

SUPPLIER INVOLVEMENT IN NEW PRODUCT DEVELOPMENT: A CASE STUDY FROM THE SEMICONDUCTOR INDUSTRY

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Introduction

For the last years, global competition has strengthened the significance of a company's ability to introduce new products, while responding to increasingly dynamic markets with customers rapidly changing needs, and thus claiming for shortening the time required to design, develop and manufacture, as well as for cost reduction, increased reliability, quality improvement and sustainability. In this context, firms are implementing a wide variety of different techniques, management processes and development strategies in their quest for shorter development cycles and permanent business alignment with the market requirements (Cunha & Putnik, 2006).

Competition in the global world has dramatically increased throughout the last three decades because, among other factors, (1) technology is complex and changes rapidly, and it is nearly impossible for any company to possess all the technical expertise needed to develop a complex product on time; (2) the amazing developments in information and communication technologies (ICT) that provided unprecedented ease of connection, communication and collaboration in real time with any point in the world, and hence unprecedented efficiency in global design, management, information and decision making processes, and (3) the global geopolitical changes that, from the business point of view, provided a global free market both of clients, suppliers and subcontractors.

The shortening of the cycle time as a means of introducing new products more quickly into the market gave the involvement of suppliers in the design phase a fundamental importance, along with the sharing of information and responsibility with suppliers (Carlile, 2002; Hou et al., 2006; Olson et al., 1995; Page, 1993; Ragatz et al., 1997; Tomek & Chromcová,

2002; Twigg & Slack, 1999; Veryzer, 1998). New Product Development (NPD) is a must in this global competition. NPD is a process that intends to assure competitiveness and innovation, as the launch of a new product or service will put the company to a better position than competitors (De Brentani et al., 2010).

The main purpose of the paper is to demonstrate the importance of supplier involvement in NPD, buyer-supplier relationships and their effects on buyer's NPD process, highlighting the benefits of supplier involvement, the barriers, the strategic aspects and industry aspects. The theory presented in the paper is supported by a case study performed in 2012 in a company of the semiconductor industry sector (designated as "the Company"). Companies in semiconductor industry follow many NPD processes in shorter time scales; the technological changes happen fast, while projects are complex and require special expertise. Companies invest in R&D resources and capabilities, and tend to be involved with different partners to satisfy the market needs and trends.

The case study represents the NPD process in The Company. The Company is a supplier itself and develops, manufactures and delivers high technology products to the buyers, who deliver consumer products to the communications, digital, computer, automotive and industrial areas. Besides helping to understand NPD in the semiconductor industry, the contribution and findings of this work are clear: the results achieved confirm the findings of studies referred in the literature review, and confirm that the semiconductor industry sector requires a closer and more complex relationship structure with suppliers. In this sector, design and production are linked together with special expertise, performance, quality and cost criteria. The Company's NPD process

is involving the buyers, the suppliers and the competitors at various levels (definition of technological roadmap, R&D in manufacturing technologies, alliances with equipment and CAD-development suppliers, etc.).

Section two introduces the theory related to the topic, section three introduces some information about the semiconductor industry and section four introduces the case study. Section five discusses the main findings, relating them with the literature, and the last section concludes the study.

1. Literature Review

This section includes a literature review on the topics related to this research.

1.1 Innovation and Competitiveness

One of the classical definitions of "innovation" is the process of making improvements by introducing something new; it may refer to both radical and incremental changes to products, processes or services, and implicitly it means bringing solutions to problems (Baregheh et al., 2009). Innovation has always been at the center of competitiveness, with academics and practitioners devoting significant amounts of effort and resources to the identification of organizational and individual correlates of innovation for five decades (Cooper, 1998).

Coming out from the Latin *innovationem*, noun of action from *innovare*, which in turn comes from *innovatus*, innovation means to renew or change into new (*novus*). Innovation means, according to the Merriam-Webster Online Dictionary, (1) the introduction of something new or (2) a new idea, method, or device.

Companies can be competitive by providing better manufacturing and service delivery, but sustaining the competitive advantage over time requires competitive and evolving skills in developing new products and services (Chen & Muller, 2010; Lengnick-Hall, 1992). The technological changes happen rapidly and the effects of globalization are increasing in the current business environment. The competitive advantage for many corporations now lies in their ability to effectively implement on-going product, service, and process innovations (Zhang et al., 2004). Product innovation cycles become shorter and more frequent. Innovation becomes a strategic tool, and the companies will be forced to exploit synergies between

products, services and processes (Smart et al., 2007).

Several authors (Smart et al., 2007; Swink, 2006; Tomala & Sénéchal, 2004) emphasize the outcomes of innovations that add competitive advantage: meet new consumer needs, offer a wider range of products and services, increase the quality and the reliability of existing products, succeed in new markets, reduce environmental damage, satisfy legislation, regulations and standards, increase production flexibility, reduce costs and improve the performance of the various product linked services.

Product innovation requires knowledge creation, dissemination and application, since it is a knowledge-based process (Terziovski & Sohal, 2000). But it also involves creativity; as Tomala and Sénéchal (2004) state, design activities are problem-solving and object construction activities designed to satisfy various constraints and fall under the heading of creativity. Another requirement for innovation is collaboration among different parties, like customers, norms and standards organizations, distributors and competitors (Emden et al., 2006; Nieto & Santamaria, 2007; Oke & Idiagbon-Oke, 2010; Sammarra & Biggiero, 2008; Swink, 2006; Tomala & Sénéchal, 2004).

Tidd et al. (1997) introduce a topology of innovation networks, presented in Table 1. In this typology, organizations come together to share knowledge, develop innovative practices, create new technologies and products, and obtain economic growth.

1.2 Supplier Involvement

The supplier is a participant in the innovation networks (Smart et al., 2007), and according to Petersen et al. (2005) companies benefit from supplier involvement in NPD mainly in three areas: design, development and manufacturing.

