Analysis of Supplier Involvement in New Product Development and Launch

by

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Abstract

New or innovative products are growing in importance both in numbers and revenues, putting an extra stress on most current supply chains – defined conceptually as a buyer with a network of suppliers - as those were originally designed for efficiency purposes and existing products. While new products due to their characteristics, such as short life cycle, demand variability, and high investment risk, require responsive, flexible, adaptable supply chains and relevant practices. Those practices need to be properly tailored for specific different types of new products, perceived as a continuum of newness and change.

This thesis examines supply chain management and supplier management practices for new products across different industries. This study has been conducted within the MIT Supply Chain 2020 Initiative using the academic and business literature research and an online survey as the methodology, and new product analytical framework as the study deliverable.

The results of this study demonstrate that though there is a pronounced tendency to use suppliers more extensively to improve new product performance and general competitiveness, companies approach the supplier new product involvement very differently - depending on the type of new product in question and the specific mix of its key activity categories, which were identified in this study and corresponding framework as Flexibility, Control, Technology and Cost Focus.

Thesis Supervisor: Christopher G. Caplice,
Executive Director, Master of Engineering in Logistics

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Biographical Note

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1 - Introduction

In this chapter we define the objective of our research and its motivation as well as describe the the overall structure of the thesis.

1.1 Objective of the Research

For the last two decades, the role of new products and specifically supplier involvement in new product development and launch has come to be considered among the most important factors of competitiveness for businesses. In the context of the above, the purpose of this paper is to:

- Identify opportunities and benefits for supplier involvement in the New Product Development (hereafter NPD) process in the context of the supply value chain;
- Compile a comprehensive list or toolbox of the best supply chain practices used in connection with and in order to optimize the supplier involvement in NPD;
- Test the prevalence and importance of the above best practices with the industry practitioners;
- Construct a robust across-industries conceptual framework allowing the selection and implementation of the best supply management practices as per a specific new product type, and corporate/industry requirements.

1.2 Motivation

Over the last decade we witnessed an explosive growth and proliferation of new products. Packaged consumer goods in the United States alone grew by more than 112% from 1992 to

1993. New product introductions in the same US packaged consumer goods industry rose by 94% over the years 1993-2003 - from 17,363 to 33,678 per year (Productscan Online, 2004).

Besides simply a numeric growth, new products are an increasingly important revenue source. New products account for 25.2% of revenues for the average US company and for more than 49.2% in Product Innovation Leaders, defined as those companies that consistently focus on and succeed in product innovations (Cooper, 2001). New products are also a source of a higher profit margins. The premium bonus on new products varies from 20 to 50% and more, or even 70 to 90% for such companies as Procter & Gamble (Cooper, 2001). While the success rate for new products does not exceed 55% with an average company, product innovation leaders could boast up to 95% of new product successful introduction (Cooper, 2001).

The importance of new products emerged in the 1980s as companies with strong product development capabilities consistently outperformed their counterparts. For example, throughout the 1980s, Honda and Toyota introduced new models every three years, compared with a five-year cycle for General Motors and Ford (Brown and Eisenhardt, 1995). As a result, these automakers gained market share at the expense of their US rivals. Similarly, Canon was able to establish itself as a major player in the photocopier industry by introducing over 90 new models in the six-year time-period from 1976-1982. Only when Xerox responded by improving product quality and dramatically reducing its own product development time was it able to stem its loss of market share (Nonaka and Kenney, 1991).

These examples highlight the fact that new product introduction has become increasingly important as a competitive weapon. In fact, over the past 20 years, profits derived from new products have steadily increased. In the 1970s, new products accounted for 20 percent of company profits. By the 1980s, the profit contribution of new products rose to over 30 percent. This profit impact has strengthened throughout the 1990s and recent years. (Cooper, 2001)

Due to the powerful trends of mass customization, globalization, as well as consumer choice, media and technology driven changes, new products become one of the few most effective competitiveness and growth strategies available. In the next 5 years, products that represent almost 75% of a company's revenues today will be obsolete (Cooper, 2001). Product life cycles are getting shorter, for example, the average shelf life of PC's decline from 12-18 months in 1990 to 4-6 months in 1998 (Rigby and Zook, 2002).

While supply chains are critical pipelines for new product introductions, only 33% of the companies are doing a relatively good job managing them properly in terms of new product success and profitability and only about 7% could be called leaders in supply chain management of new products (Cook, 2002). The growing importance of new products coupled with the still largely untapped supply chain potential for improvement presents a strong motivation and reasoning for research. This is where research could bring value by educating the industry.

1.3 New products typology

The new / innovative products are covered rather extensively in academic and business literature.

Cooper (2001), for example, gives a comprehensive general framework and widely accepted classification and typology of new products. These are:

1.) **New to the world products** – those new products that are the first of their kind and create an entirely new market. They represent approximately 10% of all new products. Examples include the Sony Walkman and the Palm Pilot.

2.) **New product lines** – those new products that are not new to the market place but new to the particular company. They allow a company to enter the established market for the first time. This category accounts approximately for 20% of all new products. Examples include Canon introducing its LaserJet printer after this product was already created by Hewlett-Packard.

3.) **Additions to existing product lines** – those new products that fit within an existing product line of the company in question. This is the largest new product category accounting for about 25% of all new products. Examples include Hewlett-Packard's introduction of its LaserJet 7P, a smaller and cheaper printer for domestic usage.

4.) **Improvements and revisions to existing products** – replacements of existing products in a company's product line with improved performance or greater perceived value over the replaced product. This category accounts for about 25% of new products. Example: Kennametal improved drill bits.

5.) **Repositionings** – new applications of existing products. Those products account for about 7% - 8%. Example: aspirin (ASA) marketed as a preventer of blood clots, and heart attacks versus the old application of a headache reliever;

6.) **Cost reductions** – new products designed to replace existing products. They provide similar benefits at a lower cost due to production or design improvements. This category accounts for about 11% - 12% of all new product launches.

We deemed it expedient for the purposes of this research to create a simplified new products typology: Radical, Substantial and Incremental.

Radical Innovative products - Products that are new-to-the-world or breakthrough, for example, Sony's Walkman, 3M's Post-it-Notes, Xerox Laserjet Copier, Gillette Safety Razor, Procter & Gamble Tide powder. Those are identical to the new-to-the-world products as per (Cooper, 2001) new products typology (about 10% of all new products).

Substantial Innovative products - Products that are new lines to the organization, or additions to existing product lines, or major revisions and next generation advances of currently existing products. For example, Canon LaserJet Copier, Diet Coca Cola, P&G Tide in Tablets, Gillette Fusion Razor. Those are similar to Cooper's n**ew product lines,** and **additions to existing product lines.**

Incremental Innovative products - Products that are improvements, or repositionings, or cost reductions of currently existing products. For example, Gillette Fusion Turbo, P&G Tide in tablets with Bleach, Diet Coca Cola caffeine-free. These are Cooper's **improvements and revisions to existing products, repositionings** and **cost reductions**.

1.4 Literature Review

We reviewed academic literature on new products from the supply chain perspective. There is a general consensus among authorities on unique requirements new products pose to supply chains. For instance, Fisher (1997) argues that the key quality from supply chain perspective of any innovative product is an enhanced risk through short cycles, highly variable demand and accordingly increased need for forecasting. He further indicates that there exist essentially two types of supply chains: physically efficient and market responsive. New / innovative products should use a "responsive" supply chain, which does not maximize efficiency, but rather maximizes availability of product to the customer. Fisher claims that the majority of supply chain suboptimal issues are a result of "efficient" supply chains imposed on innovative products, which causes a mismatch.

The discussed proliferation of new products and mass customization is also causing increased complexity and complications in supply chains, which can erode profit margins. This issue is addressed by Anderson (2005) in his article promoting the need for simplification and spontaneous supply chains. He further states that this unnecessary proliferation comes from three sources: (1) too many older, low-volume products that have too many unusual parts; (2) lack of part and material standardization; and (3) too much outsourcing with too many suppliers and too many "links in the chain." Anderson proposes supply chain simplification as the first step in establishing a spontaneous supply chain, based on steady flows of very standard parts and automatic resupply techniques such as kanban (widely used signaling system for resupply).

He further describes simplification steps for supply chain, such as: standardization, automatic resupply techniques, and rationalization with the overall goal of dramatically reducing the variety of parts and raw materials.

Anderson then reviews product customization as a form of standardization. There are three ways to customize products: modular, adjustable, and dimensional customization. Adjustable customization provides the ability of the product to be customized by adjusting the features. Dimensional customization refers to permanent dimensional change. A modular customization approach can reduce the variety of components offering at the same time a greater range of end products. This approach is based on the concept of modularity, which allows part(s) of the product to be made in volume as standard modules with product distinctiveness achieved through either combination or modification of the modules. Modularity provides both economies of scale and economies of scope (Baldwin and Clark, 1994). Modular approach is especially important for new products, and will be investigated in detail further on in this research.

Lee (2004) explains that a high demand variability typical for new products requires an adaptable supply chain, which has two key components: the ability to spot trends and the capability to change supply networks. Efficient companies, as Lee argues, tailor supply chains to the nature of the markets for products. Gap, for example, uses a three-pronged strategy. It aims its Old Navy brand at cost-conscious consumers, the Gap line at trendy buyers, and the Banana Republic collection at consumers who want clothing of higher quality. Rather than using the same supply chain for all three brands, Gap set up Old Navy's manufacturing and sourcing in China to ensure cost efficiency, Gap's chain in Central America to guarantee speed and flexibility due to a high

number of new product launches in this product line, and Banana Republic's supply network in Italy to maintain quality. The company consequently has higher overheads, lower scale economies in purchasing and manufacturing, and larger transportation costs than it would if it used just one supply chain. However, since its brands cater to different consumer segments, Gap uses different kinds of supply networks to maintain distinctive positions. The strategy has worked. Many consumers don't even realize that Gap owns all three brands, and the three chains – channels and production capabilities - serve as a backup buffer capacity in case of emergency or dramatic demand fluctuations. Production and distribution could be shifted or relocated temporarily from one chain into another and vice versa.

According to the proceedings of Supply Chain 2020 (2004), MIT Center for Transportation and Logistics multiyear research project to analyze critical factors for future supply chains, there is a pronounced move to velocity or the rapid flow of the new products in the supply chain. This pulls companies toward the Zara or Dell model of local manufacturing and very short cycle time replenishment / fulfillment processes.

As a summary, new products pose unique requirements on supply chains, most of all variability and uncertainty of demand. There is a consensus among the authorities that the solution lies in bringing a degree of responsiveness, or adaptability, or velocity to how supply chains function.

1.5 Thesis Roadmap

The remainder of the thesis is organized as follows. Chapter 2 focuses on the academic literature dedicated specifically to supplier involvement in new product development. Chapter 3 identifies

and explores in detail those 15 selected practices that are most widely used by companies for new products within the context of supply chain and supplier management activities. Chapter 4 provides description of the undertaken survey on supplier involvement in new product development, together with the survey results and key insights. Chapter 5 covers our developed conceptual model on supplier involvement in new products. Chapter 6 provides concluding remarks, together with the research summary and recommendations for future research.

2 - Supplier Involvement in New Product Development

As discussed earlier, for the last two decades, we witnessed proliferation of new products, which become the nexus of competition for many firms (e.g. Clark & Fujimoto, 1991). As a result there has been an increase in importance of properly managing new product development process, which in turn cannot be done effectively without supplier involvement and integration. Indeed, all across worldwide manufacturers, purchased materials account for more than 50% of the total cost of goods sold (Handfield et al., 1999). Additionally, suppliers have a direct and large impact on the quality, time to market and technology. Thus effective involvement and integration of suppliers in new development process becomes a critical factor for the companies to remain competitive (Handfield et al., 1999).

'Supplier involvement' refers to the resources (capabilities, resources, information, knowledge, ideas) that suppliers provide, the tasks they carry out and the responsibilities they assume regarding the development of a part, process or service for the benefit of a current or future buyer's product development projects (Carr and Pearson, 2002).

As noted by Christopher (2000), process integration (collaboration between buyers and suppliers in joint product development, common systems and shared information) is becoming ever more prevalent in the supply chain, as companies focus on managing their core competencies and outsource other activities. This process at its culmination is causing some of the front or customer facing companies (such as Dell, GM, or Boeing) to primarily become the prime coordinator for suppliers, marketing front-end, and service provider for products (Roy, 2005).

