research, which is described in section 3.2.

3.1.2 Step 2: The Brazilian Design Houses

This second exploratory study aimed to understand how Brazilian design houses are operating as players in the national industry and the semiconductor global supply chain. The primary source came from semi-structured questionnaire and interview procedure (Appendix B). The interview protocol was developed to bring elements to understand and analyze the perceptions about semiconductor national industry, main issues about the DH development, issues on product development process, collaboration with partners, sourcing, market perceptions, role of innovation, barriers and opportunities. The interviews were conducted with three CEOs from three Brazilian design houses (Table 3). Industrial reports and empirical studies were used as secondary data in order to complement this second exploratory investigation.

Table 3 - Interviewee's profiles – step 2

Interview focus	Interviewee position	Education level	Years of experience	Interview time	How
Private DH	CEO	Msc	34	0:55:25	Skype
Nonprofit DH	CEO	PhD	12	1:10:03	In person
Public DH	CEO	PhD	25	1:01:22	In person

Source: The author

The results of this phase showed the guidelines of the Brazilian industrial policies, the enterprising character of DHs created from these programs, and how they are advancing and reaching the first results. Those results were presented and discussed with experts in the 21st EUROMA Conference (BORGES; VIEIRA, 2014b), and accepted as a chapter in the Handbook of Research on Global Supply Chain Management (in press), that will be launched by IGI Global in 2016.

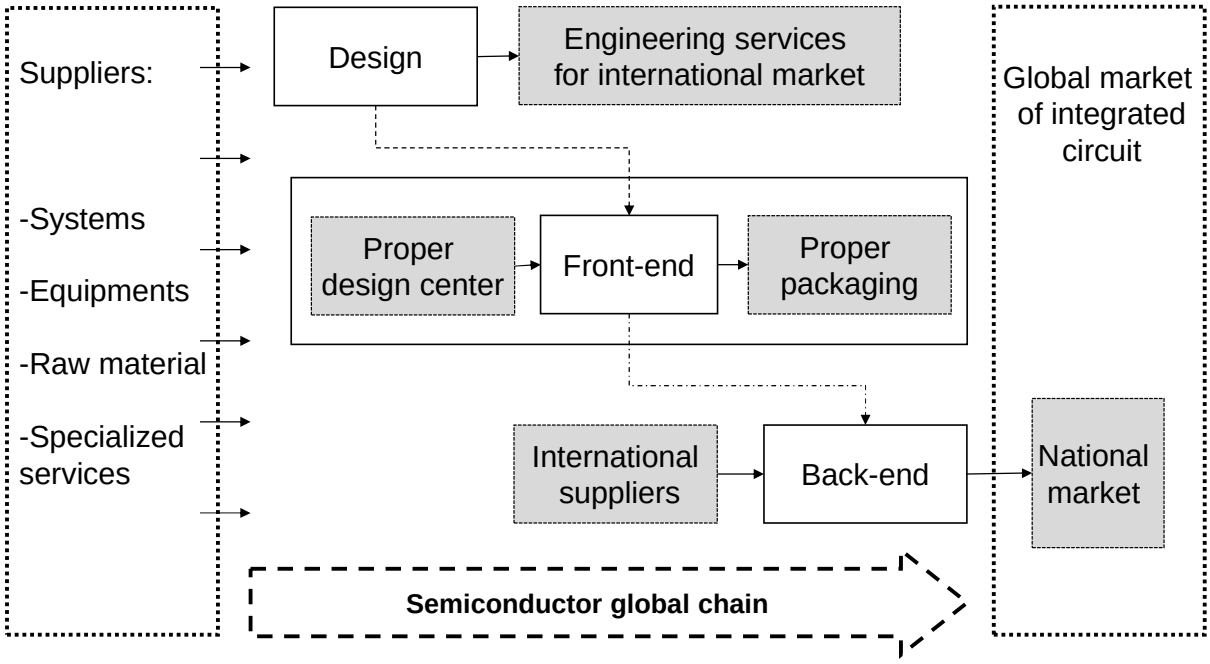
After the conclusion of this second step, it was possible to carry out this research with drivers to plan cases selection, data collection and data analysis, described in the following subsections.

3.2 Cases Selection

The research structure is based on multiple case studies. According to Yin (2008), the development of multiple case studies is considered a way to achieve more convincing results as they represent more robust studies reflecting different design situations. In multiple case studies, the case selection is a vital issue to carry out the research (VOSS et al., 2002; EISENHARDT, 1989; YIN, 2008).

Currently, Brazil has companies that are able to operate in the three main activities of the semiconductor supply chain, but, at the same time, it is not possible to identify direct business relationship between these companies. Figure 8 represents the current operations of Brazilian companies in the semiconductor global chain.

Figure 8 - Brazilian operation in the semiconductor global chain activities



Source: The author

In the design activity, there are 22 design centers and two training centers in Brazil that were fostered to supply engineering services to the international market. The international market for the design centers is justified specially because there is no scaled production of chips in Brazil. In the front-end activity, there is one public company, where the production capacity is used to serve and supply its own design center and packaging operation. In the back-end activity, there are mainly two companies operating. Currently, both companies are supplying the national market with activities of packaging and test and they import the chip from international foundries. In this scenario, the decision for this research is to focus only on the design house activity because of the following reasons:

- the number of companies operating in this value activity is more significant;
- this activity is important to foster innovation in the semiconductor chain;
- it was established as a priority in the Brazilian strategic planning to launch the country in semiconductor global industry;
- they are already developing products and services;
- they have international partners;
- they are developing marketing and commercialization activities.

The cases were composed by different Brazilian design houses that are operating in the semiconductor chain. Each case selected had to fit the following characteristics: i) it must be supported by public policies; ii) it must have developed international partners for its operations; iii) it must have some service or product already developed or in the development process; and iv) the characteristics of its ownership must represent the different ones presented in the universe of Brazilian DHs.

Thus, for the purpose of this study, four design houses were selected according to their characteristics. In the total of 24 DHs and training centers distributed throughout the national territory, four different features were identified: private DHs, state-owned DHs, nonprofit DHs, and those developing and commercializing intellectual properties (IPs). Each DH selected for this study is supported by public policies and represents one of these ownerships/features.

- DH1 is a spin-off of a research center that deliveries engineering services. Nowadays, this DH is changing its strategy to move focus to products instead of services. This new strategy involves the source of international foundries and back-end operations to work together in the parameterization of the product and also to outsource the production.
- DH2 is a nonprofit organization, stablished as a project in a research institute. In parallel to the service delivery activities, it has been developing products. During this process, it has also sourced international suppliers to configure and prototype the product.
- DH3 is a private design center that deliveries engineering services, but has the commercialization of IPs as one of its main business focus. Especially to develop its IPs library, it has developed international supplier. For both, engineering services and IPs, this DH is prospecting the global market.
- DH4 is a state-owned company and the only one that has manufacturing capacity to produce, package and test a microchip. It has the biggest national design center, but it does not deliver engineering services to the market. The focus is to develop and commercialize final product to the national market. Once it is not possible to have all the manufacturing technology to produce what their design house is able to project, the DH also has to make international agreements.

Table 4 presents a summary of the sample.

Table 4 - DHs profiles

Company	Type of company	Main focus
DH1	Private company (spin-off)	Integrated circuit (IC) design from specification to prototyping and manufacturing of the chip
DH2	Project in a nonprofit foundation	Development of customized projects and services of a new chip
DH3	Private company	Development of analog intellectual property (IP) and design services
DH4	State-owned company	Development and production of the chip

Source: The author

3.3 DATA COLLECTION

This sub-section describes the data collection in order to find the evidences to answer the research question and evaluate the propositions. According to Thomas (2011), data is a bit of information of whatever kind, whether they can be observation records, numbers, interview transcripts, photographs or documents that compose the evidences to analyze and support certain propositions. Voss et al. (2002) pose that such sources can include interviews, questionnaires, direct observations, content analysis of documents and archival research. Yin (2008) points out the importance in case studies of different sources of evidences. The use of multiple methods of data collection is to gain information about different aspects of the phenomena in study. This strategy reduces the risk of having conclusions reflecting only the biases of a specific method, and allows getting a more secure understanding of the issues involved in the investigation (MAXWELL, 2013).

Evidences can come from primary or secondary sources. According to Myers (2009), primary sources of data are those which are unpublished and that the researcher has gathered directly from the people or organization. They include data from interviews, fieldwork and

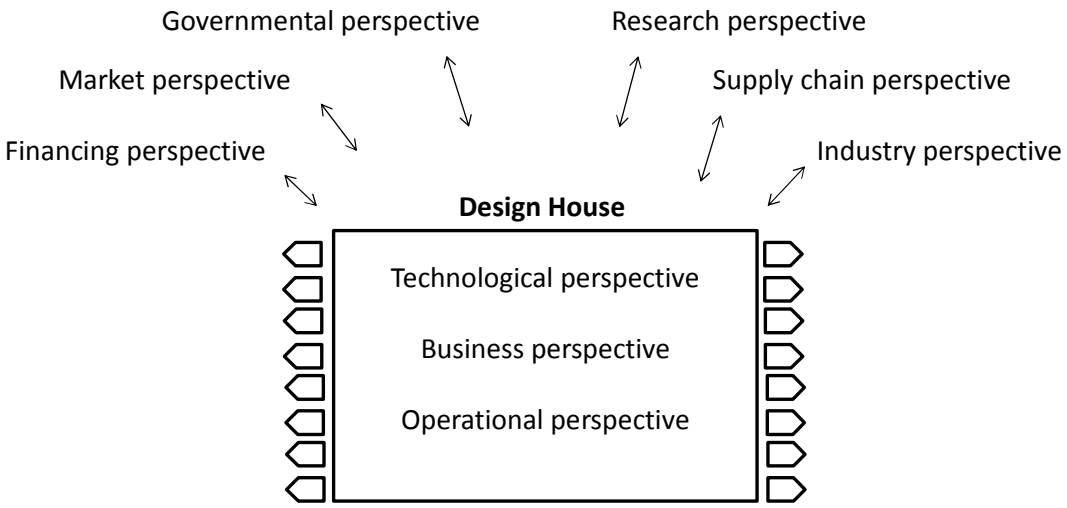
unpublished documents, such as minutes of meetings and so forth. Secondary data refer to any data gathered that have been previously published. They include previously published books, newspaper articles and journal articles. An important point to note is that primary data add richness and credibility to qualities manuscripts. It represents the added value that you bring to the table.

In this research, data were collected by semi-structured interviews as primary source and document analysis as secondary. Semi-structured interviews are composed by a list of issues to be covered with freedom to follow up points as necessary. According to Thomas (2011), because of these advantages, it is the most commonly used kind of interview arrangement in social research, in which researchers are not obligated to go through the list in an order. They have to remind what they want to cover, and questions should encourage the interviewee to say more.

The development of interview questions (and observational strategies) requires creativity and insight rather than a mechanical conversion of the research questions into an interview guide or observation schedule. It depends fundamentally on the understanding of the context of research and how the interview questions and observational strategies will actually work in practice (MAXWELL, 2013).

Figure 9 presents different perspectives that had to be considered in the definition of the interviewees profiles to this research. To understand the capabilities development in the companies, it was important to bring to the research the companies' operational, technological and business perspective. In relation to the environment, it was important to collect different perceptions, building a context with market, financing, governmental, research, supply chain and global industry perspectives.

Figure 9 - Internal and environmental perspectives to build the cases



Source: The author

Interviews were carried out with two executives and one project manager in each company. The executives provided strategic insights, while the project leaders provided a clearer view of operational issues of product development and relationship management. As the theoretical framework also presents external factors as drivers of capabilities development, it was important to enrich the research with an understanding of the business environment. For this reason, specialists in semiconductor industry were also interviewed. It was important to capture the perception of executives from financial institutions that have funding for this industry (two interviewees), policy makers that have worked in the industrial policy design (two interviewees), researchers (two interviewees), experts in the industry (two interviewees), executives from other DHs (two interviewees: one CEO from an international DH and one CEO from a Brazilian DH that has closed its operations), and executives from companies from other value activities of the semiconductor chain (two interviewees) (see Table 5).

It is possible to see the interviewees profiles covering all the perspectives presented in Figure 9. Furthermore, the sample is qualified considering the educational level of the interviewees (88% have master or doctoral degree), their position (currently, 75% are executives or managers) and experience in the area (the average is 19 years of experience). Interviews add up to a total of 26 hours, and 71% were made in person. The interviews were conducted mainly between October and November of 2014.

Table 5 - Interviewee's profiles

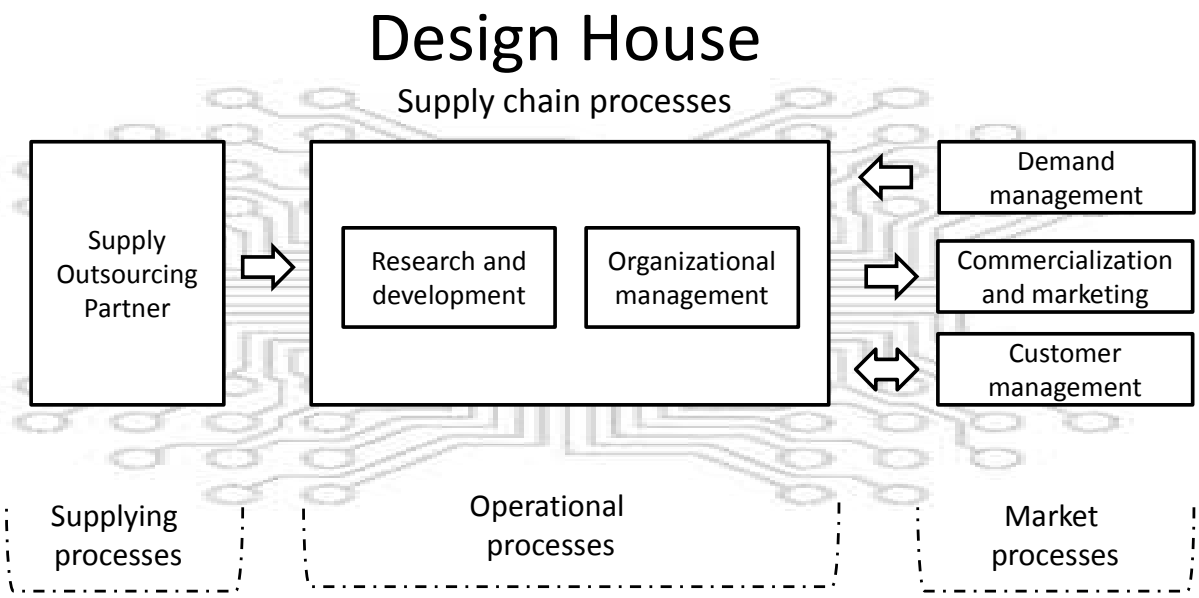
Interview focus	Interviewee identification	Interviewee position	Education level	Years of experience	Interview time	How
Case 1	CEO1	CEO	PhD	22	1:20:59	In person
Case 1	CTO1	CTO	Msc	34	1:42:25	In person
Case 1	PLR1	Project leader	BsC	5	0:27:33	Skype
Case 2	CEO2	CEO	Msc	12	1:26:03	In person
Case 2	CTO2	CTO	PhD	17	1:20:43	In person
Case 2	PLR2	Project leader	Msc	8	0:46:50	In person
Case 3	CEO3	CEO	Msc	14	1:18:27	In person
Case 3	CTO3	CTO	Msc	12	1:05:26	In person
Case 3	PLR3	Project leader	Msc	8	0:52:33	In person
Case 4	CEO4	CEO	PhD	25	1:07:07	In person
Case 4	CTO4	CTO	PhD	25	1:01:27	In person
Case 4	PLR4	Project leader	PhD	16	0:55:50	In person
Financial institution	FIN1	President	Msc	10	0:55:28	In person
Financial institution	FIN2	Manager for ICT	Msc	8	0:54:13	In person
Executive	EXE1	President	MBA	32	1:16:46	Phone
Executive	EXE2	R&D manager	Msc	21	0:31:59	Phone
Policy maker	PMK1	Manager	Msc	9	1:20:20	In person
Policy maker	PMK2	Especialist	Msc	33	1:04:25	Phone
Global DH	ODH1	Director of R&D	Msc	35	1:00:11	Phone
DH out of operation	ODH2	CEO	PhD	19	1:40:37	In person
Researcher	RES1	Professor	PhD	17	0:47:18	Skype
Researcher	RES2	Professor	PhD	34	1:08:25	In person
Expert	EXP1	Head	BsC	10	1:07:39	In person
Expert	EXP2	Global adviser	PhD	37	0:52:53	Skype

Source: The author

The protocols for the semi-structured interviews were developed considering the proposition that the supply chain processes are the mean to generate capabilities to upgrade in the global chain (see Appendix C). Figure 10 shows those processes organized into three groups of processes:

- supplying processes: supply, outsourcing and partnership;
- operational processes: research and development and organizational management;
- market processes: demand management, commercialization and marketing, and customer relationship management.

Figure 10 - Supply chain processes

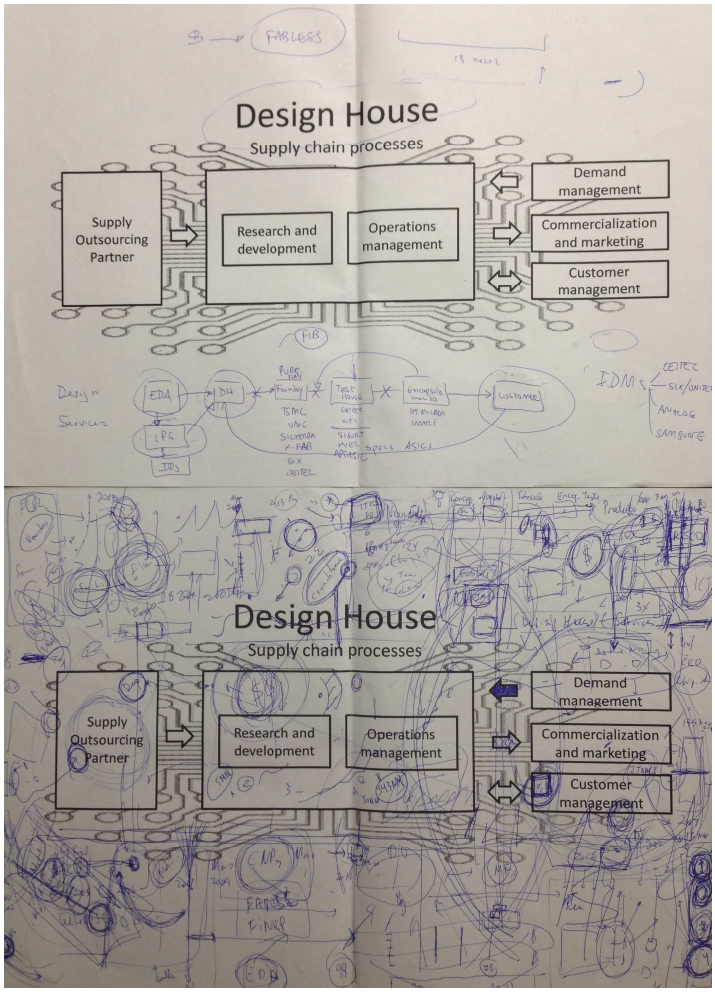


Source: The author

The interviewees were invited to discuss the maturity of those processes expressing also elements such as: i) the motivations that are promoting the national semiconductor industry and attracting foreign direct investment; ii) the impact of public policies and national infrastructure in the development of capabilities; iii) how those internal processes are managed; iv) understanding the process that generates firms capabilities; and v) how these capabilities can promote competitive advantage. The interview protocol used with the interviewees from the companies focuses on the perceptions of the specific DH development in the industry context, whereas interview protocol used with the specialist focuses on the development of Brazilian industry and Brazilian DHs in the same context.

In order to conduct the interview, the interviewees had a printed copy of Figure 10 in A3 format. The objective was to discuss the questions and map the DHs operations in accordance to supply chain processes. They also had a pen to make comments and observations on the paper. Figure 11 shows some results of this procedure.

Figure 11 - Example of the supply chain process map used during the interviews



Source: The author

The structure of the protocols was built after pilot interviews with three representatives of three different Brazilian design centers during the second exploratory investigation described in section 3.1.2. This phase allowed the empirical validation of the interview protocols. After this exploratory interview procedure, the protocols were reviewed and the final questions were discussed in the research group, at Unisinos, called Observatory of Innovation in Global Chain. This group is focused on monitoring information and knowledge production to generate opportunities for innovation and competitiveness of Brazilian companies. It is specialized on food, IT and semiconductor global chains. The researchers allowed making the scientific validation of the interview protocols.

Documents are the main source of secondary data for this research. The documents considered for the data collections are composed by international and national industrial reports and organizational norms and guidelines from the companies.

3.4 DATA ANALYSIS

Data analysis represents the transformation of data into something that is meaningful to the intended audience (MYERS, 2009). The initial step in qualitative analysis is reading the interviews transcripts, observational notes, or documents that are to be analyzed (MAXWELL, 2013). Consistent with the research objectives, the data analysis was conducted by two steps: i) content analysis; and ii) triangulation.

According to Myers (2009), content analysis seeks to demonstrate the meaning of written or visual sources by systematically allocating their comments to pre-determined, detailed categories, and then both quantifying and interpreting the outcomes. It can be used for analyzing historical trends. During the listening or reading, notes are written and rough observations allow the development of tentative ideas about relationships and categories (MAXWELL, 2013).

In qualitative data analysis, relationships are identified among data in a specific context. For that, coding is the main categorizing strategy used (arrange into categories that facilitate comparison between things in the same category and that aid in the development of theoretical concepts) (Maxwell, 2013). According to Myers (2009): i) a code can be a word that is used to describe or summarize a sentence, a paragraph, or even a whole piece of text, such as an interview; ii) a code helps to reduce the size of your data; iii) codes are tags or labels for assigning units of meaning to the descriptive or inferential compiled during a study; and iv) varying on size, a code can be a word, phrases, sentences, or whole paragraphs, connected or unconnected to a specific setting.

Software designed specifically for qualitative data analysis is now widely used, and is almost obligatory for large-scale projects, because of these programs facility in storing and retrieving large amounts of data and in coding and sorting these data. NVivo® currently has the largest market share (MAXWELL, 2013).

Content analysis was used to organize criteria and elements for the data interpretation. The categories for coding were based both on theory and on insights of the interviews. The content of the four cases' interviews and the content of the specialists' ones were coded separately once they have different purpose in this research. The contents of DHs' interviews were used to describe the cases, and the contents of the specialists interviews were used as context for the analysis. This data systematization was made by the use of NVivo®. Table 6 presents how the interviews' content was organized. The subcategories allowed the

understanding of the global chain, national chain and Brazilian DH strategy are mapped. The subcategories also allowed the description and analysis of the cases in chapter 5. The description was made according to the supply chain process, and the analysis considered the following elements: global supply chain operation, the impact of the public policies in the capabilities' generation, the development of global supply chain capabilities and the upgrading level. All the interviewees' content was used to discuss the propositions in chapter 6.