It is possible to gain volume, design and technology capabilities through strategic supply chain management (Auramo & Ala-Risku, 2005; Chang et al., 2006). Supplier involvement in NPD brings new competences, fast penetration to new markets and resource conservation to the buyer (Wagner & Hoegl, 2006). Supplier involvement reduces new product development time and manufacturing cycle time, and has increasing impact on responsiveness to market uncertainties Incorporating suppliers in project

Tab. 1: Typology of Innovation Networks

Type of innovation network	Primary purpose (innovation target)
New product or process development consortium	Sharing knowledge to create and market a new product or process concept.
Sectoral forum	Shared concern to adopt and develop good practices across a sector or product market.
New technology development consortium	Sharing knowledge in joint research projects in newly emerging technologies.
Emerging standards	Exploring and establishing standards around innovative technologies and developments.
Supply chain learning	Developing and sharing innovative good practices in shared product development across a value chain.
Cluster	Exploiting innovation synergies in a regional group of companies, to gain economic growth.
Topic network	Mix of companies to gain traction on key new technology.

Source: adapted from Tidd et al. (1997)

teams enhances the information and expertise exchange regarding new ideas and technology; and through efficient communication and information exchange links the delays can be reduced, enabling the completion on time (Mclvor et al., 2006). Inemek and Tuna (2009) present a very comprehensive and deep analysis of NPD benefits and of supplier evaluation and selection criteria, based on a literature review covering the period 1990-2007.

Since the complexity of the products is increasing, in-depth knowledge and specialization are required. Outsourcing to specialized suppliers can reduce the internal complexity of projects and provide extra resources to reduce the critical path (Mclvor et al., 2006; Sammarra & Biggiero, 2008); many complex products are provided with the cooperation of external suppliers. Involving suppliers early in development is an important issue in terms of product quality (Wagner & Hoegl, 2006).

Potential problems can be identified early, what improves the product time-to-market (Forslund & Jonsson, 2010), increases quality, eliminates rework and reduces the development and production cost (Hou et al., 2006; Mclvor et al., 2006; Primo & Amundson, 2002; Wagner & Hoegl, 2006). With the improved buyer-supplier relationships, suppliers have project concerns and take responsibilities in it (Mclvor et al., 2006), improve buyer's performance, and

share risks (Chang et al., 2006; Wagner & Hoegl, 2006). Supplier involvement allows companies to focus only on their core businesses (Hou et al., 2006; Mclvor et al., 2006; Reed & Walsh, 2002).

On the other hand, some studies show that there is no positive effect of supplier involvement in product development (Gotzamania & Theodorakioglou, 2010; Lam & Chin, 2005; Li et al., 2010; Van Echtelt et al., 2008). There is resistance of the buyer or supplier to share proprietary information, as well as reluctance to a different design culture (Bstieler & Hemmert, 2008). There is also resistance of design personnel to an increasing level of supplier involvement during the design process (Li et al., 2010). Cooperative culture and trust should be established at both sides (Bstieler & Hemmert, 2008).

Some authors refer that the buyers want to protect core competences, and therefore limit the supplier involvement in R&D activities related to the company's core business (Wagner & Hoegl, 2006). Suppliers are also uncomfortable when the buyer requests the supplier's cost information, because of: (1) lack of trust in the buyer and lack of confidence in the accuracy of their own cost structures; (2) cost information may be used by the buyer to exercise power over the supplier. It is therefore difficult to persuade the supplier to share this information. Beside this, the suppliers require more active participation in buyer's cost

reduction program during the contract life time rather than just having cost discussions at the time of contractual period (Mclvor et al., 2006).

Supplier involvement can be ineffective in rapidly changing and technically complex environments and can create delays in the product development in case of high technology uncertainty (Mclvor et al., 2006). Product development with the suppliers can be more expensive and slower, when the supplier makes the management of projects more complex (Hartley et al., 1997; Wagner & Hoegl, 2006). The buyers create a competitive buyer-supplier relationship where they negotiate with different suppliers for an optimum buy, what causes lack of trust and commitment at supplier's side. The policies for the level and time of supplier involvement may not be available, unclear or inconsistent for the employees of the buyer company (Mclvor et al., 2006). The buyer's systems of exchange information can be incompatible with the suppliers one, creating obstacles to data sharing. And buyer's engineers that are not trained in the supplier's products, so invalid data, and inadequate guidelines, can cause communication problems (Mclvor et al., 2006). The cultural differences between buyer and supplier can put barriers to supplier involvement. The embedded culture of both sides should be changed for the cooperative nature of supplier involvement (Homburg et al., 2009; Mclvor et al., 2006; Ruey-Jer et al., 2010). The geographical distances and language, the inappropriate team structures, the lack of work coordination, the protection of intellectual property rights and the lack of competent suppliers can be listed as other barriers (Homburg et al., 2009; Ruey-Jer et al., 2010).

Table 2 summarizes benefits and barriers of supplier involvement in the NPD process.

1.3 Strategic Implications of Supplier Involvement in NPD

The strategic implications of supplier involvement in NPD can be grouped under five items: the extent of involvement, the nature of buyer-supplier relationship, the degree of information exchange, supplier involvement at the organizational and project level, and building a buyer-supplier project team. The five items detailed below reveal the effecting factors that should be considered in decision about the supplier involvement in NPD. When

and how to involve suppliers in NPD is critical for the success of the joint activities.

Complex and innovative products require the early involvement of supplier in NPD such as definition and planning phase of a new product. The nature of buyer-supplier relationship should be supported by trust, reliability, openness, support, flexibility, commitment, shared interdependence, shared expertise, shared responsibility and power in NPD. The information exchange links should be more robust than the traditional supplier relations. Information contains more sensitive and complex data. Communication is more frequent and it involves more people from both buyer and supplier side. Supplier involvement is differentiating at organizational level depending on type of product and sub-systems, supplier performance and capabilities. Coordinating project tasks between buyer and supplier are also critical for the success. The fifth item emphasizes the human aspect. Buyer and supplier establish a project team during the NPD process. Team structure, cultures, personalities and competencies of members are very important to successful supplier involvement in NPD.