2.1 Supplier Involvement Advantages

There are many advantages for a firm that involves suppliers in its NPD activities. For instance, supplier participation in NPD reduces project development lead times and project costs, improved perceived product quality, and better manufacturability (Gupta and Loulou, 1998). The supplier involvement in NPD not only brings the supplier and the firm closer in sharing knowledge and learning, but allows to reduce technological risks as well by pooling their technological expertise and capabilities.

Suppliers also have been shown to provide a source of innovative ideas and critical technologies (Nishiguchi and Ikeda, 1996). At the same time, however, some studies have demonstrated that managing supplier involvement in product development is quite difficult and might not always lead to perceived early supplier involvement benefits (Hartley, et al., 1997).

Especially so in the case of final products consisting of parts from many different suppliers, supplier involvement may actually increase the complexity of managing new product development projects. One critical issue in such a situation is to determine what type of involvement a manufacturer / buyer should have with the various engaged suppliers. Indeed collaboration with suppliers takes time, effort and money through coordination and communication. Supplier involvement is not very useful then if the same amount of time that was saved internally is now being spent on additional communication with suppliers (Wynstra & ten Pierick, 2000).

While essentially the importance of supplier involvement is mostly endorsed in the academic literature, it is apparent that organizations still struggle with the fundamental changes to the new product development process that must happen to facilitate supplier integration.

2.2 Supplier Involvement Opportunities

The supplier involvement or integration into the new product development process can occur at any point in the five stage new product development process model, provided below in Figure 1. The five stages precede full scale production and include: idea generation, preliminary business/technical assessment, product concept development, product design and development, prototype build, test and production ramp up.

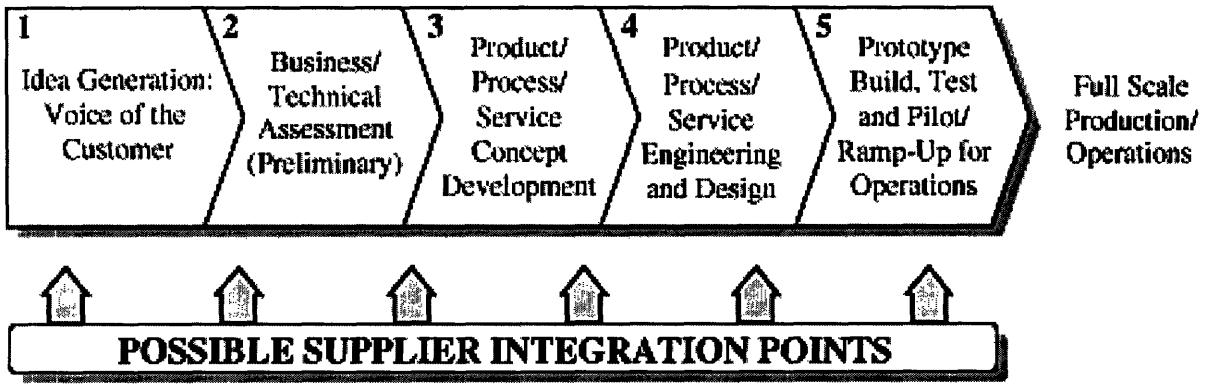

Figure 1 - Source: Handfield et al., 1999

Ernst and Kamrad (2000) report that approximately 80 % of the manufacturing cost of a product is determined by the design of the product. Thus significant opportunities for further savings could lie in the integration of product design and the supply chain (see above Figure 1 for specific points of possible integration). The integrated supply chain brings suppliers and customers closer to the manufacturer so increased value can be created due to the sharing of resources and availability of more accurate and timely information. Conceptually the earlier this integration happens, the higher are the benefits.

Hsuan (1999) considers supplier involvement as an important function of the Supplier-Buyer Interdependence. In developing a product innovation, the degree of interdependence relies on the proprietary sensitivity of the new product in question as well as supplier management practices, that in turn determine how responsibilities for functional specification and engineering are split between the supplier and the buyer.

Studies have found that there is a variety of benefits and opportunities that are attributable to supplier involvement / integration into new product development. First, including suppliers on new product development / project teams adds information and expertise regarding new ideas and technology, and helps to identify potential problems so they could be resolved earlier. Second, supplier integration helps to reduce the internal complexity and shorten the critical path for new product development projects. Third, it helps to improve coordination and information exchange, which in its turn reduces delays. Finally, it creates an improved smoother relationship with suppliers (Clark and Fujimoto, 1991).

Clark and Fujimoto (1991) further compared Japanese and U.S. companies' use of suppliers in new product development in the auto industry, and found that the contribution of suppliers to competitive advantage is especially critical in cases where R&D activities are shared. They also found that Japanese manufacturers made more extensive use of supplier development to reduce concept to customer cycle time, leading to high market entry barriers, cost leadership, higher quality, and technologically leading edge products.

Clark (1989), studying the involvement of suppliers in the NPD in the Japanese auto industry, reports the following: Intensive supplier involvement in product development brings significant advantages in lead time and cost. Supplier involvement (and stronger supplier relationships) brings a saving of about 33% in the personnel work hours and contributes to four to five months lead time advantage. A developed network of integrated suppliers enables many Japanese firms to use more unique, design-rich components, thus improving the performance of their products.

It is important to note that supplier involvement redefines relationship and type of partnership between supplier and buyer. The nature of such partnerships can be broadly assumed to vary from one extreme, an arm's-length relationship, to the other extreme, a strategic partnership. The key question is to decide, which type of relationship the firm should develop with each supplier. Dyer et al., (1998) suggest a segmentation of suppliers into three categories: short-term arm's length relationships, durable arm's length relationships, and strategic partnerships. Short term arm's length relationship is minimizing dependence on suppliers at the same time maximizing the buyer's bargaining power. Durable arm's length relationships simply refer to a longer timeframe (on average 4-5 years contracts versus 2-3 in short term arm's length relationship). While strategic partnerships are such buyer-supplier relationships that are based on sharing more information, intense coordination, trust as relationship governance principle and dedicated or relation-specific assets. Dyer et al., (1998) argue that depending on a supplier type, buyer's relative dependency, performance criteria and most importantly the strategic value a supplier's product could bring, one or combination of the above relationship models should be used.

There is a substantial anecdotal evidence on suppliers having an early impact on new product development: for example, Cadillac, have supplier representatives on 75 percent of their development teams; Xerox, include suppliers in product development partnerships since the early 1980s; Boeing, colocate suppliers in their manufacturing facilities; and Volswagen select suppliers, which could build not only components but complete modules as well (Twigg, 1998)

As a summary of our academic review and current chapter, we have come to the conclusion that by leveraging the skills, capabilities, and resources of suppliers and involving them in new development process, buyers / manufacturers can gain significant benefits, such as reduced development costs, product cost, quality and technology leadership, compressed development cycles, improved coordination, information exchange, and finally better relationship. Indeed, quite a few major U.S. corporations such as Whirlpool, McDonnell Douglas, Boeing, and Chrysler have shifted many of their design activities to key suppliers (Hartley et al., 1997). At the same time those benefits are not automatic and require manufacturers to use discretion on when, how and to what extent involve suppliers in new product development process and how to manage them properly and effectively, while involved.

3 - New Product supply chain related practices

Based on our academic and business literature review, we developed 5 clusters or groups of supplier management practices. These practices cover all key aspects of supplier involvement in new product development, such as product and product design management, production capacity, suppliers and costs. These groups are:

1.) Product & process management practices – those activities that are directed at optimizing utilization and manufacture of products and product components;

2.) Capacity management practices – the activities directed at improved matching between supply and demand;

3.) Supplier management practices – those activities that help manage and optimize supplier involvement;

4.) Cost management practices – the activities directed at improving product and production costs;

5.) Product design management practices – those activities that help maximize and / or optimize supplier's input into the product design process.

The following sections describe the practices that fall under those clusters.

3.1 Product & process management practices

These practices all concern the optimized utilization and manufacture of products and product components. They include: Proprietary components reduction; Modularity / common platforms; Postponement, and Test launches.

3.1.1 Proprietary components reduction

There is a growing trend towards standardization and modularity of the components and assemblies, to make them easily replaceable and thus more cost efficient, which in turn drives reduction in the number of proprietary components..

Historically, most personal computer assemblers have sought to distinguish their products from competitors by building in some proprietary component technology. Typically, these custom-designed, proprietary components have included application-specific integrated circuits, the layout of the motherboard, local bus technology, integrated controller circuitry, and so on. Recent well-publicized examples of proprietary features have been "plug and play" upgrades for microprocessors, detachable screens for laptops, and the pointing device incorporated into IBM laptop computers (Tassey, 2000).

One of the central features of commoditization in the personal computer industry has been the shift from custom to standardized technologies. Many manufacturers of clone computers (copied more or less close on brand name computers), for example, purchase standard-design motherboards from external vendors. By contrast, companies such as IBM and Compaq have committed substantial resources to in-house technology development for personal computers.

The difference between these two groups of firms is clearly seen in terms of Research & Development expenditures. ALR, Dell, Zeos, and other clone manufacturers commit less than 3 percent of revenues to R&D, as compared to R&D investments of 7-8 percent at IBM, Apple, and other technology-driven firms. Compaq, with a reputation as a "premium" clone manufacturer that includes considerable proprietary technology in its computers, had R&D expenditures in 1992 of $172.9 million, or 4.2 percent of its revenue. Clone manufacturers conduct little in-house technology development, manufacturing computers largely on the basis of standardized technologies purchased from outside firms (Tassey, 2000).

The design and development of proprietary component technology typically takes place in-house at the main computer manufacturing facility in the United States. The actual production of the technology, however, often takes place elsewhere, and in many cases is performed by external subcontractors (Gomes-Casseres, 1993)

Sometimes though proprietary components are intentionally used by the companies for radical innovations or their critical high value products, to protect against competitor's threat of copying and to increase the level of control over the product. This is, for example, done by IBM for their high value internet servers, which are also finally assembled by IBM only (Roy, 2005).

In short, reduction of proprietary components allows for improved manufacturability, product assembly and integration-friendly architecture, reduced costs of redesigns (Mikkola and Gassmann, 2003), larger number of product variations, and decreased production costs.

3.1.2 Modularity / platform sharing

Modularity is defined as building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole (Baldwin and Clark 1997). In broadest terms, modularity is an approach for organizing efficiently the design and production of complex products and processes (Baldwin and Clark, 1997). Complex tasks are decomposed into simpler elements so that they can be managed independently and yet operate together as a whole. A motivation behind decomposition of a complex system into parts is to gain flexibility and cost savings. Modularity in terms of maximizing economies of scale through standardization of components was already practiced in the early 1900s. For example, inspired by Taylor's idea of using standard components, Ford Motors reduced the Ford Model T assembly time from 12 to 1.5 hours in 1913, thus creating the concept of mass production (Hsieh et al., 1997).

Modularity often forces tighter relationships between suppliers and manufacturers. OEMs have to work with first tier suppliers to design parts for practicality, manufacturability, and style. The only way to achieve tighter connection and collaboration is to consolidate the suppliers by focusing on the critical ones. This is exactly what has been happening in the automotive industry. For example, a typical car requires parts from about 200 1st tier suppliers. The Smart car, a vehicle produced by Swatch and Mercedes, is heavily modular and only uses about 25 first tier suppliers (Doran, 2003). Currently most automotive manufacturers are not at this level of integration, and still have several hundred 1st Tier suppliers.

According to Baldwin and Clark (1997), modularity boosts the rate of innovation, as it shrinks the time business leaders have to respond to competitors' moves, and modularity can spur

innovation in design as the manufacturers can independently experiment with new product and concepts. Schaefer (1999) focused on modularity's role in increasing product variety. Modular design can reduce the cost of the increased variety of a product line. The process of mixing-and-matching can aid the firm in learning about the interactions between components.

As discussed earlier, modularity also serves as an important prerequisite for postponement. The ability to standardize components of different product models has an important effect on the type of postponement strategy used. At the very minimum, there needs to be some degree of standardization in the product design and the manufacturing process before the form postponement can be adopted. In a system involving modularization, the composition of end products is separated into sub-assemblies that may or may not be common to different products. For example, DeskJet printers produced by Hewlett Packard (HP), have the same casing, circuit boards and print head components irrespective of the market they are to be sold in while power supplies, manuals and packaging vary from country to country (Wind and Rangaswamy, 2001).

