INTER-FIRM COST MANAGEMENT IN HIGH-TECH PRODUCT DEVELOPMENT PROJECTS IN THE PLASTICS PROCESSING INDUSTRY

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ABSTRACT
Companies are compelled to develop new products that accomplish several objectives simultaneously. Furthermore, competition is forcing organizations to collaborate more with their business partners. To meet this wide set of objectives, companies are embracing new tools and techniques to support successful new product development (NPD) projects. Inter-organizational cost management (IOCM) has been used by organizations to achieve the collaborative management of costs throughout projects of NPD. Effective cost management which cross organizational boundaries has the potential to improve the overall performance of the project.

This paper presents and discusses inter-firm cost management in high-tech NPD projects, particularly the use of nanomaterials and nanotechnologies in the plastics processing industry. Processors are being asked to add value, complete more operations, deliver around the world, develop products and engage in partnerships with customers. In many cases, the supplier is becoming so integrated with the client that the former (supplier) is becoming linked to the success of the client. One result of this new strategic focus could be the “evolution” of IOCM.

INTRODUCTION
Advanced transformations in NPD have forced firms towards utilization of technologies that lie outside of their firm boundaries. In the automotive industry OEMs (Original Equipment Manufacturers) have formed partnerships with suppliers to take advantage of their technological expertise in development, design, and manufacturing. Accordingly, these firms continue to integrate suppliers earlier in their product development projects and to a greater extent. In fact, in recent years, firms in many industries have increasingly extended their NPD activities across organizational boundaries and outsourced innovation (Engardino and Einhorn, 2005). Researchers have perceived the benefits of supplier involvement in product development to be very significant (Winstra et al., 2001). It has been argued that buyers can benefit from involving suppliers early in the development process, rather than working independently when it comes to time-to-market of new products, product quality, development cost, and product cost. Supplier involvement in NPD can also help the buying firm to gain new competencies, share risks, move faster into new markets, and conserve resources. As such, to generate inter-organizational competitive advantage through supplier involvement in NPD requires the firm to build up and maintain appropriate routines and processes to and work with suppliers possessing complementary competencies in product development projects (Dyer and Singh, 1998; Johnson, 1999).

Cost is a crucial issue for enterprises’ operation. Nowadays, the conventional cost management model may not be applicable on high-tech firms. Thus, industry managers and academics have been showing a particular interest in the use of sophisticated cost management (CM) practices in comparison with the long-established ones. The cost management concept - in high-tech firms – is itself innovative, scientific and technical driving model. High-tech enterprises are characterised by high technological and added value products as well as high qualified employers. Moreover, these companies are highly sensitive to scientific and technical development and external market changes. As a result, they are considered a business with high risks. On the other hand, with the purpose of realizing sustainable development, the high-tech enterprises will transfer from its single profit maximization target to multiple targets of advanced technology, customer satisfaction, high-quality products and leading position in market, as well as human resource capital increment, i.e. non-profit income.

Accordingly to Cooper and Yoshikawa (1994) and Cooper and Slagmulder (2004), nowadays the cost management process in the high-tech firms are blurring their organisational boundaries in many different ways, including sharing research and development projects,
placing their employees in other firms and developing target costing (TC) and IOCM. For Cooper and Slagmulder (2004) formal buyer-supplier initiatives undertaken to reduce costs through collaborative efforts must be included in a specific domain that they called IOCM. According to them, IOCM is characterised by three main concepts: the quality-functionality-price (QFP) paradigm, inter-organisational cost investigations (IOCI) and concurrent cost management (CCM). These three concepts or techniques have, as a common objective, the reduction of costs through changes in the initial specifications of the product or components, i.e., in the early phases of NPD process. The purpose of this paper is to present and explain inter-firm cost management in practice and, particularly, to demonstrate how/why this approach may contribute to new paradigms in NPD management characterised by high levels of sharing, involvement and interactivity among the different players (buyers-suppliers relationships) in a supply chain. This paper presents and discusses inter-firm cost management in high-tech NPD projects, particularly the use of nanomaterials and nanotechnologies in the plastics processing industry. Furthermore, this work offers a discussion basis on the role of advanced cost management practices in NPD process and buyer-supplier relationships. Accordingly, the article is structured as follows. Firstly, it presents a literature review on NPD and inter-firm cost management. The example of using nanomaterials and nanotechnologies in NPD projects in the plastics processing industry is presented in section two. Thirdly, the case in point (inter-firm cost management in NPD high-tech environments) is explained and discussed. Finally, conclusions and some implications and opportunities for future work are presented.