The Extent of Involvement

This aspect points emphasizes the timing of supplier involvement and degree of competition among suppliers (Mclvor et al., 2006); firms can benefit from early involvement of suppliers when NPD is considered. The different timings for involving suppliers are discussed in the literature. (Mclvor et al., 2006) describes three phases for involvement: concept stage, detail engineering stage and process engineering stage. In (Wagner & Hoegl, 2006), early stage of supplier involvement includes research on concepts, technologies and innovative solutions in the definition phase of products and the definition of common technical and commercial objectives. (Hartley et al., 1997) emphasizes the involvement during idea generation and project planning of a new product, since design specifications are mainly affecting a product's performance, quality, and cost and only incremental improvements can be made after production has started. And know-how NPD projects that utilize supplier knowledge require early involvement during idea generation, technical/commercial definition (Wagner & Hoegl, 2006). Early involvement provides time

Tab. 2: Benefits and barriers of supplier involvement in NPD process

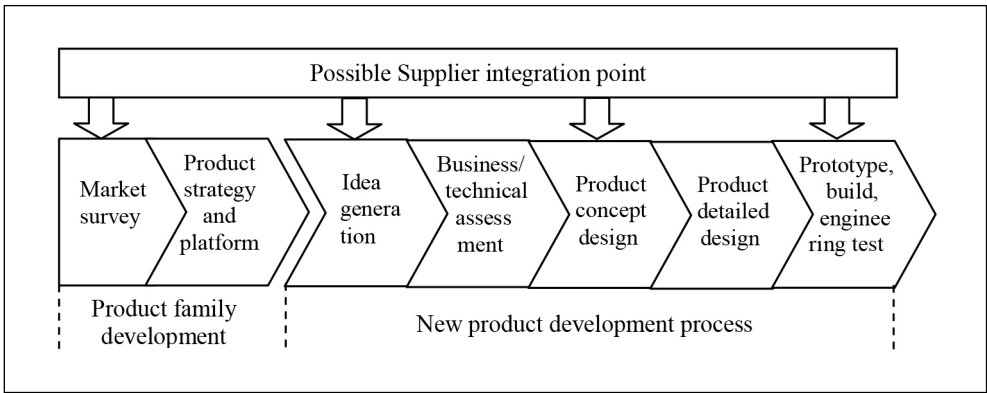
Categories	Benefits	Barriers
Competences & Capabilities	Extra volume capability (Chang et al., 2006)	
	Extra design capability (Chang et al., 2006)	
	Extra technology capability (Chang et al., 2006)	
	Reduced internal complexity of projects (Mclvor et al., 2006)	
	Buyers focus on their core businesses (Hou et al., 2006; Reed & Walsh, 2002)	Buyers want to protect core competences by limiting supplier involvement in activities related to core business (Wagner & Hoegl, 2006)
	New competences (Lawson et al., 2009; Wagner & Hoegl, 2006)	The lack of competent suppliers (Wagner & Hoegl, 2006)
	Improved performance (Chang et al., 2006; Englhardt, 1993; Lawson et al., 2009; Petersen et al., 2003; Song & Di Benedetto, 2008; Wagner & Hoegl, 2006)	
	Shared responsibilities and risks (Chang et al., 2006; Englhardt, 1993; Wagner & Hoegl, 2006)	
Greater information and knowledge sharing (Knudsen, 2007; Lawson et al., 2009; Petersen et al., 2003)	Firms from their own industry tend to contribute similar knowledge, which ultimately may endanger the creation of new knowledge and therefore more radical product developments (Knudsen, 2007)	
Time	Reduced NPD time (Chang et al., 2006; Forslund & Jonsson, 2010; Primo & Amundson, 2002)	Product development is slower when supplier makes project management more complex (Wagner & Hoegl, 2006)
		Frequent phone-calls and meetings with the suppliers make the processes slower (Wagner & Hoegl, 2006)
	Reduced manufacturing cycle (Chang et al., 2006)	
	Reduced critical path by extra resources (Mclvor et al., 2006)	
	Fast move to new markets (Wagner & Hoegl, 2006)	
	Early identification of problems (Hartley et al., 1997; Hou et al., 2006; Wagner & Hoegl, 2006)	
	Elimination of rework by early involvement (Hou et al., 2006; Wagner & Hoegl, 2006)	
Fast response to market uncertainties (Chang et al., 2006)	Delays in the product development in case of high technology uncertainty (Mclvor et al., 2006)	

Source: simplified from Inemek & Tuna (2009)

to know each other and to build a partnership-like relationship. Suppliers of non-critical and simple items can join during engineering or prototype stages. Figure 1 presents the timings for supplier involvement in NPD (Hou et al., 2006), and states that the suppliers contribute to the design more in early stages such as product family development and product concept design. They can introduce new technologies, design solutions and suitable materials. At later stages, when the buyer defines the specification, the contribution would be weaker.

Supplier involvement in NPD is compliant with concurrent engineering (CE) concept that suggests parallel and collaborative design, development and production activities, early communication of different groups in design process, cross-functional teams and early supplier involvement (Liker et al., 1996; Reed & Walsh, 2002). The degree of competition among suppliers is related to the number of possible suppliers at the time of involvement; if there are more than one supplier that can be selected, there is competition between them.

Fig. 1: Timings for supplier involvement in NPD



Source: Hou et al. (2006)

The Nature of Buyer-Supplier Relationship

Managing relationships among many companies in a chain of buyers and suppliers is required to establish supplier involvement in product development. Especially, technologically complex designs and product uncertainties stress the importance of close partnership with suppliers and interface management (McIvor et al., 2006). Partnership, strategic alliances and contract management are types of relationships with suppliers (McIvor et al., 2006; Wagner & Hoegl, 2006). Companies establish partnerships with suppliers to benefit from their technological expertise in development, design and manufacturing (Wagner & Hoegl, 2006). Buyer-supplier relationships evolve from traditional relationships to strategic alliances and the joint activities with suppliers through strategic alliances are reducing the customer total cost of installation and ownership (Wagner

& Hoegl, 2006). NPD related benefits of those activities can be the joint development of new technologies, accuracy and quality of products and on-time deliveries. there exist three types of alliances: maintenance, repair, and operation (MRO) product alliances, engineering alliance and engineered product alliances. Engineering alliances provide the supplier’s involvement in NPD.