Table 6 - Categories for the analysis

Category	Subcategory
01 Industry features	National industry
	National industry perspective
	Global industry
02 DH's GSC evidences	Relationship with suppliers
	Relationship with market
	Product characteristics
03 Impact of public policies	The role of public policies
	CI-Brasil
	PADIS
	Other laws
	Financial support
	Human Resources issues
	Infrastructure issues
04 Market for DHs	National market
	Global market
05 Portfolio of products and services for DHs	Focus on services
	Focus on products
06 Global supply chain capabilities	Productive capabilities
	Relational capabilities
	Innovative capabilities
07 Upgrading	Process upgrading
	Product upgrading
	Functional upgrading
08 Operational processes	Organizational processes development
	R&D processes development
09 Supply processes	Supply processes development
	Outsorcing processes development
	Partnership processes development
10 Market processes	Demand management processes development
	CRM processes development
	Marketing and sales processes development

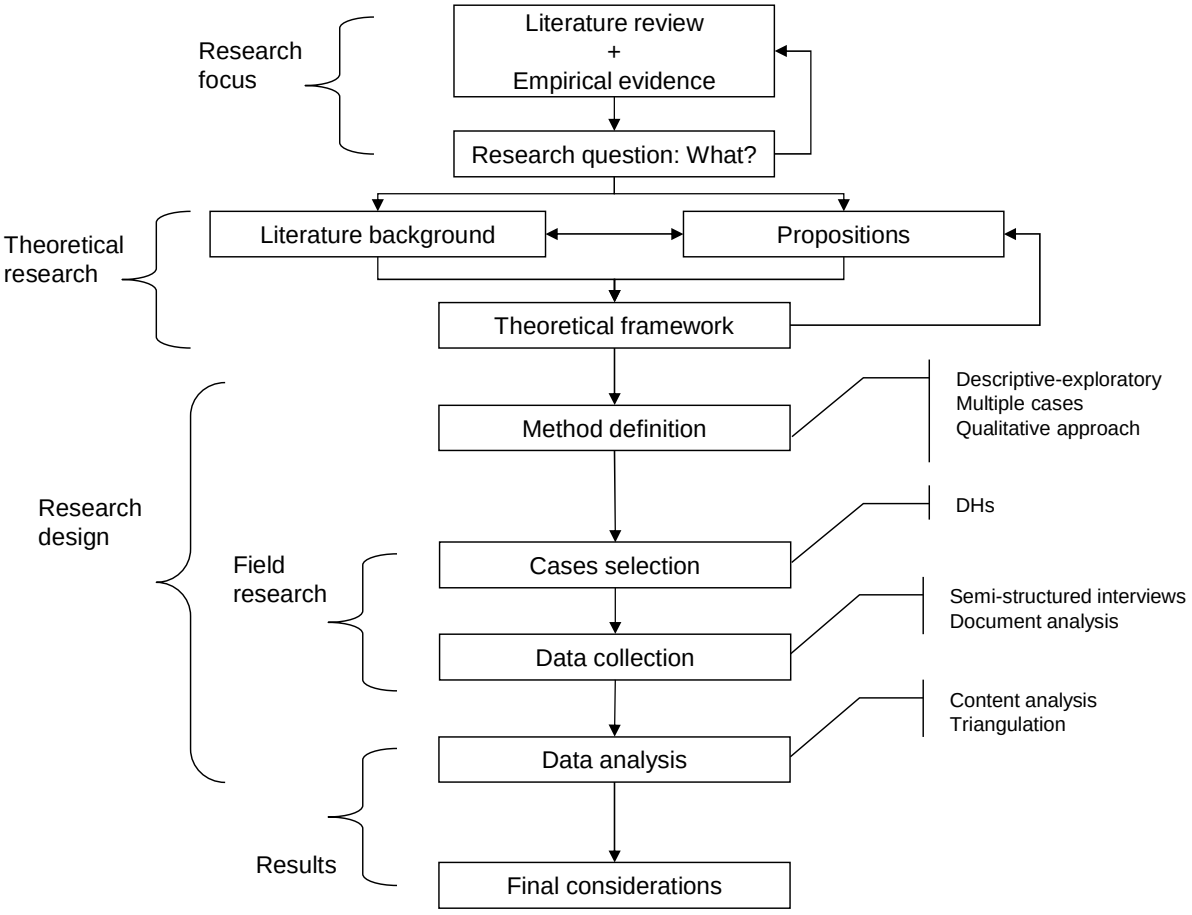
Source: The author

The term triangulation means that viewing from several points is better than viewing from one (THOMAS, 2011). Triangulation is the idea that a researcher should consider more than just one point of view in a study, i.e., more techniques should be used to gather data or combine qualitative and quantitative research methods. It is worth seeing the same topic from different angles. It allows triangulating data from interviews with data from documents or data from other different research method (MYERS, 2009). Thus, for this research, the results of the interviews with the companies, interviews with specialist and secondary data were triangulated in order to map the semiconductor chain and DH's strategy in chapter 5 and to complete the analysis to accomplish the objectives proposed in this study in chapter 6.

3.5 RESEARCH PROCEDURES

The research procedures represent the flow of different activities that must be accomplished to achieve the results expected by this investigation. Figure 12 summarizes the organization of this research project describing the workflow employed.

Figure 12 - Research workflow



Source: The author

The flow highlights the main activities, starting by the focus definition, presented in chapter 1. The research problem was proposed based on literature review and empirical evidence of the semiconductor industry in the world and in Brazil. The following activities are related to the theoretical research presented in chapter 2. Literature related to global supply chain, public policies, capabilities and upgrading were used to present propositions that composed the basis for the theoretical framework construction, described in chapter 3. In the sequence, it is proposed the research design presented in chapter 4. Considering the nature of the research question, the method is characterized as descriptive-exploratory, using multiple cases with a qualitative approach of investigation. The field research is formed by multiple cases, where data were collected through semi-structured interviews and document analysis. The result and final considerations were reached by content analyses, supported by NVivo®, triangulation of different data and crossed with theory.

4 THE SEMICONDUCTOR GLOBAL SUPPLY CHAIN

This chapter presents the semiconductor global supply chain and the Brazilian initiative to promote an industrial policy to foster national players in the semiconductor global chain and the Brazilian focus on the design centers development. It is based on secondary data from empirical studies and industrial reports.

A new pattern or structure of the economy, the Information and Communication Technology (ICT) paradigm was established by the end of the twentieth century, having as leading producing players the United States, Europe, Japan, and East and South East Asia (FREEMAN, 2009). It has caused many transformations in the world not only by the rapid growth and development of new ICTs but more importantly by their pervasive application throughout virtually all sectors of the economy (MELODY, 2009). The rise of the Internet spawned new forms of transacting business in many of these other industries and services, including retail and wholesale distribution, travel and tourism, financial services, auctioneering and gambling, as well as publishing and information services (FREEMAN, 2009).

The semiconductor production is an important industry developed within the ICT paradigm. Integrated circuit, sometimes called chip or microchip, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated (PINGQING, 2007). The semiconductor industry's productivity has been historically driven by Moore's law, which predicts that the numbers of transistors on a chip will double every 18-24 months. By following Moore's law and reducing the transistor cost or cost per function by 30% each year, the industry has achieved unparalleled growth by providing more capability at equal or lower cost (LI et al., 2010).

The impact of the chips to the global economy can be realized by the increasing applications of this industry in both social life and professional activities. In today's world, semiconductor has permeated in every part of people's life like nothing did before. From computers, automobiles, office equipment, iPods, iTouch and iPhones, entertainment devices to all home appliances, none can function without the integrated circuit semiconductor devices (JIANG et al., 2010). The semiconductor industry is widely recognized as a key driver for economic growth in its role as a multiple lever and technology enabler for the whole electronics supply chain network (LU et al., 2013). The worldwide semiconductor sales

for 2013 reached $305.6 billion, the industry's highest-ever annual total and an increase of 4.8% from the 2012 total of $291.6 billion (SIA, 2014).

A great challenge for chip design is the increasingly demanding performance requirements for electronic systems (Ernst, 2005). The introduction of a new semiconductor product typically necessitates significant changes and innovations in products and in the underlying manufacturing process, and the ability to increase output of a new semiconductor chip rapidly before imitators enter is crucial to profitability (MACHER; MOWERY, 2003).

According to Jiang et al. (2010), as the trend of globalization of the semiconductor industry looms largely and rapidly, countries in the Asia-Pacific region, such as Japan, Taiwan, China and India, have identified their key strengths in this space. Taiwan has focused on value added IC design, production and advanced IC manufacturing, while China has relied on low-cost manufacturing and regional distribution. India is also a frontrunner in this race with its expertise in the chip design and software development. Over time, each country will make efforts to leverage its advantages to the fullest under ever-changing market and competitive dynamics.

4.1 Semiconductor Global Chain

Semiconductor manufacturing involves a range of activities, including everything from growing silicon ingots (the source of silicon wafers upon which integrated circuits are grown) to the actual placement and soldering of finished chips to a printed circuit board (DENTON et al., 2006). From the early 1960s, the US semiconductor industry started moving certain supply chain activities to foreign countries in order to take advantage of the relatively inexpensive labor overseas. The success of the initial move, together with the receiving countries' government support, and the availability of highly skilled labor in these countries have motivated the industry to shift gradually greater number of its supply chain activities overseas (JIANG et al., 2010). By now, the semiconductor industry has formed a fully integrated global supply chain with very high levels of outsourcing and offshoring activities.

Because of its critical position in modern industry, the research on the semiconductor industry is plentiful (LI et al., 2010). The semiconductor industry has a supply chain network that is distributed worldwide, and its manufacturing process has the particular characteristics that should be considered in the supply chain framework (LEE et al., 2006). Due to its upstream position in the electronics supply chain, the semiconductor industry has been

plagued by demand unpredictability, and moving up the supply chain from the end-consumer to semiconductor manufacturing and final testing companies, the demand fluctuation is amplified (LU et al., 2013). Considering it is represented by a worldwide industry, global supply chain management strategies have helped the semiconductor companies to gain competitive advantage, with high investments in international operations and successive stages of outsourcing and offshoring activities (JIANG et al., 2010).

For a period of time, the vertically integrated model appeared to have its major advantages: the deep knowledge of the design of the system helped in-house producers design products that would work in those systems. As the semiconductor technology became more diffused and better understood, startup companies began to emerge and grow with newly developed business models, which were different from the vertically integrated model (JIANG et al., 2010). The reorganization of global semiconductor production from a vertically integrated, geographically concentrated, closed system to a vertically disintegrated, geographically dispersed, open system forces companies in the global production system to share their knowledge more aggressively with distant network partners as they are under constant pressure to deliver the products faster and at lower costs (ERNST, 2002).

For this capital-intensive process, the incentives for outsourcing are not only the cost of direct labor but also the proximity to skilled labor, tax advantages, and favorable government regulations. Asia, including Greater China, Malaysia, Korea, Singapore, among others, with a strong government support, accounts for the lion’s share of the worldwide fabrication capacity with the largest two foundries in Taiwan: TSMC and UMC (JIANG et al., 2010). LEE et al. (2006) pose that semiconductor companies are running a global business through multiple manufacturing sites, warehouses or distribution centers, subcontractors and suppliers. Manufacturing sites may consist of multiple fabrication sites, probe sites, assembly sites, and final test and packaging sites throughout the world. It is necessary for the supply chain model of the semiconductor industry to include the entire network stream starting from suppliers of raw materials to customers of the final products. Along with the deepening of specialization, some new business models emerged: integrated device manufacturers, foundries, assembly and test, fabless and design houses.

Integrated device manufacturer (IDM) is a company that performs every step of the chip-making process, including design, manufacture, test and packaging. Examples of IDMs are Intel, AMD, Motorola, IBM, TI and Lucent (PINGQING, 2007). Traditionally, IDM is regarded as a technology leader and contributor, whereas foundry is considered only a

manufacturing capacity provider. In this case, the commercial suppliers do not make the final system, but serve as links in the semiconductor industry supply chain, providing semiconductor elements needed by other systems companies (JIANG et al., 2010).

Foundries are providers of contract chip fabrication, like TSMC, UMC, and Global Foundry (LI et al., 2010). It may be a large chip maker that sells its excess manufacturing capacity or one that makes chips exclusively for other companies (PINGQING, 2007). In the semiconductor production stage, maximizing throughput and utilization of bottleneck machines are important in wafer fabrication, while the assembly and test line have been evaluated on due date performance and customer satisfaction (LEE et al., 2006). These practices and strategies have allowed semiconductor companies to split manufacturing processes into multiple stages, with each stage being performed in the most efficient and cost-effective way, and the foundries were a more cost-effective way to aggregate market volumes to spread the large and increasing costs of semiconductor fabrication over more units than the IDMs could hope to achieve (JIANG et al., 2010).

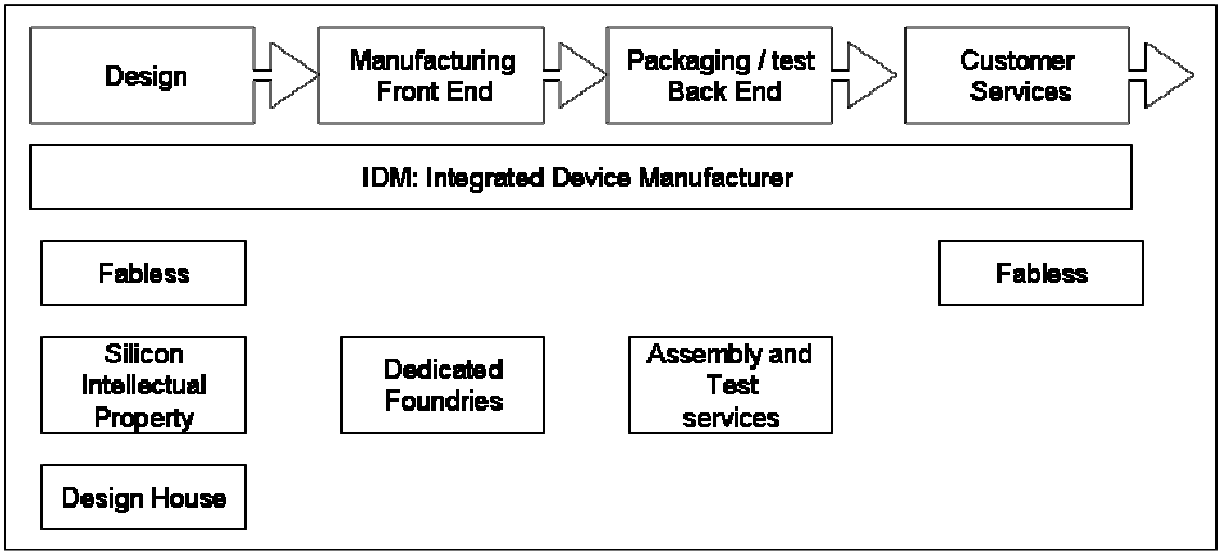
The labor-intensive chip assembly/testing functions were the first semiconductor manufacturing activities to be moved offshore (JIANG et al., 2010). Assembly is, typically, the process of cutting the wafer into individual chips and packaging the delicate chip in a protective shell that includes connections to other components (BROWN; LINDEN, 2005). As the assembly process became more and more automated in 1980s, other factors, such as government support, land cost and economic stability, became determinants in the choice of locations for semiconductor assembly offshoring (JIANG et al., 2010).

Fabless, in tis turn, is a semiconductor vendor that does not have in-house manufacturing facilities. Although it designs and tests the chips, it relies on external foundries (fabs) for their actual fabrication. Fab is a manufacturing plant that makes semiconductor devices (PINGQING, 2007). The fabless design/foundry model is characterized by the total separation of the semiconductor design process from the semiconductor fabrication process. The fabless design firms rely exclusively on external foundries for the manufacturing of their designed integrated circuit chips (for example, Elpida Memory, Infineon and Motorola have outsourced to overseas foundries an increasing amount of their chip production) (JIANG et al., 2010).

Finally, a design house is dedicated to IC circuit design and sales, like Qualcomm, Broadcom and NVIDIA (LI et al., 2010). Chip design is highly skill-intensive, since it employs only college-trained engineers (BROWN; LINDEN, 2005). In short, chip design has

become by itself a highly complex technology system, where multiple communication and knowledge exchange interfaces must be managed simultaneously (ERNST, 2005). The primary reasons for opening offshore design centers are the need for closer contact with customers, access to specialized skilled labor, and cost reduction. In this case, all parts of a design, including the whole procedure from specification to finished chips, can be outsourced (BROWN; LINDEN, 2005).

Figure 13 - Semiconductor Supply Chain



Source: Adapted from Consórcio A.T.Kearney/Azevedo Sette/IDC apud Gutierrez and Mendes (2009)

Figure 13 presents a map of the semiconductor supply chain, highlighting the main activities and characteristics of the companies that operate in each value chain activity (GUTIERREZ; MENDES, 2009). The whole process is composed of four different phases:

(i) the product design: it makes an assessment of market demands and it designs the products;

(ii) manufacturing: it is performed by means of physical-chemical processes to produce the wafer. This phase is called front-end;

(iii) packaging and test of the IC, denominated back-end;

(iv) customers' services.

The producers of ICs operate in different ways in this supply chain and are classified according to their business model:

(i) IDMs (integrated device manufacturers): they operate in all of the chain activities, from conception to customer services;

(ii) fabless: they accomplish the conception and customer services activities and outsource the front and back-end. They own the brand, the market and the product;

(iii) dedicated foundries: they perform the physical-chemical processes of the components;

(iv) assembly and test services: they are responsible for the back-end activities;

(v) design houses: they are independent and are hired by manufactures, by IDM or by fabless;

(vi) silicon intellectual property (SIP): companies that license their technology to a customer (IDM, fabless or design house) as intellectual property.

The industry demands that semiconductor companies improve performance more quickly than their competitors (MACHER; MOWERY, 2003). That is why global supply chain management strategies have helped the semiconductor companies gain their competitive advantage in the intensive international competition (JIANG et al., 2010), where large semiconductor manufacturing firms have many facilities and outsource some operations (DENTON et al., 2006). Thus, the semiconductor industry, as a pioneer to invest in successive stages of outsourcing and offshoring activities, has contributed to the development of supply chain management studies (JIANG et al., 2010).

4.2 Brazil in the Semiconductor Chain

Semiconductor production is one of the priorities of Brazilian economic planning and technological development. The country aims to move from a strong consumer of microelectronics items to a strong player in the semiconductor chain. According to ABDI (2011), the consolidation of a semiconductor industry in the country is a key element to achieve competitiveness in its final goods industry, with expansion of technology and innovation domain and wealth generation.

The consumer electronics industry in Brazil emerged during the late 1960s, under the import substitution industrialization (ISI) policy and a heavily protected market. Soon after, during the 1970s, it expanded as a result of economic growth and the expansion of durables consumption in Brazil (FIGUEIREDO, 2008a). Brazil was one of the first developing countries to use and produce electronic equipment, and in the 80s there was a significant local production of computers and peripherals and a microelectronic industry (MCT, 2002). According to Figueiredo (2008a), Brazil began to receive a considerable number of TNC

subsidiaries from the 1960s, and, by the late 1960s, there were about 20 consumer electronics companies in Brazil, of which three were foreign.

The implementation of the “market reserve” policy (Law no. 7,232/1984) stimulated the emergence of a local electronics components industry in Brazil, and, by the late 1980s, there were nearly 23 semiconductor firms in the country (FIGUEIREDO, 2008a). In 1991, Brazilian industry was shocked by the end of the market reserve policy. In order to protect Brazilian electronics sector from the sudden competition with international companies, a tax reduction policy for local manufacturers was issued in the same year (FINK et al. 2010). According to those authors, however, the law only ran after 1993, and this two-year gap was enough to significantly harm the sector. Consequently, 20 of the 23 semiconductor firms that were in operation during the 1980s disappeared from the industry in the early 1990s (FIGUEIREDO, 2008a). In 10 years, the local production of semiconductors fell from over US$ 200 million in 1989 to about US$ 54 million in 1998 (MCT, 2002).

The opening of the Brazilian market made possible to import products and the implementation of new routines, which can be viewed as a paradigm shift (BORTOLASO et al., 2014). There was an imbalance in the trajectory of the semiconductor industry, since the import of electronic goods was facilitated, discouraging domestic production. While Brazil regressed, Korea, Malaysia and Taiwan were moving fast in the production of goods in the electronics industry, especially due to institutional cohesion with their respective governments and companies (MCT, 2002). Currently, Brazil is one of the few countries among the world’s major economies that do not have an electronic complex that includes the manufacture of integrated circuits (GUTIERREZ; MENDES, 2009).

In the view of the economic importance of microelectronics and the precariousness of the national industry, after 2000 a new strategy was implemented considering the need for a new microelectronics policy in Brazil. In March 2004, the federal government's industrial policy was launched, which elected microelectronics among the priority sectors to be promoted. The ensuing discussions about this sector within government joined studies of Ministry of Science and Technology (MCT), which, in 2002, launched the Microelectronics National Program (PNM) (GUTIERREZ; MENDES, 2009). The PNM is the result of a national study in Brazilian microelectronics sector. According to Fink et al. (2010), the PNM consists of subprograms intended to develop design, manufacturing and packaging sectors. This program was developed to combine short-term actions to establish the instruments of fiscal policy, credit and logistics infrastructure to attract enterprises, with policies and actions

that have focus on results in the long term, including specialized human resources and investment in R&D activities related to microelectronic complex, investment attraction and internal market development (MCT, 2002).

Each subprogram outlines opportunities, actions and policy mechanisms (FINK et al. 2010). The main subprograms that can be detached under this PNM are the new Information Technology Law (beginning of 2000), Innovation Law (from 2004), Bem Law (from 2005), CI-Brasil – Implementation of Design House (from 2005), PADIS – Support Program for Technological Development of the Semiconductor Industry (from 2007), and PACTI – Action Plan for Science, Technology and Innovation (from 2007).

- New Information Technology Law (beginning of 2000)

The main purpose of the new Information Technology Law is to stimulate research and development (R&D) in ICT throughout the country. According to Gutierrez (2010), it was established in 1991, known as Information Technology Law, which lasted through the end of the 1990s. This law was extended and amended by subsequent legal instruments up to the end of 2019. In order to use such benefits, enterprises should apply in R&D the equivalent to at least 5% of their gross sales in the domestic market. Investments in R&D to external companies must be made in teaching and research or business incubators focused institutions ICTs, usually linked to such institutions (GUTIERREZ, 2010). The incentive is a reduction on industrialized products tax, and companies must then invest a share of the income from the supported products in R&D. Tax reduction amounts to 80% of the original tax value, and these benefits are guaranteed until 2014. Four percent of revenue must be spent in R&D, either inside the company (total income less than USD 8 million) or both internally and in external R&D projects (FINK et al. 2010).

- Innovation Law (2004)

The Innovation Law, among other things, authorizes and organizes the R&D activities and the use of research infrastructure of scientific and technological institutions (ICT), as well as economic exploitation and allocation of intellectual property associated with the products of these activities, including relationship between ICTs and the market (GUTIERREZ, 2010). However, its most important features are the measures to foster the development of innovative products and processes. These measures include economic subsidy, i.e., non-refundable funding to finance projects with technological risk (GUTIERREZ, 2010).