LITERATURE REVIEW

New Product Development Projects

The success of NPD depends on several factors, such as: introduction of new raw-materials, growth complexity’s product and customer needs. On the other hand, it is extremely important to achieve a desired efficiency taking into account the developing and launch times of products, by controlling costs and developing high performance products (Osteras et al., 2006). Hubka and Eder (1988) defined the product performance variables in three different categories: design properties (e.g. function, surface, raw-materials and dimensions), internal properties (e.g. resistance, tenacity, hardness, elasticity and corrosion) and external properties (e.g. ergonomic, aesthetic, maintainability and safety). To the final customer it is particularly interesting the later properties.

In the literature, the NPD process is normally divided from six to nine steps. Calantone and Benedetto (1988) and Griffin (1997) address, at the earlier NPD stages, alignment activities of the new products with the company’s strategy. Ulrich and Eppinger (2000) and Cooper (2001) also mentioned that these tasks are important for the development process, at the earlier stages, but they did not include them specifically into the NPD flow. In the model developed by Osteras et al. (2006) the NPD process is divided in six phases: i) front-end, ii) design, iii) design details, iv) components development, v) product prototype development, and vi) production and two stages: i) pre-development, and ii) development and production. Tzokas et al. (2004) suggested that the NPD process is followed by six evaluation phases, named by gates or convergent/decision points. The end of a phase and the beginning of another is marked with a gate, where all performed activities and obtained results are verified. Approval in such gate means that the process is ready to jump to the next phase. The evaluation gates allow: cleaning ideas, testing concepts, analysing on the business perspective, performing functional tests on the product, analysing the research market results and, finally, evaluating the product launch to the market.

In the plastics processing industry, product development is an interdisciplinary activity that requires contributions from nearly all the functions of a firm. However, three functions are almost always central to a product development project: marketing, design and manufacturing (Barbosa, 2008). The marketing function mediates the interactions between the firm and its customers and also facilitates the identification of product opportunities, the definition of market segments and the identification of customer needs. Marketing also typically arranges for communication between the firm and its customers, sets the target prices and oversees the launch and promotion of the product. Furthermore, the design function plays the lead role in defining the physical form of the product to best meet customer needs; it includes engineering design (mechanical, electrical, software, etc.) and industrial design (aesthetics, ergonomics, user interfaces). For example, when all aspects are closely interwoven, polymeric materials are able to solve design problems most elegantly and with certain economic advantages. Finally, manufacturing is primarily responsible for designing and operating the production system in order to produce the product. The manufacturing function often includes purchasing, distribution and installation activities. A successful design is usually a compromise between the requirements of product function, productive and cost. Basically design is the mechanism whereby a requirement is converted to a meaningful plan (Rosato et al., 2000).

In this industry, a multidisciplinary team develops the majority of the products and very few of them can be developed less than 1 year. This team usually has a team leader who could be drawn from any of the functions of the firm. The team can be thought of as consisting of a core team (mechanical designer, purchasing specialist, marketing professional, manufacturing engineer, etc.)
Inter-firm Cost Management in NPD Projects

The literature regarding target costing suggests that this internal cost management technique is not actively involved in the cost management program of partner firms (Monden 1995; Cooper and Slagmulder 1997, 2004). TC aims to identify the cost at which a product should be manufactured. When the target cost is broken down to component level, the supplier is usually involved. The key extension of TC that brings it into the realm of IOCM is the active involvement by both the focal firm’s and the partner firm’s design teams in the joint identification, management, and resolution of cost issues (Cooper and Slagmulder, 2004). This makes TC one of the most important parts of IOCM practices that involve both buyers and suppliers in NPD projects. One of its most prominent characteristics is that it tends to push cost pressure further upstream in the supply chain. The importance of the supply chain is therefore often stressed in the TC literature. Ansari and Bell (1997) argue that “An optimized supply chain is one of the most critical elements in attaining the target cost”. Sakurai (1996) stated that “the primary objects of target costing are direct material costs and direct conversion costs”. It is, therefore, not surprising that most stage models of TC should deal conveniently with the supplier or the purchasing function (Ellram, 2000).