Wagner and Hoegl (2006) distinguish projects in terms of supplier involvement level and mention that the relationship structure at “know-how projects” is different than “capacity projects”. The know-how projects are those where supplier’s knowledge is mostly technological. They are innovative projects, since they are knowledge-based and the effort is spent to introduce new products. Suppliers are responsible for critical modules or systems. They are highly integrated and involved very

early in the projects. The relationship is close like partnership. Shorter time-to-market of new products and reduced costs force the buyers to involve suppliers in know-how projects. The capacity projects focus on getting extra R&D resources and gaining R&D flexibility. This enables the reduction of internal R&D headcounts and resources that are seen as cost items. They are less innovative, such as changing an existing product. Suppliers are responsible for less critical components or sub-systems. Their involvement time is not critical and their integration is limited. The relationship is more traditional.

The both buyer and supplier have its embedded culture at organizational and project level. Involving suppliers requires a cooperative environment where joint problem solving and decision-making activities are occurring and therefore cultures of buyer and supplier should be aligned. There is a need of change in cultures and establishment of a shared culture to overcome the barriers (Gotzamani & Theodorakioglou, 2010).

Trust, reliability, openness, support, flexibility, commitment and appropriate governance of interfirm relationships are important features of buyer-supplier relationship in an NPD project (Binder & Clegg, 2007; Chang et al., 2006; Mclvor et al., 2006; Wagner & Hoegl, 2006). Flexibility and support are rephrased in (Chang et al., 2006) as the supplier responsiveness to product changes, delivery time and volume changes, assistance in product and process design and innovation.

One of the significant benefits of involving suppliers is to gain new technical competencies (Wagner & Hoegl, 2006). However, cooperativeness of the supplier can be more important than its technical competence in consideration of its selection for the future projects (Mclvor et al., 2006). The longer and more stable relationships are better for the joint efforts (Wagner & Hoegl, 2006). A cooperative work provides the match of goals of both supplier and buyer and win-win environment.

Wagner & Hoegl (2006) suggests that supplier should also be able to provide outside point of view beside its technical competence that will bring more system understanding and more innovative solutions. (Hua & Wemmerlöv, 2006) examined the personal computer market that is rapidly changing and found that the innovative supplier actions are positively

affecting the buyer's innovations. Innovation frequency is highly related to close buyer-supplier relationships and the link between them is stronger when the buyers face a tough competition.

The level of dependency affects the relationship. A cooperative relationship suggests a shared interdependence and expertise, distributed responsibility and power (Mclvor et al., 2006). Suppliers are expected to take responsibility for development, design, integration, manufacture, qualification, delivery, target performances and quality for the items those they provide (Wagner & Hoegl, 2006).

Supplier development (SD) activities and supplier optimization bring more competitive supplier capabilities (Chang et al., 2006). The rapidly changing environment introduces the development of new products, services and suppliers. The buyer quality relies highly on the quality of their multiple suppliers and it becomes more important in this environment to ensure the supplier quality through supplier quality improvement (SQI) programs (Walker & Hon III, 1988). Reed and Walsh (2002) found that SD enhances indirectly the technology capabilities of small suppliers by providing processes of technology innovation and technology future view. Beside this, it strengthens the buyer-supplier relationship and builds mutual trust, since it enables better communication links and sharing strategic data such as technology roadmaps. As a result, the suppliers are able to follow the technology and to involve more in NPD.

Johnson et al. (1997) mention the environmental considerations of the buyers that want to be more competitive by responding to customers' requests for environment protection. This forces them to have or manage suppliers during development and manufacturing of new products according to environmental awareness.

The Degree of Information Exchange

Communication is needed for an effective team-work, problem solving and decision making activities; an information exchange system should be structured between firms and teams. In a successful product development with supplier involvement, the teams are encouraged for external communication, and co-development communication links should be provided between firms. Multi-organizational product development is a strategic choice for

the companies that produce many products containing different technologies, such as telecommunication products (McIvor et al., 2006).

Design and quality specifications, cost, inventory, forecasts, schedules, production plan, material requirements, test processes, tools and production process can be shared data between buyers and suppliers to develop a new product on-time with required features, quality and price (McIvor et al., 2006). Trust is important when sharing such sensitive information and the level of communication becomes a critical issue. Supplier and manufacturer plant visits, electronic data interchanges (EDI) automate purchasing systems, information systems, computer-to-computer links with key suppliers are mentioned as types of information exchanges (McIvor et al., 2006).

Supplier Involvement on the Organizational and Project Level

In (Wagner & Hoegl, 2006) two domains are mentioned as critical for the success of supplier involvement; (1) contingency factors on the organizational level and (2) the management of supplier involvement on the project level.

Contingency factors on the organizational level concern product architecture, type of design and development interaction with suppliers, partnering relationships, evaluation of supplier's performance, R&D, manufacturing, assembly and logistics capabilities.

In modular product architecture, functional elements have one-to-one mapping to physical components and there are standardized interfaces between sub-modules, therefore design can be split easily between buyer and different suppliers. In integral product architectures, designs are complex, a functional element consists of many physical components, a change of a component requires the change of another component, and therefore it is difficult to manage the involvement of suppliers in the projects and innovation processes. As a result, supplier involvement depend on the product architecture and the design and development interactions with suppliers which can be classified as "none", "white box", "gray box", "black box" or "traditional", "advanced" and "integrated" subcontracting (Wagner & Hoegl, 2006). For example, at a "white box" design, the buyer has the whole internal view of the supplier's sub-system. At a "gray box" design, the buyer has the limited internal view of the

supplier's sub-system. These two designs can be result of joint design activities. The "black box" designs meet the buyer's functional requirements and buyer does not how these are implemented internally. Supplier involvement can be limited when the buyer uses an existing part. If a new part design is required, supplier can contribute more to buyer's new project.

A cooperative buyer-supplier relationship also depends on organizational structures. Partnership with suppliers is a critical organizational factor and depends on that the buyer provides cooperative environment, open communication, a high level of trust and commitment.