- Bem Law (2005)

The Bem Law reduces to zero the rates of the Social Integration Program (PIS), the Public Employee Patrimony Formation Program (PASEP) and Contribution to Social Security Financing (COFINS) on the sale of low cost microcomputers—priced up to US$ 2,000. This action was part of a list of measures for the Digital Inclusion Program, that aimed the spread of computerization in class C families and small businesses (GUTIERREZ, 2010).

- CI-Brasil – Implementation of Design House (2005)

The CI-Brasil program was created in 2005 as an effort to develop Brazilian IC design sector in the scope of PNM's actions. The mission is to contribute to the creation and organization of an ecosystem of microelectronics, seeking innovation in products and the inclusion of the country in the semiconductor scenery (CI-Brasil, 2014). The main objectives are the creation of national design houses and the attraction of IC design activities developed abroad (FINK et al., 2010). The CI-Brasil program is structured to foster economic activity in the project area of ICs, expand and qualify designers of integrated circuits and promote the creation of a national semiconductor industry (ABDI, 2011). In order to stimulate the creation of design houses, the government, through this program, gives infrastructure incentives (buildings, workstations and EDA tool licenses) and also focus on human resources development, creating training centers and offering scholarships (GUTIERREZ; MENDES, 2009).

With investments exceeding US$ 50 million since 2005, Brazilian government aims to develop technical and business capabilities to insert Brazilian DHs worldwide, enabling the country to participate of the semiconductor global industry (ABDI, 2011). According to ABDI (2011), the government investments are focused on: i) training of specialized labor, through the creation of training centers with a capacity to develop 200 designers per year; ii) supplying licenses of software for projects: electronic design automation (EDA), hardware infrastructure (servers, workstations, plotters, special printers, etc.) for DHs hosted in universities and in institutes of science and technology (ICTs); iii) providing scholarships for graduate and undergraduate programs. Some scholarships are available for the development of project activities of ICs at the DHs and centers project dependencies; and iv) attracting of foreign companies by productive investment in Brazil.

- PADIS – Support Program for Technological Development of the Semiconductor Industry (2007)

On May 31, 2007, the Support Program for Technological Development of the Semiconductor Industry (PADIS) was created, contemplating a series of tax incentives, including exemption from income tax, for the realization of chip projects in the country (GUTIERREZ; MENDES, 2009). According to the Law no. 11,484, of May 31st, 2007, a beneficiary of PADIS is a legal entity that invests in R&D and conducts, either jointly or severally, in what regards: i) semiconductor electronic devices in activities of concept, development and design; diffusion or physicochemical processing; or encapsulation and test; and ii) displays in activities of concept, development and design; manufacture of photosensitive elements; photo or electroluminescent and light emitters; or final assembly of displayer and electrical and optical tests. The PADIS combines incentives to reduce taxes on production and export. It offers incentives to companies that, in return, need to invest at least 5% of their local revenue in research and development. Another support mechanism offered by the government is the financing lines by BNDES (Brazilian Development Bank) for projects in design house, front-end (wafer fab) and back-end (assembling and testing) (ABDI, 2011).

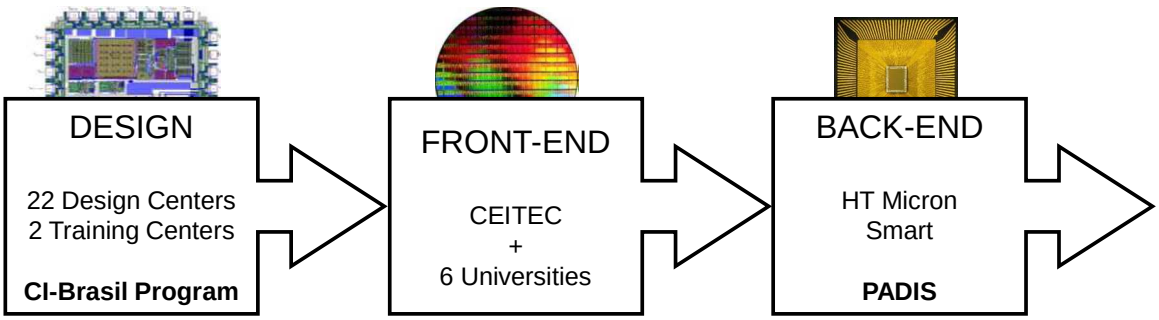
- PACTI – Action Plan for Science, Technology and Innovation (2007)

The Action Plan for Science, Technology and Innovation (PACTI), launched in November 2007, is intended to integrate other governmental action plans in the scope of science and technology. These action plans are in the areas of education, agriculture, health and industry, where science and technology become a strategic issue. PACTI's main objective is to create conditions for Brazilian companies to develop technology, thus leading to increased added value products, and competitiveness in the global market (FINK et al., 2010).

The difficulties of creating a microelectronic ecosystem characterize a great challenge that should be overcome to reduce the trade deficit in electronics, that between January and October of 2008 was US$ 19.42 billion (US$ 3.62 billion were specifically related to semiconductors) (GUTIERREZ; MENDES, 2009). Figure 14 shows that this movement has already begun, highlighting Brazilian participation in each main step of the semiconductor chain. All Brazilian companies are spread throughout the country, without a clear pattern of location for the industry setting. The design houses are located close to universities due to

their vocation for researching. Manufacturing activities (front-end and back-end) located their plants looking for government support, tax incentives and availability of investors.

Figure 14 - Brazil in the semiconductor chain



Source: Adapted from Peter (2011)

4.2.1 Design

The design is the value chain activity that represents a good opportunity to develop technological capabilities to join the semiconductor global chain. This is a knowledge-based activity that uses logic blocks and electronic elements to develop new integrated circuits with the functionality demanded by customers (KIMURA, 2005).

The Brazilian Ministry of Science and Technology established the CI-Brasil program, which is in the scope of the Microelectronics National Program and, since 2005, has been inducing the creation and implementation of the microelectronics design in the country. Currently, there are 22 design houses distributed throughout the national territory. Partially, they are supported by the program and 13 of these companies are non-profit organizations. Most of them are spin-offs that have emerged or are connected to universities or public research institutions (CI-BRASIL, 2014). Furthermore, the program has actions to fulfill the conditions and demands of this sector, such as infrastructure and human resources (FINK et al., 2010).

4.2.2 Front-end

The front-end is considered the activity with higher value added in the process (GUTIERREZ; LEAL, 2004), but it also requires large investment in infrastructure and

equipment (Kimura, 2005). It is very difficult for a developing country to begin an operation in semiconductor chain by the wafer production. Currently, in Brazil, the only organization with infrastructure, capacity and expertise to produce wafers is the Center of Excellence in Advanced Electronic Technology – CEITEC S.A., supported by technology transferred from Motorola (FINK et al., 2010). It is a Brazilian public company that develops and manufactures applications of semiconductors for three segments: RFID, wireless and digital multimedia. CEITEC is considered an important tool to develop productive and innovative capabilities in all the three main steps of the semiconductor chain.

A manufacturing operation has already been announced in Brazil, the Unitec Blue (former Six Semiconductors), with investments of more than half a billion dollars. The new plant began to be built in 2013 and operations are planned start in 2015. National Bank for Economic and Social Development (BNDES) is one of the senior partners. This plant will generate 300 new direct jobs. Other partners are IBM, BDMG and the groups Matec Investments and Tecnologia Infinita WS-Intecs (VEJA, 2012). The goal is to produce 360 wafers per day, with a focus on specific applications for sectors such as medical, industrial, smart cards and documents (BAGUETE, 2012).

4.2.3 Back-end

As back-end activities demand less investment than foundries, Brazilian government considers them an opportunity to prepare the necessary supply chain elements for the attraction of new investments (FINK et al., 2010). To promote the back-end operations in Brazil, as public policy it is possible to highlight the role of the Support Program for Technological Development of the Semiconductor Industry – PADIS, which offers tax incentives to stimulate the sector (GUTIERREZ; LEAL, 2004). It is also possible to detach the back-end operations of two companies in Brazil: HT Micron and Smart Modular Technologies.

HT Micron is a joint venture between the South Korea's Hana Micron and a pool of Brazilian companies led by group Altus (FINK et al., 2010). This joint venture has an initial investment of US$ 30 million, with revenues of US$ 300 million by 2012 and US$ 1 billion by 2014. In regard to the participation in the Brazilian semiconductor market, which is currently US$ 17 billion per year, HT Micron expects a share of 20% of this value by 2014.

Itaucom left the packaging market in 2004 and was readily substituted by the American company Smart Modular Technologies. This company has already invested US$ 100 million in the country, operating mainly in the packaging and testing operations. Smart foresees for the next three years an investment of US$ 150 million in advanced technologies for packaging operations. Its intention is to meet the high demand for domestic components used in mobile applications.

4.3 Design House Strategy

Until quite recently, chip design has indeed remained heavily concentrated in a few centers of excellence, mainly in the United States, but also in Europe and Japan. However, fundamental changes have occurred over the last few years in the location of chip design, signaling a growing geographical mobility leaded by Asian countries (ERNST, 2005). Concerning the actions intended to foster the performance of chip design in Brazil, the Ministry of Science and Technology (MCT) established, in 2005, the CI-Brasil program, featuring the creation of the so-called design houses (DH). These companies would be structured pursuant to either strategy: connected with Brazilian technological institutions or to multinational companies in the sector (GUTIERREZ; MENDES, 2009).

According to MCT (2005), CI-Brasil is an important instrument for making it possible to:

- develop final product engineering in Brazil focused in the electronic complex systems;
- develop computer tools for supporting IC projects by companies and/or software development centers located in Brazil;
- stimulate synergies and externalities drawn from the strengthening of technological parks focused in various segments of the electronic complex with the creation of IC advanced design centers and advanced infrastructure for telecom, cutting-edge electronic design automation – EDA tools (specialized software), high performance workstations and shared-use libraries;
- increase competition in the different national economic sectors through the supply of innovative products and services, both differentiated, and value added with the use of ICs developed in Brazil;
- broaden personnel training and capacity-building supporting projects cooperated among education institutions and research centers and companies, with the major purpose to meet

the real needs of the production sector; promote the exchange with internationally renowned companies so as to train designers and faculty members in state-of-the-art techniques, methods and tools;

- strengthen the national electronics industry by means of the spread of concepts related to the manufacturing of semiconductor devices and techniques and computer tools used in the IC project with Brazilian electronic engineers;
- encourage technology-based entrepreneurship focused on ICs and software development to support this activity (EDA).

Two main reasons can justify this choice: the importance that the design phase plays in the development of a semiconductor ecosystem; and low cost for their development (ABDI, 2011).

The design phase, considered crucial and decisive in generating innovation, is the first stage, characterized by the creation and design. In this context, innovation refers to the creation of new features and capabilities in integrated circuits (chips) that will be used in the final products (ABDI, 2011). A design house gathers human capital and specialized tools for computer hardware and software for the creation and enhancement of integrated circuits (IC), ranging from the very IC design and the reference design project associated to the IC up to the creation of IC simulators, operating systems and software development kits, as well as the firmware design, the embedded software for the integrated circuits (MCT, 2005). The design stage triggers advances in the front and back-end as it determines the geometric and new features of the new generation of chips, acting as a driver for the miniaturization of semiconductor structures and technological advances (ABDI, 2011). A new evolutionary cycle (new technology node) of the semiconductor industry triggers an evolutionary cycle in several other related industries.

Regarding the costs for implementations, a little amount of capital makes it possible to structure a design house (DH), with a small infrastructure, design tools and some technicians. The activity of such a business is likely to be just providing design services to fabless companies, IDMs or electronic goods manufacturers seeking a differential for their products (GUTIERREZ; MENDES, 2009). According to MCT (2005), the investment on the implementation of manufactured units capable of producing chips typically ranges in the hundreds of millions of American dollars, or at least tens of millions when considering the plants needed for the encapsulation and testing stages. In manufacturing, where hundreds or thousands of chips are produced (depending on the size of each chip and the size of wafers),

the necessary investments start at US$ 500 million and can reach values of the order of US$ 5 billion. This step loads the greatest technological challenges and executes operational procedures of high complexity. Packaging and testing require investments between US$ 50 million and US$ 500 million, depending on the size, types of packages and complexity of the products (ABDI, 2011). Nonetheless, it is possible to engage the integrated circuit business with relatively modest investments (of about hundreds of thousands of dollars per installation) beginning with the design activity in the country, at the same time contributing for the training of personnel that are indispensable for a further expansion of local supply activities in producing integrated circuits (MCT, 2005). The project operations under the domino of the design houses require investments between US$ 5 and US$ 50 million, depending on size (ABDI, 2011). Chip design is highly skill-intensive, since it employs only college-trained engineers. A couple of medium-size chip designs will employ as many electrical engineers as a fab for a year or more. In practice, design teams can also be as small as a few engineers, and project duration varies from months to years (BROWN; LINDEN, 2005).

The Brazilian government is aware of this issue and of the strategic importance of having an effectively implemented microelectronic ecosystem in the country, which includes design activities. Many initiatives and efforts have been applied to foster the creation and consolidation of Brazilian DHs and draw semiconductor design centers of major international companies (GUTIERREZ; MENDES, 2009). In order to move up as players in the global semiconductor chain, Brazilian DHs still need to develop capabilities to upgrade in terms of product and processes and achieve global standards operations. So, it is important to identify and manage the main internal and external drivers responsible for these capabilities generation. According to ABDI (2011), building confidence in DHs entrants, sustained in the ability to design and deliver products, is an important factor for the success of this movement.

5 THE BRAZILIAN DESIGN HOUSES

This chapter presents the results obtained in this research and it is organized in two parts. The first part presents the description of the cases, made according to the supply chain process, divided into three groups: supplying processes, operational processes, and market processes. For that, primary data came from the interviews accomplished with the companies' members. The second part presents a cross-case analysis, considering as primary data the content of the interviews of both companies and specialists. It is structured by four perspectives: global supply chain operation, the impact of the public policies in the capabilities' generation, the development of global supply chain capabilities, and the upgrading level.

5.1 Cases

The content of the interviews carried out with the companies' members of the four Brazilian DHs allowed to understand their current operations. Four cases were analyzed, each one with specific differences: one is a spin-off of a research center, one is a nonprofit organization, one is a private design center focused specially in IP's development, and the last one is a state-owned company. Even considering that the four DHs present different features, all of them had, in common, the following characteristics: they emerged from the new Brazilian industrial policy for the microelectronics, they are supported by public policies and are developing international partners for their operations.

The cases are described according to the content analysis of the interviews carried out with three members of each company, considering executive, technical and operational points of view. The description of each case considers three groups of supplying processes: the first one focuses on processes related to operational issues, such as organizational and structural processes, products and services, and initiatives in research and development; the second set of processes presents the companies relationship with partners and suppliers; the last one is focused on market processes such as demand management, marketing and commercialization, and customer relationship.

5.1.1 Case 1: A Spin-off of a Research Center

The first case concerns a private design house (DH1). It is a spin-off of a research center selected as one of the companies that are part of the CI-Brasil program in the federal semiconductor initiative of 2008. DH1 is aligned to the national interest of promoting growth within the semiconductor industry and, thereby, placing Brazil in the international arena. According to this DH's executives, the foundation year was influenced by the public policies:

> *The plan was to open the company in 2010, but we anticipated it because of the CI-Brasil public notice that was offering incentive for private Brazilian DHs (CEO1).*

Its mission is to create products and solutions capable of optimizing self-sufficiency in the management of environmental energy harvesting, by developing high-performance, low-power integrated circuits. The company aims to become reference for promoting renewable energy in the semiconductor energy industry.

5.1.1.1 DH1: Operational Processes

As a design house, the initial mission of this startup was to develop a portfolio of customized projects and services including consulting services, ranging from feasibility studies through the initial production stages of a new chip. It delivers analysis, requirements, IC specification, implementation, including verification, prototyping, validation of electrical parameters and robustness, final test development and field tests of ICs. The DH faced difficulties and weaknesses to maintain the preliminary strategic focus.

> *We have been working with services since the beginning of the business. We know that it is not sustainable for the long term. We do not have a regular demand, and each project has a long lead-time. We also have few companies in Brazil buying this type of service. We are proud about the service we deliver, but we do not have enough demand to sustain our business. We have tried to sell our services to foreign companies, but we compete directly with India, China and Eastern Europe that are more competitive in terms of cost (CTO1).*

So, the difficulties to supply domestic customers, related to the shortage of companies that invest in R&D in Brazil, the difficulties to operate for the international market, related to the low competitiveness in terms of price, and the difficulties to seek founding to invest in

service in Brazil led the company to review its own operational strategy. The company's main strategic focus became a combination of services and products. Regarding this perspective of products, the company operates as a fabless[1], without investments in manufacturing facilities. According to the CEO, the main strategy is to develop the product, keep the intellectual property, invest in project infrastructure and commercialize the products. The CTO reinforces that this business model depends not only on technical issues but also on capabilities to develop suppliers to manufacture and assembly the products.

To foster the product strategy and the fabless business model, the research and development resources are oriented in three directions: market analysis to identify opportunities, structuration of an engineering team focused on product development, and the identification of funds to finance the product development.

> *We have made all this market analysis, but we would prefer to start the development process to attend a specific demand of customers. We have industrial policy, but it is not clear what are the problems and the market demand that we should cover (CEO1).*

The company keeps the same group of engineers working in the development of products and in the development of services. However, according to the CEO, gradually the group is focusing more on products. This is the company's priority for growing and the company does not have resources to keep two different teams. The team of engineers is supported especially by the CI-Brasil program that offers scholarships from CNPq. The company recognizes that scholarship is not the best mechanism to work with such a specialized team. This is what the government offers as part of the industrial policy and the company does not have resources to hire and bear all labor and legal obligations.

> *There is a risk. We have good and skilled professionals, but we cannot offer guarantees to keep them for a long time in the company. It is the wrong mechanism, but it is what is possible to do at this moment (CEO1).*

Developing and launching a microchip in the market involves a high level of investment. The company does not have enough guarantees to offer to banks. So, it requires a great effort to search for different kinds of public and private funds to finance specific

[1] Fabless is a business model. The company accomplishes the conception and customer services activities and outsources the front and back-end. They own the brand, the market and the product and do not invest in manufacturing infrastructure (GUTIERREZ; MENDES, 2009)

activities of the development product process. According to the CTO, this great effort to seek for different sources of funding also reflects in the efficiency of the product cycle:

> *We spend a lot of time focusing on the financial part, raising funds. Part comes from CNPq, part from FINEP, a little from the Foundation and CRIATEC. If we could have access to a single resource, that concentrates all of the investments, it would be easier to only manage and focus on the product and how to put it on the market. That would allow us to be more efficient (CTO1).*

5.1.1.2 DH1: Supply Processes

To operate as a fabless, it is necessary to search for suppliers that can accomplish all the manufacturing activities. The company needs to develop suppliers to outsource the main value activities that involve production infrastructures to manufacture (front-end), package and test (back-end) the microchips. According to the project leader, the choice of the factories and suppliers is closely linked to the project. Although there are companies in Brazil working with these activities, they cannot meet all national demands, both because of technological and capacity constraints.

> *We do not have in Brazil a company that can offer the type of services our chip needs. On the other hand, our volumes are not attractive for a national company to develop a specific assembly line to attend our needs. The companies abroad are more flexible and work with different technologies and smaller batches, attending different companies with more competitive prices (CTO1).*

It was not easy for young Brazilian companies to develop suppliers globally. The CTO commented that Brazil is not seen as a country with capabilities to supply technology for the semiconductor industry. The government has promoted some events to approximate the Brazilian companies to international suppliers, but those are very specific actions. To negotiate with those global players, the CTO told that they were received sometimes with surprise, skepticism or even curiosity. However, there are, in the global industry, companies that have consistent manufacturing process, interested in meeting the demands of startups and smaller DHs. The main element used for trading was the cutting edge of technology developed by this DH.

> *At the end, when they understood the product that we are developing, that it is really at the forefront of technology to solve global problems and linked with the*

> *internet of things, sensors and those global demands, they became interested in negotiating (CTO1).*

One of the greatest mistakes made by the company was related to the outsource process development. Their main supplier went bankrupt in the middle of the product development process. For this kind of operation, it is necessary to choose the supplier before starting the development process, because the company has to work under the supplier library technology.

> *It was painful. The first factory we hired went bankrupt exactly when we made the first production order. We had spent almost two years working under their technology. In this industry, the product is completely dependent on the technological supplier choice. The product was supposed to be on the market two years ago. Imagine the chaos. The supplier is a very serious problem (CEO1).*

After this experience, the company improved the supplier qualification process, including new elements of analyses, such as ranking the best companies in the industry, market operation, economic and financial report analysis.

According to the interviewees, there is one important restriction of the fabless model that needs to be considered. Nowadays, the national industrial policy does not recognize the fabless operation as a priority in its guidelines. So, there is no incentive for all this efforts of outsourcing the manufacturing activities abroad.

> *The PADIS does not have tax incentives for a fabless operation. We have to pay all the taxes to contract the services with the global players, what increases the costs in a noncompetitive way. To bring the product back, we have to pay the same taxes that some foreign competitor would pay to bring its product to Brazil (CTO1).*

5.1.1.3 DH1: Market Processes

Considering that the long term strategy is focused on products, the following challenge is to prospect demand and distribution channels. In terms of products, the company did not start with a specific demand for a customer. It was motivated by a market analysis and a business plan. They do not consider this the best strategy, but it was the opportunity they had to start:

> *The best would be to begin with a demand of a customer, and then develop the supply chain. All this development process has a high cost, and nobody pays for that. Fortunately, we are confident that we are investing in a promising solution to the market* (CEO1).

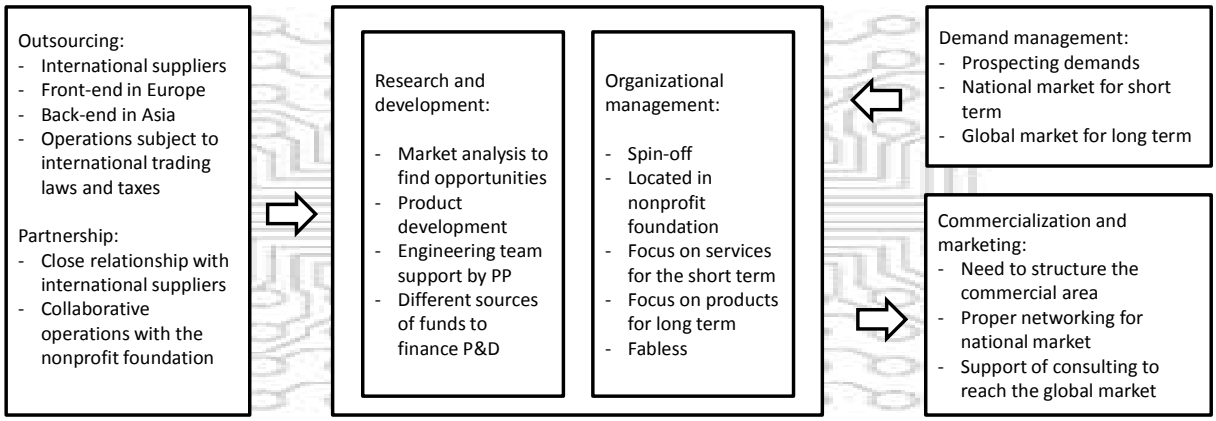
Once the development product process is under completion, the next challenge lies on the marketing and sales processes. The product is receiving some adjustments and the company is preparing all the instructions and documentation necessary for the specifications. The supply chain is set to process the first orders. However, the DH still needs to sign the first contracts to consolidate the product strategy:

> *We are prospecting, but we do not have order yet. The challenge now is in charge of the executives. I believe that, after we have the first order and the product running in some customers, it will be easier to expand market and consolidate the product (PLR1).*

The DH is developing its structure for the commercial area. According to the CTO, there is no public incentive for marketing and commercialization. So, the company is using its own resources to sell the products. The foundations support with its commercialization and communication area.

