

ACCOUNTING AND DISTRIBUTED PRODUCT DEVELOPMENT

Martin Carlsson-Wall, Kalle Kraus and Johnny Lind

**Department of Accounting
Stockholm School of Economics**

Martin.Carlsson-Wall@hhs.se

Kalle.Kraus@hhs.se

Johnny.Lind@hhs.se

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ABSTRACT:

This paper deals with the nature of product development and the impact of accounting practices on such developments. Through an in-depth case study at ABB Robotics we extend Dubois and Araujo's (2006) work on distributed product development.

We find that distributed product development encompasses a mix of hierarchical and collective systems integration, planning and improvising. We thereby contribute to the emerging literature on distributed product development by highlighting the combinations of the hierarchical view (c.f. Brusoni et al, 2001) and the interactive view (c.f. Dubois and Araujo, 2006)

We also show how a financial logic, captured through target costing, influences many of the pragmatic decisions concerning technical and organisational interfaces in distributed product development processes. We therefore argue that the literature on distributed product development could be extended by making the financial logic explicit and treating it on the same level as the technical logic and the organizational logic inherent in the development processes. Distributed product development is about reaching viable compromises between technical, organisational and financial features. Target costing was also found to have different roles in distributed product development. During hierarchical systems integration, target costing functioned as a hierarchical planning and evaluation technique. During collective systems integration, target costing was used to give focus to joint problem-solving, to aid knowledge integration, as well as to guide the creation of consensus around prioritisations.

Keywords: accounting, target costing, distributed product development, networks

Acknowledgement: We thank Håkan Håkansson, Trevor Hopper, Bob Scapens, our colleagues at the Stockholm School of Economics and ABB Robotics for their comments and participation in this study. We are also grateful for the financial support from the Swedish Agency for Innovation Systems and Jan Wallander and Tom Hedelius Foundation for Social Science Research.

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INTRODUCTION

This paper deals with the nature of product development and the impact of accounting practices on such developments. More specifically, we focus on multi-technology products. According to Brusoni et al (2001, p.597), “multi-technology products are artefacts made of components and embody a number of technologies”. A large number of empirical studies have shown that multi-technology products come from a network of distributed suppliers (Baraldi & Strömsten, 2006; Dubois & Araujo, 2006; Gressetvold & Torvatn, 2007; Håkansson & Waluszewski, 2002). The product development process can then be called *distributed product development* (Dubois and Araujo, 2006). The IMP literature on distributed product development has emphasised that product development is a puzzling process between actors embedded in a complex network of relationships (Baraldi & Strömsten, 2006; von Corswant, 2003; Dubois & Araujo, 2006; Håkansson & Waluszewski, 2002).

From a financial point of view, product development is crucial as 70-80 % of total product cost is fixed during this stage (Ansari & Bell, 1997). The importance of economizing in business relationships and networks has been recognized within the IMP literature (Gadde & Håkansson, 2001; Håkansson & Lind, 2004; Håkansson & Snehota, 1995; Johanson & Mattsson, 1985; Lind & Strömsten, 2006). The authors discuss cost and revenue consequences of business relationships and networks and how the relationships can be characterized as long term investments. However, no studies explicitly examine how the financial logic impacts on the distributed product development process. The financial logic derives from the company owners’ demand of financial return on invested capital. A common way to specify the financial return is to use different forms of accounting measures (Jensen, 2001; Johansson & Östman, 1995; Stern et al, 1995). On a company level there are measures such as return on capital employed (ROCE), return on equity (ROE), economic value added (EVA), cash flow return on investment (CFROI) and cash value added (CVA). However, the demand of financial return has been specified further down in companies through other accounting practices such as target costing, product costing, customer accounting, performance measurement systems and budgets. To meet customer demands and financial market expectations in product development processes, target costing has been put forward as the central accounting practice (Ansari et al, 2007).

In a recent review, Ansari et al (2007, p.513) argue: “Rather than the inward orientation of traditional cost methods, target costing is externally focused, taking its cue from the market and customers.” The external focus of target costing also includes the importance of supplier involvement (Ansari et al, 1997; Kato, 1993). For multi-technology products, collaboration with suppliers becomes crucial for financial success as 60-70% of product development costs come from close suppliers (Carr and Ng, 1995; Cooper & Slagmulder, 2004). Target costing thereby becomes important for creating and sustaining profitability and control in inter-organizational product development (Ansari et al, 1997; Carr and Ng, 1995; Cooper and Slagmulder, 1997).

This paper reports an in-depth case study of the interrelationships between distributed product development and target costing at ABB Robotics (Robotics), a Swedish producer of industrial robots. By focusing on target costing and its role in distributed

product development, the present study puts the financial logic to the foreground. The purpose of the paper is to investigate the nature of distributed product development and the impact of target costing practices. As such, this paper extends the knowledge established by Dubois and Araujo (2006) of distributed product development projects by explicitly highlighting the financial logic and its consequences for development processes. We find that distributed product development in Robotics is characterised by a mix of both hierarchical planning (Brusoni et al, 2001) and collective improvisation (Dubois & Araujo, 2006). Instead of highlighting the incompleteness of hierarchical planning, we show how the two views are complementary and combined. We also found that many of the pragmatic decisions in the development process were driven by a financial logic, i.e. the importance of the target cost. The target costing process impacted on the search pattern for technically and organisationally viable solutions. Target costing created boundaries around the different sub-functions and the involved participants tried to avoid collapsing these boundaries. Further, target costing had different roles in the development process. During hierarchal planning, it functioned as a planning and evaluation technique following the “plan and execute” logic of development processes. During collective improvisation, the target costing process was more interactive and non-hierarchical. Target costing had a guiding role and gave focus to the problem solving, thereby facilitating and directing knowledge integration between Robotics and its suppliers.

The paper is organized as follows. Section two reviews distributed product development and target costing, first by highlighting two research strands: a hierarchical and an interactive view, second by illustrating how target costing can be used to capture the financial logic in distributed product development. In section three, research methods are presented followed by the empirical case description of Robotics. In section five, the case is analysed and the paper ends with conclusions.

DISTRIBUTED PRODUCT DEVELOPMENT AND TARGET COSTING

Two views on distributed product development

The distributed product development literature has a number of common characteristics. Empirically, the focus is on multi-technology products (Brusoni et al, 2001; Dubois & Araujo, 2006). Through in-depth case studies of aircraft engines (Brusoni et al, 2001), trucks (Dubois & Araujo, 2006) and customized electronics (Gressetvold & Torvatn, 2007), two issues are particularly emphasized. The first issue is unpredictable product interdependencies (Brusoni et al, 2001). Since the products' systems functionality concerns the entire architecture, suppliers cannot be studied in isolation. Instead, as Dubois and Araujo (2006) illustrate, companies must be willing to improvise when unexpected interdependencies occur during the process.

The second issue is the uneven development rate of technologies (Brusoni et al, 2001). This puts a high demand on timing. For example, Håkansson and Waluszewski (2002) show how the development of green paper technology was highly dependent on the development (or lack of development) of surrounding technologies. Multi-technology products are therefore an area where both the spatial and temporal boundaries of single companies need to be extended. Theoretically, there is also common ground in the literature on distributed product development. Key inspiration is found in Penrose (1959) who emphasizes resource heterogeneity and Richardson (1972) who focuses on inter-organizational relationships. Citing Richardson (1972), Brusoni et al (2001, p.598) note: "Firms are not islands but are linked together in patterns of coordination and affiliation. Planned co-ordination does not stop at the boundaries of the individual firm but can be affected through co-operation between firms". Theoretically, distributed product development is therefore frequently compared and contrasted with transaction cost economics (Brusoni et al, 2001, Dubois & Araujo, 2006).