IOCM refers to a set of activities, processes or techniques that managers can use to manage costs that span organizational boundaries (Cooper and Slagmulder 2004). According to Cooper and Slagmulder (1998a), IOCM practices facilitate the coordination of cost reduction in two ways: i) helps identify ways to make the interface between the firms more efficient, and ii) helps the firm and its buyers and suppliers find additional ways to reduce the costs of products. Cooper and Slagmulder (2004) identify three specific IOCM approaches resulting from target costing processes that progressively involve more collaboration between the focal firm and the partner firm: i) the functionality-price-quality paradigm, ii) inter-organizational cost investigations, and iii) concurrent cost management practices. FPQ tradeoffs are associated with small design changes that can be accommodated by a single firm in the supply chain with the permission of at least one other firm. It is useful for resolving minor cost overruns and requiring limited interaction between the design teams of the focal and partner firms. IOCI are associated with more significant changes that require modifications to the design or production processes of the items produced by more than one firm in the chain. These design changes are interrelated, but they can be accompanied with relatively low levels of communication between the design teams. Finally, CCM is associated with the most significant changes. It requires significant interaction and collaboration between design teams and can lead to fundamental changes in both firms’ product and processes. It aggressively reduces costs by increasing the scope of design changes that the supplier can undertake involving suppliers early in the NPD project. Cooper and Slagmulder (2004) provide a complete discussion of these three techniques via case analysis, demonstrating how these IOCM techniques have been used in three Japanese supply chains to cooperatively identify mutually beneficial low-cost solutions.

Karjalainen and Ojapalo (2006) verified, for the first phase of NPD process, that the definition of target cost is an important issue on the NPD but does not present itself as a fundamental principle – otherwise it could harm the technology as well as the product functionalities and, consequently, challenge the customer satisfaction. In the model developed by them seven steps for the cost management in such cases are presented: i) identification of customer needs, ii) market research in order to analyse the most competitive products, iii) concept generation, iv) exclusion of other generated concepts in order to get/select only one concept, v) goals definition as well as TC by means of economic analysis, vi) project planning and development, and vii) description, in detail, of the product specifications with the purpose of verifying the product position in the market. The later step is supported by concept generation teams which are interacting with customers.

On the other hand, Davila and Wouters (2004) found out that in this kind of companies, TC management presents four strong limitations: i) it concerns only with product costs discarding the product’s ability to generate profits, ii) is a long term implementation technique, iii) extremely bureaucratic, and iv) is a linear technique implementation and particularly detailed. These authors identified and analysed techniques which require a lower focus and degree of complexity than those based on TC in order to allow a more effective costs reduction on the model costs development. For instance, the formation of parallel multidisciplinary teams for cost management, the definition of cost management strategies, the use of components and common processes, the modular conception and the development of product planning platforms. A weak point of non-TC approaches is related to the fact the multidisciplinary team is particularly focused on technology undervaluing cost management.