Figure 15 presents the main elements identified for the supply chain processes in DH1. The case's description demonstrates maturity in terms of organizational, research and development, and outsourcing processes. Market processes are still in progress and represent the next step and challenge of this DH, both to seek national and global customers.

Figure 15 - Map of DH1 supply chain processes



Source: The author

5.1.2 Case 2: A Nonprofit Organization

The second case concerns a nonprofit design house (DH2). It is linked to a research foundation of a public university and began its activities in July 2009 under the CI-Brasil program.

> *We have been using the benefits of the CI-Brasil program since the first version. The scholarships and the software provided by CI-Brasil allowed us to develop our operational structure (CEO2).*

Its objective is the design of integrated circuits from specification to prototyping and manufacturing of the chip. Beyond engineering services, this DH has developed a 100% Brazilian microcontroller. In partnership with the university and private companies, this DH aims to turn possible the political initiative of the federal government to spread the development of nanotechnology and capabilities of Brazil in the microelectronic market.

5.1.2.1 DH2: Operational Processes

The main characteristic of this DH is the fact that it is a nonprofit organization. It emerged as a linked project of a foundation in a public university attending demands of engineering services. As a nonprofit organization, this DH is able to use the whole package of benefits of the CI-Brasil program.

> *Since we are a nonprofit organization, besides the benefits of scholarships to hire engineers, we also have the access to software licenses for integrated circuits development (CTO2).*

According to the CTO, the fact of being part of the foundation allows the DH to use physical structure, laboratories and the purchase system of the university that has tax incentives in international trade. This organizational ownership also presents barriers that create some constraints in terms of bureaucracy and limit some entrepreneurial initiatives:

> *We are subject to some bureaucracies of accountability, which increases the time of development of our projects (PRL2).*

> *We have to be linked to some project, and it is not possible to structure a sales area and commercialize products or services (CTO2).*

Originally, the company was created with focus on engineering services to support the foundation projects. Now, it mixed its portfolio focusing on services and product development. DH2 does not see opportunities for growing with a strategy based on services. They argue that there is no national market and they do not have capabilities to compete with foreign design centers for the global market. The services are sustaining the business, but the long-term strategy is based on products.

> *The intention since the beginning was to work with products and operate as a fabless. To work with product development, prototype, control the manufacturing and generate intellectual property and royalties. Engineering services was a beginning opportunity (CEO2).*

Regardless of this decision, both the CEO and the CTO affirm that the main restriction to focus on products is the fact that there are no incentives in national industrial policy to operate as a fabless.

> *The PADIS, for example, has taxes incentives for front-end and back-end manufacturing activities. To commercialize a product using a fabless model, I have to outsource all these activities abroad. Nowadays, there is a high tax burden involved on those transactions that affect the final cost (CEO2).*

Since the beginning, the company had a clear idea of the product they should develop. According to the project leader, the necessity of the product came from a specific customer's need. This condition avoided an intensive market analysis, and the company concentrated energy in the product development, seeking funds and sourcing of suppliers.

While operating as a fabless, one of the challenges is to seek funds to finance the product development. The characteristic of this business model is that customers pay for products, not for projects.

> *There is not enough specific fund to support all the costs involved in a microchip development. So, we had to compose different projects to use the resources of different public funds, such as FINEP, CNPq and Sibratec (CEO2).*

The company has no access to private venture capital and the national companies do not have the culture to invest in research and development.

> *Our second customer is investing in the project, but with a participation of only 10%. We are still deeply dependent on the government (CEO2).*

When asked about the innovations issues involved in the process:

> *Our product is innovative, because there is market opportunity. In addition, the process was innovative because we developed it with a low cost compared to the market average. The product architecture has generated a patent (CEO2).*

Another challenge is how to retain all the engineers if most of them receive scholarships. The CTO comments that nobody develops a career with scholarship. This situation will only change with the success in commercializing the products.

5.1.2.2 DH2: Supply Processes

The main effort related to supply processes was the development of the international networking to outsource the manufacturing activities to prototype and prepare the engineering batch of the product. According to the CEO, the need for international suppliers was because of the absence of national ones to attend their specific needs in terms of technology and volume.

> *In order to use the benefits of PADIS, it would be important to have manufacturing activities processed in the country. I am dealing with a national supplier, but he argues that our volumes do not justify investments in technology needed to produce it (CEO2).*

They hired a foreign company that was interested in the Brazilian market and could work with low volumes:

> *We are dealing with global players. We are learning how to do that. Our main supplier is a German company, with a factory in Asia, and we are dealing with its office in the USA (CTO2).*

The market is pressuring for cost reduction. Since the DH does not produce, the only alternative for cost reduction is on the negotiation with those suppliers. For the mass production batches, the company needs two different suppliers: one for front-end and the other for back-end. To avoid paying importation taxes twice, they decided to hire one company that will be responsible for executing the front-end and subcontract the back-end to deliver to final product. This is the alternative they found to have only one contract and pay all the taxes only once. Considering that there are no specific rules to support the fabless

model, they are subject to the international trading tax burden. They have an intensive and long-term relationship with the international suppliers and it is considered collaborative:

> *We have a very good and collaborative relationship with the supplier. They are very interested in the Brazilian market (PLR2).*

In terms of partnership, the company detached some situations about DH3 (the third case of this study), one customer and a national start up. DH3 is developing part of the product, thus, according to the CEO, the product belongs to both companies. In addition, one of the customers is considered a partner because it is financing part of the product development. The CTO poses that it is an initiative of private funding and the company provided 10% of the amount of the money invested in one of the products. Also, the national startup developed part of the product. According to the CTO and the CEO, there is a possibility that this company pays royalties to commercialize the product; they are still studying this alternative.

5.1.2.3 DH2: Market Processes

Nowadays, the demand management is oriented to specific customers' needs. The first customer came with the necessity and the company had the technology and interest to develop and produce the microchip.

> *The product emerged from a customer need, and we are a small company with a flexible team capable to focus on different demands (PRL2).*

The CEO poses that, for this kind of market, only high production scales justify all the investments:

> *There is a great pressure for low costs. For this specific product, there is a demand for 1 million of chips. So, it is the moment to prospect new demands of new customers (CEO2).*

Considering that the product can be used in applications of different customers and the supply chain has a long lead time, the CTO reinforces the need for a demand forecast procedure. He argues that the international production logistics is long and the customs

procedures in Brazil are not as efficient as this industry needs, what will lead the company to work with stocks. When asked about national or global market:

> *We will focus and consolidate our product in the national market. There is a local demand. Once we achieve maturity, we can think and look for the global market (CTO2).*

According to the CTO, now that the product is developed and prototyped and the supply chain is structured, the DH needs to concentrate efforts to find alternatives for mass production and commercialization.

> *For the next months, I will be dealing with private companies and public institutions to raise funds to finance productive batches. We did our part as a DH, we developed a microchip, with low cost and marketable (CEO2).*

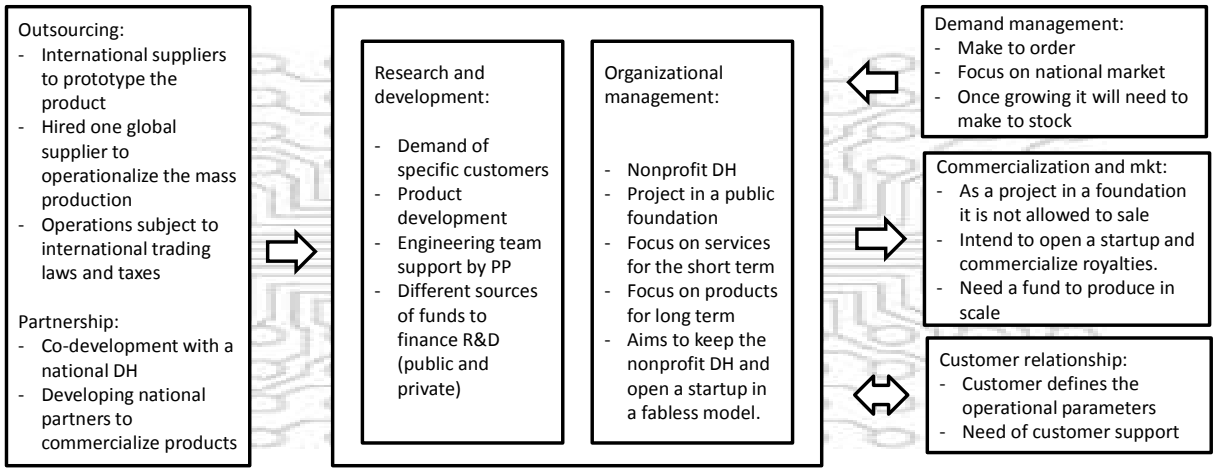
For commercialization, the interviewees mentioned some possible alternatives such as to create a startup and to license royalties. Anyway, it will be important to have the recognition and fiscal support from the government for the fabless model.

According to the CEO, an element is still missing and will be fundamental to start the product commercialization.

> *Once we commercialize the first batch, it will be important to have a support for technical and operational issues in the customer applications. We are also looking for this solution jointly with the alternatives for commercialization (CEO2).*

Figure 16 presents the main elements identified for the supply chain processes in DH2. The case's description demonstrates maturity in terms of organizational, research and development, outsourcing and demand management processes. Commercialization and marketing processes are still incipient in DH2 once it operates as a project in a nonprofit organization.

Figure 16 - Map of DH2 supply chain processes



Source: The author

5.1.3 Case 3: A Private Design Center

The third case concerns a private design house (DH3) that began activities in 2008 under the CI-Brasil program. This program announcement focused on private design centers and it was the main driver for the opening of this company.

> *The program encouraged the opening of our business, because it was necessary to have a company to use the resources. We used those resources for four years and we have signed a contract with CNPq for new resources by 2016 (CEO3).*

It is a startup with focus on the development of an IP portfolio with silicon-proven status. Its IP's architectures allow higher level of customization together with high portability, providing unique level of freedom on customer design requirements. According to the CTO, the company's current operational strategy follows the model of a design center as foreseen by the CI-Brasil program, delivering engineering services and IPs, which is an intermediary between service and product.

5.1.3.1 DH3: Operational Processes

In order to begin its operations, this DH used the benefits of scholarships offered by CI-Brasil and set up its structure within an incubator for technology-based companies. Nowadays, the DH has finished its period of incubation and it is already able to afford its own

structure. The scholarships are still important to subsidize part of the engineers hired by DH3. The previous professional experiences of the founders have driven the business plan of this DH. Both the CTO and CEO have international experience and they have worked and researched with successful global players.

> *We have worked, studied and researched abroad. This period was important because we have developed the networking to start our operation (CEO3).*

> *This experience abroad was fundamental for the definition of the focus of our business (CTO3).*

According to the CEO, DH3 started the activities with some services and consulting activities to sustain the business, but the focus was to develop an IP library. It is accompanied by close and flexible support for IDM, pure play foundries and fabless companies worldwide. It also has a complementary services portfolio that includes studies and design of analog circuit blocks to ASIC development solutions and consulting services.

> *Since the beginning, we were looking for the international market. The advantage of IPs for us is the fact that we have the possibility to commercialize one IP for different customers. In fact, a portfolio of IPs is a portfolio of products* (CTO3).

The DH is in a moment in which it has to make new decisions and reformulate the strategic business plan if it wants to achieve superior levels of sales.

> *We believe that, if we want to continue growing and have considerable improvements in terms of incomes, we will have to think in a microchip development and commercialize products (CEO3).*

Both the CEO and CTO believe that this will be an important decision and they are not prepared to make it now. It will involve more analysis and internal discussions, especially because it implies in the adoption of a fabless model and there are no clear governmental benefits for this kind of operation.

The use of an IP is only justified if it is integrated to the functionality of a microchip. So, the objective of the engineering team is to seek the IP feasibility, working closely with the customers. The CEO’s position is that IP brings more results for DH in terms of incomes.

> *An IP can be reused. This is not the case of a pure engineering service. I believe all the DHs should work on this model.* I could say that an IP can be a service on the shelf. Nowadays, we have about 140 IPs on our shelf (CTO3).

The company uses the benefits of PADIS in order to finance its own R&D. In order to use the benefits of this law, 5% of all income has to be invested in R&D.

> *As R&D is the nature of our operation, we are able to invest internally the limit of 4% required by the law* (CTO3).

5.1.3.2 DH3: Supply Processes

The DH outsources all the manufacturing activities needed to develop the IPs and to guarantee their quality and functionality in the customer's product. According to the project leader, they have different relationship and contracts with different suppliers. Most of them are international suppliers. DH3 works with foundries to manufacture the chip, companies to package and test houses to ensure the operability of products.

> *We are working with international suppliers because there are no foundries operating in Brazil. There are companies with back-end capacity in Brazil, but they do not work with the technology and low volume we need (PLR3).*

It is important to work with companies that operate with low volumes and are flexible to negotiate costs. DH3 searched for suppliers that were interested in dealing with Brazilian companies.

Seeking for international players is part of the semiconductor industry. However, the CTO argues that it would be easier if there were suppliers in Brazil. It would not involve international trade, especially for prototyping, reducing the design costs. In some specific cases, it is possible to outsource packaging activities to some Brazilian CTIs. As they are nonprofit organizations, there are opportunities to negotiate lower costs.

In terms of partnership, DH3 points out the relationship with suppliers, customers and other national design houses. The relationship with suppliers and customers can be considered part purely commercial and part collaborative.

> *It takes time to develop a good partnership. Because of our previous experience, we had our networking. However, it is different when you look for those*

> *companies as new and small company. We had to build trust and credibility (CEO3).*

When they start to develop their process of research, development and supplier sourcing, the decision was to look for companies of the same size.

> *Dealing with smaller companies allowed us to have a balanced relationship, with similar bargain power. To this day, we keep a good business relationship with them. Nowadays, we are more experienced and confident to deal with bigger players, both suppliers and customers (CTO3).*

DH3 also highlights the importance to cooperate with other national DHs. They believe that working in partnership with other DHs represents opportunity to add up different expertise and reinforce the design activity in the national industry. They have already developed IPs to projects carried out by DH1 and DH2.

> *We are co-developing a product with DH2. Both of us have different expertise and responsibilities in the project (PLR3).*

The possibility to produce and sell this product in scale may open opportunities to start thinking about upgrading from services to products and accomplish the plans to move up from a design house to a fabless.

5.1.3.3 DH3: Market Processes

The initial challenge would be how to develop sales channels for their services. Since the beginning, the DH understood that, to grow in this industry, they should seek both domestic and global market. In order to develop their sales plan, DH3 highlights two elements that helped it to foster the commercial area: networking and incubator assistance.

The previous professional experiences of the CEO and CTO helped DH3 in the commercialization process. The incubator offered assistance to help the company to develop commercial capabilities.

> *All the incubators have this type of service. With this service, I understood how to develop a plan to present the potential of our business. Even being a small company, it is necessary to show self-confidence and know how to sell the gains and benefits of the products and services (CEO3).*

The CTO reinforced that it is not easy to commercialize projects and ideas when the company has no tradition in the market. So, even nowadays, the involvement of the founders in marketing and sales processes is important:

> *We have tried the experience of hiring a consultant to work with the international market. It was not a good experience. We spent money with no results. We believe that in our case it is important to understand the technologies and characteristics of our business (CTO3).*

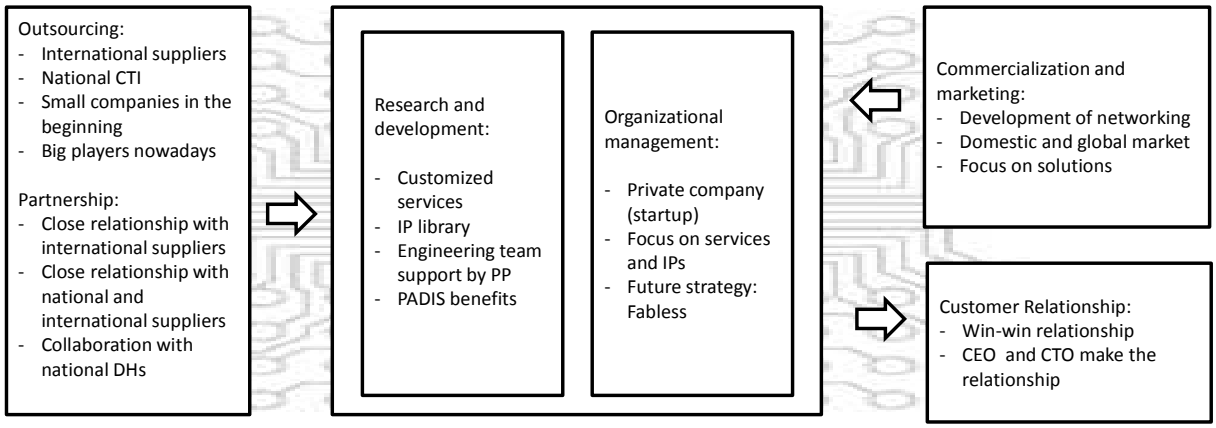
They reached maturity and recognition of its business model. Next challenges will come with business growth. If the companies migrate to the product development strategy and operation as a fabless, a new marketing and sales structure will have to be defined.

DH3 attributes its advancement in the commercial area to the close relationship it keeps with its customers. The first IPs were developed in a win-win relationship.

> *The customer financed the IP development and, in exchange, we provided an IP with the specific characteristics needed by the customer. This process gave us expertise and confidence to deal with big players in the global market (CTO3).*

Figure 17 shows the main elements identified for the supply chain processes in DH3. Operating as an IP provider, this DH presents maturity in all supply processes. It has capability to develop, outsource the manufacturing activities and commercialize the IP library. The challenge will come if this DH decides to change from IP solutions to microchips. This DH considers this perspective as future strategy for growing.

Figure 17 - Map of DH3 supply chain processes



Source: The author

5.1.4 Case 4: A State-owned Company

The fourth case concerns a state-owned design center (DH4). This company was founded in 2008 and works with the development and production of integrated circuits to RFID (radio frequency identification) and specifics applications. Its design center employs more than 120 engineers and it is part of the CI-Brasil program. This company plays a strategic role in developing the microelectronics industry in Brazil and part of its mission is to develop people to the semiconductor industry in Brazil and contribute to fulfill the strategic necessities of integrated circuits of the state. The investments to this company's implementations were around R$ 500 million.

> *We should carry out projects to support the development of other companies and design centers of the Microelectronics National Program, especially with our manufacturing capacity. We cannot lose this guideline (CEO4).*

It has a design center and a factory that are unique in South America, as it is able to produce semiconductors (chips) on a commercial scale. It operates with conception, prototyping and validation of ICs, manufacturing, sale and microelectronic solutions based on these circuits.

5.1.4.1 DH4: Operational Processes

It was originally created as an IDM, with all the main value activities of the semiconductor chain. According to the CEO, in the beginning it was important to invest in a factory to create capabilities, train people and start fostering the industry. The factory should contribute to fulfill the strategic necessities of national industry supported by federal investments.

> *In this industry, the investments are so high that, compared to the global standard, this company can be seen as a startup. The return on those investments is not in short term. We are a young company with only 5 or 6 years of operation. We are still newcomers in this industry (PLR4).*

Since the foundation, the company has been working to find its identity. It has found some difficulties, especially in terms of using and updating its capacity and manufacturing technology. According to the CEO, nowadays they can better understand the semiconductor

value chain activities and choose the ones with whom they have competence and opportunities to operate.

> *We needed to rethink this model. Some national regulations that would foster the beginning factory strategy did not work as expected. Higher investments would be necessary to keep the front-end updated (CEO4).*

In order to consolidate its business model, the company decided to promote the design center as the core business competence, to outsource the microchip manufacturing to foreign foundries, to invest in infrastructure for back-end operations and focus on the commercialization of products. The front-end capacity is not following the company's growing neither regarding to its capacity nor regarding to its technology.

Nowadays, the front-end is in technological transfer. The interviewees argue that keeping it updated according to the companies needs would involve a high-level investment.

> *We have a specific technology. Our front-end is used only for part of our products. Most of our needs are supported by global foundries (CEO4).*

According to the interviewees, this new strategic model put the company in a consolidation process. During the last year, the production and sales achieved around 15 million of products. This growth was based on the consolidation of old projects. With this volume, they are using all the capacity of its design center and back-end. With the consolidation in progress, they have plans to upgrade this capacity. The CEO believes that fabless is the best way to classify this business model. It is not so clear, because they still use their own back-end capacity to process the products.

The CTO argues that the company is still learning how to penetrate in the market and the manufacturing facility is growing only in the back-end activities. The back-end facility is now certificated by ISO, which means that they have standards of quality and repeatability. The CTO also says that, without this internal activity, the company could not be competitive.

> *Outsourcing all the manufacturing would increase the cost, not only because of the service prices but also because of the international trading taxes. Technically, it is possible, but not economically. Because we add value in the product through our back-end facility, we can use the full benefits of PADIS. Now, we are studying how to use our front-end capacity and technology (CTO4).*

In relation to the company's characteristics, the CEO commented about some aspects in its institutional model that create some barriers.

> *We are dependent of contests to hire people and there is the law 8.666 for acquisitions. As a state-owned company, we have to learn how to deal with this scenario. It is important to say that more flexibility in these two items would have great impact in our efficiency. Efficiency is something important when dealing in the semiconductor supply chain (CEO4).*

The strategic goal is to develop products to the market, but they are still designing customized services to some specific and strategic customers.

> *As we are working with the fabless logic, we are first looking to the market and searching for opportunities to develop our products. We also develop based on specific demands of specific customers. Normally, it happens with strategic business and customers. Even in these cases, we try to keep the intellectual property. The objective is to migrate only to products. We want to be more a fabless and less a DH (CEO4).*

5.1.4.2 DH4: Supply Processes

The current strategic focus of this company is to build expertise and infrastructure in design and back-end. The decision was to stop investing in front-end and outsource the wafer manufacturing. The company is working with different global suppliers, according to their needs and convenience.

> *We are not linked or dependent of a single supplier. We use the supplier whose technology, delivery time, quality and costs fit to a specific project (PLR4).*

The interviewees argue that it was not easy for a new company, operating in Brazil, with low volumes, to deal with global foundries. The company had to learn how to approach those companies. So, the negotiation could not be based on volumes. They used promise of higher demand, a new market, but they specially used the endorsement of the Brazilian government.

