CONCURRENT PRODUCT AND DEMAND CHAIN CREATION – IN SEARCH OF CONTINGENCIES AND STRATEGIC CHOICES

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ABSTRACT
This paper presents tentative results of ongoing research into understanding how to manage the interface between product creation and demand chain creation. Further, we discuss why different companies seem to manage this interface differently. The purpose of the paper is to present the research problem, to present and discuss tentative findings from three case studies, and to propose some explanatory propositions to guide future research. The paper sets out with an introduction to the research problem. The second part discusses selected theoretical elements and the third explains the research approach. The penultimate part presents preliminary results from case studies in three companies. The final part discusses the compatibility between theory and case findings, and suggests further research ideas to continue the search for explanations how companies successfully organize their concurrent engineering efforts.

Keywords: demand chain, product creation, contingency approach

INTRODUCTION

During the latest decades focus of operations management has considerably broadened, from a view on manufacturing to supply chains. Recent research now suggests the use of the term demand chain management instead of supply chain management, suggesting that the emphasis should be put on the needs of the marketplace and designing the chain to satisfy these needs, instead of starting with the supplier/manufacturer and working forward (Vollmann and Cordon 1998; Vollmann, Cordon and Heikkilä 2000; Heikkilä 2002; Childerhouse 2002).

Fine (1998) stated that companies could no longer have a significant differential advantage by focusing on improving the interface between products and manufacturing, but they need to

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have a balanced three-dimensional view on operations including product, process and supply chain. Earlier research has extensively addressed the product / process interface under the concepts of Design-for-Manufacturing and Design-for-Assembly (Boothroyd & Dewhurst 1994; Paashuis & Boer 1997; Ulrich & Eppinger 2000). Our current research, however, focuses on the interface between product and demand chain creation. In order to point at critical issues in managing the product / demand chain interface, we decided to look into three different companies with - as it turned out - different ways of managing the interface.

LITERATURE REVIEW

Product architecture

Product architecture is defined as the assignment of the functional elements of a product to the physical building blocks of the product (Ulrich 1995). An important characteristic of a product's architecture is its modularity. The opposite of a modular architecture is an integral architecture. Hence, modularity is a relative property of product architectures. Products are rarely strictly modular or integral (Ulrich & Eppinger 2000). Furthermore, over time dominant product architectures oscillate between open and closed architectures, driving the industry from vertical to horizontal, and back again (Fine 1998). It is widely recognized that the reasons for success are often related to the influence of the modularization on other organizational functions and aspects rather than related to the features and functionality of the product itself.

Clockspeed

Fine (1998) suggested "clockspeed" as a metric for the dynamics of an industry. The idea of clockspeed is that each industry has its own evolutionary pace, measured by the rate at which it introduces new products, processes and organizational structures. Fine argued that companies in any industry can learn from the highest pace industries. Using the examples of bicycle, pharmaceutical and semiconductor industries, Fine suggested that competitive advantage can be lost or gained by the way a company manages the relationships in its network of suppliers, customers and alliance partners.

Eisenhardt & Brown (1998) proposed time-pacing, i.e. scheduling change at predictable intervals, as a proactive means to cope with an industry's rate of change, perhaps even to set the pace of change. Their key message was that companies need to have capabilities to be, at least, in step with the rhythm of the industry it is doing business in. Time pacing was said to have a direct impact on timeliness and effectiveness of the product creation process, which is important for competing in high pace industries with rapid introduction of new products, high product variety, and decreasing technology lifecycles.

Concurrent engineering

Many companies apply Design for Manufacturing (DFM); the discipline of viewing the manufacturing process as a part of the whole when designing new products. This means not choosing the cheapest design solution, but the solution that also results in low manufacturing cost. A supplementary discipline is Design for Assembly (DFA), in which the assembly process is taken into consideration when deciding which parts will be part of the product and how they should be joined together. Design for Logistics (DFL) means designing products with a low total cost approach in mind, taking into consideration the logistics solution that the product needs to fit in.

Concurrent Engineering (CE) means “a systematic approach towards the design of products and the way they are manufactured, assembled, stocked, transported, distributed and recycled, which aims to optimize product designs in terms of both external demands (e.g. price, quality, delivery time, delivery reliability, range, recyclability) and internal demands (e.g. cost, lead time, manufacturability, assemblability)” (CERC 1992). Paashuis and Boer (1997) emphasize the integration aspect of CE, saying that “CE encompasses a wide range of strategic, process, technological and organizational integration mechanisms, aimed at closer collaboration, earlier and more frequent communication between the functions involved in the design, manufacturing and marketing of new products, and a certain degree of overlap of the stages constituting this process”. Though CE, in principle, can include Design for any X (Quality, Logistics, etc.), Fine (1998) and Dowlatshahi (1999) report that focus has primarily been on manufacturability/assembly issues. From observing the PC industry, Fine (1998) proposes companies to perform 3-dimensional CE, by adding a supply chain perspective to the product / process unity.

A challenge in designing for several X’s, also referred to as Design For eXcellence (DFX), is to integrate all relevant perspectives in each design choice. Questions of timing and balancing DFX are vital, but not very well treated in theory. Paashuis & Boer (1997) noted that in most cases it is not feasible to integrate all functions.