Despite commonalities, two research strands have emerged. Based on systems engineering, the *hierarchical view* emphasizes how single companies act as system integrators (Brusoni, 2005; Brusoni & Prencipe, 2001; Brusoni et al, 2001; Hobday, 2000; Hobday et al, 2005). To handle unpredictable product interdependencies and an uneven rate of technological development, system integrators extend their knowledge into the domains of suppliers. By "knowing more than they make", system integrators coordinate hierarchical networks of suppliers (Brusoni & Prencipe, 2001). The hierarchical view emphasizes linearity and planning. In terms of the development process, it is initiated and controlled by the one party, i.e. the systems integrator (Brusoni, 2005). In terms of the development content, it is decided by the systems integrator and there is a clear division between planning and implementation. Finally, in terms of development participants it is possible for the systems integrator to plan in advance which participants are needed to solve the problem (Brusoni et al, 2001).

Dubois and Araujo (2006) propose an alternative *interactive view* of distributed product development. Instead of focusing on systems integrators, they emphasize the process of collective systems integration to handle unpredictable product interdependencies and an uneven rate of technological development. They argue: "Innovations can emerge from complex and distributed interaction patterns rather than being pursued by a single systems integrator." (Dubois & Araujo, 2006, p.35). Multi-

technology products soon become overly complex. It is not possible, nor necessarily desirable, that one firm directs all the development (Dubois & Araujo, 2006; Håkansson & Waluszewski, 2002). Studying the development of a Scania truck, Dubois and Araujo (2006, p.34) find: “Numerous and often conflicting aspects and features need to be dealt with holistically in order to reach a viable compromise”.

Dubois and Araujo (2006) further argue the network level has been neglected within the hierarchical view. Even though large automotive companies might be able to influence suppliers, priority cannot be taken for granted. Suppliers have other customers which both facilitate and hinder development (Dubois & Araujo, 2006; Persson & Håkansson, 2007). Compared to the hierarchical view, the development process, the content and the participants are therefore viewed differently. The development process is seen as mutual. Processes are not controlled by one party and can be initiated or ended by both (Dubois & Araujo, 2006). Development content is not pre-determined. In contrast to the hierarchical view, focus therefore shifts towards improvisation and learning (Dubois & Araujo, 2006). In terms of participants involved, new actors can emerge and responsibilities can change throughout the project. Dubois and Araujo (2006) show how the development process involves a network of actors, some of which are part of the original development team and others which temporarily are mobilized to solve complex problems. This means that distributed product development needs to be analysed at multiple levels: within a company, within dyadic relationships and in a network of connected relationships.

Table 2.1 summarizes the differences between the hierarchical and the interactive research strands within the distributed product development literature. Although treated as analytically separable in the literature, in real life the two views may well be intertwined, something which will be explored in the empirical study.

Distributed Product Development	The hierarchical view	The interactive view
Overall focus	One single firm as system integrator	Collective process of systems integration
Process	Developing products in a linear fashion with clear goals and phases	Developing products in a non-linear fashion through a series of pragmatic decisions
Dynamics	Discrete development of products in well-defined projects	Incremental development of products in time and space

Table 2.1: A summary of the hierarchical and the interactive view of distributed product development.

We submit to Dubois and Araujo’s (2006) view on distributed product development as interactive, non-hierarchical, and unpredictable. The development process is studied by examining the interaction between technical and organisational interfaces

at multiple levels of analysis. Empirically, the interactive view can be linked to several recent contributions (Baraldi & Strömsten, 2006; Dubois & Araujo, 2006; Gressetvold & Torvatn, 2007).

Studying the development of customized electronics, Gressetvold and Torvatn (2007) focus on customers. Finding joint solutions between customers is a key issue. Similar to Dubois and Araujo (2006), they illustrate how systems integration is a collective process characterized by improvisation and learning. Compared to the hierarchical view, both Dubois and Araujo (2006) and Gressetvold and Torvatn (2007) emphasize that product development occurs through a series of pragmatic decisions over time. As Gressetvold and Torvatn (2007, p.51) state: “The issue whether to develop a product, or how to develop it, becomes not a single decision that can be taken in advance, but rather a series of decisions”.

Baraldi and Strömsten (2006) provide another perspective. By comparing simple and multi-technology products, they illustrate when a hierarchical view might work. A key issue is resource configuration. If the product is embedded into few and known resource interfaces, it is possible to act as a hierarchical systems integrator. This is shown with IKEA and their furniture table “Lack”. Being a large customer, IKEA defines the problem and then outsources development and production to a few key suppliers. In contrast to the Scania truck (Dubois & Araujo, 2006) or the customized electronics (Gressetvold & Torvatn, 2007) development is a planned and linear process. Implicitly, Baraldi and Strömsten (2006) also point to the importance of the financial logic. The Lack table had a target cost of 9.90 Euro. To maintain the price without reducing profitability, constant development efforts occurred (Baraldi & Strömsten, 2006). The mentioning of the financial logic is also shown in Dubois and Araujo (2006). To reduce costs, Scania re-organized the development process into supplier teams and for Dayco, product costs were reduced by 40-50% (Dubois & Araujo, 2006). Drawing on Penrose (1959), Håkansson and Waluszewski (2002, p.215) also refer to the financial logic: “In accordance with Penrose’s observation, we have seen how companies are constantly struggling to solve imbalances, old and new, social, technical and economical.” However, the studies do not give an explicit and thorough consideration of the financial logic. We now move on to target costing, a way of making the financial logic explicit.

Making the financial logic explicit through target costing

Parallel to the advancements in distributed product development, target costing has provided an accounting perspective on product development. Originating from Japanese automotive and electronics companies, the literature has received increased attention in the West, both among academics and in practice (Ansari et al, 2007). In contrast to traditional costing, target costing starts from an external perspective and focuses on design and development (Ansari et al 1997, Kato 1993, Monden and Hamada 1991, Sakurai, 1989). The basic idea with target costing is expressed in the following equation (Kato, 1993, p. 38):

Expected Sales Price – Required Profit = Target cost

Expected sales price is determined by what the customers are willing to pay. Important aspects concern how well the product satisfies customer needs and the prices offered by competitors for similar products. Target profit is determined by the return on capital required from the owners. Thus, the starting point is customer requirements and capital market demands, which gives the company the target cost for the new product (Ansari et al, 1997; Kato, 1993). Simply said, the target cost is the cost level the company can afford to sell the product to its customers and still make enough profit to satisfy its owners. The financial logic is explicitly handled in the target cost of the product through the necessary target profit.

The financial logic is further specified to parts of the product through functional analysis, an important aspect of target costing. The functional analysis divides the product into functions that to a large extent are treated separately from each other (Ansari et al, 1997; Kato, 1993). Each identified function receives an estimated cost. The customer requirements are identified through important features for the customers and these features are linked to the identified functions (Mouritsen et al 2001). This means the company can trace expected benefits and costs to each function. The functional analysis makes it possible to break down the target cost into functions and even sub functions and as such integrate the financial logic into the daily operations. Target costing-advocates state that a common conclusion of the functional analysis is that the company need to reduce the different functions' current cost levels to be able to reach the target cost of the product as a whole (Ansari et al 1997; 2007; Cooper and Slagmulder, 1997; Kato, 1993). Functional analysis is then the point of departure from which the company identifies possible cost reductions. The cost reductions and benefit improvements are decided to a large extent in the product development projects and are closely linked to suppliers and customers (Carr and Ng 1995; Tani et al, 1994).