NANO-MATERIALS/TECHNOLOGIES – IN THE PLASTICS INDUSTRY

The Plastics Production Chain

In 1951, two young research chemists of Phillips Petroleum Company in Bartlesville, Okla., made discoveries that revolutionized the plastics world. Today, the plastics they discovered – polypropylene and
polymers – are used to produce the vast majority of the thousands of plastics products all over the world. The technological road from oil field to finished plastic products presents numerous side trips, as it can be seen in Figure 1. First of all, petroleum is extracted and transported to a refinery company, known as 1st generation petrochemicals; here, oil is refined into numerous petrochemical products. From a colourless liquid fraction of oil, named naphtha, raw-materials such as ethane, propane, etc., are obtained and "cracked" into monomers (ethylene and propylene, respectively) using high-temperature furnaces. Afterwards, in the 2nd generation petrochemical companies, catalysts are combined with specific monomer in a reactor, resulting in "fluff," a powdered material (polymer) resembling laundry detergent that is combined with additives in a continuous blender. The melted plastic resin (combination of polymer and additives) is then cooled and fed to a pelletizer that cuts the product into small pellets that are shipped to customers. The latter, represent the 3rd generation companies, manufacture plastic products for the final customer by using processes such as extrusion, injection moulding, and blow moulding. At this point, it is important to distinguish between polymer and plastic. Thus, in the practical case, the macromolecular substance, or polymer, will contain adventitious impurity or impurities arising from its production process as well as intentional additives to achieve specific effects either during fabrication or in the end product (Ogorkiewicz, 1974).

![Figure 1: Technological road from oil to plastic products](image)

It is precisely the inclusion of these additives, and even reinforcements (such as fibres, the much spoken nanoparticles, etc.), that can change some properties (for instance: mechanical and electrical properties, corrosion susceptibility and degradation, wear resistance and frictional properties) of original polymers. Injection moulding, right after extrusion process, is the most widely used process to form plastics. Its principle is quite simple: a thermoplastic, in the form of granules or powder, passes from a feed hopper into the barrel where it is heated so that it becomes soft; it is then forced through a nozzle into a relatively cold mould which is clamped tightly closed; when the plastic has had sufficient time to become solid the mould opens, the article is ejected and the cycle is repeated. This processing technique is used for a wide variety of plastic products, from small cups and toys to large objects weighing 30 pounds or more. The major advantages of the process include its versatility in moulding a wide range of products, the ease with which automation can be introduced, the possibility of high production rates and the manufacture of articles with close tolerances. Injection moulding is considered the most important of all the commercial methods of plastics processing. Many variations have been developed and one of the rapidly expanding fields is multi-material injection moulding. This is particularly important where processors are looking to gain technological advantages over rivals and even clients by adding value to products. Whilst tooling costs can be very high, cost savings can be obtained by eliminating assembly steps (Barbosa, 2008).

**Nanomaterials and Nanotechnologies**

Nanotechnology is a technological revolution that will radically impact almost every sphere of modern society, particularly manufacturing processes and the way businesses operate. It will enable the manufacture of products with incredible precision that will be stronger, lighter, and “smarter” than anything that exists today. During the initial phases of the life of a product – R&D, prototyping, and initial production – there is no revenue generated from the product. Since the initial development costs are higher in nanomanufacturing, the losses in the initial period are higher as well. However, the situation changes once sales commence. The use of nanotechnology will result in much lower production costs and consequently higher gross margins. Thus, the increase in profits in a nanoenvironment due to an increase in sales will be greater than those in a traditional manufacturing environment (Dutta et al., 2006).

As nanotechnology evolves from the laboratory into an industry, one of the greatest challenges still to be overcome is the penetration of nanotech products into mainstream user markets. It takes time and effort for nanotech companies to find potential customers, convince them to evaluate a new product, and ultimately have them purchase the product in commercial amounts. There are many things within management control that can reduce the time for transforming sophisticated nanotech research into revenue-generating products. These include decisions related to what and how has been developed, how the resources have been applied, and how convince potential customers to buy sooner rather than later (Gordon, 2002).

In the plastics processing industry, nanocomposites are a novel class of polymeric materials exhibiting superior mechanical, thermal, and processing properties, suitable to replace metals in automotive and other applications.
The use of nanocomposites in vehicle parts and systems is expected to improve manufacturing speed, enhance environmental and thermal stability, promote recycling and reduce weight, enabling the automotive industry to capture a leadership position in fuel-efficient, higher-quality, and durable vehicles (Garcés et al., 2000). Nanocomposites may be produced by the incorporation of nanometre-size particles in polymers such as polypropylene (PP), polyethylene (PE), polyesters, epoxies, etc. Several routes are currently proposed to make polymer nanocomposites. The nanomaterials can be dispersed into polymers by conventional melt compounding or solution methods. Alternatively, nanocomposites can be made by the in-situ polymerization method. This method was pioneered by Toyota Motor Company to create Nylon 6-nanoclay hybrid (NCH), used to make a timing-belt cover, the first practical example of polymeric nanocomposites for automotive applications (Garcés et al., 2000).