Evaluation of suppliers is needed to get a better performance from supplier involvement. The buyer firm can select supplier and distribute responsibility according to the performance, R&D, manufacturing, assembly and logistics capabilities of the supplier. (Hou et al., 2006) proposes an evaluation index system including satisfaction, flexibility, risk and confidence index for the supplier selection in new product development. A system is needed to decide the time and extent of supplier involvement. Table 3 presents sub-indices for this evaluation system. Most of the items in this table are explicitly mentioned in this literature survey at several places. If a supplier ranks high in these dimensions, the supplier can be selected to contribute early in NPD process and it can be responsible for more critical and complex tasks. The supplier gain also credits for the future projects.

The second domain is about coordination of project tasks between buyer and supplier, interaction and inter-organizational exchange of project members from buyer and supplier side. In NPD projects, the collaboration quality of the members from both sides is more important for the project success than giving more tasks to the supplier. Therefore, the main focus should be the relationship between members.

Building a Buyer-Supplier Project Team

In a buyer-supplier project team, members of two different organizations work cooperatively to achieve common goals. Size and composition of the team are critical factors for the NPD (Wagner & Hoegl, 2006). The size increases with the complexity, since complex designs require more people with different competencies. Some of the members build

Tab. 3: Supplier selection and evaluation indices for involving suppliers

Satisfaction Index	Product quality (certification, quality feedback speed)
	Product cost (development cost; raw materials cost and raw materials source)
	Technical capability (process capability; production capacity; new technologies adaptability)
	System support (organization, training and process feasibility)
Flexibility Index	Product standardization
	Quantity feasibility
	Developing capability (R&D budget and expense, new technologies adoption ratio, innovation capability)
	Product modularization
	Speed of information interchange
	Management level (level of IT and software tools usage, Product Data Management normality degree)
Risk Index	Consistency (commercial /business culture, technical tools, enterprise/organization architecture, development strategy)
	Collaborative experience
	Technical risk (technical specialization and technical change ratio)
	Enterprise power (corporate scale, trading position, financial status, market competition power)
	Development perspective (capacity planning, sustained improving capacity, market share)
Confidence Index	Business credit standing (contractual damage ration, completion ration, customer compliant ratio)
	After service feasibility and capability
	Depth of information sharing
	Security classification of information

Source: Hou et al. (2006)

the interface between buyer and supplier, and the number of interfaces among engineers depends on the number of team members. Smaller teams have more direct and efficient intra-team communication, greater effort of all team members and better usage of team members' potential.

The composition of a successful project team has several requirements. The communication capability of the team members is the most desired feature while composing the team (Wagner & Hoegl, 2006). Open, accurate, spontaneous and on-time communication is critical for the project scheduling, since it reduces time losses and overlaps between tasks. On the other hand, the problems can be quickly communicated to other side and the

solutions can be found easily. For successful product development, McIvor et al. (2006) suggest that team include interfaces, who encourage external team communication, and powerful project and senior managers, who communicate externally. Such teams are busy with task-oriented external communication.

The team should possess the necessary technical competences. Besides this, the personal characteristics and culture of team members should fit to each other by being compatible or complementary. A high motivation, project commitment and interpersonal trust are necessary. Mutual support and participative decision making should be established. And other aspects affecting the success of team structure are the capabilities of project leader,

team-work and interdisciplinary work abilities and also language skills for international groups.

2. The Semiconductor Industry

Semiconductors are technology enablers of many daily-used products – automobiles, televisions, cell phones, computers – and of an enormous variety of appliances in medical and agriculture areas, for instance. Besides, the rapid rate of innovation in the semiconductor industry facilitates the information technology revolution that affects many sectors. It has become the vital core of an entire ecosystem that drives innovation and growth in all sectors of the economy (SIA, 2006).

Global semiconductor industry spreads to USA, Europe, Japan, China, India, Korea and Taiwan. Although the United States is still the world leader in semiconductor technology, their position is not secure. China has become the world's largest market for semiconductors, reflecting a dramatic shift in electronics equipment manufacturing to the Asia-Pacific region in general and China in particular. And China has decided supplying most of its domestic needs for semiconductors from domestic production. In China, India, Eastern Europe, Russia and a host of other countries not traditionally associated with promoting free enterprise, governments are offering incentives to companies that will invest in manufacturing and R&D facilities (SIA, 2006).

The players in this industry vary from research and development companies or organizations to semiconductor manufacturers owning the fabrication facilities. Some of them have all capabilities: research, design, development and manufacturing of semiconductors. The major players in the field of semiconductors are, according to semiconductor industry (2007-2010) market research (RNCOS, 2007), Intel®, Samsung®, Hynix®, Micron Technology®, Toshiba®, TSMC Group®, Powerchip®, AMD®, STMicroelectronics®, Infineon Technologies®, Texas Instruments® and NEC Corporation®. There are always new entrants, since it is a growing market.

Semiconductor industry operates in an environment of tough global competition. The semiconductor market shows continuous growth but in a cyclical pattern, that always forces companies to offer products at lower prices. Companies try to gain a place in the

global market and fight against the growing costs; they develop strategies to improve time-to-market cycle of a new product and to respond rapidly to the global market (Lou et al., 2010). These strategies can consist in the reduction of the number of suppliers and building stronger and long-lasting relationships, and early involvement of suppliers. (Keller & Pauly, 2009) state that in this sector, partnering relationships with suppliers bring quality improvements beside the improvements at cost and delivery time. The manufacturers in semiconductor industry build agreements with competitors, create joint venture companies in other countries, and establish global partnerships for developing new products. All these efforts aimed on increasing capacity and global market share, reduce the costs and share risks.

Some manufacturers provide manufacturing services to other companies that do not want to make investments and take risks for building and maintaining their own foundries (SIA, 2011), allowing them to concentrate on product design and development. Foundry suppliers are specializing in manufacturing processes to control manufacturing costs and to improve productivity.