Thus, form postponement might involve standard components being produced in one stage and customized features being added at a point further down the channel. HP has taken this approach in its manufacturing DeskJet printers manufacturing for European and Asian markets. This has reduced inventory levels and allowed the company to be more flexible and has also lowered transportation costs since modules are light by weight while heavier components are added at the local markets (Feitzinger and Lee, 1997).

One of GM's methods for improving the production process and catering to the large variety of consumer choices at the same time not giving up manufacturability is platform sharing (which is another form of modularity). Platform sharing is when several vehicle models have the same base of a vehicle, which can include anything that is not essential in determining the stylistic aspects (Miller, 2000). The benefit of platform sharing is that parts can be shared across models, demand for shared parts can be aggregated, and overall manufacturing efficiency could be improved because of decreased parts proliferation.

3.1.3 Postponement

The concept of postponement is about delaying activities (as to the form and /or place of goods) until the latest possible point in time, or delaying the point of production differentiation until better demand signals can be obtained.

The logic behind postponement is that the delay leads to the availability of more information and thus the situational risk and uncertainty. This concept was first proposed from a marketing management perspective on how to cope with the uncertainty of customer demands by postponing the differentiation of a product (Van Hoek, 2001).

In the 1960's postponement was proposed for introduction into the distribution channel, focusing on where and by which player in the channel inventories should be positioned. It has been concluded that the benefits of postponement include saving transportation, assorting, storage and obsolescence costs by delaying a product's variety, volume, weight and/or value increases, and, more importantly, final configuration (Van Hoek, 2001).

Zinn and Bowersox (1988) describe different types of postponement that could be used. These include labeling postponement, packaging postponement, assembly postponement, manufacturing postponement and time postponement. Labeling postponement is a situation where a standard product is stocked and labeled differently based on the realized demand. In packaging postponement products are not packaged into individual packs until final orders are received. Assembly and manufacturing postponement refers to situations where additional assembly or manufacturing may be performed at the assembly facility or at a warehouse before shipping the product to the customer after demand is realized. Finally, time postponement refers to the concept that products are not shipped to the retail warehouses but are held at a central warehouse and are shipped to customers directly.

On a more conceptual level, there are two notions of postponement: The first postpones changes in form and identity to the latest possible point in the distribution system, while the second postpones changes in inventory location to the latest possible point in time.

Examples: Fashion producer Zara / Inditex of Spain is using postponement for 50% of their products. The key consideration of Zara's production management is the time factor, considered by Zara above all costs (Chu, 2005).

In the classical postponement example in Benetton, 90% of its sales are of standardized items with a seven month advance committed order while the remaining demand pattern of 10% is unpredictable and hence is postponed to manufacture until just five weeks before delivery. This

offers the company strategic and operational flexibility time. That is Benetton subcontracted the base part of a product's demand to low-cost sources that have long lead times while they produce the surge part of the demand in their own flexible facilities which are 10% more expensive but have shorter lead times (Yang and Burns, 2003).

Postponement is related to modularity. The degree of modularity in product development and production process plays an important role in determining the adoption of postponement strategies. Modularity means building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole (Baldwin & Clark, 1997).

The degree of modularity in the production development or production cycle is a key indicator of the degree or type of postponement provided. When high modularity occurs, product development postponement and production postponement could be implemented to cope with the high level of uncertainty (Yang et al., 2004).

Faced with a high level of uncertainty where information becomes obsolete quickly, it is difficult to finalize specifications early and keep them frozen for the rest of the development process. For example, companies could lack the power to resist changes in design specifications because of changes in customer needs and / or the arrival of new technology or regulatory standards. It has been found that changes in customers' demands could lead to 25% of the delays in new product introduction (Kalyanaram and Krishnan, 1997).

In this respect, the concept of the so-called product development postponement presents a valuable insight. Defined as the convergence of postponement with product development, where information (such as customer requirements, suppliers' inputs etc) drives all the development process. Product development postponement could lead to significant reductions in lead times as well as fewer redesigns, especially from changes later in the development processes (Yang and Burns, 2003). At Toyota, the implementation of product development postponement enables Toyota to design better cars faster and cheaper (Yang et al., 2004).

As a summary, postponement is an extremely important practice, which allows for more flexible and economical management of product innovations through delay of certain activities.

3.1.4 Test launches

Effective product launch is a key driver of top new product performance, and the launch is often the single costliest step in new product development (Di Benedetto, 1999). The concept of test launches is defined as an attempt to possibly collect relevant market and demand information for new products through experimental or market trial activities.

Market testing by test launches and thorough analysis of customer feedback helps prepare for further large scale successful launches. Experimental launchings of new products are intended to expose problems that would otherwise go undetected until full-scale introductions were underway. We have to note though that not all products could be tested or test launched. For example, if an average car was supposed to be test launched (1,000 units sample deemed sufficient), a full production line would be required that could produce 75,000 cars with all the

relevant production, equipment set up and other costs approaching many millions. This is exactly the reason why cars are never market tested / test launched (Urban et al., 1990). There are significant cost and design limitations for those products that could be test launched. Car prototypes refer to a very different issue as they do not test market reaction.

New products from consumer goods industry (deodorants etc) are being tested in large numbers every year. It is accordingly widely used by such companies as Procter & Gamble, Gillette, etc. It is argued that a good test / market launch could decrease demand uncertainty significantly. The success ratio for the "correctly predicted" launches reaches 54% (Urban and Silk, 1978).

An interesting test strategy is used by Sport Obermeyer, fashion ski-wear designer and manufacturer, which starts with minimum production quantities of new products (40%) and then utilizes the Las Vegas annual show for the market feedback before the second production installment (Fisher and Raman, 1996).

There are certain issues with test launches. Besides being an expensive way of detecting new product problems and failures, test launches could also compromise new products to competition. Another pre-test market method for evaluating new packaged goods is the "laboratory" or "simulated" test launch. The concept is to simulate the purchase process through laboratory and usage tests. A good example is a widely used pre-test market model ASSESSOR, boasting up to 66% of the performance accuracy (Urban & Katz, 1983).
Test launches are thus a practice to mitigate and control demand uncertainty in new products.

3.2 Capacity management practices

These practices concern the improved matching between supply and demand. They include: Flexible contracts; Launch buffer facilities; Slack production / warehousing facilities.

3.2.1 Flexible contracts

The Flexible or Quantity Flexibility (QF) contracts are arrangements, which couple the buyer's commitment to purchase no less than a certain percentage below the forecast (a minimum purchase agreement) with the supplier's guarantee to deliver up to a certain percentage above (Tsay and Lovejoy, 1999). These contracts define terms under which the quantity the buyer ultimately orders from a supplier may be different from the planned estimate without penalty.

To mitigate the risks of lost sales and / or stockouts in the market environment of volatile uncertain demand and seasonality fluctuations, companies work out flexible contractual arrangements.

For example, Sun Microsystems uses QF contracts in its purchase of various workstation components. Solectron, a leading contract manufacturer for many electronics firms, has recently installed such agreements with both its customers and its raw materials suppliers, implying that benefits may accrue to either end of such an arrangement (Wang, 2002). QF type contracts have also been used by Toyota Motor Corporation, IBM, Compaq, and Hewlett Packard. Similar arrangements called Backup agreements are also used in the apparel industry by such companies as Anne Klein, Finity, Catco, DKNY etc (Eppen and Iyer, 1997)

3.2.2 Product launch buffer facilities

IBM's launch buffer manufacturing sites (ramp-up facilities to buffer demand fluctuations for new products) are critical to bringing its new products to the market at the fastest possible time. Using the launch-buffer practice IBM makes sure it meets all fluctuations in demand.

These sites are manufacturing facilities geographically close to the markets they are deemed to serve. Those facilities are used both as research & development centers and as quick ramp-up locations once the new product is introduced into the market. As the product matures and its demand stabilizes, IBM off-shores the manufacturing operation to low cost facilities, including outsourced. These launch buffer sites have reportedly infinite (allowing for 3 to 5 times increase in demand) manufacturing capacity, so that these sites are designed to scale up productions if there is a sudden surge in demand and scale back when there is a drop in demand (Roy, 2005). Product Launch Buffer facilities are becoming important vehicles to manage demand uncertainty in product innovations.

3.2.3 Slack production / warehousing facilities

One of the key requirements of an effective supply chain for innovative products is the ability to respond in real time to high variability in demand, including demand fluctuations and peaks potentially surpassing the average level of demand very significantly. When time becomes a critical production and delivery constraint and when the customer purchasing decision is mainly based on the product availability, some form of a slack production or less so warehousing capacity is most sensible. The difference between this method of managing demand variability and that of buffer product launch facilities lies in the fact that buffer launch facilities are

dedicated stand-alone assets with a clear geographical market focus serving two different purposes: launching new products and providing production capabilities for demand fluctuations.

For example, Zara, a Spanish fashion producer with a wide proliferation of new products, has the factories intentionally scheduled to operate for one shift only so that when it is necessary, they could add shifts and capacity in high season or peak demand periods. The same concept of planning on the underutilization of the available capacity is used in Zara's Logistics Centers, when huge 500,000 sq. meters Logistics Centers are normally operating at 50% of their maximum capacity (Chu, 2005).

Zara's management very astutely based their capacity planning on the concepts of the queuing theory, indicating that waiting time increases exponentially when capacity is tight and demand variable. Thus due to a slack in production and warehousing capacity utilization, and as a result wait time minimization, Zara is in a position to rapidly react to demand fluctuations.

3.3 Supplier management practices

These practices all concern the management and optimization of supplier involvement in the product development and production process. They include: Outsourcing and Contract manufacturing; Supplier base reduction; Supplier segmentation, and Single sourcing.

3.3.1 Outsourcing & contract manufacturing

Hiemstra and van Tilburg (1993, as cited by Fill and Visser, 2000) define outsourcing as "subcontracting custom-made articles and constructions, such as components, subassemblies,

final products, adaptations and/ or services to another company". On another hand, Wasner (1999) defines outsourcing as an outside company's provision of the products or services previously carried out within the company. With outsourcing, a company enters into a contractual agreement with a supplier concerning supply of capacity that has previously been carried out in-house (Momme et al., 2000).

One of the strongest industry trends over the last fifteen years has been the move toward outsourcing. Organizations increasingly have sought to build flexibility, reduce costs and restructure by contracting out activities historically provided in-house (Fill and Visser, 2000). The logic behind this movement is simple: If contracting out parts of the operation or activity is more cost efficient than doing it in-house, this is a candidate for outsourcing. Besides efficiency gains, outsourcing allows organizations to focus more on those activities that they can better do in-house (Fill and Visser, 2000).

Hiemstra and van Tilburg (1993, as cited by Fill and Visser, 2000) distinguish two forms of outsourcing, capacity outsourcing and non-capacity outsourcing. The former relates to activities which are also performed by the outsourcing company. With the reason for capacity outsourcing being in insufficient internal production for whatever reason – temporarily or permanently. Non-capacity outsourcing refers to the outsourcing of the activities which are no longer done by the outsourcing organization.

According to Winkleman et al., (1993) there exist two drivers behind the growth of outsourcing, cost reduction (efficiency focus) and a strategic shift in the way organizations are managing their

business. Hiemstra and van Tilburg (1993, as cited by Fill and Visser, 2000) further indicate four reasons for outsourcing: costs, capital, knowledge and capacity.

But one of the main purposes of outsourcing is to have the supplier assume certain investments and risks, such as quite often demand variability. Due to greater complexity, higher specialization, and new technological capabilities, suppliers can perform many activities at a lower cost and with a higher added value than a fully integrated outsourcing organization itself. Outsourcing is also about mitigating risks as in a decentralized system with multiple parties there is more and better information available about cost or future demand (Corbett, 2001). Outsourcing has also helped companies ameliorate competitive pressures that squeeze profit margins and eliminate investments in fixed infrastructure and inventories. It has also allowed for improved quality and efficiency, increased access to functional expertise, potential for creating strategic business alliances and fewer internal administrative problems.

Examples: In the late 1980s, the three US automobile manufacturers outsourced many of their small models. About 38% of their mini compact and sub-compact cars were outsourced (for Chrysler the number is almost 50%). By 1990 Chrysler and Ford directly produced only about 30% and 50% of the value of all their cars respectively.