A wide variety of types, morphologies and dimension of nanomaterials are becoming available from a number of commercial sources. Nowadays, the polymer composite community is presented with the challenging task of producing composites bearing the multifunctionality of these nanomaterials. Each nanoapplication requires customized nanomaterial that may need additional developments. Recent results on production of polyolefin nanocomposites by melt processing of organo-clays with modified polymers or by various in-situ polymerization methods suggest that these materials can be produced with current technologies (Garcés et al., 2000). The current challenge is to develop nanocomposites at competitive cost and with superior performance – which requires a great investment in R&D – to replace metals and/or existing polymeric filled composites.

The Use of Nanoparticles in Colouring Technology to Avoid Additional Painting and Reducing VOCs

Automotive manufacturers are on quest to reduce weight and fuel consumption, increase the recyclability of automotive parts and body panels while maintaining their capability to compete based upon cost, appearance, and performance. In order to meet those goals, an automotive manufacturer have undertaken a NPD project aiming to produce a part of a car, in a more automated, cost-efficient and integrated process. It is an assembled component, composed of two different parts, currently produced by two different companies; each developed separately but finally assembled together. This case reveals the possibilities open to SMEs operating in intensive supply chain environments in the car manufacturing industry. Thus, this case shows how the integrated effort of the different companies work in the development of the integrated component can significantly increase the pace of product manufacture from the initial concept to the final part. It demonstrates also the importance of including 2nd generation petrochemicals (raw-material developers/suppliers) in the product development stage.

The initial approach is to make use of nanoparticles in colouring technology to avoid additional painting and reducing VOCs (volatile organic compounds). This new technology will allow manufacturers to increase production rates and consolidate scattered production sites to reduce manufacturing costs by, for instance, lowering equipment and labour requirements. Firstly, the customer contacts the design/engineering consultant company about a specific need for a plastic component. The customer has an initial concept of the component and the specifications that constrain its development. The specifications must reflect customer needs, differentiate the product from the competitive products and be technically and economically realizable (Ulrich and Eppinger, 2003).

In these cases, one of the main factors influencing the product development is the correct material selection. Factors that need to be studied include strength, stiffness, ductility, hardness, fatigue resistance, impact strength, processability, and costs (both raw material and manufacturing) - Crawford (1985). This stage is usually completed by analyzing available material databases (which may be supported by appropriate computer software). However, when a new material (with nanoparticles for colouring technology) is required, it is vital that the raw-material supplier is involved in this stage as there is very little or none information at all in the above mentioned material databases. Furthermore, each nano-application requires customized nanomaterial that for sure needs additional research and development efforts. Additionally, in selecting a polymeric material, it is vitally important to decide at the same time on the method of manufacture of the component, and to take account of the effects of processing on properties (McCrum et al., 1988). In possession of such information regarding material properties and characteristics, and processing technique, design engineers are able to move forward in concretion/project phase. The philosophy behind this stage is to create a high-quality information channel that runs directly between customers in the target market and the product developers. Here, there is a premise that those who directly control the details of the product, including the engineers and industrial designers, must interact with customers and experience the environmental use of the product.

Reducing cost at the design phase is very important in terms of cost management and it has a rapid reimburse for the effort involved. Defined the length, width, height, wall thickness and material type, at least 80 % of the product cost is defined. With any design project the first 15 to 20 % of the project involves very little actual cost but it defines and commits between 80 to 90 % of the final product cost (Kent, 2002).
Flow and structural analysis (such as finite element analysis, using commercially available software packages) are generally carried out in order to minimize all the repetitive/iterative and time and cost consuming tasks necessary for part’s optimization. At this stage, designers predict the physical behaviour of a part under loading conditions. This analysis enables faster, cheaper, and optimized product development, as well as more in-depth examination of product performance than it would ever be possible using the most detailed prototypes (Barbosa, 2008).