3. The Case Study

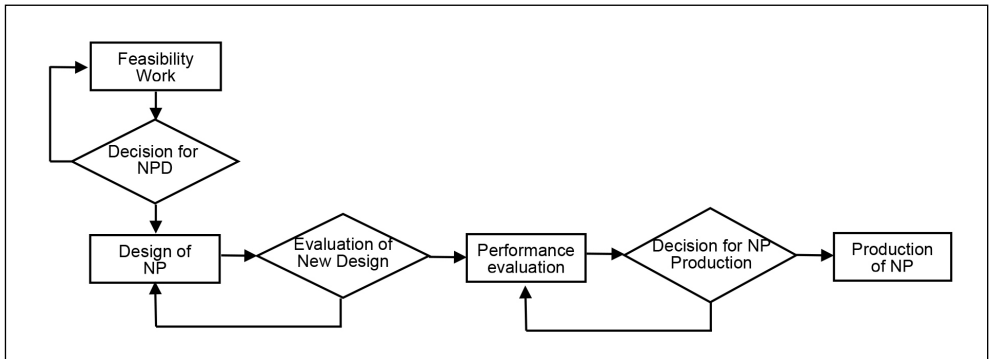
The study presents the joint NPD activities of a semiconductor supplier, its customers, competitors and suppliers. The company will be referred as "the Company" for confidentiality.

3.1 Company Profile

The Company develops and delivers semiconductor solutions for the microelectronics applications. It follows an aggressive growth strategy, investing heavily in R&D, establishing strategic alliances with blue-chip customers, other semiconductor manufacturers, suppliers and academia, building up an integrated presence in major economic regions, and leading very efficient manufacturing operations. Today, the Company possesses silicon and system expertise, manufacturing strength, distinctive concurrent engineering capability, Intellectual Property (IP) portfolio, industrial and academic partnerships, and a broad product range. Its sales are spread to the industrial sectors such as communications, digital consumer, computer, automotive and industrial.

The Company understands the competitive structure in the semiconductor industry and pays

Fig. 2: NPD flow



Source: own elaboration

high attention to innovation. The semiconductor industry is highly cyclical and has been subject to significant economic downturns at various times. This means performance can vary significantly from one year to the next. The Company is following the trends, tries to forecast the future technologies and to show good performance in this industry.

New product development is mandatory to stay competitive in this rapidly changing environment. The Company NPD flow is shown in Figure 2.

3.2 NPD Flow of the Company

New product plans are based on understanding the customer's requirements. The customer communicates its technological roadmap and the Company involves the customer in the NPD process. This involvement can start from the concept stage, project planning or design stage of the customer product. The customers' needs are translated into technical requirements as product specifications, process operations and manufacturing process controls. The Company understands the importance of concurrent engineering by stating that manufacturing and reliability must be considered at the design level in order to manufacture reliable products meeting customers' expectations.

The Company defines the NPD flow as consisting from four steps: feasibility assessment, NP design, performance evaluation and NP (New Product) production. This procedure governs the entire life cycle of a product from

new product proposal to its manufacturing and introduction to market. Each new product begins with a feasibility work to detail business and technical aspects, to see the potential of the product and to decide the allocation of the design resources. The feasibility results are reviewed by a board of people from several departments in the Company. The review and detailing can be done several times. When the feasibility report is approved, the NP design starts.

The designers work according to the clearly defined design rules and describe the functionality of Integrated Circuit (IC) using special design tools; it is reviewed periodically, and new customer requirements can be added. The process technologies are considered in the design. Then, the physical IC structure is defined and wafer evaluation brings more manufacturing considerations to design. The design results in working samples of the product. After the tests of the first working samples, the design is ready for performance evaluation step, where it is tested for characterization and reliability. The performance evaluation step involves a considerable investment; therefore approval of new design should be done carefully.

The working samples may be given to customers for application study; this action is a part of supplier involvement in NPD process at customer side. In the performance evaluation step, new product is qualified through characterization and reliability tests. If the result reports are approved, the new product is ready to be manufactured.

3.3 The Scope of the Relationships with Suppliers

The Company keeps relationships mainly with three types of suppliers: equipment suppliers, raw material suppliers and external subcontractors:

- Equipment suppliers: The limits of the technology in semiconductor manufacturing processes highly depend on the quality and technology of equipment. Semiconductor producers should follow and use the latest process technologies to produce smaller chips and consequently remain competitive. The Company establishes strategic alliances with equipment- and CAD-development suppliers to cooperate closely and to follow advances immediately.
- Raw materials: these include silicon wafers, lead frames, moulding compounds, ceramic packages, and very high-purity chemicals and gases. As the Company depends on a limited number of suppliers for several materials, they have strong partnerships for on-time and quality deliveries.
- Subcontractors: The Company outsources wafer manufacturing, assembly and testing of finished products and some other services. Depending on the market conditions and its available capacity, these subcontractors play a significant role in optimizing cost and focusing on critical proprietary processes.

The Company develops equipment- and CAD-development alliances with major suppliers to sustain competitiveness of process technology. It has vendor certification and Ship-To-Stock programs to assure the quality of purchased materials. The Company preferably chooses subcontractors to manufacture assembly and test the products in the regional areas where the customers are residing. There are also intellectual property (IP) suppliers that deliver sub-systems.

The NPD and delivering these semiconductor solutions are building the core business of the Company. Although it is highly affected by the supplier's technological capabilities, the relationship types stated above suggest that there is not much supplier involvement during the design and development of a new product. Mainly manufacturing processes are affected by the suppliers. However, the Company applies concurrent engineering, and technology used in manufacturing processes brings design rules during the NPD design phase.

Material suppliers are selected according to specific business, quality and service criteria. Business agreement starts with selected strategic suppliers by going through negotiations of price, delivery and payment terms. Then, the quality management process conducts audit controls, qualification follow-up, qualification list coordination, certification program, performance measurement coordination, setting long-term targets. The approval of supplier includes completion of a questionnaire based on international standards and an assessment of the adequacy of the suppliers' organization in achieving total customer satisfaction. At material qualification, after successful business discussions and audit results, the material is analyzed, and then submitted to qualification tests. All supplier performance is followed at plant level in terms of quality, delivery and service, a supplier's report card is created and all the results are consolidated at corporate level. In continuous improvement process, all strategic suppliers with significant business are requested to enter into a continuous improvement program with the Company.

The Company sees that the consistent supply and continuous improvement is mandatory for its continuous improvement and fulfilment of its commitments to customers. It established staff functions to ensure supplier quality, control and compliance, purchasing administration, and supplier innovation. The supplier quality department has grouped suppliers into categories, such as 'high-risk' or 'strategic.' Suppliers in each group must perform according to a specific dashboard of indicators. All key suppliers must be 100% in line with industry standards, from finance and quality to environment and social.