> *Considering the fact that we are a state-owned company, we can work with cooperation between states (nations). In this way, the government can open doors and we gain credibility because we are supported by the Brazilian government. The fact that we have an industrial policy for the sector attracts interests. Without*

> *that, they would runway. It gives guarantee and perspective of potential market (CEO4).*

The company keeps some partner relationship with some customers. It is related to specific projects in which the production and sales are linked to the customers' demands.

5.1.4.3 DH4: Market Processes

The department of products and business is responsible for searching and defining opportunities in the market. This market definition is important as facilitator to the commercial initiatives. According to the CEO, once they define the product and market, the demand is prospected in parallel with the product development:

> *In our case, the number of tablets or smartphones consumed in the national market does not make sense to prospect demands and opportunities. There are no investments in research and development for this area in Brazil. We decided to invest in products related to the internet of things, RFID, traceability, logistics, identification, etc. This area can generate demands and sales that can really impact on trade balance. It will also generate volume to leverage the company as an important player in the market (CTO4).*

Only part of the demand depends on government programs and regulations.

> *In this case, we depend on the success of those programs. That is why we are expanding our demand prospection into private company to consolidate the fabless model (CEO4).*

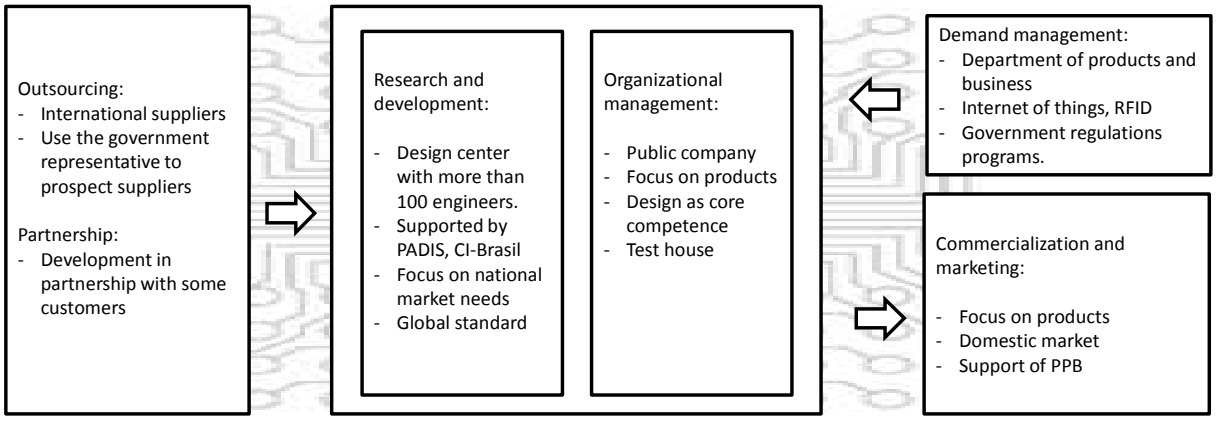
The product and business department is also responsible for sales. The focus for marketing and sales is the national market. According to the project leader, there are some studies for moving to the global market, but the current plan is to consolidate their operation in the domestic market. The CTO poses that companies from Mercosul may be the first international prospects. Short cultural differences and distance are elements conducive to begin negotiations.

The law called PPB (Basic Productive Process) is very important for the recovery of their products. Through the PPB, there is valorization of national content. However, the CTO comments that the criteria are not so clear.

> *I recognize the importance, but we need improvements in the PPB process to guarantee more market penetration. It makes difference for us and for all national companies (CTO4).*

Figure 18 shows the main elements identified for the supply chain processes in DH4. Because of the federal investment, this DH presents maturity in all supply processes. It has capability to develop, outsource the manufacturing activities and commercialize products. The DH recognizes that is still in consolidation, and the next challenge will come with growing strategy based product development.

Figure 18 - Map of DH4 supply chain processes



Source: The author

The item 5.1 presented the trajectory, challenges and achievements of four different Brazilian DHs. All companies were created around the same time, motivated by the same public policies; however, they presented different results and levels of maturity that brought some elements for the evaluation of these research objectives. Thus, next sections develop this evaluation based on global supply chain operation, the impact of the public policies in the capabilities' generation, the development of global supply chain capabilities, and the upgrading level.

5.2 The DHs' global supply chain features

It is important to understand the reasons that are leading the national DHs to face the challenges to operate in global chain and how they are developing capabilities to deal and integrate their operations with different companies, from different countries, languages and cultures, and different economic and technological level. The four cases' descriptions

highlight the efforts of those companies to establish agreements and achieve quality and performance standards to operate as a player in the semiconductor global chain. It possible to separate those efforts according to the characteristics of the product, the relationship with global supplier and the relationship with global market, as follows.

- Product Characteristics

DH1: The company chose product instead of services because of the difficulties to negotiate services contracts with the global market. The argument is that the market for engineering services in Brazil is very restrict with scarcity of public and private funds for investment in services development. There are few investments in research and development in Brazil. The market analysis and the business plan considered that the possibility of growing should be the development of a product to attend the necessities of the global market. In this way, the product development had to reach international parameters in terms of functionality and costs.

DH2: Even considering that the company's focus is the domestic market, the product meets international standards. The DH presents two main arguments for this affirmation. The first is that, in the semiconductor industry, all the operational features need to follow global characteristics. A DH customer can be domestic, but the microchip is a component of electro-electronic devices, which is an intensive global industry. Those global players are distributing their products globally. The second argument is that only the domestic demand will not be enough for the company's growth. So, once they consolidate the national market, they will develop a plan to prospect global customers.

DH3: The choice for the development of IP was important for the global strategy of this DH. The IP is midway between product and service. It can be considered a service because it supports some customer product development, but it also gives the company the possibility to have something ready for commercialization. The IP enabled DH3 to work in partnership and with financial resources of some customers and focused on the global market.

DH4: Although the company's focus is the domestic market, its products fit global efficiency and operational standards. They are focusing on RFID solutions with global protocols for connectivity. Global standard is a characteristic of the products in this area, and the company recognizes that it can generate opportunities to achieve the global market in future growing strategies.

It terms of products characteristics, the four DHs had to develop products following global standards, even if the focus is the national market.

- Relationship with Global Suppliers

DH1: The choice for not investing in manufacturing infrastructure, the adoption of the fabless model, and the absence of national suppliers led the company to develop an international supply chain. Even though it was in the position of a client, it was necessary to demonstrate the potential of the product to attract the interest of suppliers. The long term relationship established in this global chain requires investments of both buyer and supplier. Only a product with potential of market adherence and scaled production would justify such investments. The hiring of the global company to support the search and qualification of international suppliers also demonstrate this DH's effort to advance in the global chain.

DH2: To operate as a fabless and to use the national incentives of national laws, it would be necessary to accomplish manufacturing activities in the country. The fact of the absence of companies in Brazil has forced the company to develop suppliers globally. DH2 established contracts with companies that are able to work with lower volumes and are interested in the national market. Those companies have idle capacity in their production systems, which gave DH2 opportunities for negotiation in terms of deadlines and costs. DH2 also made a contract with a global trader that will operate with all the subcontracting abroad. Otherwise, the DH could incur double taxation to bring the product and send it back for the following manufacturing activities.

DH3: Considering that DH3 needs to outsource front-end and back-end activities, and these services are not available in the country, the alternative was to search for global suppliers. In order to prototype the IPs and guarantee the functionality and efficiency, they had to hire wafer production, packaging and testing. This DH argues that, even being a small company, it is possible to find suppliers because those companies are interested in the Brazilian market and they have idle capacity. For this kind of company, it is important to keep high utilization of resources and productivity.

DH4: This company was originally built to operate as IDM, with capacity to process all the main value activities to produce a microchip. The decision to stop investing in the factory led the company to the need of searching for foundries to outsource the front-end activities. Because of the absence of suppliers in Brazil, the company has been dealing with

global players. It has different suppliers in different countries selected according to the specificity of each product.

In terms of relationship with suppliers, the four DHs had to develop global suppliers to outsource manufacturing activities.

- Relationship with Global Market

DH1: Although it is still at an early stage, DH1 is prospecting global customers. The business plan will only be consolidated with scaled production and distribution to the global market. Another important action that can be identified as a global supply chain initiative is the hiring of a company to support the approximation of this DH with potential customers located in the USA and Europe.

DH3: Since the beginning, DH3 was conscious that the potential for growing was in the prospection of the global market. The fact that the founders had previous international experience allowed them to deal with the first contracts. The strategy of this close relationship with international suppliers also helped the prospection of new contracts. DH3 recognizes the difficulties to deal with global players. For this reason, they have started with smaller companies to get confidence and advance in the market. Nowadays the company has contracts with big players in the global market.

In terms of relationship with market, only DH1 and DH3 are prospecting global customers. DH2 and DH3 are focusing only on national market.

Table 7 - Links of the national DHs with the semiconductor global chain

DHs' participation in the Global Supply Chain				
	DH1	**DH2**	**DH3**	**DH4**
Product features	Global standards	Global standards	Global standards	Global standards
Relationship with suppliers	Outsourcing front-end Outsourcing back-end	Outsourcing front-end Outsourcing back-end	Outsourcing front-end Outsourcing back-end	Outsourcing front-end
Relationship with customers	Prospecting global customers		Global customers	

Source: The author

The Brazilian DHs face what Christopher et al. (2006) pose as the challenge of today's global business, that is, to identify the appropriate supply chain solutions to meet the different needs of the different product/market characteristics. Globalizing the supply chain requires the development of good relationship across multiple cultures (MAYERS et al., 2007) and negotiation with global players who act as buyers and sellers of goods and services (MATTSSON, 2003). Table 7 presents those elements that demonstrate the DHs' participation in the semiconductor global supply chain. It is possible to evaluate this scenario within the semiconductor industry from elements such as the characteristics of the products and their international standards, the relationship with global suppliers to outsource production and market prospection for the achievement of global customers.

All the DHs have products with global standards, what seems to be a condition to operate in this industry. The microchip is not considered a final product; it is a component that integrates different kinds of electro-electronic products. According to EXE1, none of those products is developed to attend only national needs. EXE1 also argues that, if some company decides to focus on the national market in this industry, it will probably compete with some Chinese company. So, its characteristic needs to be designed to fit the operational requirements of products that, regardless of where they are produced, are distributed and used globally.

> *The products in the semiconductor industry are global. Even if a company intends to reach the domestic market, it will have to meet those global standards (PMK1).*

> *The semiconductors products are components of electro-electronic products. So, they need to have world-class operational standards. The microchip can be part of a notebook, a smartphone, a television, a car, etc. (EXE2).*

Another important perspective that shows the participation of companies in the global chain is the relationship with global suppliers. According to EXE1, considering the Brazilian current reality, the only alternative to prototype, produce, package and test the products designed by national DHs is outsourcing in the global market, especially if the national DHs intend to have products and operate as a fabless. FIN1 considers it a condition to operate in the global market, to invest in product development and outsource all the production.

> *I absolutely agree that we have to use the global chain and outsource activities of high complex technology and infrastructure needs. Nowadays, it is the only*

> *alternative. There are companies in the global market evaluated in billions of dollars that do not produce. They are focused only on design and they are associated with big players, like Toshiba, for example (EXE1).*

The national DHs are still immature in terms of technology and volumes to deal with global players to outsource their production. There are some companies in Brazil providing the service to put those DHs in touch with foreign suppliers, to access front-end, back-end, testing and logistics activities. According to EXE2, high investments are needed to have a foundry in Brazil, but there are risks, and it is expensive to outsource it abroad. The scenario is complex, with complex decisions, but there are some alternatives pointed out by the specialists:

> *Normally, small startups do not have this kind of contact. It is difficult, but there are solutions in the market through those kinds of brokers. And the costs are accessible to those startups (RES1).*

In relation to the market, the path for the national industry would be the achievement of global market. According to ODH1, the global market is 70 times bigger than the Brazilian one. So, he argues that the company cannot be satisfied with the national market. The challenge is to build strong companies and strong brands with global presence. Although there is an agreement in terms of the importance to prospect for global market, this is not the reality of Brazilian companies. National companies are still in a consolidation process, anchored in serving the domestic market. According to EXE1, exports are insignificant. He argues that national industry does not know its values, what can be offered in terms of solutions and products to attend global demands. The great players are looking for suppliers in Taiwan, India or USA; they do not see Brazilian companies as potential suppliers.

According to Mentzer et al. (2007b), the demands for mass customization, the pressure for time and high quality, and a strong dependence on government policies are leading companies to operate and deal with global players. It is the creation of what Connelly et al. (2013) call the globalization of demand and supply chain. Considering that the scope of a global chain is more complex in terms of mission, structure, infrastructure, capability, and design process (SHI; GREGORY, 1998), it is important to understand the reasons that motivate companies to assume all those risks and challenges. The Brazilian DHs are learning how to develop their strategic position in the global supply chain, which, according to Paulraj and Chen (2007), involves broad and complex interactions with global players. It also

involves multiple elements that are important to the characteristics of the semiconductor chain, such as long-term relationships, inter-firm communication, interorganizational teams for product development and buyer-supplier integration. The relationship between Brazilian companies and their suppliers are recent and still focused on buyer-supplier integration for product development. Maturity will come only with long-term relationships for mass production contracts.

5.3 The impact of public policies on DHs' supply chain capabilities

The Brazilian DHs are subject to a long list of issues that affect the configuration and managerial demands of the semiconductor supply chain. Considering the environmental conditions, Skjøtt-Larsen et al. (2007) pose that this list may include political and cultural issues, information and communication technology, legal systems, and labor markets. According to those authors, the regulatory developments and national policies are critical in the choice and prioritization of these elements for the industry upgrading. In this direction, Brazilian government is responsible for making strategic choices and composing public policies capable to affect the national semiconductor industry. It is what Murtha and Lenway (1994) call the governments' ability to implement industrial strategies. A link between the countries' political institutional structures is necessary in order to promote innovators' approaches to technological entrepreneurship and governments' technology policy orientations (MURTHA et al., 2001). Currently, public policies are affecting the DHs operation and influence capabilities' development in different supply chain processes. Even when the DHs present the difficulties faced in each process, the improvement suggestions and criticisms also fall on the setting of public policy incentives. According to Mentzer et al. (2007b), those are the opportunities to compose strategic planning able to identify the nature of the external environment, including domestic and global market, government and regulatory conditions, to foster a global strategy. The national DHs' supply chain processes impacted by the public policies are described below.

- Impact on Organizational Management

DH1: It is possible to verify that the Microelectronics National Program (PNM) motivated the opening of a company, through the launching of the CI-Brasil program. DH1 uses the scholarships provided by CI-Brasil to pay its technical staff, composed by engineers

trained in the national training centers. The choice for products for the long-term strategy is also consequence of the policies, once the company affirms that the public funding available in the market prioritizes products instead of services. The main criticism here is related specially to absence in the law of a support for the fabless operation model. The constitution of PADIS is based on taxes incentives for manufacturing. It is not the case of a fabless, which outsources all the manufacturing activities, focusing on product development, intellectual property, and market and commercialization. Even recognizing the importance of the scholarship as incentive, the DH believes it is questionable. DH1 argues that it works better for research institutions and less for private companies.

DH2: The ownership of DH2 demonstrates the impact of public policies in its organizational management processes. Operating as a project in a public university allows the DH to use and share infrastructures and resources of the university. Its projects and its image are also backed by the reputation of the university. As a nonprofit DH, it can also use all the benefits promoted by CI-Brasil. They can apply for scholarships to hire engineers that are prepared in the national training centers and receive software licenses for integrated circuit development. DH2 recognizes the importance of this program to support its engineering infrastructure. The DH's executives admit that CI-Brasil was the motivator to start this business. The company believes that it will be fundamental that the industrial policy recognizes the operation of the fabless model.

DH3: The opportunity for DH3's foundation came from the benefits promoted by the Microelectronics National Program. The scholarships offered by CI-Brasil program were essential because they represented an important subsidy to ensure skilled labor for the beginning of the company's operations. DH3 renewed with the program to extend the benefits up to 2016. The company attributes the first results to an alignment between CI-Brasil, the expertise of the founders in the microelectronic industry and the networking formed by their previous experience. Those elements turned possible the development of a consistent business plan.

DH4: The company's ownership reveals the influence of public policies in the structuration of its organizational processes. The Microelectronics National Program points out an investment of R$ 500 million to leverage this business. Its opening represented one of the main governmental initiatives to bring back the national semiconductor industry.

Even presenting different operational characteristics, the four DHs are dependent of public policies for their organizational process, especially considering the support of CI-Brasil benefits.

- Impact on Research and Development

DH1: The engineers are supported by the CI-Brasil program. The funds to finance the product development come from different public funds, such as CRIATEC, FINEP and CNPq. The main criticism here is the absence of private capital venture in Brazil. So, DH1 is strongly dependent of those financial resources. None of these funds recognizes the high investment involved in microchip development process and the production of the first batch for commercialization. Once again, DH2 attributes it to the fact of the absence of a policy with incentives to the fabless model.

DH2: The public policies affect the research and development in two different aspects. The first one is with the infrastructure. They use the benefits of scholarships and software of the CI-Brasil program. The executives recognize that this support is fundamental to execute the projects. The second element is related to the public funds that DH2 uses to finance the product development processes. They mentioned resources from CNPq, FINEP and Sibratec. Once there is not a specific fund to support all the development process of a microchip, they need to compose the amount of money into different projects. Up to then, only 10% of one product development investment came from a private venture capital.

DH3: DH3 characterizes research and development as its main operation. Nowadays, through the benefits of PADIS, this DH is able to reinvest the limit of 4% of its income in its own R&D activities. CI-Brasil is also important for this area, not only because of the scholarships but also because of the national training centers that are responsible for the training of engineers in microelectronic design. DH3 is in a moment in which it believes that the growth can be associated with a new strategy related to the product development. The main constraint for this strategy mentioned by the DH is the absence of benefits to a fabless operation and public funds to finance the product development.

DH4: Part of the money invested in the company was allocated to research and development structuration. The company also used all the benefits promoted by the Microelectronics National Program to encourage research, development and innovation. It is registered in the CI-Brasil program for the utilization of scholarship for engineers and it is able to reinvest part of the incomes according to PADIS’s benefits.

All DHs used the scholarships from CI-Brasil and hired the skilled engineers prepared by the national training centers to structure their research and development processes. They are also using different public funds to finance their products development.

- Impact on Outsourcing

DH4: The national microelectronics companies reported difficulties in dealing with global suppliers, especially for issues such as low volumes and low investments in R&D and lack of tradition of Brazilian semiconductor industry. In this case, this company used the fact of being state-owned to deal not in between companies, but in between nations. It gave the company more credibility among global players.

DH1, DH2 and DH3's respondents did not mention the support of public policies over their outsourcing activities.

- Impact on Marketing and Commercialization

DH1: This DH is enabled by PADIS to get tax exemption in services commercialization. It is very important to be competitive in terms of price. Once again, the problem is related to the development and commercialization of products that have a high burden of taxes, affecting the final price and reducing the competitiveness.

DH3: This DH participates of all the events promoted by the government to approximate the national DHs to potential customers. Despite not being dependent on these events to deal with customers, the DH recognizes the importance of its participation to enlarge the networking.

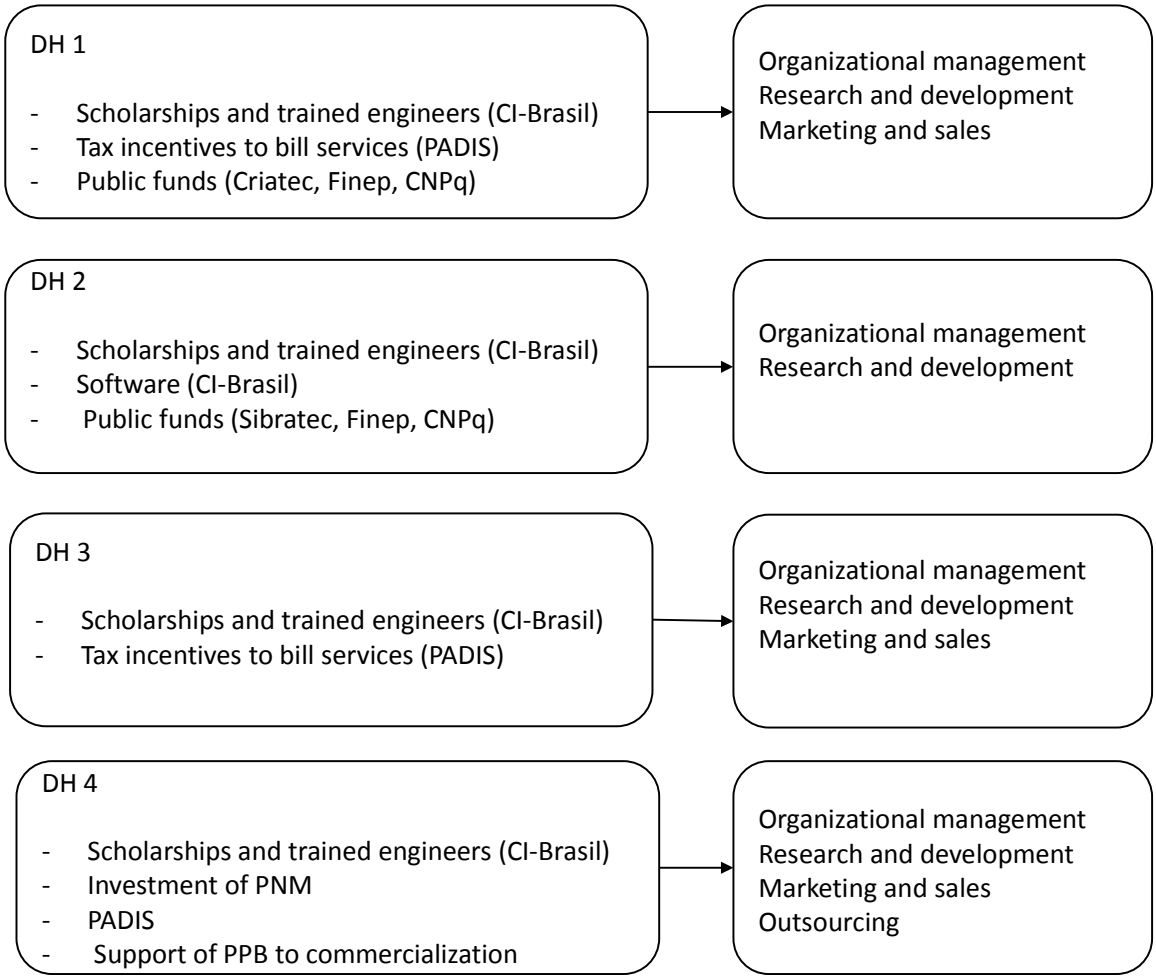
DH4: With the focus on national market, the valorization of the national content through PPB is an important support for the company's commercialization process.

Those three DHs' respondents did not emphasize the impact of public policies over marketing and sales. Anyway, they highlighted some different aspects. DH1 is not mentioned because it is still finding a solution for commercialization.