When prototypes are suitable for the preliminary testing and evaluation of a product they will provide a way to evaluate the product’s performance before going into production. They are used to validate the concept, which in turn may be realized that require additional refinements. It must be kept in mind that prototype testing to verify performance is usually the most important step in the overall design process of any product because, a visual, tactile, three-dimensional representation of a product is much easier to appreciate than a verbal description (Barbosa, 2008). Furthermore, these prototypes are usually requested to ensure that components of the product work together as expected. At this moment, the product development stage ends.

Injection moulding company is then contacted to produce the final integrated component. However, the manufacturing tool (mould) is necessary, and the product manufacturer usually outsources its development. The mould design presents itself as a challenge. The mould designer must take numerous factors into account, such as the intrinsic characteristics of the material, in order to prevent further issues. To provide the best design, the product designer, processor, and mould designer may want to jointly review where compromises can be made to simplify meeting product requirements. For the tool development, flow analyses are also required. These analyses are also useful for optimizing processing conditions in the production stage.

It becomes clear that a correct integration of all participants in the production of a product, from its initial concept to its production, reduces the risks for the occurrence of errors, enables refinements of the product, tool or process without compromising delivery times, costs or performance. Specially, when these “complex” products consists of multiple components that require multiple domains of technical expertise to produce and integrate, produced by several organizations and integrated by a systems integrator who defines their overall technical architecture. The example presented in this section shows how the use of nanomaterials and nanotechnologies will ask for a higer involvement of materials suppliers (who in general are not involved in the NPD process) and will extend cost management to R&D activities.

The inherent technological complexity of designing and producing these products should result, since the beginning of the new component development process, in networks of sub-system producers and specialized suppliers collaborating around the required product. Figure 2 presents these network processes with its participants and relationships.

High-tech environments as they are those based on nanomaterials and nanotechnologies demand for complex and interrelated NPD processes where suppliers have a much more active role than in traditional NPD projects. Supplier involvement in NPD projects has been increasing these last years from superficial and episodic collaborations to deep and early contribution to the design of new products. High-tech products, materials and technologies represent a new step in suppliers’ involvement in NPD projects.

**INTER-FIRM COST MANAGEMENT IN HIGH-TECH NPD PROJECTS**

Suppliers’ participation in cost cutting plans and efforts has been moving from the production stage (with kaizen costing for example) to the design stage (IOCM practices) and more recently to the conception stage. This happens because suppliers have now more and important competencies (particularly in manufacturing operations and technology) than in the past. Nevertheless, the use of high-tech materials and technologies reinforces suppliers’ relevance into the NPD processes and definitely includes them into the value chain R&D activities. Consequently, inter-firm cost management practices in NPD projects are now more demanding and involve buyers and suppliers in an extended and deeper way. The literature on IOCM should be extended with this different type of inter-firm cost management in high-tech NPD environments. The plastics processing industry is a very interesting case study.

In fact, cost management is a vital topic in plastics processing. Processors are being asked to engage in
partnerships. Suppliers and buyers are becoming so integrated that the former is becoming definitively linked to the success of the buyer. The increasing customer pressure for “cost down” or “target cost” production is creating a new climate for processors that now need to have exceptional control over the real costs on processing. Increasing competition has seen plastics processing become a truly global business and companies that are not able to compete in a global market will soon find even their local markets disappearing. Processors need to compete not only with the best in their local area but with the best in the world. A good cost management will improve profits and margins. It will improve management control and it will open the door to becoming a world-class company. Indeed, cost management is still seen as vital to the success of any manufacturing company in any sector (Kent, 2002).

In the plastics processing industry, the design and development process locks cost into the product at a very early stage. The new product design starts to become fixed at a very early stage and the basic costs become fixed early in the project. The control of the number of parts, the materials content and the basic processing methods are all fundamental to cost management and the decisions that govern these are all made during the design and development phase. Product designers/engineers and their assumptions influence product cost from the very start of any project (Kent, 2002).