Target costing is described as something more than just another accounting technique. According to its proponents, target costing is a systematic strategic profit management system (Ansari et al 2007; Cooper and Slagmulder, 1997). Target costing covers more aspects and processes than just the financial calculations. Ansari et al (1997) established six fundamental principles to define the content of target costing: price led costing, customer focus, design centred, cross-functional teams, life cycle orientation and value chain involvement. Price led costing, customer focus and supplier involvement principles show the strong external emphasis of target costing. The design centred principle stresses the importance of spending time and resources in the early phases of product development before costs have incurred. Thus, product development is the key for effective cost management. The emphasis on cross-functional cooperation between different competencies such as production, engineering, development, purchasing, accounting and marketing shows the broad focus of target costing. The life cycle orientation principle stresses the importance of minimizing the cost of ownership of the product. The importance of value chain involvement is put forward in most of the mainstream target costing literature (Ansari et al, 2007; Carr and Ng, 1995; Cooper, 1996; Cooper and Slagmulder, 1997; 2004; Ellram, 2002; Kato, 1993; Sakurai, 1989). A common argument in the literature is that the company needs to develop a trust-based partnership relationship with its suppliers. Carr and Ng (1995, p 357) for example reports that Nissan is "careful not to break confidences" with suppliers as this is critical to maintaining trust.

To sum up, we see that target costing is described as hierarchical and planned in the accounting literature. Managers can at the outset specify the product into different functions that are relatively independent of each other. Functional analysis links target costing demands on an organisational level to demands on a project level. The implicit view of product development is a hierarchical “plan and execute” process. That view breaks with the interactive view on product development. For companies working on industrial markets we submitted to the view that the distributed product development process can be expected to be interactive, non-hierarchical and unpredictable (Dubois & Arajou, 2006; Gressetvold & Torvatn, 2007). In contrast, target costing builds on a logic of “plug and play” where functional analysis implies predetermined functions of the final products, functions that are unrelated to each other and thereby can be planned separately and executed separately by the systems integrator. The contrasting views on product development bring out the question: what happens when target costing enters an interactive and unpredictable world? Further, how will the financial logic, captured through target costing, be involved in the “series of pragmatic decisions” characterizing distributed product development (Dubois & Araujo, 2006; Gressetvold & Torvatn, 2007)? These are questions raised by the theoretical discussions in this paper, questions which will be explored in the empirical section.

METHODS

Research design

This paper presents a case study conducted in 2002-2007 at a business unit of ABB, a large multinational company. The business unit in focus is ABB Robotics, which manufactures, develops and sells robots. The annual turnover of Robotics is about 250 million Euros and the company employs 600 people at the site in Västerås, Sweden. All major functions of the company, such as product development, marketing, purchasing and production are located in Västerås. In 2002, Robotics was the first robot producer to reach an installed base of more than 100 000 robots. The annual sales volume varies between 8 000-10 000 robots. The most important customers are car manufactures and their suppliers, accounting for more than 65% of the total volume.

Robotics was selected for three reasons. First, it develops multi-technology products and has extensive experience of distributed product development. Second, Robotics has close supplier relationships with both Swedish and foreign suppliers. This gives us the opportunity to get access to suppliers, giving a complementary perspective on the product development process. The main project in this paper is “Voyager”, a large generation project of new robots that includes the involvement of several suppliers. The development of individual modules in cooperation with suppliers can therefore be studied on both a dyadic and a network level. Finally, personal ties provided us with a credible contact person within Robotics.

Data collection and data analysis

The study began in 2002 and the data collection can be characterized as exploratory (Eisenhardt, 1989). The overall frame of the study concerned accounting and its role in distributed product development. As with many development projects, a research process is rarely a linear process between intentions and outcomes (Håkansson & Walsuzewski, 2002). We therefore took a broad view and then let intriguing questions guide more detailed investigations (Dubois & Gadde, 2002). However, in line with Dubois and Araujo (2006), a starting point for our data analysis was a component (motor) and how it was first embedded into a product (robot) and then secondly into a larger technical system (use of robots in production systems). With this approach, we got a pragmatic start for grappling with the series of decisions required to conduct network studies (Halinen & Törnros, 2005).

Data collection consisted of three phases. The first phase was conducted in fall 2002. In order to get a feel for the research site, one of the researchers worked at Robotics one or two days a week, in total 22 days. During this time, he had a desk and computer in the product development department office landscape. This enabled him to interact with engineers, purchasers, quality- and production personal. The researcher was also given access to all internal documents on the intranet. This included strategic product development plans, minutes from current and past development projects, lessons learned from earlier projects and development routines used in supplier relationships. He was also given financial information in terms of the content of contracts, overall sales and profits. During the first phase, 32 semi-

structured interviews were conducted with individuals at Robotics. These were made on all levels of the company, including top management. Two interviews were conducted with the two most experienced managers at one of the suppliers. These managers had both worked with Robotics for more than 10 years. The interviews focused on characterizing complex outsourcing relationships and the use of accounting. On average, these interviews lasted 65 minutes. In order to gain trust, it was decided to conduct these interviews without a tape recorder. Instead detailed notes were taken and 10 follow-up interviews were done in the end of 2002. Additional to this, the researcher participated in a two-day course called Robotics Supplier University. During the course, he was introduced to about 15 suppliers and was given their view on Robotics. When the data collection for the fall was evaluated, it was decided to dig deeper into distributed product development and extend the knowledge of some product development projects.

The second phase in the spring of 2003 focused on accounting and distributed product development. In order to get the depth needed, it was decided to increase the focus with one of the key suppliers, DriveSys. The reason for this was that distributed product development had been carried out for more than 10 years in the relationship Robotics-DriveSys. 16 interviews were made with key personnel involved in the development with DriveSys. Similar to the first phase, detailed notes were taken after each interview. These interviews lasted on average 70 minutes. After the first two phases, the research team had collected large amounts of data. Except for the detailed notes, there were two full folders with minutes, routines and powerpoint slides.

The third and final phase started in the spring of 2004. During this phase, data has been collected to complement the main themes identified in phase one and two. During phase three, 25 additional interviews were conducted at Robotics and 12 interviews at DriveSys and another supplier. All these interviews were tape recorded and transcribed and lasted an average of 80 minutes. A more detailed description of those interviewed in all phases is described in the Appendix.

The next step was to use the transcripts, the detailed notes, minutes, powerpoint slides and additional material to start writing the case study. The analysis was conducted in several steps. First, quotes related to Ansari et al's (1997) definition of target costing were gathered. Second, the quotes were structured in tables according to themes as patterns became clearer. Third, drafts were written up, which subsequently were improved after comments from colleagues and from the interviewees. The data analysis process followed Dubois and Gadde (2002) who propose a constant iteration between data, analysis and theoretical framework.

TARGET COSTING AND DISTRIBUTED PRODUCT DEVELOPMENT AT ROBOTICS

Target costing is described in two product development projects. Our focus is on the role of target costing in the evolving product development process. This means that the process of estimating the selling price and the required profit is taken for granted. Rather, our starting point is the estimated target cost as such and how it relates to the series of pragmatic decisions concerning technical and organisational interfaces. As figure 4.1 illustrates, we study this through two development projects. The first project, Voyager, is a large platform project, planned in advance and involving several suppliers and sub-suppliers. Due to unforeseen technical interdependencies, Beta, a second project was required. This project was smaller and unanticipated as a technical problem from Voyager needed to be solved.