The Company avoids over-dependence on single suppliers. It combines more volume at global and regional levels, increasing the purchasing volume for a smaller number of service and material suppliers. While aggregating groups of suppliers, it assigns special responsibilities to the largest among them. One of the main things the Company considers is communicating with its major suppliers to ensure they felt comfortable with both the short-term needs of its cost-reduction strategy and with the medium- and long-term benefits of working with the Company. This also includes working with smaller local suppliers to explore how they could grow by working with the Company.

3.4 Other Relationships of the Company

The Company has a worldwide network of strategic alliances, including product development with key customers, technology development with customers and other semiconductor manufacturers. These industrial partnerships are complemented by a wide range of research programs conducted with leading universities and research institutes around the world. The Company is able to offer leading-edge solutions to customers in all segments of the electronics industry by complementing its portfolio of proprietary technologies and core competencies with the expertise of strategic partners.

Joint activities with other semiconductor manufacturers are typical relationships established with competitors. These are referred as joint semiconductor R&D activities, and they are mainly focusing on *wafer* testing, packaging and developing process technologies for *wafer fabs* that require a great amount of investment. The manufacturing capability is also complemented by the subcontractors, those provide manufacturing, assembly and testing facilities. The Company cooperates with competitors also to create a common standard for a new technology.

Joint NPD activities are performed through strategic alliances with customers. The Company gets involved in the technological roadmap of the customer and fulfills the requirements of the customer. The Company does a large amount of R&D with customers. The design is partially done by the customer and partially by the Company.

Customer quality support system provides an environment that takes customers' suggestions for product improvements and analyzes them. Failure analyses of a product and reliability data is given to the customers. The design specifications, agreements or special requirements are properly coordinated between the Company and customers. Contract reviews are made to follow customers' expectations. The sales personnel, including marketing support, coordinate customer communication links with manufacturing, product groups, quality, and other company functions. The customers perform independent quality audits units of the Company.

The Company management systems assures compliance with customers'

expectations in relation to environmental, health and safety, and wider corporate responsibility issues. The customers are concerned about the management of social, ethical, and environmental risks in their supply chain and they increasingly expect the Company to monitor their suppliers' performance through self-assessment and audit.

3.5 Case Study Outcomes

The Company is a semiconductor supplier that designs, develops and manufactures semiconductor systems and competes in a rapidly changing environment. Therefore, the Company runs many NPD processes in parallel and makes large investments in R&D and manufacturing processes to keep the pace with technology. The manufacturing technologies that the suppliers of equipment and Computer Aided Design (CAD) systems develop have great impact on semiconductor NPD flow. Each manufacturing process change brings change in the existing products (smaller or low-power microchips), new design rules at design phase of NPD, new characterization and reliability tests at development phase. The change in manufacturing is needed to stay competitive. Therefore, manufacturing considerations are part of NPD process in the Company and all participants have contributions in different scopes.

The products are the results of high-technology know-how of the Company and its collaborative work with customers, competitors and suppliers; each partner in the joint activities has an important impact on the success of the Company. The NPD in the Company does require not only the supplier involvement, but also the involvement of customers, competitors, suppliers, universities and research institutes to cope with technological changes, costs and risks. There is a balanced relationship with each contributor during the Company's NPD process. Figure 3 shows the relationship links.

Relationships with customers effecting NPD process includes sharing technology roadmap and market analysis data, joint design and development activities and customer quality audits. There are suppliers, competitors, universities and research institutes on the other side of the chain.

Suppliers deliver IPs in complex sub-systems; improve manufacturing process technologies through strategic alliances for equipment and

CAD-development. The Company makes quality audits and introduces social and environmental norms to the suppliers. It also communicates its cost strategies with the suppliers. And it helps them grow and reach industry standards.

The Company establishes and follows joint research programs with universities and research institutes. The outcomes are contributing to the development of new technologies.

The joint activities made with competitors to develop new technology standards and manufacturing process technologies are also highly affecting NPD process in the company.

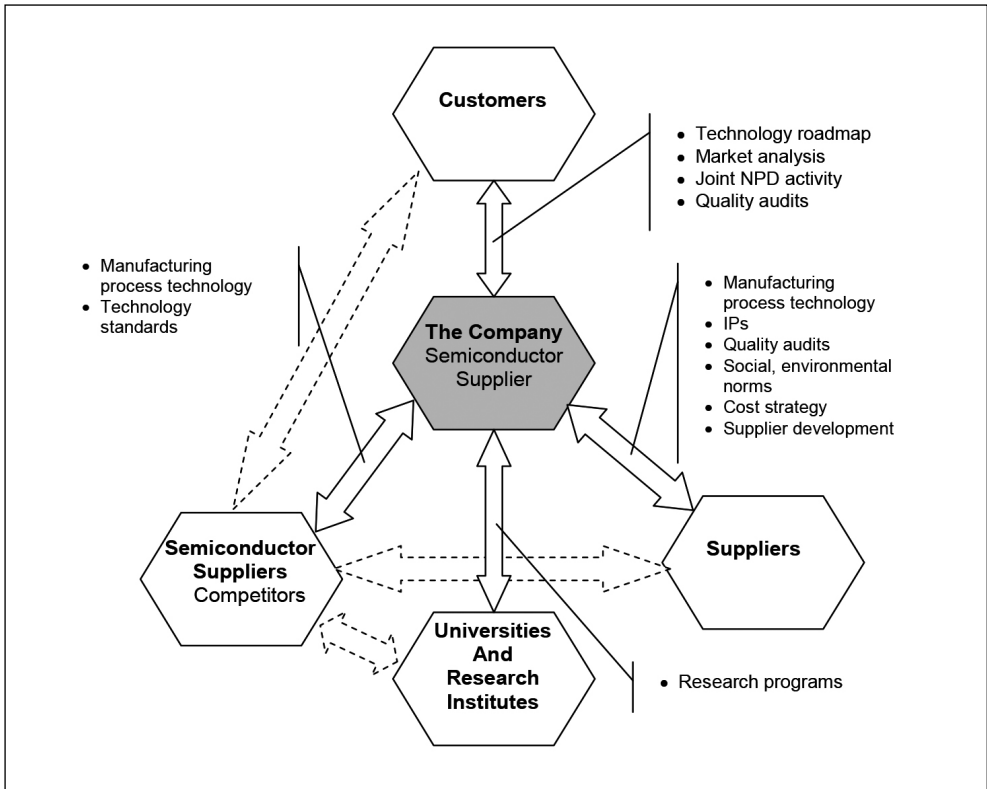
Implicitly, there exist the same kind of joint activities between the competitors and the customers, suppliers and universities those the Company is working with.