An effective IOCM, according to Cooper and Slagmulder (1999a), requires the integration of both disciplining and enabling mechanisms to reduce costs across the supply chain. Disciplining mechanisms aim to transmit the cost-reduction pressure throughout the network by setting objectives for every aspect of buyer-supplier interactions. The objective of the enabling mechanisms is to help the firms in the network or chain to find ways to pool their skills and co-ordinate their efforts so they can collectively achieve the cost-reduction objectives. The potential for cost reduction via product design is enormous.

In this context, information sharing and inter-firm collaboration are central to the success of NPD projects. A symbiotic relationship develops whereby co-operating organisations share cost and performance information resulting in analysis and adjustment of interdependent activities and some sharing of costs and benefits (Dekker, 2003). Different forms of relational context exist, ranging from relationships that closely resemble markets to strategic partnerships in which organisations signal their desire to work very closely over the long-term (Cooper and Slagmulder, 2004).

IOCM is concerned with the cooperative efforts of members of separate organisational units to modify cost structures and create value for its participants. When trying to reach the target costs at the component level, the buyer can approach its suppliers in various ways and the degree of cooperation varies. Ellram (2000, 2006) points out that if the purchased component has significant economic impact, more efforts will be spent on supplier selection and changes in design and materials. Less important components lead to more distant approaches, e.g., competitive bidding. Activities related to product development are often critical and during this process, cooperation between buyers and sellers can become very close. To reach the target cost, it may be applied techniques such as quality–function–price tradeoffs, interorganizational cost investigations and concurrent engineering.

Target costing (TC) means determining the expected selling price, derived from the market (as opposed to the costs), before the product is developed, and then calculating the target cost subtracting the expected profit to the price. Therefore, the TC process covers the entire life cycle of a product, although the focus in the literature is on preproduction stages. The literature on IOCM has made valuable contributions to our understanding of these buyer-supplier hybrid relationships. Nevertheless, there remains plenty of scope for further development. Nanotechnologies and nanomaterials will have a huge impact in NPD processes and consequently in cost management practices in NPD projects; particularly, in inter-firm cost management practices with the increased relevance of suppliers from R&D to production stages of a new product. Nanotechnologies and nanomaterials will significantly reduce production variable costs but they will require significant up-front technological investment. The advent of nanotechnology is likely to affect the extended value chain in every major industry. For some organizations, nanotechnology will have a direct effect on their internal value chain. For others, it will have an indirect effect through the external value chain (which extends forward and back to include suppliers’ and customers’ value chains) of which they are a part. The impact of nanotechnology, from a profitability and cash flow perspective, will likely be far greater for those organizations that adopt this technology, thereby affecting their internal value chain, than for those that are a part of an extended value chain adopting this technology. The impact will primarily be restricted to the shifting of costs from downstream (such as failure costs) to upstream (higher cost for parts manufactured through nanotechnology). This shift in costs, however, may be accompanied by a shift in the profitability of the various segments of the external value chain, and companies should perform a value-chain analysis prior to negotiating with suppliers or making strategic investment decisions in this new environment (Dutta et al., 2006).

Under conventional technology, typically 80 to 90 per cent of the total costs associated with a product are committed in the early stages of a product’s life cycle. By the time production begins, while much of the costs
remain to be incurred, there is little ability to control the magnitude of these costs, as they have already been “designed in”. With nanotechnology, both the percentages of costs committed and costs incurred early in the life cycle of a product will be even higher. Early consideration of the total cost incurred over the entire life cycle of a product, rather than just the cost of manufacturing, becomes much more important. Thus, cost management in NPD projects will be particularly relevant in these environments. Furthermore, the role of suppliers in the cost reduction effort will be higher and it will appear sooner asking for effective inter-firm cost management practices. Indeed, organizations adopting nanotechnology in their manufacturing will face much higher initial developmental costs than previously incurred. However, nanomanufacturing techniques will reduce the costs of production and other downstream costs. In traditional manufacturing incurred costs are more evenly spread over a product’s life cycle, with significant costs incurred in the production, sales, and after-sales phases. Companies utilizing nanomanufacturing techniques will incur most costs upstream in the development and prototyping phases and relatively few costs in the production, sales, and after sales phases (Dutta et al., 2006). This fact contributes also for the relevance of inter-firm cost management in these NPD environments.