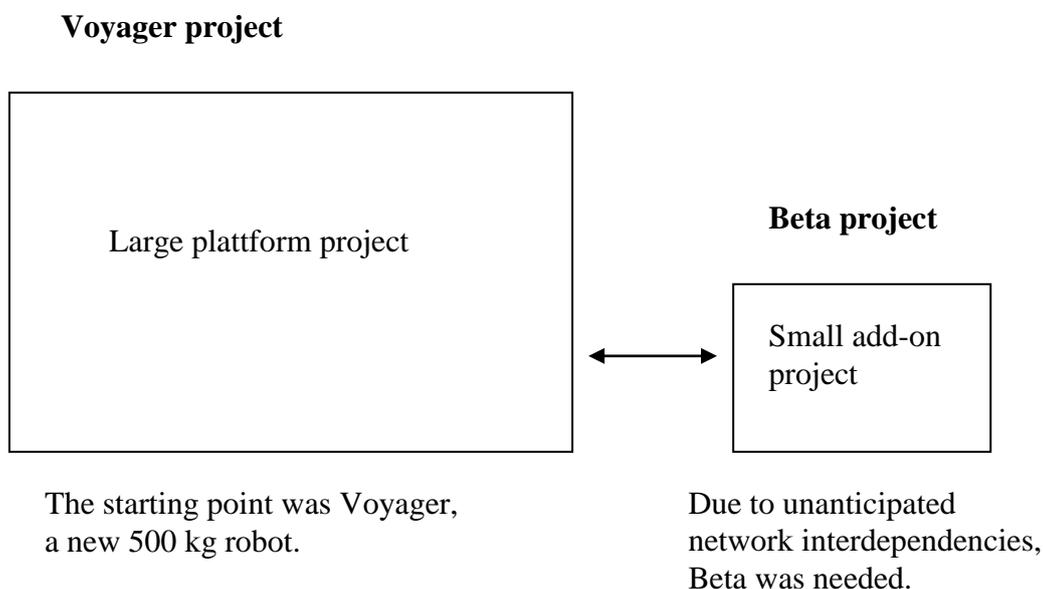


Figure 4.1: The two development projects in the empirical section.

4.1 Target costing in the Voyager project

In the mid 1990's, the first ideas of Voyager emerged. Robotics had successfully grown from an annual volume of 1000 robots to about 8000 robots. However, other robot manufacturers had developed robots with new functionality and prices had decreased by more than 50% compared to 1990. Therefore, in 1999 Robotics decided to launch "Voyager". The new robot had two important features. First, it could handle 500 kg, which made it the strongest robot in the world. Second, Voyager had a "bending-backwards" function. This meant the robot could turn its arm 180 degrees and bend itself backwards. This reduced cycle time and improved flexibility. However, both functions made Voyager more expensive. Target costing was considered a critical part of the development process.

Figure 4.2 shows the major components of Voyager. The components are characterized by high technical complexity and they are supplied by single source suppliers. These suppliers are important from a financial perspective, because they

make up a majority of the material cost. In order to illustrate the use of target costing in distributed product development, we focus on the two most expensive components, motors and gears.



Figure 4.2: The “Voyager” robot with the cost for key sub-systems.

Target costing and early supplier involvement

The process of working towards a target cost involved many of Robotics’ present and potential suppliers. Initially, a challenge was to develop a basic technical specification that could be sent out to suppliers. To handle tensions between cost and functionality, Robotics started an early dialogue with the present gear and motor suppliers. A purchaser at Robotics describes:

We started to talk to the strategic suppliers already during the pre-study. At gate zero so to speak. “Now, we are thinking about developing a new robot family”. Already at that stage they have given us some indication of prices and if they are interested in the project. However, as a rule of thumb we are not satisfied with the prices at this point. We are still negotiating.

During 1999, the purchasing department at Robotics contacted several gear and motor suppliers to get a first estimate. The contracts for both the gear and the motor supplier included several parts. First of all, the robot target cost was broken down into sub target costs for the gear and the motor. This cost was further specified according to volumes Robotics planned to purchase. Here Robotics used functional analysis which divided the final product into separate functions. Another part was the target cost for the development project, called the “non-recurrent engineering” cost. This sum was paid in parts after passing several gates during the development project. Finally, the contract included issues of intangible rights, quality and logistics levels and the processes for how the development work would proceed.

Initially, the project team had a preliminary view of favourites. For gears, the favourite was Gear.Inc, a previous supplier from the mid 1990's. One project engineer at Robotics said:

First of all, all these projects are golden opportunities to negotiate. Since you are making a new product, all cards are open. I guess, it's the phase where we have the least partnership and the rawest bargaining between us and the suppliers. You go to Gear.Inc and tell them "we are going to change all the gears, you are welcome to bid, but this is our target cost but we are also seeing other suppliers". For Voyager, it came very handy that we had changed supplier to GearY in the previous project.

However, even though Gear.Inc was the favourite, Robotics still gave three other gear suppliers the opportunity to bid on the project and was also prepared to change suppliers if necessary. The price estimations from the other suppliers were used as a benchmark to assure a fair price. The interaction with other suppliers was also used to get second opinions about technical solutions and integrate new knowledge. In the end, Gear.Inc was chosen, but the target cost was not met.

On the motor side, the current supplier Engine.Inc was the favourite. The relationship had been successful for a number of years. For example, Engine.Inc had performed well both in terms of logistics and quality. Engine.Inc had a relationship with a local engine work shop in order to handle all the service issues that came up. This had especially been important during the late 1990's when Robotics grew considerably and needed suppliers that would solve unforeseen problems "on the fly". They also had a Key Account Manager who was successful in getting Robotics' demands being prioritised within Engine.Inc. However, during contracting it became obvious that Robotics and Engine.Inc had different view points. When Robotics received the initial estimated target costs from Engine.Inc, they were much more expensive compared to other suppliers. According to the senior engineers at Engine.Inc, it was impossible to reach the target cost, given the effects Robotics wanted Voyager to run at. This surprised both the project group and the senior management at Robotics, because Engine.Inc was seen as a valuable partner. More intensified discussions therefore began. However, this did not result in any large reductions in the price offered to Robotics. Parallel to intensified discussions with Engine.Inc, the purchasing department deepened their investigations with other suppliers. One such option was a Japanese company, Motor.Inc. Compared to Engine.Inc, the offer from Motor.Inc was more than 10% cheaper. Since the motors for Voyager built on a new technology, it was necessary to conduct a number of technical tests. Robotics had also learnt from previous development projects to focus harder on quality aspects. Therefore, Motor.Inc was especially audited on their quality processes and how they handled their suppliers. Audits were also conducted on logistics to see if Motor.Inc had the ability to deliver increased volumes for large automotive customers. After thorough investigations, Motor.Inc was chosen as supplier for Voyager.

The contracting resulted in changing two important suppliers. Gear.Inc returned after having lost a previous project and Motor.Inc was awarded the contract instead of Engine.Inc. The choice of Motor.Inc was made because of the difference in prices they offered. One manager at Robotics explained:

Tacit knowledge will never appear in any technical specification in the world. So when Motor.Inc gives us a good offer, they really have a different perspective than Engine.Inc. I don't know if it motivates the large price difference between the two, but it could be that Engine.Inc knew too much of us and thereby disqualified themselves.