4. Discussion of Findings

The Company follows a strategy that relies on the introduction of new products and new technologies, where innovation plays an important role. The structure of the industry, where the technological changes are happening frequently, is also forcing it to innovate to stay competitive. The Company conducts co-operative and collaborative actions with customers, suppliers, competitors and research organizations, those mentioned as network of actors in the literature.

In the literature, supplier involvement in NPD is mainly focused at buyer side. The buyer establishes an environment where the supplier participates on the different stages of the buyer's NPD process. Our case study presents the NPD flow of a supplier that enables joint

Fig. 3: Balanced relationship link in the NPD process of the Company



Source: own elaboration

activities with several types of participants: customers, suppliers, research groups and competitors. Fast moving market, the need for high-technology know-how at IC design and semiconductor manufacturing, the large R&D expenses, expensive semiconductor process technologies, pressure for lower costs forces the supplier Company to have joint activities. These activities can take place during the definition of new products or technologies, the consideration of quality and cost aspects or during the development of new process technologies.

The literature mentions two project categories: know-how projects and capacity projects. Both categories can be seen in the case study. Joint product development with customers is a part of know-how projects where innovative solutions are produced. Research performed together with universities, joint R&D activities for process technologies with other semiconductor manufacturers are capacity projects where extra R&D resource is gained and investment costs are reduced.

The rate of joint activities is high and this indicates that the culture of the Company has grown towards co-operation. However, it does not want to depend on single supplier. The company works with a group of suppliers in order to respond quickly the customer requests. It can create competition between them and this can be a barrier as mentioned in the literature. Beside this, it may suggest lack of trust. Reducing the number of suppliers has been mentioned as a strategy in the semiconductor industry, but this is not valid for the Company's case.

Communication links are emphasized in the literature. Balanced relationship link in NPD process of the Company brings the necessity of powerful communication links. Shared technology forecasts and market analysis with customers, shared quality norms and cost strategy with suppliers are examples for shared data. The sales and marketing people are interfaces coordinating communication links between customer and manufacturing, product groups, quality, and other company functions.

The Company assigns special responsibilities to most of the suppliers. The shared responsibility is a key feature of cooperative relationship as mentioned in the nature of buyer-supplier relationship.

Supplier development mentioned in the literature is enabled in the Company by helping

the suppliers achieve quality, social and environmental norms.

The semiconductor industry aspects – rapid technological changes, need for innovation, global competition, need for reducing cost and time-to-market cycle, partnerships to increase capacity and market share, to reduce the costs and to share risks – exist in the Company's environment.

Conclusions

The global competition requires that companies rapidly adapt themselves to technological changes, develop new products, reduce the cost, shorten the time to market, and increase the quality. The improvement of existing product and services is not enough to sustain competitiveness today. NPD process becomes a focus point when projects are complex, and the cost, time and quality considerations are determinant. In NPD processes, the companies tend to establish partnerships with other organizations to increase their R&D resources and capabilities; companies focus on the specialization in their core businesses and complement the missing competencies in synergy with other companies.

The paper focuses mainly on the supplier involvement in NPD. The case study from semiconductor industry shows that a more complex relationship structure is affecting the NPD process for high-technology products. Many NPD processes are frequently being established in the semiconductor industry, because projects are complex, require special skills and time-to-market is very short. In this environment, there is a networking approach and only supplier involvement is not satisfactory. The customers, suppliers, competitors, universities and research institutes are expected to work collaboratively to reach the common goals, and to answer to the market needs and trends. Each partner is contributing according to its specialized area and capability. Partners share R&D resources, technology roadmap data, quality, social and environmental norms and cost strategies to reach the consumers' expectations.

Joint activities between the different participants depend on trust and reliability, openness, support, flexibility and commitment as it has been suggested only for the suppliers in the literature. They are established according the level of complementary skills and

technological know-how to reach the innovative solutions. Another aspect is to be close to the regional costumers or to be able to enter regional markets.

Further research can be conducted to see if the networking approach during NPDP process is valid in other semiconductor companies and in different sectors, to understand the contribution of different participants in different industry sectors and the different relationships with participants.

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Abstract

SUPPLIER INVOLVEMENT IN NEW PRODUCT DEVELOPMENT: A CASE STUDY FROM THE SEMICONDUCTOR INDUSTRY**Özalp Vayvay, Maria Manuela Cruz-Cunha**

The global competition requires that the companies adapt themselves to technological changes rapidly, develop new products, reduce the cost, shorten the time to market, and increase the quality. In this context, supplier involvement in New Product Development (NPD) is determinant for a company to respond to the requirements of the increasingly dynamic markets. The main purpose of the paper is to demonstrate the importance of supplier involvement in NPD, buyer-supplier relationships and their effects on buyer's NPD process, highlighting the benefits of supplier involvement, the barriers, the strategic aspects and industry aspects. These issues are addressed with a case study from the semiconductor industry. Besides helping to understand NPD in the semiconductor industry, the contribution and findings of this work are clear: the results achieved confirm the findings of studies referred in the literature review, and confirm that the semiconductor industry sector requires a closer and more complex relationship structure with suppliers, given the specificities and challenges of the sector, such as rapid technological changes, permanent innovation, global competition, reduction of cost and time-to-market cycle, increased capacity, among other. The main contribution of the paper to the scientific literature and to managers is the better understanding of the buyer-supplier relationships in NPD in the semiconductor industry.

Key Words: *New product development, supplier involvement, semiconductor industry, buyer-supplier relationship.*

JEL Classification: L21, L23, L25, M11.

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