Furthermore, much of the capital investment of a nanoproject will be required early in the product life cycle. Additionally, there is a higher degree of uncertainty regarding the initial cash outlay, due to the newness of nanotechnology. For nanotechnology, although the break-even point is achieved later in a product’s life cycle, profit grows at a faster rate than with traditional manufacturing and could eventually exceed the profit levels attained under traditional manufacturing. Similarly, although the payback period is likely to be longer for nanotechnology, future cash flows could also be larger in the later stages. The gross margin in the nanomanufacturing environment is higher – this outcomes in a greater sensitivity of profit to changes in sales volume. The profit margin in the traditional manufacturing environment is lower due to relatively higher production costs; hence, there is less sensitivity to errors in forecast. This is represented by a narrower probability distribution for traditional manufacturing techniques, denoting a lower variance in profits (Dutta et al., 2006).

CONCLUSIONS AND FURTHER RESEARCH

In this research project, inter-firm cost management in high-tech product development projects in the plastics processing industry and related techniques were analysed. The objective was to contribute to the understanding of inter-firm cost management in high-tech product development projects and related techniques in practice. Traditionally, cost management has been concerned with cost reduction initiatives (i.e. cutting costs plans), the development of costing and cost information systems and the establishment of effective cost control procedures. Nowadays, firms are developing methodologies for reducing the cost of the product before it’s manufacturing. Effective management of costs, which cross-organizational boundaries, has the potential to improve the overall performance of each firm in the value chain. In particular, high-tech enterprises must know about its characteristics by analysing the value chain and constructing its own featured value chain that may consist of supply, production, storage, marketing, service, purchasing, technology development and human resource management as well as auxiliary works and management functions. It must be sure what kinds of activities are useful for reducing cost and carrying out competitive strategy to eliminate no added value works and realizes overall cost management.

In this context, supplier involvement in NPD implies the combination of the buyer's and supplier's R&D resources and the exploitation of joint capabilities through strategic integration of the buyer–supplier relationship. The firm's new product related competitive position hinges on the supplier's resources and capabilities as well as the inter-firm relationship maintained. The need for achieving target performances, quality characteristics, and target prices for all systems and subsystems are major drivers for the involvement of suppliers. Furthermore, being earlier part of the product development process, suppliers are expected to accept more responsibility for development, design, integration, manufacture, qualification, delivery, target performances, and quality for their particular systems and subsystems on the basis of frame specifications and target prices.

This paper shows how inter-firm cost management contributes to NPD management and buyer-supplier relationships in product development projects in the plastics processing industry. Particularly, how and why inter-firm cost management may contribute for new paradigms in NPD management characterised by high levels of sharing, involvement and interactivity among the different players in a supply chain (i.e. buyers and suppliers) as it is the case of using nanomaterials and nanotechnologies in the plastics processing industry. Organizations adopting nanotechnology in their manufacturing will face much higher initial developmental costs than previously incurred. One result of this new strategic focus could be the “evolution” of IOCM (Coad and Cullen, 2006). Cost management was extended to suppliers through Kaizen costing activities which means cost reductions in the production stage. Nevertheless cost reduction targets at this stage are limited and suppliers have been progressively included into the NPD process in deeper and earlier ways. IOCM represents this new approach. Suppliers became important partners in the conception
and design phases of a new product. However, R&D activities and the involvement of materials suppliers are not characteristics of IOCM environments. The use of nanomaterials and nanotechnologies is pushing an evolution of IOCM where suppliers and inter-firm cost management are more complex, appear earlier and are vital for the success of the entire NPD process. The adoption of this extended IOCM approach will contribute to blur cost management and further research should be made in order to validate and extend these conclusions. Particularly, it is expected further research through case studies in the plastics processing industry.

REFERENCES