Target costing and ongoing product development

When the two suppliers were chosen, the development work began. In order to manage time, Robotics and the suppliers started to plan the development time. This was done according to a gate-model. The gate-model stipulated different dates when Gear.Inc and Motor.Inc should deliver the first and second prototypes, when the pre-series was going to be run and when the project was supposed to be finished. Given that Gear.Inc and Motor.Inc both were suppliers which required a close relationship, the organisation of the two development processes were similar. Both suppliers had a contact person within the project team at Robotics and both suppliers had a development team internally that would develop the gear and the motor. There were also regular contacts between Robotics and the two suppliers. Most often this contact was conducted by phone and e-mail. With Motor.Inc, face-to-face meetings took place frequently. However, since Motor.Inc was a new supplier, one engineer at Robotics noted:

The problem was that we sent them a technical specification and thought that we would get a new motor in return. We should have been there more and they should have visited us more here. Generally, with global purchasing, if you don't realize it means spending a lot of time and money on travelling you have not understood the complexity.

Major and unexpected problems occurred in the end of the development project. During testing in Robotics' laboratory, the motors suddenly stopped functioning. The breaks did not work. As a consequence, the robot did not stop when told to. This was a major problem from a financial point of view since delayed launching as well as ill-functioning robots in the customers' factories mean higher costs as well as lower revenues. The manager for testing, the overall project manager for Voyager and the responsible engineer for motors formed an early crisis team. What was the problem? Taking the motor apart, it was discovered oil had leaked into the breaks. Describing the situation, a Robotics engineer says:

The situation was difficult, because the problem had never happened before. Sometimes, you do not even know where to start. However, since the motor had not stopped, we rather quickly found out it had to do with the breaks.

After about a week, the crisis team had a working hypothesis and contacted engineers at Motor.Inc. Together, the extended crisis team started to grapple with the problem. In contrast to the normal development routines, the supplier flew to Robotics in Sweden to work face-to-face. Since no one initially knew the magnitude of the problems, the crisis team was extended with purchasers and salesmen from both Robotics and Motor.Inc. In this way, technical and commercial issues could be handled "on the fly". Functionality and associated costs for new technical solutions

were related to each other. The crisis team continuously evaluated proposed solutions in relation to the assigned target cost. Describing the situation, a senior engineer at Robotics explains:

In case of the motor, it was new technology for them. We hadn't understood this before. It should...overall, one can say that when you run into trouble, when it doesn't work out, it's usually when the supplier ends up in a new technology and that we didn't realize this... sometimes they don't even realize this.

Even though the problem was rather concrete, "oil in the motor", the joint investigations took more than a month. Before a final solution could be decided, it was important to fully understand the reasons why the oil had leaked into the motor. If not, there was a risk unexpected problems would re-appear again. During the investigation, technical interfaces on both a dyadic and network level were studied in detail. First, the material of the isolation was studied. Were there any better alternatives? Second, the oil was sent to analysis. Could it be that the oil contained small fragments that caused friction and caused leakages? Finally, the interfaces between the motor, the gear and the drive were examined. Could it be that the leakage was caused because of heat when the robots were run? For each alternative, a root-cause analysis was conducted. When this was done, the joint crisis team had to "close down" alternatives to carry on. According to a senior engineer at Robotics:

We normally succeed in solving the initial problem. Rather, the challenge is to make sure new problems do not appear instead.

After the first month, a solution was decided upon. By changing the material in the interface between the motor and the gear, leakages would be avoided. A more exclusive material was therefore used. During the implementation, Robotics' engineers and quality personal also travelled to Japan to see how the new interface was produced. In this way, both parties would see the problem and agree on how the problem should be solved. The discussions between Robotics and Motor.Inc led to changing of material for the isolation. The new material was better, but more expensive. However it was still possible for Motor.Inc to fulfil the target cost.

Reflecting on the process, a Robotics manager acknowledges that even if both parties tried hard to work together, having new technology and a new relationship is an additional risk. Comparing with Gear.Inc, he argues that an advantage is that there are already personal relationships. When something unexpected happens, most people then know who to call and this is argued to be important for the development process.

To summarize, we have illustrated distributed product development in Voyager, a large platform project at ABB Robotics. Throughout Voyager, financial considerations, through target costing, were taken and this financial logic influenced the direction of the project alongside the technical and organizational considerations. Until the final stage, target costing functioned as predicted in the target costing literature (Ansari et al, 2007; Cooper and Slagmulder, 1997; Kato, 1993). The overall target cost was broken down into sub target costs for the different functions, i.e. motors and gears. In a top-down way, Robotics used planning models, such as the gate model and quality audits, to ensure that the target costs were being met. In the later stage of the project, problems with the isolation of the motor unexpectedly

occurred. Through joint problem solving, Robotics and Motor.Inc changed isolation material, something not initially planned. Here, target costing had a different role compared to the literature. It was used by both parties in the process of collective improvisation.

Target costing and the Beta project

The Voyager project could have been the end of the story. However, the choice of technical solutions in Voyager created tensions in technical interfaces on a network level and formed the need for a new project, “Beta”. One senior engineer at Robotics described:

Well, you do a sort of technology climbing... I guess it’s mostly driven by cost, but you can also be forced to substitute sub-systems because of technical reasons. Sometimes when you make a big change it needs to be supported by also substituting other components that by themselves might not be necessary to replace.

In figure 4.3, a robot system is illustrated. There is a technical interface between the Voyager robot and the industrial control system (ICS). Like a human brain, the ICS calculates how the robot can move its arm to a certain position and then control that this is carried out. The grey area highlights the driveline, consisting of the drive, the motor and the gear. If the motor and the gear are the most expensive and technically advanced in the robot, the drive is the most expensive part in the ICS.

If one compares with a human body, the drive is the heart, sending out current to the motor so it moves. From a target costing perspective, dimensioning the driveline becomes crucial for achieving profitability for Robotics. The background to the “Beta” project started in the Robotics test lab. During the testing of the Voyager robots, it became obvious that the drives were not strong enough to handle the new motors that had been developed together with Motor.Inc. One can compare this with an old PC that has too many new programs – the processor of the PC cannot “think” fast enough and becomes overheated.