GM traditionally produced up to 70% of the value of the automobile. However, by 1996, GM contracted out 57% of the components' value with Ford and Chrysler contracting out 62% and 66% respectively (Braese, 2005).

Cisco has 50,000 active part numbers. Procurement for 80% of these parts is outsourced. Cisco has 270 active suppliers, with 90% of the business concentrated with 90 suppliers. In the span of only four years, Cisco outsourced activities grew from 55% to 90% by the overall Cisco revenue value (Boasson, 2005).

An extreme case of outsourcing is the so-called de-materialized or virtual company, when even the final assembly is outsourced and all assembling activities are done by the suppliers themselves. For example, Volkswagen's truck plant in Resende, Brazil, where Volkswagen's employees are not involved in any physical production at all and all manufacturing work is done by the suppliers (Haake, 2000).

Contract manufacturing is about outsourcing production capacity and capabilities. We cover this specific outsourcing activity in more detail due to its growing importance.

Since the mid-1980s, and particularly in the 1990s, large and well-known American electronics companies such as Apple, IBM, NCR, Philips, ATT, and Hewlett Packard have been abandoning their internal manufacturing operations and turning to contract manufacturers such as SCI to build their products. At the same time, many younger, faster growing electronics firms, many of them based in Silicon Valley, CA, have always used contract manufacturers; few have built internal manufacturing capacity even as they have grown (e.g., Sun Microsystems, Silicon Graphics, and Cisco Systems). Particularly, Cisco Systems, an innovative Silicon Valley based company that designs and sells high performance switches for data communications, has gained

a wide market share without building any internal manufacturing capacity, solely depending instead on a network of contract manufacturers for all of its production (Sturgeon, 1997).

Increased outsourcing has created a boom in contract manufacturing. From 1988 to 1992 the sum of revenues generated by 1995's largest twenty contractors grew at an annual rate of 30.7%. Since 1992, however, revenue growth has been accelerating dramatically year by year: from 1992 to 1995, revenues grew 46.4% each year, while from 1994 to 1995, revenues expanded 51.2%. (Technology Forecasters, 1996).

A good example of contract manufacturing and demonstration of its benefits happened in 1996 when Apple Computer sold its largest United States personal computer (PC) manufacturing facility in Fountain, Colorado to a contract manufacturer, SCI Systems. Apple was then able to change the volume of its production, upward or downward, on very short notice without installing or idling any of its own plants and equipment. By the deal with SCI, Apple also acquired the improved "upside flexibility" (ability to quickly ramp up production volumes to meet surges in demand). Importantly, Apple was also liberated from the burden of large-scale capital investment required for manufacturing assets, allowing the firm's resources to be more focused on the critical process of new product development (Sturgeon, 1997).

As a short summary, outsourcing and specifically contract manufacturing, has proven a successful competitive strategy for the supplier - buyer cooperation in pooling resources, mitigating risks, reducing inefficiencies and acquiring new ideas, capabilities and technology. It

has been also useful as a vehicle to free a company's resources and focus on the product innovations as the critical value driver.

Outsourcing is not without downsides though. One of the biggest disadvantages might occur when firms outsource core competencies thus allowing their suppliers to develop competitive advantages. Some suppliers then can turn around and compete with the host firm. Once the function is outsourced it also may be difficult or expensive to bring it back in-house where future costs may be higher (Embleton and Wright, 1998). Outsourcing also increased the bargaining power of suppliers and in some cases went too far when organizations started to outsource literally everything, including the core activities, which often hold the essence of a company's competitiveness and corporate identity.

3.3.2 Supplier base reduction

According to Leverick and Cooper (1998), there is a general current trend among manufacturing companies to reduce their supplier base.

In the past, it was common practice for most American companies to contract with multiple suppliers. Several important factors have caused the current shift to reduced supplier base, or single sourcing as its maximum reduction. First, multiple sourcing prevents suppliers from achieving economies of scale based on the order volume and the learning curve effect. Second, the multiple supplier system could be more expensive than a single supplier system (Treleven, 1987). For example, managing a large number of suppliers for some specific item directly increases the costs, including the labor and higher order processing costs, which are accordingly

required to manage multiple inventories. Treleven (1987) also argues that multiple sourcing decreases the overall quality level because of the sometimes wide variation in the incoming quality standards among suppliers. Third, a reduced supplier base helps to improve communication and increase trust level between supplier and buyers (Newman, 1989).

Intensified competitive pressures during the early 1980s have forced Western manufacturers to look for further savings from their components. Many automakers tried to exploit economies of scale in parts production, which meant rationalizing their supplier structure and reducing the number of suppliers (Womack et al., 1990). It has been shown that every mass producer of automobiles during the 1980s reduced their number of suppliers from a range of 2,000 to 2,500 at the beginning of the decade to between 1,000 and 1,500 at the end (Womack et al., 1990).

Most importantly, reduction in supplier base has had a dramatic changing effect on the supplier-buyer relationship, especially pronounced in the case of the U.S. automaking industry. In early 1980s and before, the automakers' dealt with outside suppliers on the basis of short-term contracts (one-year or so), arms'-length relationships, little communication and many (six to eight) suppliers per part. Since then, though the automakers were moving toward a very different supplier relationship system, where only few suppliers provide each type of autoparts; the information is exchanged extensively, and contracts are long term (three to five years. Closer relationship with fewer suppliers brought about collaboration on new products and joint action on product innovations design (Leverick and Cooper, 1998).

The practice of reducing supplier base has been widely used across the industries. For example, in less than a decade Xerox reduced the number of its suppliers by almost 90% from 2,000 to fewer than 350, General Motors by 45%, and Ford by 44 % (Sheth and Sharma 1997). Lucent has reduced its number of suppliers from more than 3,000 in 2000, to fewer than 1,500 in 2002. About 60 suppliers now account for over 80% of Lucent's spend. Three years ago, more than 1,000 suppliers accounted for less than 40% of its spend. In electronics, Lucent used to have over 100 suppliers and now uses just 20 (Boasson, 2005).

As a summary, supplier base reduction is a beneficial practice as it allows for cost savings in transactional costs, reduced complexity of supply chain, deeper and closer relationship with suppliers, and better utilization of suppliers capabilities and expertise in new product design and production. On the downside, supplier base reduction could lead to less competition among suppliers with the related tariffs growth and increase in suppliers' bargaining power.

3.3.3 Supplier segmentation

Supplier segmentation is the fundamental business activity to improve the outcome of a company's efforts to maintain and enhance its position in the marketplace, as well as customer segmentation, market targeting, and positioning. The pioneering work of Kraljic (1983) is considered as a breakthrough in the purchasing area to develop a model of supplier segmentation (Svensson, 2000).

Kraljic (1983) introduced the first comprehensive portfolio approach for purchasing and supply management. It includes the construction of a matrix that classifies products on the basis of

two dimensions: importance of purchasing or profit impact and supply risk or complexity of supply market ('low' and 'high' correspondingly). The result is a 2 by 2 matrix (see below Fig. 2) and a classification in four categories: bottleneck, non-critical, leverage and strategic items. The matrix allows to segment suppliers in accordance with the items they supply.

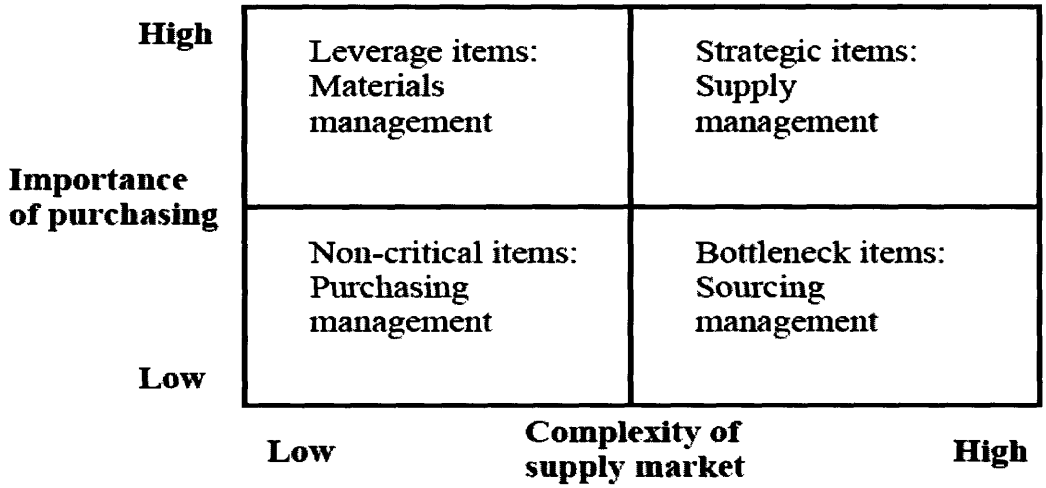

Figure 2: Source - Kraljic, 1983.

Van Weele (1984, 2000) describes a set of different strategies to be used in supplier segmentation based on two dimensions, specifically: Supplier's impacts on financial results; and Supply risk. Four strategies are also identified:

1.) partnership - strategic suppliers (market leaders, unique know-how, with different balance of power between buyers-suppliers);

2.) competitive bidding or tendering - leverage suppliers (numerous competitors, commodity products, buyer dominated segment);

3.) securing continuity of supply - bottleneck suppliers (technology leaders, with few or none alternative suppliers); and

4.) systems contracting - routine suppliers (large supply, many suppliers with dependent position, reduction in the number of suppliers).

Historically the supplier segmentation had its roots in the late 1930s in Japan after the original grouping of around 20 of Toyota's suppliers in 1939 (Nishiguchi, 1994). Over time this group developed to involve Toyota (1943), to be divided into three regional groups in Japan and to produce daughter groups led by direct suppliers such as Denso and Aisin with their own supplier associations. At least 110 of the 318 listed first tier automotive companies were operating supplier associations in Japan as early as 1978. Of these 110 firms, nearly half (47) counted Toyota as one of their top three customers (Nishiguchi, 1994).

3.3.4 Single sourcing

Single sourcing is essentially the culmination of reducing supplier base. All the discussed benefits of reduced supplier base apply here as well and in fact apply more – sufficiently to overweigh the risk of a costly mistake in supplier selection, if any. So the path takes from many suppliers to few suppliers and finally to a single supplier. In single sourcing, for each inventory item, a buyer maintains a purchasing relationship with only one supplier and places all orders with it. When replenishment orders for an item are placed with two suppliers, it is called dual sourcing. The use of two or more suppliers is also called multiple sourcing.

In Deming's 14 points for management (Deming, 1982), point 4 requires that firms purchase only from one source, as contrasted with the multiple sourcing. As Deming's point 4 indicates:
End the practice of awarding business on price tag alone. Instead, minimize total cost by working with a single supplier (Gartner and Naughton, 1988).

The most frequently cited reason behind adopting a particular sourcing strategy is the reduction of uncertainty within one of those dimensions. For example, buyers who employ a single sourcing strategy feel that the chance of a supply disruption is reduced when a buyer develops a strong relationship with a single supplier. In addition, buyers feel that they receive the best price from their single supplier because of the economies of scale achieved from being awarded all of the buyer's business. And vice versa, buyers who employ a multiple sourcing strategy feel that the chance of a supply disruption is reduced when a buyer develops relations with several suppliers and that competition among the suppliers results in receiving the lowest competitive price (Mishra and Tadikamalla, 2005)

High supplier involvement is commonly associated with single sourcing policy and low involvement with multiple or dual (parallel) sourcing. Single sourcing tends to be regarded as a precondition for extensive integration between supplier and buyer (Gadde and Snehota, 2000).

Single sourcing and multiple sourcing are both extensively used in practice. For a sample of components, Toyota and Honda had one supplier for 28 percent and 38 percent of their components, accordingly; another 39 and 44 percent had two suppliers, and the rest had three or more suppliers. U.S. government defense agencies are mandated to maintain more than one source for all but very small procurements. In 2000, a fire in a Phillips semiconductor plant in Albuquerque created a shortage of radio frequency chips for two of its buyers, Nokia and Ericsson. While Nokia, not limited to single sourcing in this case, managed the crisis successfully by working with alternative available suppliers, Ericsson lost at least $400 million in potential revenue since Phillips was its only source for these chips (Latour, 2001).