Figure 19 presents the public programs used by the DHs and the supply chain processes that are impacted by those policies. The figure describes only the processes that present some concrete benefits from the national policies. It shows that government possesses an important role in promoting a political economy infrastructure able to foster the development of new industries, entrepreneurship, innovation and trade conditions. Considering this scenarios, public policies represent an important environmental factor

(SANDERS, 2010) able to foster capabilities, attracting new businesses and investments to advances in global chains. Even presenting some restrictions, Brazilian public policies are formulated based on what Myers et al. (2007) call economic integration, with the reduction of barriers to improve services and factor of production.

Figure 19 - The impact of public policies on supply chain processes



Source: The author

The cases' analysis shows evidences that the main supply chain processes affected by the policies are still the operational ones. It is in accordance to the specialists' perception that mentioned that, during the last 10 years, the industrial policy was focused on creating opportunities to the foster companies. Organizational and R&D are the most impacted processes. DH1, DH2 and DH3 declared that CI-Brasil announcement was the motivator to start the business. In the case of DH2, it also had the free access to software for microchip

design. The scholarships paid by government and skilled labor prepared by the national training center allowed the structuration of those DHs. Despite the fact that DH4 is also enabled for CI-Brasil benefits, the impact of the public policies is specially related to the nature of its ownership. To structure this business, R$ 500 million were invested with the objective to foster productive capacity in the country. The result was the creation of the biggest national design center and a manufacturing capacity. Under those perspectives, the recovery of the Brazilian semiconductor industry is based on an industrial policy composed by different initiatives to leverage companies in the different value chain activities. The interviews made with the specialists cover the last 10 years of the PNM, with perceptions of how programs such as CI-Brasil, PADIS, PPB, the availability of funds, human resources and infrastructure have been managed to create the proper ecosystem to foster a national semiconductor industry with national companies capable to operate as players in the global chain.

According to FIN1, after 10 years, the results are still incipient and the national companies are completely dependent of public policies. So, it is not the moment to stop investing. He argues that it will take 20 or 30 years to get the first results. There is an agreement among the specialists that, during these years, good programs were created, but it gets to the moment to make a balance of the first results and review the strategic plans to improve results. Specialists point out many barriers in the PNM that should be evaluated to accelerate this industry growing, such as tax reduction, investment in research and innovation, market expansion, improvement of national infrastructure, incentive to the fabless model, attraction of foreign direct investment, etc.

FIN2 argues that there are a high number of projects and priority sectors in the Brazilian policy. With this lack of focus, it is difficult to attack all the barriers. There is certain criticism about the lack of management on investments and results of the programs:

> *There is a lack of people in the government with knowledge about the market and with technological and managerial skills to coordinate the programs (EXP2).*

> *The government is focused on the stimulation of new economies and sectors launching strategic programs. PADIS has more incentives than the majority of the national programs. It is an indication of how important PNM is. The Brazilian problem is not to create programs and laws, the difficulty is how to coordinate them (RES2).*

> *The government invested money to foster DHs, but it is not controlling and evaluating the results of these investments (EXP1).*
>
> *The government has to coordinate and align the policies to stimulate the areas with more demands to support the national companies (FIN2).*
>
> *There is not a plan to turn our national companies independent from the government. The incentives will not be available forever (ODH2).*

Data demonstrated the current focus of PNM lies on the microeconomic perspective of public policies. Programs such as CI-Brasil, PADIS and public funds are promoting national infrastructure and offering opportunities and benefits to foster and attract semiconductor companies to Brazil. Most of the shortcomings highlighted by both companies and specialists are related to the fact that PNM should also promote business transactions. This is what Mann (2012) mentions as macroeconomic perspective; policymakers should change the environment facing business to promote national and international trade and economic growth.

The CI-Brasil program has a clear purpose to foster design in Brazil. According to PMK2, the government decided to focus in this area because it involves lower risks and investments. CI-Brasil formed designers, generating nonprofit and profit companies that integrated design environment. In a DH, the highest value is on people, the designers. Twenty-two DHs started to operate under this program. Nonetheless, CI-Brasil presents some weaknesses:

> *Most of the DHs are linked to universities. It is disconnected of the industrial reality because there is not a focus on financial results. Most of the money went to the universities (ODH1).*

PADIS is another important mechanism of PNM. It gives a number of exemptions, both in the acquisition inputs and commercialization. RES2 reinforces that, in terms of tax exceptions, it is one of the best government programs. According to EXP1, it could not be different in Brazil, because it is exactly what countries such as Singapore, Germany and Korea do in the semiconductor industry. It was clearly developed to support manufacturing activities in Brazil. That is one of the reasons why there are only nine companies using its benefits, and few are qualified to use them fully. PMK1 reinforces that, if a DH intends to operate as a fabless and use benefits of PADIS, at least part of the manufacturing has to be accomplished in some national country.

Funding is another important instrument for the growing of the Brazilian DHs. According to EXP2, the industry is composed by medium and small companies, especially considering the DHs are startups and some are nonprofit organizations. It is a group of companies without capital for investments and without credit and guarantees to offer to the banks. FIN2 reinforces there is not a flexible financing system with the characteristics of this sector. Venture capital, that is common in technological cluster, is not available in Brazil.

> *We don't have venture capital available to hardware development, and the government instruments such as FINEP, CRIATEC and BNDES do not fit the semiconductor industry needs, especially for the ones that are investing in the fabless model (FIN2).*

Both the specialists and the companies pointed out the government responsibility for the continuing growth of the national industry and the consolidation of the DHs. They expect from the government more coordination of the programs, more intervention in terms of priorities and strategic growing drivers, improvement in infrastructures, more investments in R&D, attraction of global players, etc. Those perceptions allow the association of the public policies as the main external driver to foster capabilities to promote the national companies capabilities generation both in micro and macroeconomic perspectives.

5.4 DHs' global supply chain capabilities

This section evaluates how Brazilian DHs are developing capabilities that, according to Day (1994), represent key success factors to carry out in order to manage a business in a global chain. This study proposes that, to become a player in global chain, companies need to develop three different sets of those capabilities: productive, relational and innovative. Companies should focus on and invest in what is more critical in accordance to the contingencies of the market where they are operating. Bair (2005) reinforces that, especially in companies from emerging economies, to gain access to those different capabilities is fundamental seek competitiveness in the global chain.

- Productive Capabilities

DH1: The capability to produce according to international standards is clear in the description of this case. It is evident in the business plan made for the product strategy and the configuration of a fabless model to seek long-term and growing for global market. To prepare

the company for mass production, the international supply chain is also structured. The errors made during the outsourcing process and the support of companies to help with the international networking were part of the maturity acquired in terms of productive capability. The productive capabilities are still subject to some weaknesses. The company is still dependent of the scholarships offered by CI-Brasil to contract the engineers. According to the company, this situation must be changed with the consolidation of the business plan. The national environment is also not favorable to the implementation of those capabilities, especially in terms of tax reduction to support the international transactions, procedures to facilitate the nationalization of products, and access to specific fund to support the product development of the fabless model.

DH2: This nonprofit DH demonstrates capability to organize its productive structure to prospect customers, to develop a product according to international standards and to develop an international supply chain to outsource manufacturing. Even considering that the product was developed for specific customers, DH2 made a market analysis to guarantee that the same product technology could be commercialized to other customers. The international suppliers are ready to produce the first orders. The company also considers that the team of engineers is composed by flexible and efficient people, capable to adapt the products according to the customers' demands.

DH3: This DH possesses the infrastructure to support its current business model, which includes engineering services and IPs. The company structured its operational capacity to attend international standards, considering that its focus is the global market. In order to develop the IP library, DH3 also structured a net of supplier to outsource the manufacturing activities. The company has also a team of engineers with flexibility to work in different projects and to co-work with customers and partners.

DH4: After redefining the strategic focus in 2011 and with the increase in sales volume in 2014, the company began the process of consolidation. It has a design center with more than 100 engineers and back-end facility certificated by ISO. The company has also developed expertise to outsource its front-end, once the decision was to stop investing in its factory. The infrastructure and international supplier detach a good level of productive capabilities development.

All DHs developed services, products and infrastructure with global standard to operate and compete in the semiconductor global chains. It characterizes maturity in terms of productive capabilities.

- Relational Capabilities

DH1: In order to execute the product development, the company had to improve its capabilities to interact and deal with global suppliers. DH1 had to overcome some barriers to achieve the capability to interact with suppliers: the immaturity and inexperience of the process as well as difficulties in developing agreements and contracts with companies from different countries, cultures, languages and legislations. At the end, the company set agreements with companies from Europe and Asia for different stages of the production process. The support of a consulting company hired to access global supplier helped the development of these capabilities. The company is still prospecting market and structuring its commercial area. It demonstrates immaturity in global market relational capabilities. The development of these capabilities will be essential because the perspective of growing is bound to the global market sales.

DH2: The capability to search and deal with international companies was the biggest challenge for this DH. It was important to find suppliers that could work with quality, flexibility and low volume. They found global companies with those characteristics that were interested in the Brazilian market. The company also developed capabilities to work in cooperation with other national DH to develop the product. The most important product is developed and owned by DH2 and DH3. This kind of relationship is important not only for the company but also to reinforce the design in Brazil and, consequently, the national semiconductor industry.

DH3: The DH demonstrates capabilities to develop relationship with suppliers, partners and customers. Since the beginning, the strategy to seek for suppliers and customers in the global market was based on networking, using especially the previous professional contacts of the founders. The company believes in personal contacts for the prospection of partners and, even nowadays, the founders make these activities. DH3 also uses the relationship with global suppliers to prospect and deal with global customers.

DH4: The company has structured a good relationship with international players to outsource part of its production. Among the years, it has learned how to deal with global players and increase its bargaining power during the negotiations. The relationship with the global market is still a plan for a growing strategy.

All DHs reinforced their relationship with global suppliers, but only DH1 and DH3 are prospecting relationship with global players.

- Innovative Capabilities

Some innovative aspects in all DHs were identified, but none of them can be considered innovative capabilities to go global. The innovations described below can be associated with the entrepreneurial character of each DH.

DH1: The company is confident in terms of product and market choice. Although it does not present disruptive innovation, the product is aligned to the needs of technological evolution of electro-electronic devices and the internet of things. However, these innovative capabilities will only be perceived and proved with the consolidation of the product in the national and global market.

DH2: The process of product development presents elements of innovation because the costs involved were lower comparing to international standards. The company had to use different public funds, developing different projects, once there is no venture capital available to develop integrated circuit in Brazil. The products attend international standards, but they are considered innovative for the national market. The product architecture was registered as a patent.

DH3: This DH demonstrates innovative initiatives in two aspects. The first is the choice made by DH3 to develop and commercialize IPs. DH3 believes that it brought conditions to have something more concrete to demonstrate to customers and negotiate new contracts. The CTO affirms that it would be very difficult to commercialize pure services without tradition and credibility in the market. The second is the progressive use of networking to prospect new suppliers and customers. They started dealing with small players until they achieved credibility to deal with big global players. DH3 believes that, for growing, it will have to develop products and operate as a fabless.

DH4: The market analysis and product definitions are important elements that have influenced the growing in sales during the last year. It is the result of a redefinition of the business model and position in the market. Those incremental innovations are preparing the growing perspective of this state-owned company.

All DHs present important aspects of innovation, but still incipient to be considered global capabilities to affect the advance of the companies in the semiconductor chain.

Table 8 - The identification of global supply chain capabilities

	DH1	DH2	DH3	DH4
Productive capabilites	Operational structure Outsourcing	Operational structure Outsourcing Engineering team	Operational structure Outsourcing Global networking.	Design center Back-end Outsourcing
Relational capabilites	Relation with global suppliers Consulting for global networking	Relation with global suppliers	Relation with global suppliers Relation with global customers	Relation with global suppliers
Innovative capabilites	Incipient	Incipient	Incipient	Incipient

Source: The author

Table 8 presents the main global supply chain capabilities of each single case. The analysis brought elements to understand the focus and structuration of the capabilities of the national companies. All DHs present more maturity in productive capabilities. According to Grant (1991), those capabilities are the primary constants upon which the company can establish a growing strategy and achieve superior performance. In terms of relationships, supplier relationship capabilities are more developed than customer relationship ones. In relation to innovation, the incipient results demonstrate limitations for growing opportunities in the global chain.

From the cases' analysis, it is possible to highlight some similarities and differences in terms of global supply chain capabilities development. All the DHs are making efforts to structure resources and networking for the product development and commercialization. They also advanced in terms of outsourcing the manufacturing activities in the global market. The efforts and paths were different, but, at the end, all of them succeeded on those aspects. Even DH4 that has manufacturing capacity had to outsource those activities due to the need of different technological demands. The weakest production structure belongs to DH2. Since it is a nonprofit organization, it has not defined the alternative for mass production and commercialization of the products. In general, the DHs are following the elements that Fransman and King (1987) propose for productive capabilities achievement: i) searching for viable alternative technologies; ii) selecting the most appropriate technologies; iii) trying to

dominate the technology; and iv) trying to adapt the technology to suit the specific production conditions. Brazilian DHs achieved what Bell (2007) points out as capabilities to use and operate given forms of technology in specific configurations.

Regarding relational capabilities, it is possible to see strengths and weaknesses among the DHs. The main strengths are the capability that those companies developed to deal with global suppliers. Even with all the restrictions of the national industry and the inexperience of the companies, all of them stablished contracts to prototype and for mass production. Considering this dynamic, companies must develop relationship on agile basis, integrated by collaborative business processes. It is possible to observe in the companies some key elements that Christopher (2000) points out as important to enhance the relationship performance and build proper supply chain capabilities: the quality of supplier relationships; the high level of shared information; and a high level of connectivity between companies in the supply chain. All of these happen especially because of the semiconductor products' characteristics that need to be developed in accordance to the supplier technology.

EXP2 points out that it would be important to have all the chain operating in Brazil to gain power and competency to create a national industry. However, it is not the current reality. With the absence of manufacturing in Brazil, front-end and back-end operations need to be outsourced globally.

> *There is a perspective for the next two years to start the operation of a new foundry in Brazil. It will probably offer services of microchip manufacturing for the national DHs. It will help to decrease costs and also qualify the DHs to use the benefits of PADIS. However, it is still a speculation (PMK2).*

The weaknesses are related to market knowledge and prospection of global customers. Only DH3 has stablished relationship with global customers for the development and commercialization of its IPs portfolio. DH3's global customers were developed through contacts of former professional experiences. The others, DH1, DH2 and DH4, will first consolidate the national market to achieve capabilities to prospect global market in a second moment.

The national market is very restricted. According to RES1, even if the initial focus is the national market, the future strategy has to reach the global market. ODH1 reinforces that the customers are mainly in the global market. FIN1 poses that the global demand does not see any degree of excellence in these startups.

> *I do not see within these DHs a commercial approach and the capability to prospect and deal with global players (EXE1).*

Innovative capabilities are still incipient in the national DHs, representing limitations for the consolidation process of those companies in the global chain. It is possible to highlight some incremental innovations in each company. DH1, for example, has made a market analysis for the definition of its product portfolio. DH2 established relationship with customers to develop the parameters of the products and also to finance part of the product development. DH3 implemented all its previous experience and networking to develop its business focus and commercialize globally. DH4 reinvented its business model to achieve its first results and started, last year, a process of consolidation. The innovation initiatives in this industry are characterized by high investment in research and innovation for the generation of solutions for the future and development of the electro-electronic sector, which is not the case of Brazilian DHs.

Therefore, innovation is one of the biggest limitations of the national industry. Brazilian DHs are developing processes and products to follow the industry, but they are not developing new technology. According to EXE1, they can be seen as followers, reproducing what is already designed in the market and trying to find some gaps in the domestic market. It would be important to create and dominate some new product, application or technology.

> *It is a way to begin. We can start thinking about our national needs, but, globally speaking, this industry is export-based (PMK2).*

> *We have good engineers, PhDs, skilled labor, but what are they producing in terms of innovation? (ODH2).*

5.5 The Brazilian DHs' upgrading level

The concept of upgrading is important to the global chain analysis because it helps to understand and to highlight paths for companies to move up in the value chain. In order to become part of a global chain and compete according to international standards, the DHs should adapt the way they evaluate the competitive parameters of the market. Most of the DHs' strategies for upgrading are focused on fostering global capabilities to produce products based on global standards, deal with global suppliers and customers, and undertake innovations to promote business and market opportunities. They are following some of the

strategies pointed out by Tejada (2011), by entering into higher value market niches or by undertaking new productive functions with new goods or services. The main elements that characterize the upgrading level of each DH are described below.

- DH1: this DH presents productive capability maturity. It has capacity to deliver engineering services to be sustainable in the short term and it has structured an international supply chain to implement its strategy of long term focused on products. Based on these evidences, it is possible to say that the company achieved the process upgrading. The DH is prepared to develop and produce products to the national and global market. The achievement of product upgrading level will happen with the consolidation of this business strategy. The company will have to fully implement its business plan and consolidate the product in the market. For that, the company will have to improve its relational capabilities, structuring its commercial area, expanding its network of relationships, creating distribution channels and establishing contracts for global sales. The achievement of functional level will depend on the success of fabless model and advances in terms of innovative capabilities, developing a new portfolio of products and solutions and reorganizing its physical and managerial infrastructure to support the companies growing.

- DH2: According to the case description, both productive and relational capabilities presented in the company are focused on the structuration of its capacity to develop a supply network and a national microchip. DH2 is still in the process upgrading level, once it did not consolidate its marketing and commercialization capabilities. The product upgrading is still a long-term target for this DH. First, it has to find alternatives for commercialization once it is a nonprofit organization linked to a state-owed university. Second, it has to consolidate its products in the domestic market and the fabless model. Finally, it will have conditions to seek global market, improving its relational capabilities. Functional upgrading is also a target for DH2 and will be aligned with the future plan of global marketing consolidation, new products and new markets development. This future strategy depends on improvements in productive, relational and especially in innovative capabilities.

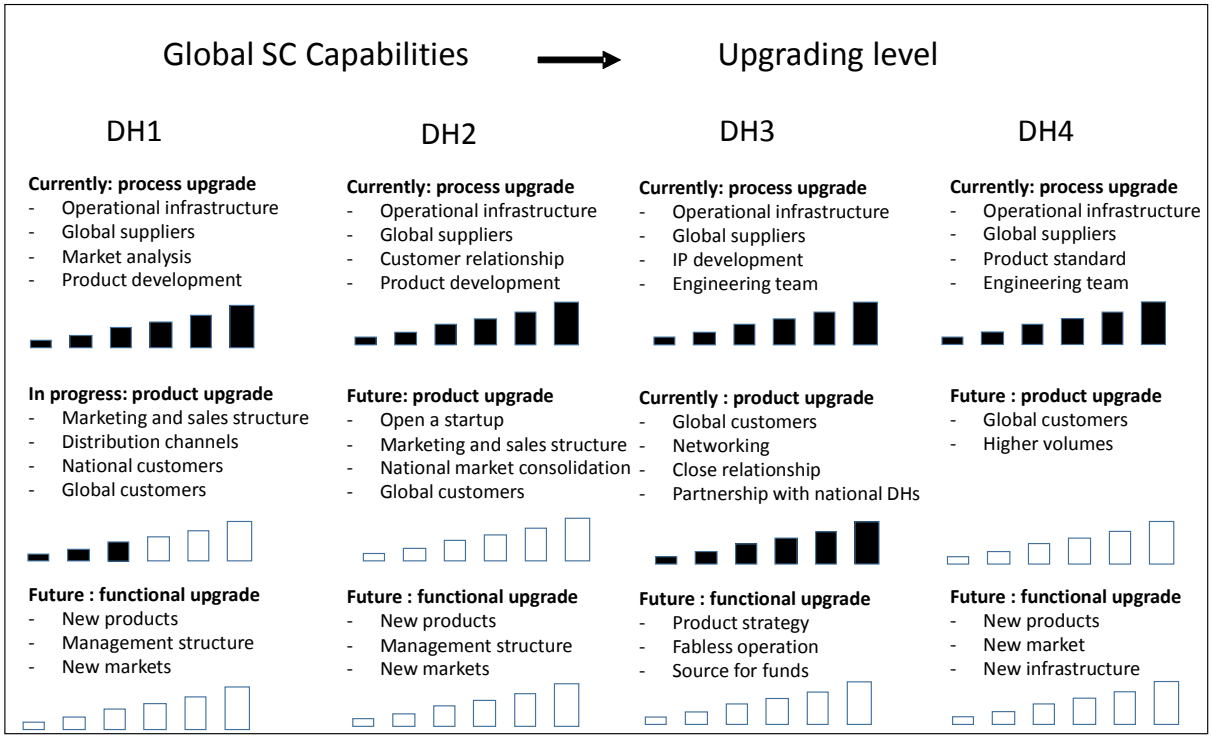
- DH3: This DH has succeeded with its business proposal. It has managed its infrastructure, human resources and international networking to operate as a design house with global operational standards, fully developing productive and relational capabilities. The company

has lived the incubator and now can afford its own facility. The engineering team is flexible and capable to co-work with suppliers, customers and partners. The DH has increased its networking due to the growth of its credibility in the market. Based on these facts, it is possible to observe maturity in terms of process upgrading. The development of an IP library and its commercialization in the global market differentiate this DH in the CI-Brasil program. So, DH3 presents maturity also in terms of product upgrading because it has consolidated its IPs portfolio in the national and global market. It has started using its own networking and dealing with small companies and now it has capability to deal with important global players. The next DH3's strategic growing plan can leverage it to achieve functional upgrading. For this future plan, the company will look for funds to finance a microchip development. It will use its networking to prototype the products for mass production and commercialization. This changing of strategy will be associated to the development of innovative capabilities.

- DH4: This company presents the biggest infrastructure among all the DH members of the CI-Brasil program, with maturity in terms of productive capabilities. Therefore, its participation in the semiconductor global chain is related specially to the operational standards of its processes and products and its relationship with global suppliers. Is has partially developed relational capabilities. These conditions situate the company in the process upgrading level. Its goal is to consolidate the products in the domestic market. The company manifested that the future plan for growing is linked to a global strategy, what can bring it to a product upgrading level. It also aims to become an important player in the global market. For that, it will be necessary a new definition of products and market channels, what can bring this company into a functional upgrading level. This growing strategy will depend on the development of innovative capabilities.

Figure 20 presents a map with the different upgrading levels achieved by the DHs according to the global supply chain capabilities development. The figure also presents the current upgrading situation of each DH and represents the main elements that compose the process to achieve higher upgrading levels.

Figure 20 - Upgrading level of Brazilian DHs



Source: The author

All DHs achieved the process upgrading, what, according to Humphrey and Schmitz (2000), means that they are capable to transform inputs into outputs efficiently by reorganizing the production system or introducing superior technology. They developed their productive capabilities with conditions to develop products and services with global standards. They also developed part of relational capabilities by the prospection of suppliers to outsource manufacturing. According to Kaplinsky and Morris (2001), it means the increasing of efficiency of internal processes. Besides, it is in accordance to what Ponte and Ewert (2009) point out as the explicit recognition of the importance of matching standards that are set by global market.