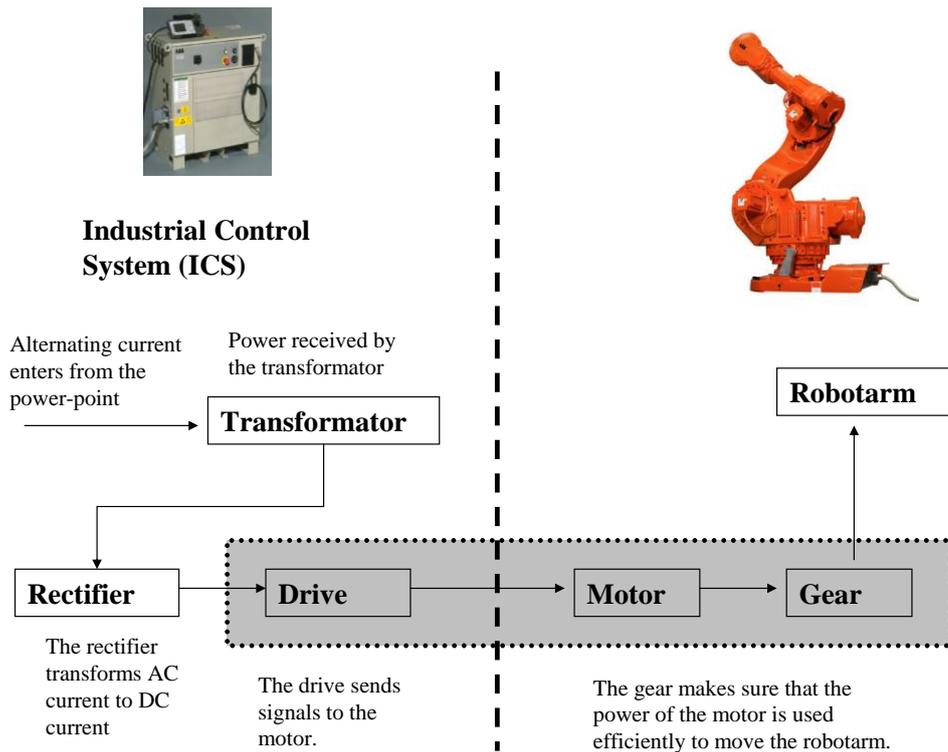


Figure 4.3: Technical interfaces relating “Voyager” and “Beta”.

Over-heated drives and problem-solving on a dyadic level

When the senior engineers responsible for drives at Robotics heard about the over-heated drives, they contacted their supplier DriveSys. DriveSys had been a supplier since 1990 and had developed two large generations of drives including several smaller adaptation projects. Over the years, the relationship had developed in a similar manner as Robotics’ relationship with Gear.Inc. One of the technical managers at Robotics described the advantages of the close relationship with DriveSys in the following way:

When I call them [DriveSys], its mostly about technical issues...however cost is often involved. You know, I want to know if they can reduce their price if we choose a certain technical solution. That’s the nice thing with a supplier that is close. You just give them a call as fast as you have a question. You don’t need a formal meeting; you don’t need to write fancy documents. Instead, you just call and get their view and see if you are on the right track. Then, if you are, you go deeper into the technical issues and ask them for a formal price.

Since it was close to launching Voyager, it was necessary to relatively quickly solve the problems with the over-heated drives. Otherwise, Robotics would not be able to sell the Voyager generation and revenue would be lost. However, when the small group of senior engineers at Robotics and DriveSys gathered to discuss different

solutions, they realized it would mean additional costs and they should not be able to fulfil the target cost. Because of this, the purchaser from Robotics and the key account manager from DriveSys got involved. DriveSys argued that it was Robotics' responsibility, since the contract for the previous drive generation stipulated which motor effects the drives should be produced for. Robotics on the other hand thought that DriveSys should pay the increased cost, since the contract stated DriveSys had a functional responsibility for the drives. The reason for letting DriveSys pay was that Robotics purchased many versions of drives and paid a different price depending on the effect needed. For robots with smaller engines, Robotics could purchase a drive with a lower effect and to a cheaper price, while the price increased when the drives were used for the largest industrial robots. The purchaser therefore thought DriveSys should see the technical modification to the Voyager generation as "part of the entire business between the two companies."

DriveSys on the other hand wanted a higher price, because the Voyager robot would require a new drive version and could not be one of the standard versions already delivered. Even though the partnership was one of mutual reciprocity, one of the main reasons behind DriveSys' argument was that the prior target cost goals had squeezed the margins in such a way that additional flexibility (and costs) could not be acceptable. The cost of the drives was also related to how the drives were embedded into other technical interfaces. For example, during the development process the prototypes were related to the production facilities and test equipment at DriveSys. The technical interfaces were further embedded into other business relationships in the network. In this case, the test equipment had two technical interfaces with the assembly line and the test equipment at ElectroProd, the supplier DriveSys had outsourced the production of the drives to. When there was no obvious solution in the relationship between Robotics and DriveSys, it was decided to look for alternatives on the network level. The financial logic inherent in the sub target cost for the drives hereby stopped technical solutions on a dyadic level to be implemented, because these technical solutions were seen as too expensive.

Over-heated drives and problem-solving on a network level

By having system knowledge of how different parts in the ICS interacted with the drive, Robotics and DriveSys decided to include the control cabinet manufacturer ControlCab, to see if new, more cost-efficient solutions could be found. Financial, technical and quality knowledge from the three companies were brought together. Because of the technical issues, the engineers cooperated with each other and when solutions were identified, the business people were given the chance to give their opinion about the solutions.

The first proposal came from DriveSys and the engineers responsible for drives at Robotics. Their suggestion focused on maintaining the costs of the drives and instead changing other components in the ICS. More specifically, the problems with over-heated drives could possibly be handled by increasing the size of the control cabinet or increasing the size of the fans. This would create an extra air channel that would lower the temperature of the drives. However, when the solution was discussed between the companies, the sales manager at ControlCab argued this solution would be feasible but the cost for the cabinets would increase. The reason for this was a new

cabinet would not be compatible with the production of the present cabinets and therefore the cost would go up. Previous work, both development projects and cost-cutting activities between Robotics and ControlCab had lowered the cost of production, but at the expense of decreased flexibility. In this specific case ControlCab had invested in a certain production line, which depended on making a certain volume of the standard cabinets. The production line was also used in a specific activity pattern, which depended on total production automation. With a new cabinet, the production process would have to be adjusted, mainly because some activities done in the new production facility would have to be done by manual labour. The consequences of rebuilding the cabinets would therefore be that the new production facility would be used less, which would increase the cost per working hour, and a new cost for the manual labour would have to be added.

The solution was therefore not possible without increasing the costs and thereby not meeting the sub target cost for the drives. The project team at Robotics, DriveSys and ControlCab had to go back and find another solution that would work for all parties. After some initial discussions, the group realized the problem required knowledge about air current and that neither of the involved parties had extensive knowledge. Instead, a technical consultant firm, "Consultant" was contracted. According to a Robotics engineer, the normal procedure of handling electronics and heating was to do manual tests in the lab. However, because of the parallel development of Voyager, it was decided to contract a professional firm instead. "Consultant" therefore simulated and measured the air currents, in order to give input for deciding the most "price-worthy" rebuilding of the drives. In the end, it was decided to leave the components in the ICS and go back to the drives. The engineers at Robotics and DriveSys therefore had to once again come up with ideas for a new solution.

To build a cost-efficient drive for Voyager, DriveSys interacted with their suppliers to reach a cost that would be acceptable. In the final solution, two things were changed. First of all, the material of the cooling flanges in the drives was changed and two extra flanges were added. This increased the cooling capacity of the drive. Second, some of the electrical connectors were changed to a higher dimension. Both these improvements made it possible to run Voyager and the final solution was seen as a viable compromise in terms of costs and technology. Robotics had to pay more than the sub target cost but the extra cost was less than the cost for the alternative solutions.

ANALYSIS

The nature of distributive product development

We find support for Dubois and Araujo's (2006) interactive view of distributed product development as non-linear, non-hierarchical and unpredictable, i.e. a collective process of systems integration. Both Robotics and Motor.Inc underestimated the level of interaction that was needed to develop a motor with a new technology. This came to full realization when the motors suddenly stopped. Trying to solve the problem, a temporary crisis team was formed where technical interdependencies both on a dyadic and network level were analyzed. As Dubois and Araujo (2006, p.36) state in their conclusion: "Changes in one interface may often have connected effects in other interfaces and to set in motion a reconfiguration of the technical and organizational structure of the project". Collective improvisation and the need for a reconfiguration came out even stronger in "Beta". The project was not planned, but emerged as a consequence of Voyager. In the beginning, the goal of coping with the over-heated drives was quickly set, but neither the full realization of the problems, nor the concrete activities could be manifested in a gate-model. Instead, senior managers at Robotics had to interact and improvise with their counterparts at DriveSys. Similar to the problems with Motor.Inc, Robotics did not hierarchically control the development process. The empirics show how the initial motor problems created reconfigurations both within Voyager, but also initiated the development of an entirely new project, Beta. This supports Dubois and Araujo's (2006) claim of the spatial and embedded nature of distributed product development.