In short, single sourcing could potentially maximize the benefits earlier discussed in the section on reduced supplier base, such as lower transactional costs and improved supplier quotes due to economy of scale. Single sourcing can help establish a very close and deep partnership relationship between supplier and buyer, maximizing on the utilization and integration of supplier capabilities and expertise in new product design and production process. At the same time, single sourcing can become a risky affair of high supplier dependence as was witnessed in the previously mentioned case of Ericsson and Phillips in the 2000 Albuquerque fire.

3.4 Cost management practices

These practices concern improvements in product and production costs. They include: "Open books" costing policy and Competitive tendering.

3.4.1 "Open books" costing

"Open books" costing policy requires the supplier to provide the buyer access to internal accounting data (Ellram, 1996). Open books or disclosed cost data refers to cost data and related process information that the supplier shares with the buyer. The purpose is to facilitate cooperation leading to the identification of critical areas and further cost reduction. This cooperation can happen in two slightly different ways. The open books approach certainly gives the management accounting system of the supplier a central position, but it also might turn out to demonstrate inadequacies in the entire system and thus stress the need for changes in the costing approach (Axelsson, Laage-Hellman, and Nilsson, 2002).

Cooper (1995) describes a similar phenomenon, but refers to it as cost breakdown. In this case, it is required that the data are presented in a form based on pre-set assumptions. This type of data can be valuable for both parties, especially during the value analysis phase. It is also possible for the buyer to use it simply for squeezing the profit margin.

Cost information not only plays a role in the strategic sourcing decision but will also influence the ongoing management of partnerships and the way they manage supply chain activities. Especially, open books policy is used to reduce the scope for squeezing margins by suppliers to exploit competitive advantage. Thus this practice increases the buyers's control. Possibilities for cost reduction may be identified at the design stage (Lamming, 1993).

Thus though the agreement has to remain competitive and the buyer needs to know it has the lowest price, this confirmation is obtained not through competitive tendering, which damages relationships but through a knowledge of supplier costs. As the partnership develops, inter-company knowledge of costs also forms the basis for the continuous improvement programs that reduce costs rather than supplier margins (Lamming, 1993).

3.4.2 Competitive tendering

In a competitive tender, or reverse auction, a buyer offers a tender (bid) to invited suppliers who bid for the right to obtain a contract at the lowest price, usually in a very short time span – days or even hours. A research by Bensaou (1999) on the automotive industry in the USA and Japan shows that typically 30-60% of the buyer-seller relationships allow for competitive tendering

strategies. Besides driving down prices and giving time savings, critical for new products, competitive tendering allows buyers an alternative more flexible approach to procurement.

Competitive tendering is considered somewhat adversarial, undermining collaborative partnerships and relationships, with the focus on price as the key deciding element. But the recent move toward a collaborative model at Covisint (an exchange that combines the purchasing capabilities of Ford, GM, Daimler-Chrysler, Nissan, Renault and Peugeot) could not seriously compete with the practice of competitive tendering at this exchange (Huang & Mak, 2000).

On the question of price, or costs to the purchasing organization, growing evidence suggests that competitive tendering generates substantial savings. Several studies indicate that savings in the order of 20% are common (Domberger and Rimmer, 1994).

3.5 Design management practices

These practices concern the maximization and / or optimization of the supplier's input into the product design process. They include: Early Supplier Involvement (ESI), and "Black (Gray, White) box" policy.

3.5.1 Early Supplier Involvement (ESI)

Early supplier involvement is a form of vertical cooperation in which manufacturers involve suppliers at an early stage in the product development and/ or innovation process (Bidault et al., 1998). The role of suppliers in the operations of manufacturing enterprises has gained tremendous importance. Early Supplier Involvement (ESI) has been advocated as a means of

integrating suppliers' capabilities in the buying firm's supply chain system and operations (Dobler and Burt, 1996). ESI is also viewed as a mechanism for the involvement of preferred suppliers in the early phases of product design and development (Dowlatshahi, 1998).

Dowst (1988) outlined nine areas in which suppliers can be involved in the buyer's design process. These areas included material specifications, tolerances, standardization, order sizes, process changes in supplier' s manufacturing, packaging, inventory, transportation, and assembly changes in buyer' s plants. The benefits of using ESI are perceived to be significant by most authors and practitioners in supply chain management (Dobler and Burt, 1996).

For example: Chrysler introduced `Prowler' at the North American Auto Show in January 1996 by clearly announcing that this specific car was the product of early supplier involvement. Chrysler passed over a large portion of the responsibility for the design and development of major components to the suppliers. The purpose of such an alliance was to create innovation and cost savings (Dowlatshahi, 1998).

Some authorities also emphasize importance of early supplier involvement in NPD as means to reduce the risks of outsourcing (Bidault et al., 1998). There are many advantages why a firm may involve suppliers in its NPD activities. For example, supplier participation in NPD reduces project development lead times and project costs, improves perceived product quality, and better manufacturability (Ragatz et al., 1997). The early supplier involvement in NPD brings the supplier and the firm closer in sharing not only knowledge and learning, but technological risks as well. This allows the firm to reduce its supply base, and allocate more NPD responsibilities to

the supplier. However there are caveats, for example, involving suppliers early does not always lead to acceleration of project cycle time (Eisenhardt and Tabrizi, 1995).

3.5.2 Black (Gray, White) box policy

The degree of supplier integration in new product development can range from having no supplier involvement to a "Black Box" approach, where the supplier provides its own design without the involvement of the buying organization. That is the supplier is formally empowered and authorized to design the component based on the buyer's performance specifications. In between are the "White Box" and the "Gray Box" stages. A "White Box" occurs when the supplier is brought in on an ad hoc basis, and acts as a consultant to the buyer's new product development team. This is largely an informal meeting, occurring only as needed. The "Gray Box" approach is more formal: joint development activities such as joint design, prototype manufacture, and testing occur between the buyer and supplier.

Black-box parts are those parts whose functional specification is done by assemblers (assembly companies – manufacturing entity transforming a set of components into a final product, web definition) while detailed engineering is carried out by parts suppliers (Clark, 1989). The development work of black-box parts is split between the assembler and the supplier. Typically, assembler's responsibilities include generating costs/performance requirements, exterior shapes, interface details, and other basic design information based on the total vehicle planning and layout. Black-box parts enable assemblers to utilize supplier's engineering expertise and manpower while maintaining control of basic design and total system integrity. To the supplier, the accumulation of engineering expertise becomes its competitive edge. Prototypes and

production parts exchange is a source for facilitating knowledge exchange between the supplier and the assembler (Clark and Fujimoto, 1991).

Added value can be attained when supplier and assembler are willing to collaborate in solving technical problems, especially in resolving interface compatibility issues when new technological solutions are created and patents attained. The higher the technical complexity of a black box part, the more necessary it is for the supplier to become involved in the assembler's engineering activities. This supplier-buyer interdependence leads to inter-firm learning as both parties rely on each other's expertise to ensure successful introduction of the innovation into the market. This practice was initially launched and still used by Toyota as well as other automakers.

3.6 Chapter summary

All the 15 practices and 5 practices groups can be used to properly manage and optimize supplier involvement in new product development and new product introductions. They all have some positive impact on new product development or supplier involvement in NPD. Through contract manufacturing companies become more agile and can dedicate more resources and focus on product innovations. Companies can establish closer relationship with suppliers by supplier base reduction, supplier segmentation, and/or single sourcing and as a result know exactly which supplier is the right one for this or that practice or activity, and if, for example, the black box policy or other specific form of ESI could be used. Through proprietary components reduction, modularity and related postponement practices, companies could achieve significant time and cost savings, reducing at the same time demand uncertainty for new products. By competitive tendering and "open books" costing policy, companies could establish more competitive prices.

Through test launches, flexible contracts, slack capacity and product Launch Buffer facilities, companies could mitigate the risks of demand fluctuations and uncertainty with new products.

The below table has the practices definitions enclosed.

Practices	Definitions
Reducing proprietary components	Shift from custom and proprietary to standardized technologies and components
Modularity / common platforms	Building a complex product from smaller subsystems that can be designed independently yet function together as a whole
Postponement	Delaying activities until the latest possible point in time getting as close to the point of actual demand and demand certainty as possible
Test launches	Collecting relevant market and demand information for new products through experimental or testing activities
Flexible contracts	Contracts, where the quantity the buyer ultimately orders from a supplier may be different from the planned estimate without penalty
Launch Buffer Facilities	Specialist facility for new product launches and ramp up production for demand fluctuations
Slack facilities	Slack capacity for demand fluctuations
Outsource & Contract Manufacturing	Outside resource using: an outside company's provision of the products or services previously carried out within the company, production inclusive.
Reducing supplier base	Reducing number of suppliers to obtain various benefits and / or savings
Supplier Segmentation	Maintaining and developing different types of relationship with various suppliers
Single Sourcing	Maintaining a purchasing relationship with only one supplier
Competitive Tendering	A tender (bid) to invited suppliers who bid for the right to obtain a contract at the lowest price within a limited span of time
"Open Books" costing	Requirement for the supplier to provide the buyer access to internal accounting data
Early Supplier Involvement (ESI)	Involving suppliers at an early stage in the product development
Black (Gray, White) box policy	Supplier providing its own design without the involvement of the buying organization

Table 1: Practices and their definitions.

The next chapter covers our NPD Supplier Involvement survey.

4 - NPD Supplier Involvement Survey

To test the role and importance of the selected supply management practices for New Product Development and launches with the industry, and to see how effectively and completely different industry practitioners are using those, we conducted an online survey.

4.1 Survey overview

A web-based survey consisting of 19 questions concerning how suppliers are managed during the NPD process was sent to 205 individuals. The survey sample population was obtained from the list of SC2020 partners and those purchasing and NPD professionals, whose contacts were procured through Internet on professional websites and forums. A total of 14 complete responses were received. Up to 26 companies provided at least some responses. Thus, the complete responding rate is 7%, and partial responding rate is 13%.

Consumer Goods and Electronics industries provided 25% of the respondents. With approximately 18% correspondingly for the Building Materials and for Semiconductor / Software industries. The remaining responses were provided by representatives of the Paper, Consumer Electronics, Food and Computer industries.

Types of questions asked:

The structure of questionnaire was based on giving an approximately equal weight to correspondingly types of New Products, suppliers, and practices. As per specific survey categories and questions please see Appendix A.

The responders could preserve their anonymity, or further collaborate with the researcher by indicating if they wished to receive a summary of the findings. The somewhat lower than desired response rate could be attributed to a variety of reasons including the relative complexity and length of the survey, and last but not least the fact that this was a weak and none that representative list for the research in question. For an example, only 3 Supply Chain 2020 partners out of almost 130 available responded to the survey.

In retrospect a good option to procure qualified responses would be contacting all the senior members of the American National Association of Purchasing Management (www.napmsd.org).

4.2 Survey results

The below sections cover our survey results and specifically the found differences in 3 types of innovative products – radical, substantial and incremental.

The section one (4.2.1) describes differences in utilization of the supply chain management practices, explained earlier in Chapter 3, for innovative products. The section two compares differences in supplier involvement in NPD for innovative products. The section three covers how differently outsourcing is used for 3 types of new products. The section four compares ratios of purchased material cost to the total cost of goods sold for 3 types of new products; section five correspondingly – types of contract manufacturers used; section six – percentage of proprietary components used; section seven – types of suppliers used; and finally section 8 – time to market for 3 types of innovative products.

4.2.1 Supply chain management practices for types of new products

For a clearer graphic representation of the practices, we put those practices on two separate tables: Importance of the above practices for existing and new products and importance of the practices for new products only. We also provided tabular information by the number of respondents and percentages to the total number of responding companies (14).

Reducing Supplier base	11	7	5	6	29
Single Sourcing	5	8	5	6	24
Flexible Contracts	7	5	6	6	24
Contract Manufacturing	8	5	4	6	23
Buffer Launch facilities	6	4	4	5	19
Reducing Proprietary Com	5	5	4	3	17
Open Books Costing	6	4	4	3	17
Modularity	6	4	3	3	16
Production Postponement	6	2	2	4	14
Test Launches	1	1	3	3	8
Packing Postponement	7	2	2	2	13
Competitive Tendering	5	1	2	2	10
Slack facilities	2	1	1	0	4

Table 2: Practices for existing and new products by number of respondents.

Practices by percentages of the responding companies to the total number of companies.