During the last 10 years of the semiconductor industrial policy, all the efforts made by companies and government are more concentrated on leveraging national productive capacity and search for opportunities for development of a portfolio of product and services. The companies are still facing difficulties and are dependent on national infrastructure improvements and availability of funds to finance productive resources, labor and product development cycles.

> *Many barriers influence the low efficiency of our industry. We have high national costs, logistics problems, slow customs, bureaucracy, etc. Policies such as PADIS eliminate taxes, but they do not eliminate those barriers (EXP1).*

Most of these barriers contribute to the lack of maturity of the national industry and limit the development of global capabilities and the achievement of higher upgrading levels. According to Humphrey and Schmitz (2000), product upgrading would be achieved by introducing new products, changing designs, improving quality, and producing a more sophisticated final output in the global market. DH3 is the only one that already achieved the product upgrading level because of its strategy of development and commercialization of IPs. DH3 is advanced comparing to the others especially because of the achievement of customers in global market. DH1 has already defined for the short term the negotiation to search for contracts with global players. Since the beginning, its product strategy was planned for the global market. DH1 has also hired a consulting firm with expertise about semiconductor global industry to help the establishment of contacts with potential global customers. The commercial strategy of DH2 and DH3 is still focused on the domestic market. Both mentioned the prospection of global players as a future strategy that will come after the national market consolidation.

There are some national incentives to prospect global customers, but DHs are not mature enough to take advantage of these initiatives. With the difficulties in export strategy and the limitation of the national market, it is important to have a reviewing and coordination of the policies to prioritize companies and improve the technological drivers for the industry. There is also in Brazil the valuation of national content. It can allow the consolidation of the DHs business, but it is not enough to foster product upgrading.

> *We can prioritize the national content. We do not know for how long the government will resign income or pay more for local content. In the future, our national companies will have to be as competitive as the global player. We need to stimulate product development (PMK2).*

> *The PPB will not last forever. In some moment, our products have to be as competitive in terms of price as Asian ones (PMK1).*

The future target of all DHs is the functional upgrading, once all of them aim to develop new products and consolidate the fabless strategy. Brazilian DHs will have to move from pure service engineering provider up to the domain of some specific technology with a business model based on research and innovation. It will involve the development of all

global chain capabilities, specially the innovative ones. For the Brazilian DHs, this level will only be achieved after the global market consolidation. It will not depend only on the entrepreneurial character of companies; the environment will also have to incorporate some of the elements described by the specialists, such as private or public funding specific for the semiconductor industry characteristics, investments in research and innovation development, attraction of global players and improvements in infrastructure. In the global market, the microchip price is decreasing. According to the specialists, what makes sense is the production and exports of electro-electronic products. In this way, the national semiconductor industry growing is dependent of a national electro-electronic industry.

> *Brazil is a great market, but we do not have companies developing hardware in the country. There is no R&D in the country. This industry is dynamic and dependent of innovation and complex products (RES2).*

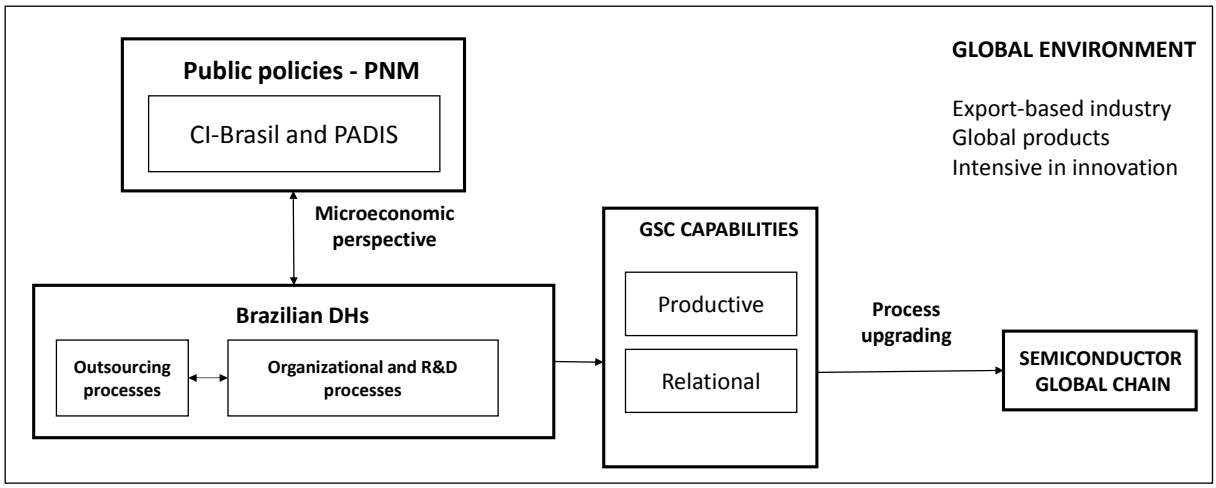
> *It is not easy to put a chip in our products because they are developed outside of Brazil. How could we put our chips on a Motorola in the USA, on an Apple in China or on a Samsung in Korea? The government cannot just think that we have to export. We must have clear guidelines development of the industry that will not happen until we develop a strong industry of final goods (EXE1).*

The development of products with new technologies and an environment capable to leverage innovation can move companies up to functional upgrading, what, according to Pietrobelli and Rabellotti (2011), will make companies to abandon existing low-value added functions to focus on higher value added activities.

6 GLOBAL SUPPLY CHAIN CAPABILITIES FOR UPGRADING

The research question aims to find out what are the capabilities needed by companies to become players in a global supply chain This chapter analyses the 4 propositions of this study. Figure 21 represents the findings achieved using the theoretical framework developed to support the propositions of this research. Brazilian DHs and their integration with the global chain compose the empirical field to evaluate those propositions. The framework proposes that upgrading is a consequence of global supply chain capabilities, driven by the supply chain processes and affected by the public policies and the industry characteristics.

Figure 21 - Brazilian DHs in the semiconductor global chain



Source: The author

The first and second propositions are focused on the environment where companies operate, composing the conditions and demands that lead to the need of integrations with the global chain. The third proposition suggests that firms can achieve sustainable competitive advantage through the acquisition and control of resources and capabilities. The fourth proposition completes the framework using the upgrading level as a mean to evaluate the advance of companies in the global supply chains as consequence of the global supply chain capabilities development.

6.1 OPERATING IN A GLOBAL SUPPLY CHAIN

The first proposition brings the idea that being part of a global chain can be a consequence of the choice of starting operating in a certain industry that presents global characteristics.

Proposition 1: Going global in a supply chain may be an option of the companies, but, most of the time, it is demanded by the characteristics of the industry and the market.

In the four cases of this study, it is possible to identify elements demonstrating that, independently of the size or nature of the business, all DHs have to follow global standards and deal with players in the global chain. This study proposes three parameters for analysis: product and service standards, relationship with suppliers, and prospection of global customers.

Semiconductor is a global industry with its main value chain activities spread in high technological countries. The decision of being a player in this industry leads to the necessity of relationship and operation in the global chain and with global standards. The content analysis shows that, in the 4 cases, the need to follow the global chain started with the characteristics of the products. Once the semiconductor products are incorporated in electro-electronic products, the portfolios of products and services of the DHs are developed considering global needs such as size, efficiency and costs of these industries. DH1, DH2, DH3 and DH4 declared the preference to work with products or IPs instead of engineering services. Specialists also mentioned that Brazilian companies will only be able to penetrate the semiconductor ecosystem if they have a project or a product with international standards. Even if it is a small company, it will not be reliable without these characteristics.

Beyond product global standards, relationship with global players appears in this study as an important issue that characterizes the operation of DHs in the global supply chain. Traditionally, the length of the chain is related to the make-or-buy decision. According to Cousins et al. (2008), the premise is that organizations do not possess all the skills and resources required to design and manufacture entire products in-house. The Brazilian DHs are facing this reality with the need to deal with global suppliers to outsource manufacturing activities. It is consequence of different facts: there is an absence of manufacturing operations in Brazil; the two national back-end companies do not attend the DHs because they have different business focus and do not have capacity or flexibility to support the different

technologies and low volumes required; currently, there is no foundry operating in the country.

RES2 poses that, when a DH makes the decision for a fabless model, it has to have domain through the supply chain and has to develop capabilities to deal with global suppliers. Although most of the specialists reinforce the need to develop a manufacturing structure in Brazil, they recognize that it will not happen in the short or middle term. Even with national production capacity, it will not be possible to support all the technologies' needs of this industry. The policy makers express that there are plans in the middle and long term to build or attract more factories. There is also the specialists' belief that the consolidation of the national industry depends on the domain of all the semiconductor value activities. Because of the high costs involved in building a factory, it is still considered a speculation. According to PMK2, the new foundry Unitec Blue (former Six), which will start its operation in Brazil in the next months, will support part or the demands of the national DHs, but not completely; not only because of volumes, but also regarding the variety of products and technologies.

Under these conditions, the only alternative to prototype and mass produce the DHs' microchips is outsourcing manufacturing using global suppliers. Even DH3, which focuses on IPs, needs these global suppliers in order to develop their prototypes. DH4 is the only one with back-end capacity, but it is also sourcing globally for front-end operations. They are dealing with critical aspects related to characteristics of the global environment to determine the proper global supply chain strategy their organization should seed to align operations with global partners (MENTZER et al., 2007b). They have to develop capabilities to deal with the complexities of cross-border operations, which, according to Mentzer et al. (2007a), are exponentially greater than in a single country, and the ability to compete in the global environment often depends on understanding the subtleties that emerge only in cross-border trade.

The next challenge commented by the DHs is related to the demand side and how to prospect global market. The factors involved in marketing and selling to global markets are complex and include customer preferences and expectations that are often unique in different global regions (SANDERS, 2012). Considering this challenge, only DH3 is dealing and commercializing to the global market. DH1, DH2 and DH4 are focusing on the national market. Those three DHs posed this situation as transitory and believe that the companies' growing will come using international channels and dealing with global players.

Both the DHs' members and the specialists presented that the condition for growing depends on the development of global market. The companies recognize that they are far away from this reality and pose the necessity of more maturity to become global. Without becoming included in a global chain, companies would be limited to have just goods and services produced within their own borders. By becoming global, companies have the opportunities to tap into huge and growing markets (SANDERS, 2012). It appears as a condition in the semiconductor industry, once, according to PMK2, all the microelectronics chain is export-based. Therefore, focusing only on national market will not reinforce the national industry. Brazilian companies need to seek the global market. It does not make sense to design or produce for the national companies, once there is no investment in R&D in the country. The products need to fit global needs or the companies will be limited to the domestic market.

Even considering that the 4 case studies operate with different kinds of ownership, differences in terms of the necessity of dealing with the global players and the development of products with global standards were not identified. Independently of being private, state-owned or nonprofit, all of them have the same perspective of national market and demonstrate the same level of difficulty to deal with global suppliers.

Both sets of data, specialists' perceptions and the four case studies, bring evidences that fit the argument of the first proposition. The participation of the Brazilian DHs in the global chain is more developed in terms of product characteristics and relationship with global suppliers. The relationship with global customers is still incipient. The national companies that have been fostered by the PNM in Brazil, even considered as startups, are dealing and operating in the semiconductor global supply chain. It is not posed as an option. It came with the decision of starting operating in this global industry. However, the growing will only come on export bases and consolidation of global customers. This position is aligned with the characteristics of the semiconductor industry, which requires mass production and global market for consolidation.

6.2 THE IMPACT OF PUBLIC POLICIES

The second proposition says that the public policies are an important environmental driver for the companies' capabilities development to operate as players in a global chain.

Proposition 2: Companies are subject to the national public policies that influence the development of capabilities to join a global supply chain.

The role of Brazilian industrial policy for semiconductor industry development was widely discussed by both the specialists and the DH's members as a key factor to leverage and to support the national DHs, especially when all the companies expressed that the decision to start the business was motivated by benefits of CI-Brasil and PADIS. It is not different of what has happened in Eastern economies, such as China, Korea, Taiwan, Singapore, and Malaysia, where the development of the innovation and technology is highly driven by government and the industrial policies (ERNST, 2009). It demonstrates how policies can create new opportunities, pressures, and incentives for local network companies to upgrade their technological and management capabilities and the skill levels of workers. This situation agrees with Lenway and Murtha (1994) when they say that states rationally have a strategic role in transitions from investment to innovation driven growth.

The DHs interviewees discussed different impacts of the public programs over their strategic and operational choices and structure. The four case studies clearly present the influence of the public policies in the capabilities development, but more focused on the microeconomic perspective, according to the model proposed by Mann (2012). Both the specialist and the companies mentioned, during the interviews, the relationship and impact of the industrial policies, especially in the configuration of the infrastructure and the leveraging of national companies. The main supply chain processes affected by PNM are the operational ones. The analyses highlight drivers for DHs' structuration, funds for research and development and infrastructural issues.

Public policies have important role to attract industry through subsidies and special financing arrangements (SKJØTT-LARSEN et al., 2007). This relationship between the industrial policy and availability of funds was also discussed both by the companies and the specialists. Because of the absence of private venture capital, the DHs are dependent on different public funds, such as CNPq, FINEP, CRIATEC, etc., to finance their projects and product development. DH1, DH3 and DH4, which are enabled to use PADIS, also have right to use 4% of the incomes on their own R&D processes. However, those initiatives are not enough for this kind of industry. Some mechanisms are necessary to finance the product development appropriate for this kind of industry. The startups are small and they still need the government support. According to the specialists, the national sector does not stand 22

DHs. So, it is important to identify which of them has potential to grown and really invest to have good cases.

PADIS was developed to give taxes exemption for manufacturing activities accomplished in Brazil. Under these circumstances, only DH4, which invested in back-end capacity, can use this benefit. During the interviews, DH1, DH2 and DH3 claimed for changes of this governmental program in order to support the fabless model. They argued that, without this support, it would not be possible to be competitive in terms of costs, compared to global players. The specialists commented that this claim will be considered by the government to review the extension of this program, and the government is already studying some changes in the program in order to accommodate the needs of the fabless environment. In this way, it is important to evaluate which DHs are succeeding and create mechanisms to support their growth. PADIS is still an alive document; things are changing and PADIS needs to be updated.

In terms of infrastructural issues, interviewees highlighted some elements that Sanders (2012) points out as relevant to leverage companies in the global chain: access to labor skills and infrastructural support. CI-Brasil is preparing qualified people to work in the industry, but most of the interviewees argue that the number is not enough for the industry growing, especially comparing to global standards. The development of skilled labor is another important goal of CI-Brasil. According to RES2, the training center has the capacity to prepare 100 new designers a year. EXP1 poses that the quality of Brazilian designers is better than in Mexico or China, what is positive, but there are some gaps that need to be considered in terms of human resources. CI-Brasil is preparing designers, but still in slow rhythm (EXP1). It is also necessary prepared people with manufacturing, managerial skills and market knowledge.

The Brazilian customs inefficiency was also discussed as great barrier for trading in the semiconductor global chain. National infrastructures are important to create the environment to foster the industry. Brazil faces a lot of inefficiency in terms of slow clearance, logistics problems, excess of bureaucracy, etc. The improvement of infrastructure should be part of the industrial policy agenda. PMK2 commented that there is a group working on country infrastructure and planning improvements to support the industry growing and to attract global players. It is necessary to accelerate customs transit, and the plan is to create a customs transit only for semiconductors in the main airports.

The study shows that, for Brazilian semiconductor industry, government is more than a facilitator, once the sustainability and competitiveness of the DHs are dependent of the public benefits. It is possible to observe that companies are still far away from their independency from the support of public policies. The main difficulties and criticisms are related to a lack of initiatives to improve competitiveness of Brazilian companies in the global market. It would involve more coordination of national programs and more incentive to promote innovation not only in semiconductors but also in electro-electronic industry. Under this perspective, PNM should change the environment to promote international trade and to support supply chain demands. It would involve macro and microeconomic perspectives of the public policies to compose a wider scenario where government's strategic choices affect companies' international strategies and operational decisions. So, investments in both micro and macroeconomic perspective of the industrial policy can move national companies up from the current operational perspective to more relational and innovative strategies.

6.3 GLOBAL SUPPLY CHAIN CAPABILITIES

The third proposition is rooted in the foundations of resource-based theory and brings parameters to evaluate global supply chain capabilities. The frame points out that the development of global supply chain capabilities are consequences of the supply chain processes management and they are characterized into three types: productive, relational and innovative.

Proposition 3: To become included in global supply chain, companies need to prioritize and manage their key supply chain processes to develop global supply chain capabilities.

The cases' description using a supply chain process structure in chapter 5 allowed a clearer identification of the DHs reality. This study considers that processes are a mean to ensure superior coordination of functional activities resulting in capabilities to advance in the global chain. The selected process, associated with global supply chain perspective, requires management's ability to develop stable, low-cost supply relations to govern those relationships as efficiently as possible. From data analysis, it was possible to verify that the four DHs have fostered capabilities in operational processes, especially in terms of organizational and research and development issues. After undertaking great effort in global sourcing, they are confident with supply processes. It means they are making efforts to

structure resources and networking for the product development and commercialization. The weakest production structure belongs to DH2. Since it is a nonprofit organization, it has no definitions about the alternative for mass production and commercialization of the products. In general, the DHs are following the elements that Fransman and King (1987) propose for productive capabilities achievement: i) searching for viable alternative technologies; ii) selecting the most appropriate technologies; iii) trying to dominate the technology; and iv) trying to adapt the technology to suit the specific production conditions. Those capabilities include the skills necessary for the efficient operation of a plant with a given technology and its improvement over time, as proposed by Morrison et al. (2008). Brazilian DHs have capabilities to produce goods at determined levels of efficiency and input requirements.

In terms of relational capabilities, this study considers how companies are interacting with global players. Zacharia et al. (2011) pose that the capabilities for the relational activities in the supply chain are necessary to allow organizations to develop and manage interactions with suppliers, market and partners. The results show that Brazilian DHs present more developed relationships with global suppliers. All DHs advanced in terms of outsourcing the manufacturing activities in the global market, which is associated to the fabless model. According to EXE1, a fabless makes sense for Brazilian reality and market structure, especially considering that there is no manufacturing capacity in the country. The efforts and paths were different, but, at the end, all DHs succeeded. Even DH4, which has a production capacity, had to outsource manufacturing activities due to the need of different technological demands.

EXP2 points out that it would be important to have all the value chain activities operating in Brazil to create a national industry. It would facilitate the development of partnership with international players. However, it is not the current reality. With the absence of manufacturing in Brazil, front-end and back-end operations need to be outsourced globally.

Regarding market process, the main restrictions pointed out in these study results are the absence of national market and the restrictions to access the global market. ODH2 affirms that the potential customers are traditionally countries such as Taiwan, India and USA, but the companies do not have capabilities to access those market channels. It is not clear who the customers for the DHs' projects are. All companies that produce equipment, such as Samsung, LG, Apple, are multinationals that do not develop their projects in Brazil (FIN1).

In the semiconductor industry, it is important to negotiate market and partnerships based on what values technologies or intellectual properties. So, there is an agreement among

the specialists that the development and commercialization of IPs is a good alternative for the national DHs. IP is a midterm between services and products, and the infrastructure is the same needed for engineering services, skilled labor and software. According to EXP2, the national DHs that are succeeding are developing IPs. It is the case of DH3 focus, the only DH of this study that is commercializing in the global market and fully developed relational capabilities.

The results show that the development of innovative capabilities is still incipient among Brazilian DHs. There are few investments in research and development in Brazil, national semiconductor industry is not consolidated in the global market, and Brazilian companies are young and small if compared to the global players. The innovative capability is characterized by technological learning processes from the company, translated into new managerial and transactional routines and new technology development (ZAWISLAK et al., 2012). Brazilian DHs are in initial stage, trying to consolidate their operations, following the market product and processes standards.

The study presents evidences that productive capabilities are consolidated. Relational capabilities are partially identified, represented by developed relationships with global suppliers and fragility in relation to global customers' relationships. Innovative capabilities are still to be developed. The DHs are finding alternatives to finance their products indicatives and opportunities for growing within the semiconductor industry. Those capabilities compose the basis for the upgrading level in semiconductor global chain expressed in the last proposition.

6.4 UPGRADING IN THE GLOBAL SUPPLY CHAIN

The fourth proposition discusses elements that promote the upgrading process. It considers a different set of drivers: internal drivers, based on supply processes; and external ones, promoted especially by the motivations and benefits of public policies.

Proposition 4: The upgrading process to move up in a global chain depends on both the capabilities of the companies and the environmental factors.

The third proposition, previously presented, discussed the impact of public policies in the development of global supply chain capabilities. Now, this last section discusses how those capabilities affect the companies upgrading level. It is known that companies can

upgrade in various ways, as, for example, by undertaking new productive or service functions, by entering higher unit value market niches, or by entering into new sectors (PIETROBELLI; RABELLOTTI, 2004). The results present elements that composed the scenarios where the national DHs are operating and the path that can bring conditions to foster the upgrading in the global chain. The elements that promote the current structure and strategies for the achievement of process and product upgrading are discussed, as well as the bottlenecks and perspectives to move up and achieve functional upgrading.

The productive and relational capabilities coming from the interaction with global suppliers place all the DHs in the process upgrading level. All DHs have capabilities to transform inputs into outputs with global standards and have structured production systems to process their products, what is in accordance to the definition for productive capability of Humphrey and Schmitz (2000). The environment described by the specialists brings important elements that justify the upgrading processes in the national DHs. The products and services need to be designed following the specifications of the electro-electronic global industry. There is also the lack of manufacturing capacity in the country, bringing the necessity of global sourcing. These challenges are improving the learning process of Brazilian DHs and moving them from pure service providers up to fables model and product developers. This situation can be aligned with what Gereffi et al. (2005) state: for many late entrants, the evolutionary process of catching up with incumbents begins with delineating the production of easy-to-produce items and may sequentially add higher value-adding activities.

All DHs are supplying national market with services or products, but only DH3 has achieved relational capabilities by dealing with global customers. In terms of developing countries, their inclusion in global chains not only provides new markets for their products but also plays a growing and crucial role in access to knowledge and enhanced learning and innovation (PIETROBELLI; RABELLOTTI, 2011). Under this perspective, only DH3 migrated from process to product upgrading level. Once product upgrading involves the achievement of global markets, it represents an important step for continuing upgrading. It is aligned to Wong (2014), which points out the need of a progressive challenge in terms of managerial capabilities when a company identifies opportunities to upgrade in the chain.

Due to the high costs involved and the need of high volumes in the microchip production, the global semiconductor industry is export-based. According to PMK2, it happens even in China, which has a large internal market. In this way, the achievement of product upgrading is dependent of prospection of global market. It is still a great barrier for

the development of the national industry. The market for design in Brazil is scarce, especially because there are few companies developing technology in the country. All the technologies are based on companies that are producing electro-electronics, such as Samsung, LG, Apple and these multinationals that do not develop their projects in Brazil (FIN1).