However, we also find support for the hierarchical view of distributed product development. The development process sometimes was characterised as planned and hierarchical in accordance with Brusoni et al's (2001) description of systems integration. The initial technical specifications, supplier selection and the ongoing development activities within Voyager are examples. Robotics acted as "manager" of the project, set the functional boundaries, selected suppliers and then monitored their development work continuously. Robotics used planning and coordination techniques such as quality and logistics audits of suppliers, as well as gate models, which stipulated different dates when the suppliers should deliver their prototypes. Robotics orchestrated the different technical interfaces and drove the project forward (Brusoni & Prencipe, 2001; Brusoni, 2005). There were also organisational interfaces in terms of planned contact meetings between teams from the suppliers and Robotics. In addition, Gear.Inc and Motor.Inc had a contact person in Robotics' project team.

By including all phases of Voyager when describing and analysing distributed product development¹, we conclude that distributed product development encompasses a mix of hierarchical and collective systems integration, planning and improvising. Figure 5.1 shows Robotics and their network of embedded relationships. When the development process was characterized by hierarchical systems integration, the network level was analyzed pro-actively with functional analysis and quality and logistics audits. The central issue was to reduce technical, organizational and financial risks. Even though there was a difference between suppliers, audits were standardized

¹ Dubois and Araujo (2006, p.34) note: "Although the case only covers a fraction of the technical and organizational aspects of developing a new truck, it highlights some of the arguments outlined earlier."

within a particular supplier segment. For example, both Motor.Inc and Gear.Inc had similar audits where Robotics knew before hand which issues they wanted to check. On the other hand, when the development was characterized by collective systems integration, the network level was analyzed in a more trial-and-error fashion. When problems occurred, the search pattern was not planned. Because of the non-routine character, it was impossible to say when the analysis was completed. Instead, pragmatic decisions guided which technical interdependencies should be analyzed and in what order. Based on learning from initial trials, it was decided if additional interdependencies should be included. Because of this, problem-solving did not stop at a “perfect solution”. Instead, it ended when the parties had reached a viable compromise from the collective improvisation.

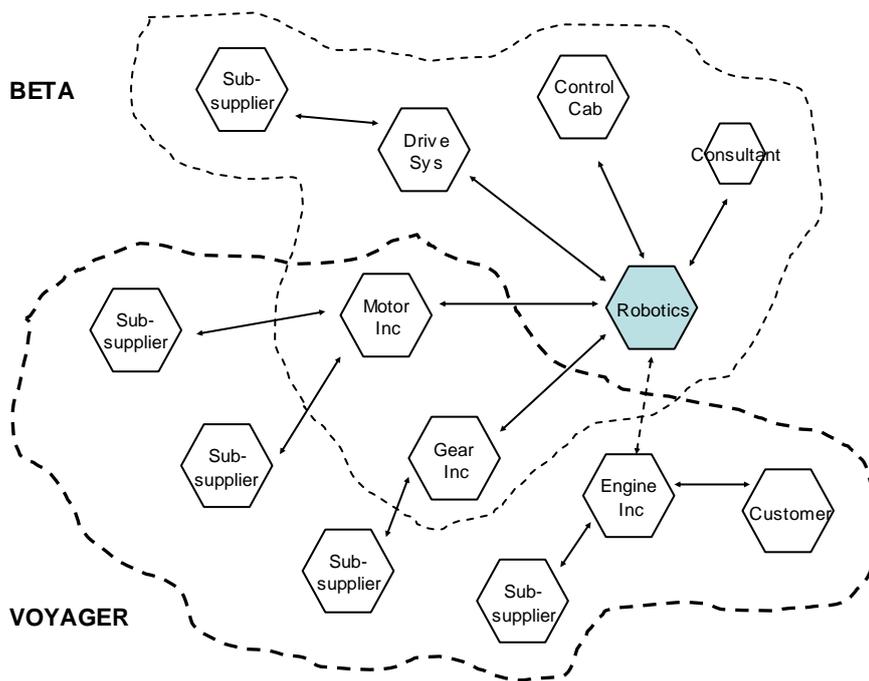


Figure 5.1: Robotics and their network of embedded relationships.

Having found empirical support for both a hierarchical and an interactive view on distributed product development, we now move on to our second contribution, the impact of target costing practices on distributed product development processes.

Target costing in distributed product development

In the Voyager and Beta projects, we see that many of the “pragmatic decisions” in the development process are influenced by a financial logic, i.e. the importance of the target cost. The target cost is continuously referred to when making decisions in the projects. Functional analysis sets the basis for discussing different ways to reach the sub target costs. When selecting suppliers, Robotics did not expect a costly offer from Engine.Inc. Even though the two parties tried to establish why there was a difference, Robotics ended up changing to Motor.Inc, based on financial arguments. The change of supplier was made even though organisational interfaces with Engine.Inc were well established and the technical collaboration had worked well.

During development, Robotics, Gear.Inc and Motor.Inc struggled to find viable compromises (Dubois & Araujo, 2006) between technical feasibility and financial boundaries in terms of sub-product target costs. Technical and organisational interfaces were important for project decisions in Voyager, but the target costs always entered the field before a decision was made. The target cost and the sub target costs for the motor and the gear even surpassed technical feasibility at several instances. Target costing thereby impacted on the development process by forming the basis for saying no to technically and organisationally well-functioning solutions because they were too expensive and hence fails to meet the target cost. We thus see that distributed product development is characterised by a simultaneous handling of technical, organisational and financial aspects as the project unfolds. This is in line with Håkansson and Waluszewski (2002, pp.10-11) who state: “Since any interaction between two companies has to lead to a solution that can create a mutually acceptable economic outcome for both parties, both are more or less prepared to adapt their original means and goals”.

Target costing, through the functional analysis and the sub target costs, also impacted on the development process by guiding the search pattern for technical solutions to problems that came up during the process. When there was a problem with overheated drives, Robotics and DriveSys started to identify technical solutions within the dyad, but they were seen as too expensive. Due to target costs from previous projects, it was not possible to find a solution that would not increase the cost for either party. A new problem-solving loop started where ControlCab got involved and new and cheaper technical solutions were searched for. Hence, the search for new solutions was extended to a network level. According to DriveSys, one solution to the heating problem could be to increase the size of the cabinet. This meant that DriveSys’ suggested solution moved the problem to another function, thereby making it possible for DriveSys to fulfil its own sub target cost. However, when ControlCab investigated its possibilities to change, this also meant increasing costs both for ControlCab and its suppliers. The proposed solution could not fulfil the sub target cost for the cabinet. In this way ControlCab acted similar to DriveSys. They searched for possible solutions within its function and sub target cost without requiring an adaptation of the technical interface to DriveSys and Motor.Inc. Robotics also took advice from Consultant. In the final solution, Robotics returned to DriveSys. Both from a financial and technical standpoint, it became a viable compromise. Robotics had to pay more than the sub target cost but the extra cost was less than the cost for the previous solutions. Organizationally, Robotics also acknowledged that DriveSys had previously helped them with complex problems.