Reducing Supplier Base	69	47	33	40
Flexible Contracts	50	36	43	43
Single Sourcing	36	57	36	43
Contract Manufacturing	50	33	27	40
Buffer Launch facilities	38	27	27	33
Open Books Costing	43	29	29	21
Reducing Proprietary Com	31	33	27	20
Modularity	38	27	20	20
Production Postponement	38	13	13	27
Packing Postponement	44	13	13	13
Competitive Tendering	36	7	14	14
Test Launches	6	7	20	20
Slack facilities	12	7	7	0

Table 3: Practices for existing and new products by percentages (to the total 14 respondents).

Taken into account also the existing products, we have found the following 5 practices as most important: Reducing supplier base, Flexible contracts and Single sourcing, Contract

manufacturing and Buffer launch facilities. Due to the fact that Production and Packaging postponement represent one practice Postponement, their combined importance index is 27 (or second most important). Additionally Open books costing, Reducing proprietary components and Modularity practices come as very important, with only a short distance from the top 5 practices.

Single Sourcing	8	5	6	19
Reducing Supplier base	7	5	6	18
Flexible Contracts	5	6	6	17
Contract Manufacturing	5	4	6	15
Buffer Launch facilities	4	4	5	13
Reducing Proprietary Com	5	4	3	12
Open Books Costing	4	4	3	11
Modularity	4	3	3	10
Production Postponement	2	2	4	8
Test Launches	1	3	3	7
Packing Postponement	2	2	2	6
Competitive Tendering	1	2	2	5
Slack facilities	1	1	0	2

Table 4: Practices for new products by number of respondents.

Single Sourcing	57	36	43
Flexible Contracts	36	43	43
Reducing Supplier base	47	33	40
Contract Manufacturing	33	27	40
Buffer Launch facilities	27	27	33
Reducing Proprietary Com	33	27	20
Open Books Costing	29	29	21
Modularity	27	20	20
Production Postponement	13	13	27
Test Launches	7	20	20
Packing Postponement	13	13	13
Competitive Tendering	7	14	14
Slack facilities	7	7	0

Table 5: Practices for new products by percentages (to the total 14 respondents).

Exclusively for new products, the top 5 practices are as follows: Single Sourcing, Flexible contracts, Reducing supplier base, Contract Manufacturing and Buffer Launch facilities. In both above cases and tables, we have the same practices in a slightly different order. Comparing specifically radical and other innovative products, we can observe that Contract Manufacturing,

Buffer Launch facilities and especially Production postponement are relatively more important for radical innovations. All the three practices are targeting demand uncertainty and fluctuations (or production flexibility), which are quite logically more pronounced for radical innovations than for substantial or incremental new products.

"Open books" costing is considerably less important for radical innovations, especially compared to existing products. This could be explained by the fact that cost is not a key priority for radical innovation decisions, while existing products are extremely cost sensitive. Companies overall use the least the practice of "Slack production facilities" – from 10% of the respondents for existing products and 5% for incremental and substantial innovations.

4.2.2 Comparing supplier involvement in NPD for types of new products

We found from the survey results two important extremes for the supplier involvement specifically in Radical Innovative products. Highest percentage of the responding companies are using suppliers for radical innovations 'Always' (19%) or 'Sometimes' (46%), that is quite infrequently. While suppliers are used for Substantial and Incremental innovations 'Often' and 'Very Often' combined in approximately 50% of the cases, in safe middle grounds.

We can assume from these results that there are two distinct and almost equally divided groups of companies with a very different approach to supplier involvement in NPD for radical innovative products: the companies involving suppliers aggressively and extensively and those that are quite conservative about supplier involvement in radical innovative products.
We also see how differently radical innovations are dealt with compared to other new products.

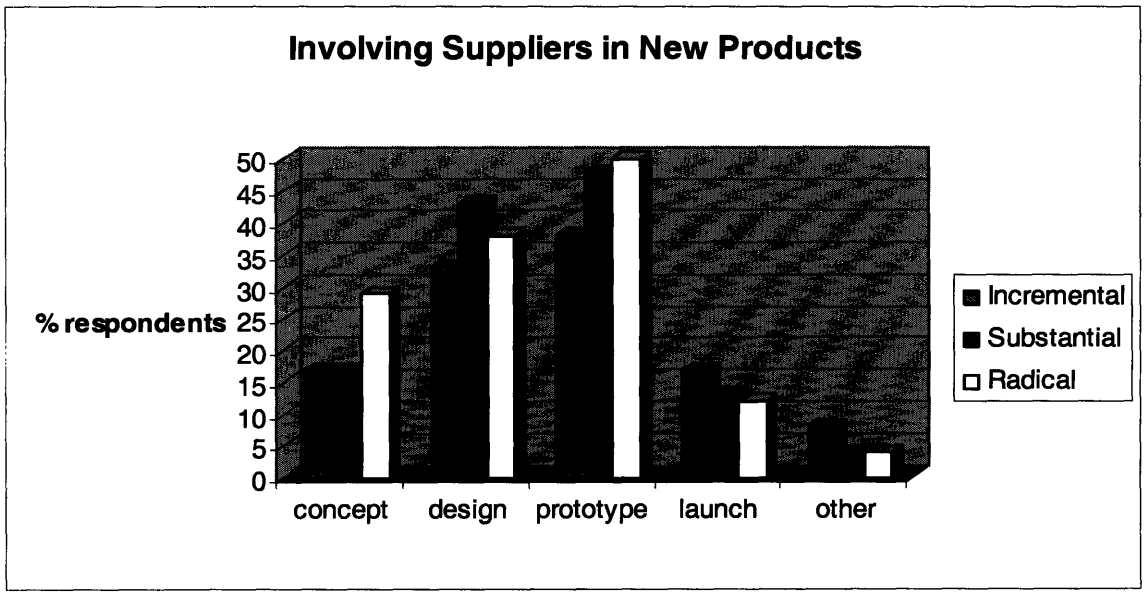

Figure 3: Involving suppliers in new products.

Thus almost 1/3 of the respondents involve suppliers for radical innovations from the very start - conceptual inception of a new product; almost twice as many compared to substantial and incremental innovations. This result could be explained by both our hypothesized trend for the growing supplier role in NPD and by the fact that companies are more actively using supplier capabilities for radical innovations at the earliest, concept stage due to the higher risks of such innovations. This is a natural risk mitigating and capability increasing technique.

4.2.3 Comparing reasons for outsourcing for innovative products

We compared in this section ranking of reasons for outsourcing, such as cost, quality, technology, location, control, technology copyright, the existing (products that are 18 months at the market) and new products. Reasoning behind outsourcing is extremely important as outsourcing is a direct indication of how far suppliers are taking over production and manufacturing responsibilities.

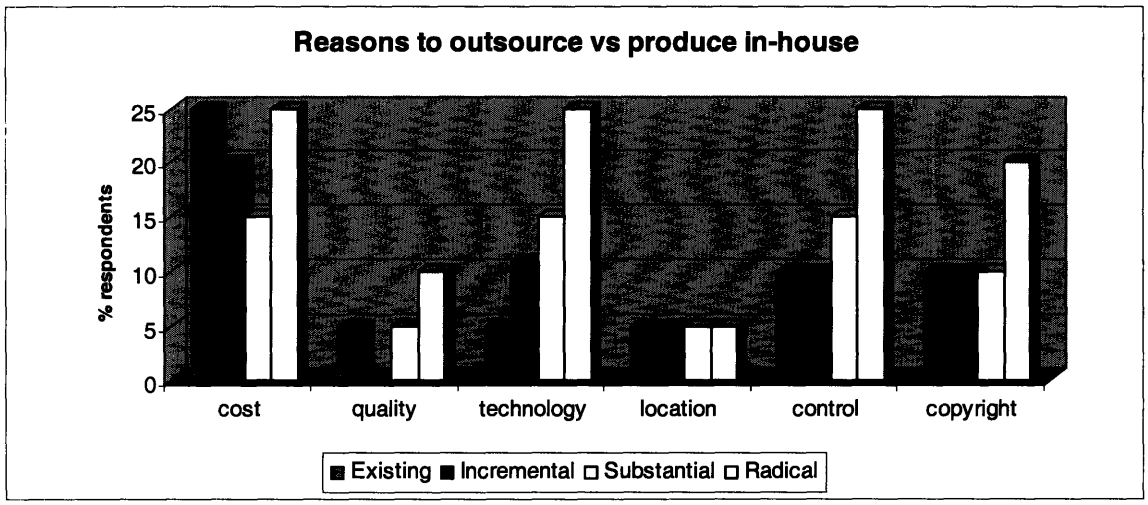

Figure 4: Reasons / rankings to outsource.

The highest rankings (25%) were given for "Cost", "Technology" and "Control" of the radical innovative products, with 20% for "Technology Copyright". Those are the reasons predominantly driving the outsourcing of radical innovation. Similar Rankings for other new product types (except "Cost") are twice lower and more. The difference is clear; radical innovative products and other new and existing products are treated certainly quite differently.

"Cost" was ranked the highest outsourcing driver for all products (new and existing). While "Technology Copyright" is very important (20%) for radical innovations, it is considered equally for other product types at dramatically lower 10% ranking. The "Quality" factor is twice as important for radical innovations (10%), with low rankings (5%) for existing and substantial innovative products. "Quality" though is hardly considered (0%) for incremental innovations.

We can also see that the level of newness in products is causing the gradual pronounced increase in importance of "Control" and "Technology" factors among product types.

4.2.4 Comparing ratios of purchased materials cost to total cost of goods

The survey results on the ratio of the purchased materials cost to the total cost of goods for different companies represent the proverbial mixed bag due first of all to very different approaches to outsourcing and supplier involvement.

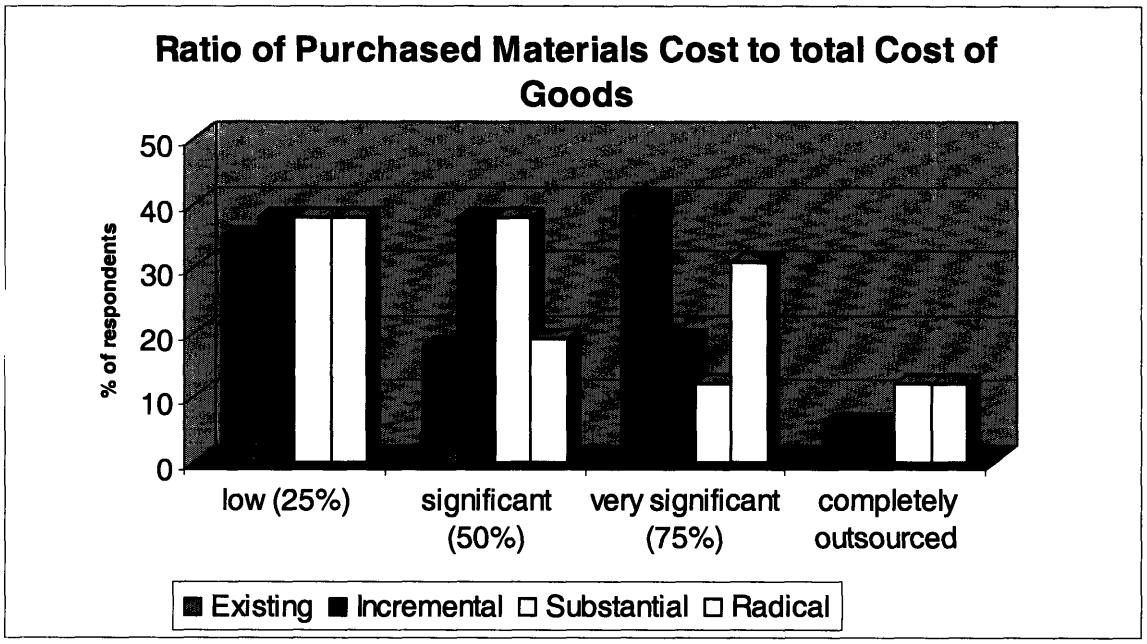

Figure 5: Ratio of purchased materials cost to total cost of goods.

Only 5% of the respondent companies completely outsource production for existing and incremental innovative products; and 10% for substantial to radical innovations. That is complete outsourcing is twice as important for radical and substantial innovations as compared to incremental innovations and existing products. The ratio of purchased materials cost to the total cost of goods sold is significantly higher for existing products and radical innovations.

We understand that the same result is due to two different reasons: for existing products because of the necessity to decrease costs to remain competitive and in case of radical innovations to mitigate the high risks and largely unpredictable demand.