Functional upgrading is not identified in the DHs researched. This kind of upgrading will only be achieved using fabless model, after global market consolidation and with the development of new and innovative products. It will also depend on the development of innovative capabilities. The environment will have to incorporate some of the elements such as availability of private or public funding specific for the semiconductor industry characteristics, investments in research and innovation, attraction of global players and improvements in infrastructure. Companies will also have to achieve managerial capabilities equivalent to the global players' level. According to FIN2, there is not an "Eldorado" where someone will give you money to develop your idea. No one will invest money if there is no trust from a technical point of view, if there is no belief in the entrepreneurial management capacity.

Currently, there are 22 DHs part of the national program. They are working for the consolidation of their infrastructure, products and services and networking, but with results that are still below expectations. There are companies, but with few success cases. The companies are not growing through the market needs, and the government programs need to be clearly defined to stimulate the successful national cases. According to ODH1, it is still necessary to create "local champions". Instead of 22, it would be better to promote three or four DHs, based on their results. It is time to make some bets. It will be important to have focus, especially to concentrate the financial support. The Brazilian industry still has to catch up some technology and develop national capabilities in the entire semiconductor chain and needs to have areas of excellence. This will give conditions to develop international partnerships and customers.

In general, the characteristics of the environment affect companies' decisions and strategies. Semiconductor global chain is embedded in an export-based industry with innovative and global products. However, the upgrading level of the Brazilian DHs is still based on processes. Product upgrading level was identified in only one case. This upgrading is consequence of productive and relational global supply chain capabilities. The supply chain processes that drive those capabilities are organizational, R&D and outsourcing. Hence, public policies are crucial for the development of these capabilities and present programs that

affect the microeconomic perspective of the Brazilian semiconductor development. Thus, the analysis brought elements that demonstrate the companies' trajectory to reach this upgrading level, as well as the perspectives to continue growing to achieve product and functional upgrading level. The fabless model has potential for consolidation of national products and projection of Brazilian companies in the global chain and it will be necessary to improve policies and increase funds to clearly promote product innovation in the country.

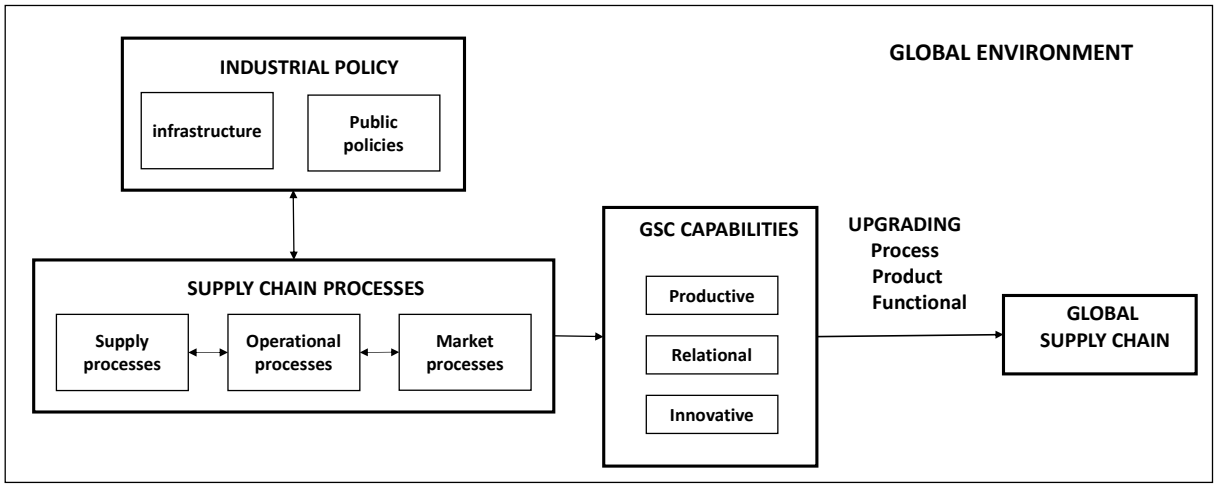
7 FINAL CONSIDERATIONS

This study was conducted under a global supply chain approach, in which the development of capabilities to become global depends not only on companies' processes but also on the environmental features where the chain is embedded. It discusses the characteristics of the semiconductor industry and the identification and evaluation of key capabilities that companies from an emerging economy need to develop to become a player in this high-tech global chain. Besides, it discusses the influence of national industrial policy to foster a new industry as well as to drive and to create conditions to leverage business globally. Considering this scenario, this research presents contributions in two different perspectives, with relevance both for academia and for business practice.

7.1 THEORETICAL CONTRIBUTION

Figure 22 represents the framework proposed for this study, highlighting the main elements used to evaluate global supply chain capabilities.

Figure 22 – The development of global supply chain capabilities



Source: The author

The main academic contribution of this research lies precisely in the development of this framework that details global supply chain capabilities. Previous studies propose elements to evaluate relational capabilities, logistics capabilities, supply capabilities, technological capabilities, among others. However, literature was still missing studies that

clearly identify elements to evaluate what main capabilities are needed by companies embedded in a specific/uncertain environment to upgrade in a global supply chain. This research framework proposes that, in a global supply chain, it is important to develop the necessary capabilities to turn the access to technologies into competitive advantage, building competence to produce, innovate and interact. These three elements compose the core to identify and manage the global supply chain capabilities. The factors that influence those capabilities consider three levels of analysis: the economic and political global environment as macro, the supply chain as meso, and the processes as micro.

- The macro level of analysis considers the environmental factors that affect global operations and highlights the role of public policies as the main external driver for the inclusion and upgrading of companies in global supply chain context. Literature discusses how public policies are essential in promoting conditions for upgrading, especially in studies on emerging economies, traditionally known as late comers. A structured way to evaluate the impact of public policies on companies' capabilities embedded in a supply chain was still missing in the literature. As a contribution, this research's theoretical framework brings public policies operating strategically in creating conditions to foster entrepreneurship, ventures and infrastructure for trading and, especially, allowing the upgrading driven by the companies' supply chain processes.
- The meso level of analysis considers the global supply chain. The conceptual fundamentals of global supply chain management remain underdeveloped and studies in this field deserve further attention. In this way, this research contributes to the advance of the area, bringing a discussion of elements involved in the underpinnings of global supply chain management and how companies can develop capabilities to advance in this context. During the literature review, a clear concept for this field was not identified. So, another theoretical contribution of this study is the proposition of a concept for global supply chain management (in item 2.1.2, p. 27).
- The micro level of analysis proposes that the mean to achieve global supply capabilities is driven by the supply chain processes. The framework considered the processes as central in the analysis of companies' capabilities. The impact of public policies is over the processes, which are considered the base for global supply chain achievement. A map of the supply chain processes was organized and used as the basis to prepare the interviews protocol and field investigation. This technique and

interview approach represent another contribution of this study (see Figure 10, p. 77 and 11, Figure p. 78) in terms of data collection method for management and business studies.

7.2 MANAGERIAL CONTRIBUTIONS

Brazil was one of the first developing countries to use and produce electronics. In the 80s, there was a significant local production of computers and peripherals, as well as an industry of microelectronics. Brazil was left behind in the semiconductor industry, especially in the production of semiconductors and other components, while countries such as Malaysia, South Korea, and Taiwan emerged as leaders in this sector. The immediate economic consequence of the industrial capacity loss is the growing weight of microelectronics negative trade balance of the country. During 2000s, the Brazilian government redefined the semiconductor industry as a priority. It shows that Brazil is moving forward in terms of development of public policies, but it is also known that the results are still incipient if compared with leading players. Considering this scenario, this investigation brings different managerial contributions for both policymakers and companies that can allow the development of the new guidelines for the continuing growing of Brazilian semiconductor sector. The study brought an understanding of what capabilities are developed by Brazilian DHs using public policies support and what kind of improvements must be made to effectively create an environment conducive to the production and trade, raising an emerging economy like Brazil as an important player in the semiconductors global chain.

Based on the findings, the public policies are more clearly supporting the DHs development of productive capabilities to meet international standards, especially how the DHs developed their operational infrastructure in order to prospect opportunities and develop product in accordance to global standards. Relational capabilities are better developed in relationships with global suppliers, but still need to be improved when interacting with global customers. There is a gap on developing relational capabilities that allows the understanding of markets and global buyers' needs. The current policy focuses mainly in technology catch-up, there is little manufacturing capacity in Brazil and commercialization has to be transferred to a third party (trader).

The engineering background of the managers and the lack of commercialization skills might explain this finding. However, the studied DHs are still far from developing innovative capabilities, maybe due to their small size or the dependence on public funding.

Additionally, findings show that the most competitive business model in this value chain activity is the fabless. The current Brazilian policy barriers this kind of inclusion in the global chain due to the lack of flexibility and taxes involved in import and export operations. These findings can highlight the difficulties that Brazilian DHs have to catch up with the global chain dynamics. They are very dependent on public policies that aim to develop technology but restrict the outsourcing of value chain activities (fabless), which is one of the main features of this global chain

Therefore, the study suggests there is a lot to do in terms of managerial and public policies actions for these companies to become included in the global chain in a sustainable way. This study can highlight some recommendations for the global inclusion of start-ups in this sector:

- Fabless: although there is government reluctance to support the development of fabless, it appears in this study as the most appropriate business model to leverage the national DHs. It is clear that PADIS cannot get away from its focus, which is to promote value added activities in the country. In a fabless, the companies outsource globally most of the value added activities, but at the same time it brings the possibility to domain the global supply chain, consolidate national products, be associate with big global players and develop productive and relational capabilities. All those elements are important to start the consolidation of PNM strategy and upgrading of national DHs in the global chain.
- Funding: once there is no private venture capital in Brazil and the national DHs have no guarantees of offer to financial institutions, it is important to predict specific funding to attend the characteristics of microchips development and the production of the first batch for commercialization. Instead of having 22 small DHs, it is the moment to concentrate resources, choose the most promising ones to support and promote three or four local champions.
- Product technology and innovation: it is important to foster research, development and innovation in the country. The development of the national companies depends on the development of a strong industry of final goods. Nowadays, global technologies are based on companies that are producing electro-electronics such as Samsung, LG,

Apple, and all those multinationals that do not develop their projects in Brazil. It is not possible to foster a national market and put a chip in a national product, once they are developed outside of Brazil. It appears as an important condition to develop innovative capabilities and achieve functional upgrading in the global chain.

- Marketing and commercialization: semiconductor is an export-based industry. So, marketing and commercialization capabilities are fundamental for global market consolidation. These skills compose important drivers for global market consolidation and development of relational capabilities, with consequent achievement of product upgrading in the global chain.
- Increase of skilled labor: the national training centers are preparing skilled labor for microchip development. The quality is good, but the number of trained people is not enough to support the perspective of this industry growing. People with managerial capabilities to operate in this sector are still missing, especially people with market knowledge and sales skills.
- Improvement of infrastructure: the efficiency of Brazilian infrastructure is important to create the environment to foster the industry. Brazil faces a lot of inefficiency in terms of slow clearance, logistics problems, excess of bureaucracy, etc. Improvements in infrastructure have to be part of the industrial policy agenda in order to support the industry growing and to attract global players and foreign direct investments.
- Macroeconomic perspective of public policies: the public policies will have to incorporate some programs and incentives in order to change the business environment to promote international trade. It will be important to develop trade agreements and pacts between countries that can encourage the inclusion of Brazilian companies in the global chain, by eliminating or lowering tariffs, quotas, and other trade barriers with the purpose increase national growth and consolidation of Brazilian companies.

7.3 RECOMMENDATIONS FOR FUTURE RESEARCH

A qualitative study based on multiple cases and interview procedures composes this research methodological choice. The characteristic of this approach is that the goal is to make analytic generalizations in theory and not to enumerate frequencies and make statistical

generalization. For this research, the theoretical framework was developed focused on an emerging country perspective, which means to evaluate the reality of companies that are not participating in a global chain yet. The semiconductor production, which is considered a supply chain embedded in high technological and global industry, was specifically studied. For the adjustment and validation of the theoretical framework, it deserves new studies to allow an in-depth understanding of its main relationships. Future studies in different industries and countries are recommended in order to identify the impact of public policies on the development of companies' capabilities and the main supply processes needed in each context to move up in global chains. Another suggestion is to study how companies from developing and emerging countries are achieving these needed capabilities when included in global supply chains. Further research can also focus on the kind of capabilities that are more relevant for companies in developing countries and those that are key for companies in developed countries. Literature has been pointing out that developed countries are more willing to have innovative capabilities, while emerging countries are focusing on productive capabilities. However, the growth of companies from the BRICS can be changing this dynamic, and the proposed framework might help to understand this through comparative studies. Quantitative empirical research would be suitable to make statistically analysis of the relationships of the framework, especially the impact of public policies on supply chain processes, the supply chain processes generating global capabilities, and those capabilities positioning companies on specific upgrading levels.

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APPENDIX A

Universidade do Vale do Rio dos Sinos
Programa de Pós-graduação em Administração – Doutorado

Aluno: Msc Marco Antonio Viana Borges
Orientadora: Dra Luciana Marques Vieira

Protocolo de entrevista

Pesquisa Exploratória:
Global Supply Chain Management x Indústria de Semicondutores
Realidade Brasileira

1) Quais são as perspectivas de uma real inserção do Brasil em uma Cadeia Global de alta tecnologia baseada em conhecimento e inovação?

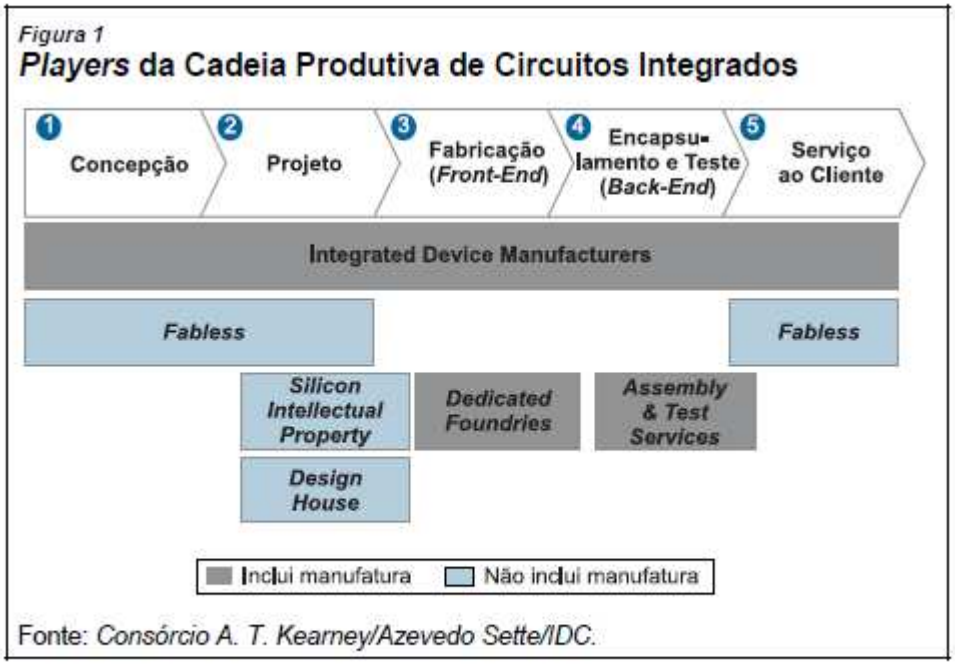
   Pode considerar aqui:
   - Fatores econômicos
   - Fatores estratégicos
   - Fatores Gerenciais
   - Impactos sociais

2) Quais são os principais desafios para a inserção do Brasil como agente ativo na cadeia global de semicondutores

   Pode aparecer aqui:
   - políticas públicas
   - mão de obra
   - infraestrutura
      Distribuição
      Suprimentos
      Terceirização

3) Papel das instituições para o fomento da inserção do Brasil na cadeia global de semicondutores (discutir diferentes etapas da cadeia)

Considerando a figura abaixo (desenho da cadeia)



BNDES Setorial, *Rio de Janeiro, n. 19, p. 3-22, mar. 2004*

4) Onde estão / quem são os principais players desta cadeia?
5) Qual é o modelo de governança desta cadeia?
6) Quais os principais insumos que alimentam as diferentes etapas da cadeia?

APPENDIX B

Universidade do Vale do Rio dos Sinos
Programa de Pós-graduação em Administração – Doutorado

Aluno: Msc Marco Antonio Viana Borges
Orientadora: Dra Luciana Marques Vieira

Protocolo de entrevista

Pesquisa Exploratória:
A operação das Design Houses Brasileiras

1) Como você o desenvolvimento da indústria de semicondutores no brasil (Aspectos mais históricos, principais eventos, motivações, vocação do brasil na cadeia)
2) Como foi o desenvolvimento da DH?
3) Como se dão as ações de prospecção de mercado nacional e internacional? Quais são os critérios competitivos que definem a venda do serviço?
4) Qual o ciclo médio de desenvolvimento de produto e como se dá a relação com o cliente durante o ciclo de desenvolvimento do produto?
5) Como ocorre o fluxo de transferência de conhecimento e tecnologia durante o processo de desenvolvimento do produto? (Explorar aspectos de relacionamento)
6) Qual o papel da inovação para a operação nesta indústria?

APPENDIX C

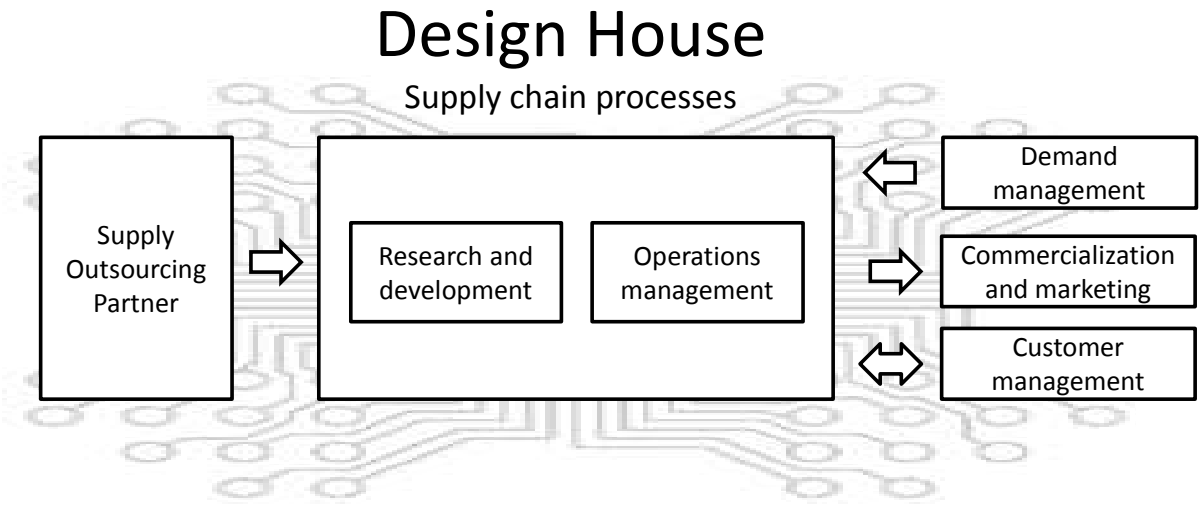
Universidade do Vale do Rio dos Sinos
Programa de Pós-graduação em Administração – Doutorado

Aluno: Msc Marco Antonio Viana Borges
Orientadora: Dra Luciana Marques Vieira

Protocolo de entrevista

- Foco: Design House

Considerando o esquema da figura abaixo que contém os seis processos principais da cadeia de suprimentos e suas relações, discuta as seguintes questões:



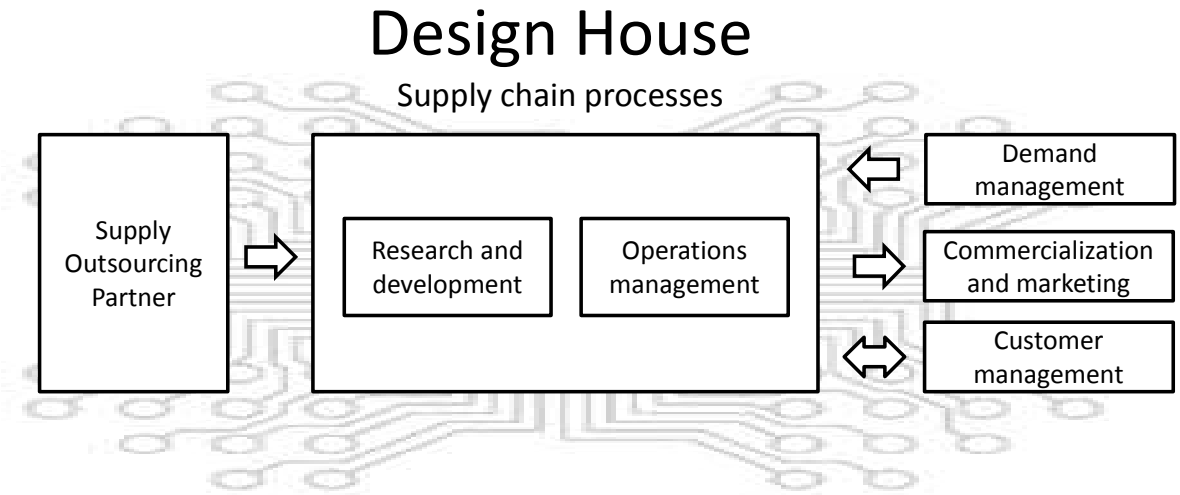
Obs: em cada uma das questões abaixo devem ser explorados: i) os pontos fortes em cada processo da cadeia, ii) as barreiras, iii) o impacto de políticas públicas, iv) o desenvolvimento de relacionamentos e parcerias para o desenvolvimento dos processos e v) aspectos inovativos envolvidos.

1. Como você caracteriza o atual modelo de operação da Design House, destacando os principais elementos de sua trajetória que influenciaram esta construção?

2. Como se desenvolvem os processos de pesquisa e desenvolvimento e qual o seu papel na configuração da atividade fim do negócio?
3. Como se deu o desenvolvimento dos principais fornecedores, terceiros ou parceiros necessários para a operacionalização dos negócio e estratégias da DH?
4. Quais modelos e técnicas são adotados pela DH para prospecção e previsão demanda por serviços e produtos?
5. Como é feita a prospecção e manutenção de clientes da DH?
6. Como a DH realiza atividades de marketing e comercialização de produtos e serviços?
7. Discuta percepções sobre o futuro da DH e o seu papel no desenvolvimento da indústria nacional de semicondutores e o seu avanço na cadeia global.

- Foco: especialista

1. Como você o desenvolvimento da indústria de semicondutores no Brasil e a escolha da atividade de Design como foco de alavangem desta indústria?
2. Como vocês avalia a trajetória das DHs brasileiras?
3. Quais processos da figura abaixo você considera que as DHs brasileiras desenvolveram em sua trajetória que caracterizam as suas principais competências e diferenciais?
4.



5. Qual o papel das políticas públicas para o desenvolvimento das competências e diferenciais das DHs e para o fomento da indústria nacional de semicondutores? (Conduzir a discussão com base nos processos da figura acima)

6. Você percebe as DHs brasileiras maduras para o desenvolvimento dos relacionamentos com fornecedores, terceiros ou parceiros necessários para as suas operações e busca de mercado?
7. Quais são as próximas fases para a consolidação das DHs brasileiras?