We see that the financial logic, specified through target costing practices, the technical logic and the organisational logic are intertwined in making pragmatic design decisions during distributed product development. The target cost creates boundaries around the different sub functions and the involved participants try to avoid collapsing these boundaries. The search pattern is to find cost-efficient solutions in the different sub target costs. If that is impossible the search pattern goes on and the actors need to blur the sub target cost boundaries. The search pattern is also affected by the fact that companies are locked in because of previous development decisions when they have fulfilled previous target costs.

We also find that target costing has different roles in the development process. During hierarchical systems integration, the role of target costing is well in accordance with the literature (c.f. Ansari et al, 2007). Functional analysis and sub target costs set limits for discussions about technical solutions as the development project unfolds. The different functions, i.e. the motors, the gears, the drives, are closed. They have different sub target costs and the buying role and the supplier role are clear where Robotics controls the suppliers through gate models. Target costing functions as a planning and evaluation technique following a “plan and execute” logic. The development process has a clear goal and target costing thereby has a disciplining role by helping Robotics see to that the different functions meet the sub target costs, the time deadlines and the technical specifications. The target cost and subsequent sub target costs for each function are not changed during ongoing product development.

On the other hand, during collective systems integration, the target costing process is more interactive and non-hierarchical. Target costing creates consensus about the fact that a problem needs full attention from both buyer and supplier and it needs to be solved quickly. The financial magnitude of the problem gives rise to the need of forming a crisis team and the need for the supplier to fly staff to Robotics. Target costing also serves as an anchor that frames what pragmatic decisions to take during collective problem-solving and improvisation. The importance of reaching the target cost and the functional analysis has a guiding role when searching for new angles to pursue and possible solutions that are technically and organisationally viable. Target costing thereby creates consensus around prioritisations, gives focus to the problem-solving and facilitates and directs knowledge integration between Robotics and its suppliers. Target costing sometimes forms the basis for saying no to technically well-functioning solutions because they are too expensive, but on other occasions target costing forms the basis for searching for possible solutions that are compromises between improved technological content and additional costs.

CONCLUSIONS

The purpose of this paper was to extend the knowledge established by Dubois and Araujo (2006) of distributed product development by explicitly highlighting the financial logic, through target costing, and its consequences for development processes. Through an in-depth case study at ABB Robotics, we find support for the advances in distributed product development described and discussed in Dubois and Araujo (2006). Robotics' product development projects were often seen to be interactive, non-hierarchical, non-linear and evolving in an improvisational way through temporary pragmatic decisions. The interaction between technical and organisational interfaces often involved a network of interconnected actors; some not initially planned to be involved in the project.

We extend Dubois and Araujo (2006) in two main ways. First, by including the entire development project when describing and analysing distributed product development we show that the nature of distributed product development is characterised as a mix of hierarchical and collective systems integration, planning and improvising. Sometimes the development process is found to be linear, planned and hierarchically run by a sole systems integrator, in accordance with Brusoni et al (2001). However, the development process is also characterised by improvisation and by being interactive, non-linear, non-hierarchical and distributed in a network of interconnected relationships, in accordance with Dubois and Araujo (2006).

Second, we show how a financial logic, captured through target costing, influences many of the pragmatic decisions involved in distributed product development. Distributed product development can hence be seen as a process where a technical logic, an organisational logic and a financial logic are intertwined and sometimes in conflict. Often target costing guides the outcome as the development project unfolds. Target costing forms the basis for saying no to proposed technically well-functioning solutions when they are too expensive. It also, through functional analysis, guides the search pattern for possible solutions thereby impacting on interaction and improvisation in the development process.

We conclude that target costing had different roles in distributed product development. During hierarchical systems integration, target costing had a disciplining role and functioned as a planning and evaluation technique, controlled by Robotics. During collective systems integration, the role of target costing was guiding and it gave focus to problem-solving, created consensus around prioritisations and directed knowledge integration that crossed company borders.

Rather than solely spelling out the characteristics of the two research strands on distributed product development, we suggest future research on distributed product development to analyse how hierarchical and interactive views are combined in development processes as well as to analyse how technical, organisation and financial logics are intertwined in these processes.

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Appendix 1: Data collection

Interviews: overview

Time	Interviews
Fall 2002	30
Fall 2002: Follow-up	10
Spring 2003	16
Spring 2004	20
Fall 2002-Spring 2004	9
Spring 2005	3
Follow-up 2007/2008	5
TOTAL	93

Interviews: details

Time	Company	Interviews	Positions
Fall 2002 Detailed notes	ABB Robotics	30 (24 new persons)	<p>Management team (3) Technology Director Supply Chain Director Chief Financial Officer</p> <p>Purchasing (6) Purchasing manager Purchaser 1 (3) Purchaser 2 Supply chain project manager</p> <p>Development (7) Technical manager 1 (3) Technical manager 2 (2) Project manager 1 Project manager 2</p> <p>Quality (3) Quality manager Quality engineer 1 Quality engineer 2</p> <p>Production and logistics (7) Production manager 1 Production manager 2 Production manager 3 Production engineer Logistic manager Material planner 1 Material planner 2</p> <p>Controllers (3) Controller 1 (2) Controller 2</p> <p>Sales (1) Sales manager 1</p>

<p>Fall 2002: Follow-up</p> <p>Detailed notes</p>	<p>ABB Robotics</p>	<p>10 (2)</p>	<p>Purchasing (3) Purchasing manager Purchaser 1 Purchaser 3</p> <p>Development (1) Project manager 2</p> <p>Quality (1) Quality engineer 1</p> <p>Production and logistic (3) Production tester Logistic manager Material planner 2</p> <p>Controller (2) Controller 1 Controller 2</p>
<p>Spring 2003</p> <p>Detailed notes</p>	<p>ABB Robotics</p>	<p>16 (5)</p>	<p>Purchasing (2) Supply chain project manager Purchaser 4</p> <p>Development (10) Technical manager 1 Technical manager 2 Project manager 1 Project manager 2 (2) Project manager 3 (2) Project manager 4 Project member Senior company specialist</p> <p>Quality (3) Quality engineer 1 (2) Quality engineer 2</p> <p>Production and logistics (1) Production tester</p>
<p>Spring 2004</p> <p>Tape recorded</p>	<p>ABB Robotics</p>	<p>20 (8)</p>	<p>Development (11) Technical manager 1 (2) Technical manager 2 Project manager 1 Project manager 2 Project manager 4 (2) Project manager 5 Project manager 6 Senior company specialist Corporate Research manager</p> <p>Production and logistics (3) Production manager 3 Production engineer Production tester</p> <p>Sales (6) Sales manager 2 (2) Sales manager 3</p>

			Customer order manager Product manager 1 Product manager 2
Fall 2002- Spring 2004 Detailed notes (2) Tape recorded (7)	DriveSys	9 (7)	Development (5) Technical manager 1 (2) Technical manager 2 Project manager Project member Quality (1) Quality engineer Sales (3) Key account manager (2) Product manager
Spring 2005 Tape recorded	D-Network	3 (3)	Management team (2) Owner CEO Development (1) Project member
Follow-up 2007/2008 Tape recorded (4) Detailed notes (1)	ABB Robotics	5 (2)	Development (4) Technical manager 1 (2) Technical manager 3 Technical manager 4 Sales (1) Product manager 2
TOTAL		93 (51 persons)	