4.2.5 Comparing types of contract manufacturers used

2nd Tier Contract Manufacturers are most heavily used for all new products. 12% of the companies are using also 3rd tier CMs for radical innovations, only 6% for incremental and substantial innovations. We explain this difference and importance of 2nd Tier Contract Manufacturers by the need for increased Buyer's control and less so for the decreased cost in radical innovations.

4.2.6 Comparing percentages of proprietary components used

We observe that proprietary components are most extensively used for radical innovations (more than 50% of the companies with a high ratio of proprietary components) compared to other product types (at 30% level).

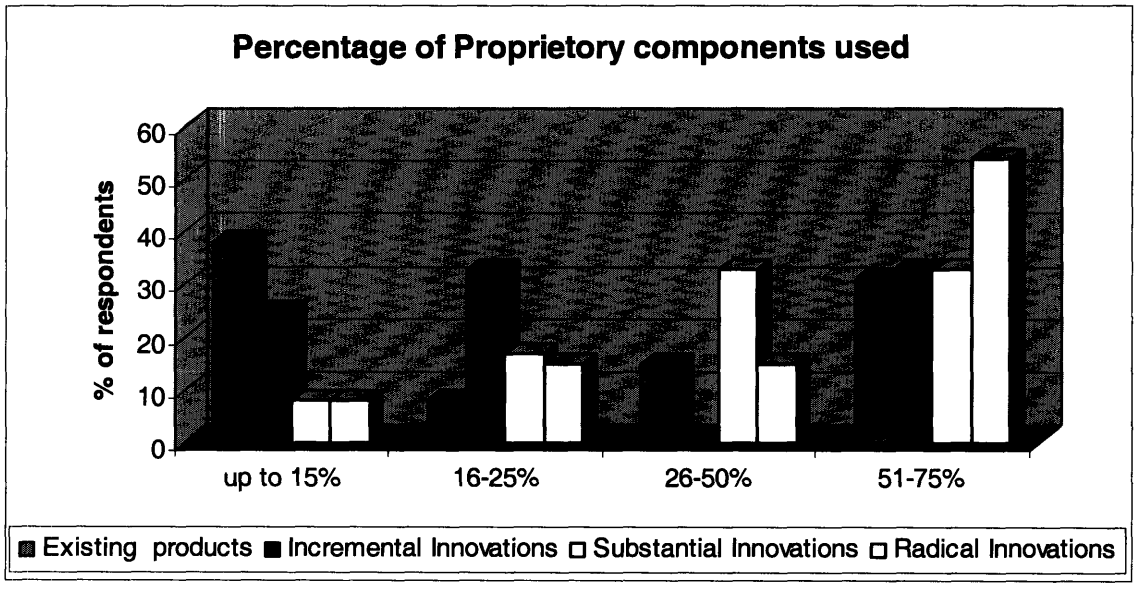

Figure 6: Percentage of proprietary components used.

This high percentage of proprietary components is obviously due to the high degree of newness in radical innovations, when suppliers cannot provide the required components, as well as to mitigate quality risks and guarantee control over new product.

4.2.7 Comparing importance of different types of suppliers (1st, 2nd, 3rd Tier)

1st Tier Suppliers are deemed almost equally critical for existing, incremental and substantial innovative products for 30% of the respondents. Less so for radical innovative products (25%), where additionally 5% of the respondents indicated 2nd Tier suppliers as critical. This is due evidently to the fact that companies tend to retain more control over their radical innovations, as well as prefer to avoid overdependence and dilute in some cases 1st Tier supplier's power by shifting to 2nd tier suppliers.

When considering combined survey results on types of critical and very important suppliers, we see almost the same parameters for all the supplier tiers across different products. 1st Tier suppliers were indicated as critical and very important by 50 to 70% of respondents; 2nd and 3rd Tier by correspondingly 20 to 35%. The differences between supplier tiers are more subdued for existing and radical innovative products. We could explain this fact by suggesting that in case of existing products tiers utilization is spread for cost implications while in case of radical innovations mostly to increase control and with the bargaining leverage over suppliers.

Overall we see the critical importance of 1st Tier suppliers all across the product range for all companies. At the same time, 2nd Tier suppliers are also extensively used for radical innovations.

4.2.8 Comparing time to market for types of new products

Incremental innovations tend to have the shortest timeframe from design to market. Most of the substantial innovations require accordingly more time to market and radical innovations take the longest time.

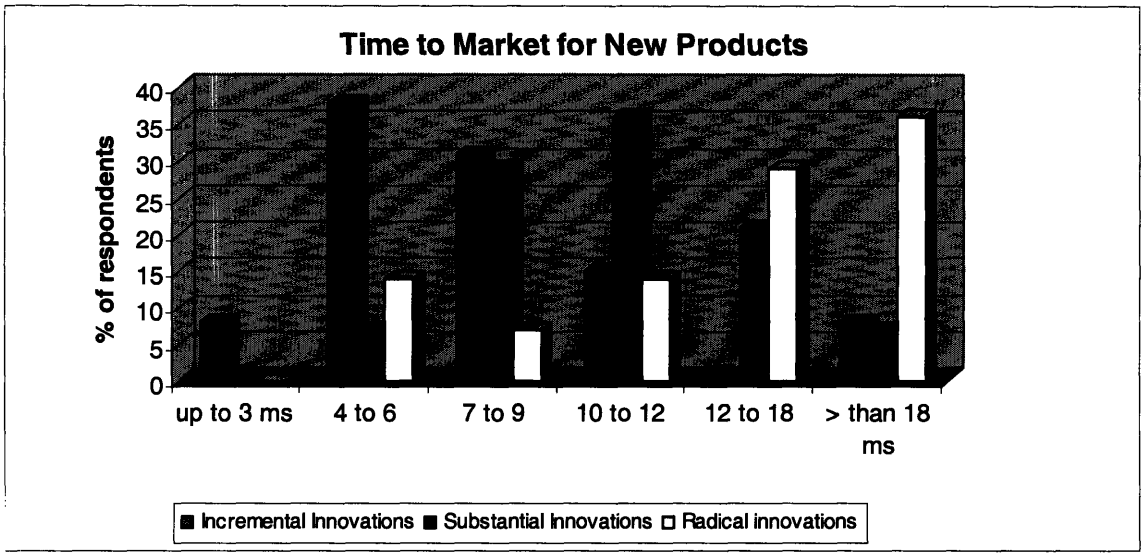

Figure 7: Time to market for new products.

Most incremental innovations (combined 75%) take less than 9 months to market. Most substantial innovations (combined 63%) less than 12 months and most radical innovations (combined 63%) from 12 to 18 months. The findings are quite consistent with our previous readings: the higher the newness level, the more time does it take from launch to market.

There is a clearly pronounced 2 to 6 months rolling gap for time to market between different types of innovations: on average 3 months between most incremental and substantial innovations, and correspondingly 6 months between substantial and radical innovations. This confirms that there is a continuum of product newness and innovation, which is reflected on time to market performance.

4.3 Survey summary

We found through our survey that Radical, Substantial and Incremental innovations in terms of supplier involvement are treated by the companies quite differently (see summary in Table 6).

Practices/Areas	Incremental	Substantial	Radical	Differences
Top 5 practices used	Single Sourcing; Supplier base reduction; Flexible contracts; CM / Proprietary components reduce; Open books policy.	Flexible contracts; Single Sourcing; Supplier base reduction; Open books policy; CM / Modularity.	Flexible contracts / Single sourcing; CM / Supplier base reduction; Buffer launch; Postponement.	CM, Buffer Launch &Postponement are more important for radical innovations. As opposed to Open books policy.
Supplier Involvement	Mostly at Launch stage	Mostly at Prototype stage	Mostly at Concept stage	1/3 of respondents involve suppliers for radical innovations from the concept stage of NPD; i.e. twice as many compared to substantial & incremental NPs.
Outsourcing Reasons	High for Cost	High for Technology & Control	High for Control, Technology, Copyright & Cost	Rankings for outsourcing radical innovations are twice higher than for other new products.
Ratio of Purchased Materials cost to Total Cost of Goods sold	Varies	Varies	Varies	Twice as many radical & substantial innovations are fully outsourced.
Types of Contract manufacturers used	Mostly 2nd Tier CM	Mostly 2nd Tier CM	2nd and 3rd Tier CM	3rd Tier CMs are used for radical innovations twice more often
% of proprietary components used	Low	Low to Medium	High	% of proprietary components in radical innovations is almost 66% higher than in other new products
Types of Suppliers used	1st Tier	1st Tier	1st and 2nd Tiers	1st Tier suppliers critical for all types of new products. 2nd Tier suppliers also for radical innovations.
Time to market	Most (75%) take less than 9 months	Most (63%) take less than 12 months	Most take from 12 to 18 months	2 to 6 months rolling gap between types of innovations

Table 6: Differences as per types of new products.

5 - Supplier Involvement in Product Innovations Model

Our objective was to create a conceptual model for supplier involvement in New Product Development, which would be at the same time practical, comprehensive and meaningful across many industries and businesses.

5.1 Model description

The biggest challenge while working on the model was in identifying the commonalities and critical reasons for the seemingly case by case decisions, those specific domains or categories of activities and practices, which involve suppliers in new products. Those categories are caused and brought about by the previously discussed new product drivers and types, such as Radical, Substantial and Incremental Innovative products.

Based on the case readings, literature review and survey results, we finally selected the following 4 supplier involvement core domains or categories of activities for Supplier-Manufacturer / Buyer interaction within the context of New Product Development & Launch :
Flexibility, Technology, Control and Cost Focus.

5.1.1 Flexibility

Flexibility is defined as "the ability to change or react with little penalty in time, effort, cost or performance" (Upton, 1994). Consequently, it is not only about coping with variety and change but also to consuming a minimum of resources in doing so.

The different flexibility dimensions can be structured in various ways. Stonebraker and Leong (1994), for example, separated product-related flexibility from process-related. In their framework product related flexibility is concerned with the ability to respond quickly to changes in (i) the demand for a particular product (volume flexibility), (ii) the mix or proportion of products of a particular family that is produced (product mix flexibility), (iii) due date or delivery quantities (delivery flexibility), and finally (iv) the ability to incorporate changes in product characteristics and to develop and produce newly designed products (modification flexibility).

Process related flexibility, on the other hand, deals with the ability of the processes to respond rapidly to (i) different production set-ups required for various products (changeover flexibility), (ii) variations in the sequence and production lot-sizes to accommodate required production volumes (scheduling flexibility), and (iii) defining and implementing new technologies in production processes with minimal disruption (innovation flexibility). In our framework, we are concerned mainly with product related flexibility.

5.1.2 Technology

Technology is defined as a unique value-added method of making products, be it through equipment, process, personnel and other corporate assets (self-developed definition).

Technology is quite often licensed or otherwise legally protected from copying and emulation at the market. In our framework the category of technology also includes Intellectual Property and quality implications, which in its turn refer to meeting the desired product requirements and standards. Firms must meet or exceed the pace of rapidly changing technology. According to Porter (1985) technological change is one of the principal drivers of competition and it is

generally brought into existing markets through new entrants. With the increasing role of technology, the importance of technological capabilities as a supplier selection criterion will only increase for specific products. Technology Copyright or Intellectual Property, product complexity also falls under this category.

5.1.3 Control

For the purposes of this research we understand the category of control as a broad dimension covering both:

AA.) ability of a buyer / manufacturer to sustain its product competitiveness and know-how from emulation by other market players (including copyright, intellectual and brand name property);

BB.) ability to dominate or gainfully and reliably collaborate in a buyer – supplier relationship, overcoming the inherent risks of the exclusively self-interest motivated behavior in such a relationship (self-developed definition).

5.1.4 Cost Focus

We define cost focus as the main efficiency parameter both in manufacturing and extended supply chain aiming at producing the biggest value for the fewest available resources used on a per unit or product basis.

5.1.5 Categories and Practices Groups

There is a relationship between the above categories and practice groups covered in Chapter 3 (see Fig. 2: Groups of Practices).

Flexibility corresponds to a combination of practices from Capacity and Product Management groups. Technology corresponds to Product Design Management group. Control corresponds to Supplier Management group. Cost Focus corresponds to Cost Management group (see Table 7).

Groups	Practices	Categories
1.) Product & process management	Reduce proprietary components Modularity / common platforms Postponement Test launches	Flexibility and Cost Focus
2.) Capacity management	Flexible Contracts Product Launch Buffer Facilities Slack production / warehousing facilities	Flexibility
3.) Supplier management	Outsourcing & Contract Manufacturing Reduce supplier base Supplier Segmentation Single Sourcing	Control and Cost Focus
4.) Cost management	"Open Books" costing Competitive Tendering	Cost Focus
5.) Design management	Early Supplier Involvement (ESI) Black (Gray, White) box policy	Technology

Table 7: Practices Groups and corresponding Categories.

5.1.6 Category Levels

Depending on the type of an innovative product, businesses tend to take their supplier involvement decisions based on a prioritized order / level of importance (High, Medium and Lower accordingly) of the above core activity categories. This specific response / importance level of a category is determined by a combination of internal and external factors and challenges, such as:

Flexibility: determined by Demand Uncertainty and / or available Demand information.

Technology: by Strain on Technological Resources and Risk of Technological Failure.

Control: by Intellectual Property value with related risk and by potential Profit margin.

Cost Focus: by level of Competition and Profit margin.

Assessing those factors in a tabular form, we receive:

NPs/Factors	Demand Uncertainty	Strain on Technological Resources	Risk of Technological Failure	IP Value & Risk	Potential Profit Margin	Level of Competition
Radical	High	High	High	High	High	None
Substantial	Medium	High	High	Medium	Medium	Medium
Incremental	Lower	Lower	Lower	Lower	Lower	High

Table 8: New Products and their determinant factors.

Combining those factors, we come to the following required response levels for different categories and new products:

NPs / Categories	Flexibility	Technology	Control	Cost Focus
Radical	High	High	High	Lower
Substantial	Medium	High	Medium	Medium
Incremental	Lower	Lower	Lower	High

Table 9: New Products and Categories Levels required.

Taking into account the relationship and correspondence (see Table 7) between the Categories and Practice Groups, we receive the following model:

Groups / NPs	Incremental	Substantial	Radical
1.) Product & process management	Medium	Medium	Medium
2.)Capacity management	Lower	Medium	High
3.) Supplier management	Medium	Medium	Medium
4.) Cost management	High	Medium	Lower
5.) Design management	Lower	High	High

Table 10: Model of Practice Groups and New Products.

5.2 New products and related practice groups

Table 10 above contains our model framework compiling together types of innovative products and the relevant practice groups by levels of importance. The detailed description of those practices could be found in Chapter 3.

In short, we could describe our conceptual model as 3 new product types, Radical, Substantial and Incremental innovative products, differently defining and driving 4 activity categories - Flexibility, Control, Technology and Cost Focus with corresponding 5 Practice Groups - by 3 Levels of Importance (High, Medium and Lower).

5.3 Innovative product suggested practice groups

We have found that companies are using different practice groups in accordance with the type of a specific innovative product at hand. Thus, our three types of innovative products – radical, substantial and incremental innovations – are the key drivers behind those practice groups.
We further indicate the suggested or preferred practices as per a specific innovative product.

5.3.1 Radical Innovative Products

As per our model the recommended path for Radical Innovations is as follows:

1.) Medium importance of Product & Process management practices; 2.) High importance of Capacity management practices; 3.) Medium importance of Supplier management practices; 4.) Lower importance of Cost management practices; 5.) High importance of Design management practices.

When planning for radical innovations, the most important core category is that of Flexibility. Because demand for radical innovations is extremely variable, if not totally unknown, the investment risks are often very high; we would normally need to select the highest level of Flexibility available. The same recommendation applies to the categories of Technology and Control – the whole gamut of their practices needs to be used for Radical innovations. Indeed, Radical innovations being the most complex and risky ventures need the maximum resources available. That is why the three complete categories - Flexibility, Control and Technology – are required for Radical innovations at the high level of importance. Finally, radical innovations are normally less dependent of the cost considerations, due to high potential profit margins, and lack of competition.

5.3.2 Substantial Innovative Products

The common path for Substantial Innovations is as follows:

1.) Medium importance of Product & Process management practices; 2.) Medium importance of Capacity management practices; 3.) Medium importance of Supplier management practices;

4.) Medium importance of Cost management practices; 5.) High importance of Design management practices.

Demand variability / uncertainty and accordingly investment risks are significantly less for substantial innovations, as there is some market information available already. Accordingly the amount of newness and change in the substantially innovative product and related processes simply does not require a safety cushion of maximum responsiveness and flexibility as in radical innovations. Control and Cost Focus categories also come at a Medium level, while Technology is still at the High level – very much like in radical innovations. This is explained by the fact that substantial innovations normally have the same level of technological newness and complexity to a company as radical innovations.

The difference here is about being aware of the market response to a generic product. The internal company's technological response and management of the product challenges is still largely in unchartered waters. Accordingly the high level of importance of Technology category / Design management practices is recommended for utilization in case of Substantial innovations. Cost Focus becomes important at the Medium level for Substantial innovations because one has to consider a market competition now – hardly existent for radical innovations – and the profit margin for substantial innovations in case of success is significantly lower than for radical ones.

Control category / Supplier management practices for substantial innovations are at a Medium level. This is explained by the fact that a lot of new products have a license or trademark protection, with the competition at this stage normally going on between similar and / or

substitute products. There is often also some protection in economy of scales and built-in product expertise and knowledge. Generally speaking, substantial innovations are literally a battle field of extreme practices for quite a few companies. We suppose this happens because it is extremely difficult, if not impossible to keep the equidistant balance between incremental and radical innovations.

5.3.3 Incremental Innovative Products

The common path for Incremental Innovations is as follows:

1.) Medium importance of Product & Process management practices; 2.) Lower importance of Capacity management practices; 3.) Medium importance of Supplier management practices; 4.) High importance of Cost management practices; 5.) Lower importance of Design management practices

We indicated medium importance of Product & Process management practices as they correspond both to Flexibility (Lower level) and Cost Focus (High level). We also found in our research that neither Flexibility, nor Technology, or Control categories are that important for incremental innovations. This is due to the fact that most of incremental innovations are simply replacements, repositionings, and cost reductions for existing products and as such their demand dynamics, profit margin potential and technological requirements and complexities are close and / or very close to that of the existing products. Accordingly Flexibility is not needed very much and can be hardly afforded too (low margins). As for product improvements, they are either marketing-based, or very basic and marginal, or well established already and do not need the extensive Technology category's toolbox.

The most important category for Incremental innovations is Cost Focus / Cost management practices. Indeed while having incremental innovations companies have to deal with a strong competition, as well as relative easiness to replicate minor improvements, and especially repositionings. The logical response to remain competitive in this situation is by maximum focusing on Cost and by implementing Cost management practices.

6 - Summary and Conclusions

The final chapter contains our investigation summary and recommendations for future research.

6.1 Findings and conclusions

According to our research suppliers have a direct impact on the cost, quality, technology, and time-to-market of new products as well as are being a valuable source of innovations, technologies and capabilities. Thus there are clear benefits of supplier involvement in new product development and launch.

Based on our literature review and online survey we identified a comprehensive toolbox of the supply chain management and supplier management practices widely used across industries in connection with and in order to optimize the supplier involvement in New Product Development. Those practices include: Reducing supplier base; Competitive Tendering; "Open Books" costing; Flexible contracts; Early Supplier Involvement (ESI); Black (Gray, White) box policy; Outsourcing & Contract Manufacturing; Reducing proprietary components; Postponement; Product Launch Buffer facilities; Test launches; Slack production / warehousing facilities; Supplier Segmentation; Modularity / Common platforms.

We tested the prevalence and importance of the above best practices with the industry practitioners during our online survey and received the following results and insights:

Almost 1/3 of the respondents involve suppliers as early as at the Concept stage for radical innovations, which is twice as high as for incremental and substantial innovations. This finding

confirms the growing early supplier role in New Product Development process and the fact that companies are more actively using supplier capabilities specifically for radical innovations at the concept stage due to the higher risks of such innovations. This is a natural risk mitigating and capability increasing technique.

There are two distinct groups of companies with a very different approach (laggards and winners) to aggressive supplier involvement in NPD. Companies are almost equally divided in how aggressively they involve suppliers in radically innovative products.

There is also a distinct difference in how various supply management practices are used for different types of innovative products. Specifically demand uncertainty or production flexibility with related practices (Contract manufacturing, Buffer Launch facilities, Postponement) is more important for radical innovations than for other products. We are further using those findings to construct the model of supplier involvement in product innovations.

We constructed an across-industries conceptual model allowing the optimized selection and implementation of the supply and supplier management practices for a specific new product type.

We identified the commonalities and critical reasons for those specific domains or categories of activities and practices – namely Flexibility, Technology, Control and Cost Focus, which involve suppliers in new products - brought about and caused by such drivers as Radical, Substantial and Incremental Innovative products. Every category of activities has 3 levels of importance: High, Medium and Lower. We also identified 5 management practice groups: Product & Process

management practices; Capacity management practices; Supplier management practices; Cost management and Design management practices, which correspond to specific activity categories with importance levels and accordingly to types of new products.

Accordingly we worked out the comprehensive model with 3 detailed suggests pathways for specific mix of supply management practice groups for correspondingly Radical, Substantial and Incremental innovative products.

6.2 Recommendations for future research

Among potentially challenging and interesting areas of research on new products, one can readily mention the relative value and importance of an individual product cost. That is how different are the approaches and practices companies are using for new products when a developed product is either of a very high or low value ("winches versus planes").

Another area of potential future research is investigating in detail benefits and issues with supplier involvement in product development across various industries: what are the commonalities and differences and if there are any interesting lessons, which could be cross taught and cross implemented. How are specifically our selected key practices used in various industries and why.

One more area of potential future research could be comparison of the effectiveness of supplier involvement in new product development among Japanese and U.S. suppliers and companies, as

those present apparently the biggest difference in supplier management approaches and accordingly the research could be most insightful.

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Appendix A

There were 7 categories of questions asked:

I.) Involving suppliers in NPD (how often, at which stages, to what extent).

II.) Ranking of reasons / drivers for outsourcing, such as cost, quality, technology, location, control, technology copyright, the existing (defined as products that are 18 months at the market) and new products. This section explores the level of outsourcing or supplier content in new products.

III.) Revenue power and purchased materials cost for existing and new products.

IV.) Activities to improve NP performance:

1.) Supply Chain Management practices to improve New Product performance (Contract Manufacturing; Reducing proprietary components; Reducing supplier base; Production postponement; Packaging postponement; Product Launch Buffer facilities; Slack production facilities; Test Launches; Modularity / Common platforms);

2.) Types of Contract Manufacturers used - hereafter - for existing and new products;

3.) Percentage of proprietary components used;

4.) How many suppliers are used per product.

V.) Specific supplier management practices to improve New Product performance (Competitive Tendering; Single Sourcing; Open Books costing, Flexible Contracts.

VI.) Importance of different types of suppliers (1^{st}, 2^{nd}, 3^{rd} Tier suppliers).

VII.) Time to market.

Specific Survey questions were as follows:

1.) What percentage of your revenue comes from each of the following groups of products the total should add to 100% : Existing, Radical, Substantial, Incremental Innovative products.

2.) What is your ratio of purchased materials cost to the total cost of goods sold for different types of products?

3.) At which stages do you involve your suppliers?

4.) How often do you involve your suppliers?

5.) To what extent do you involve your suppliers?

6.) How important are different types of suppliers for your existing products?

7.) How important are different suppliers for your Radical Innovative products?

8.) How important are different suppliers for your Substantial Innovative products?

9.) How important are different suppliers for your Incremental Innovative products?

10.) What is your average time to market (design to market) for new products?

11.) What specific supplier management practices, if any, are you using to improve on your new products performance vs. existing products?

12.) For Radical Innovative products, what are your most important reasons to outsource versus produce in-house?

13.) For Substantial Innovative products, what are your most important reasons to outsource versus produce in-house?

14.) For Incremental Innovative products, what are your most important reasons to outsource versus produce in-house?

15.) For existing products, what are your most important reasons to outsource versus produce in-house?

16.) How many suppliers per product are you using for new versus existing products?

17.) What types of Contract Manufactures (CM), if any, are you using for new versus existing products?

18.) What specific practices are you using to improve on your new products performance versus existing products?

19.) What percentage of proprietary components, if any, are you using for new vs. existing products?