Another challenge to the CE discipline is that today many companies distribute parts of their product creation task to partners, in order to extend their development capacity and get access to outside capabilities. This brings along a need for inter-firm coordination of development and production tasks. Smulders et al. (2002) provided a typology of intra/inter-firm interfaces between product creation and operations (broadly defined), and proposed various integration mechanisms to increase the effectiveness and efficiency of product creation processes.

Many CE solutions are provided in the literature. However, all companies are not alike and the specific context for the problem differs from one company to another. According to Paashuis & Boer (1997) there is a lack of methods to adjust the solutions to the specific company context. Furthermore, this is said to explain why many proposed solutions are not widely implemented in the industry. Therefore, we endorse the need for a contingency approach to manage the product – demand chain interface.

The contingency approach

The contingency approach departs from the general system theory, especially open and goal-oriented systems. A fundamental attribute is the importance of situational factors thus rejecting a universal system design to fit all situations. Instead the contingency approach advocates that a system’s design parameters be configured to a specific context, i.e. the configuration of situational parameters (e.g. Lawrence & Lorsch 1967). As a related example, Arlbjørn (2000) provided a framework to structure a company's logistics system, i.e. demand chain, based on seven product characteristics as situational parameters.

Fine (1998) discussed the relationship between the architecture of the product and the architecture of the supply chain. He stated that integral product architectures tend to be met by integral supply chains featuring close proximity along four dimensions: geographic, organizational, cultural and electronic. Modular product architectures tend to be met by modular supply chains exhibiting low proximity along most of the dimensions.

RESEARCH APPROACH

The research objective was to increase understanding of concurrency in product and demand chain creation. In this particular study the research question was formulated:

> *How do companies manage the interface between product and demand chain creation and what are the factors influencing differences between companies in managing the interface?*

To answer the research question three case studies were conducted. The case studies were implemented together with three companies working in different fields of electronics industry. Since responsibility for the two business processes - i.e. product creation and operations - often are separated in an organization, focus was on the integration of these processes. To guide data collection, the unit of analysis was split into three sub-units:

- Structural view: organization, products, formal coordination mechanisms and responsibility.
- Process/task view: how is the integration task defined, what business processes exist, how is the product creation process carried out, and what activities does it consist of.
- Tools/methods view: what tools and methods does the company make use of, e.g. for product costing, designing supply chains, and integrating product, process and supply chain perspectives.

The research approach was inductive case research, based on one longitudinal case and two "snap-shot" cases. In one case data was collected through a two-year part-time presence in the company. In the remaining two cases the method of data collection was 8-12 semi-structured interviews. The analysis of research data consisted of within-case analysis, cross-case analysis and expert analysis (joint panel meeting with key actors from the case companies plus senior researchers).

CASE STUDIES

The case studies were implemented together with three companies working in different fields of electronics industry. The companies varied in size, from a mere 650 to more than 20.000 employees. All three companies have been successfully in business for a long time, and therefore considered well-performing. Table 1 lists some general characteristics of the three cases Alpha, Beta and Gamma.

The findings from the three cases were divided into three categories: similarities between the companies' concurrency efforts, differences in means and approach, and significant differences that are supposed to influence the interface between product and demand chain creation.

Table 1. General characteristics of the case companies

	Alpha	Beta	Gamma
Years in Business	In Digital technologies since 1990	In Mobile networks since 1980's	In Electronics since 1980's
Turnover (Euro)	550 million	7000 million	80 million
Strategy	Differentiation	Focus (system delivery capability) & cost	Differentiation
Market position	Niche leader (technology follower)	Technology leader (market shaper)	Niche leader (market shaper)
Competitive advantage (order winner criteria)	- Unique design - Brand - Seamless integration of A/V-technology	- Performance (capacity/prize) - Process innovation - Brand	Combining low-power electronics, water-proof mechanics, industrial design and 'clever' SW
Industry clockspeed	Medium/high	High/very high	Medium/high
Product launches/year	5-10	5-10	5-10
Product (sales) Life-time	5-10 years (decreasing)	1-3 years	5-10 years (decreasing)
Main logistic challenge	Global sourcing and distribution, with small volumes	Operational costs and prize erosion on key components	Forecasts from DC's to assembly plant and backwards to suppliers

Similarities between the cases

All three companies pursued modularity in their product architectures, with Beta having the most modular products. Also the term 'architecture' was widely used in all three companies.

All made use of the Assembly to Order principle, but there were different definitions of customers. For Gamma the customer was a country distribution center (DC), for Beta the customers were network operators, and for Alpha customers were consumers.

Stage-gate models were used to guide the companies' product creation processes. In Alpha the model seemed to be continuously evolving. In Beta various variations of the model existed, depending on the scale and scope of the product creation project. In Gamma the model was newly implemented. In all the three cases, not all design engineers possessed knowledge of downstream processes (the processes to design for).

Table 2. Similarities between the case companies

	Alpha	Beta	Gamma
Product Architecture	Modular	(Highly) Modular	Modular
Assembly principle	Assembly-to-Order	Assembly-to-Order	Assembly-to-Order
Product creation method	Stage-Gate	Stage-Gate	Stage-Gate

Differences between the cases
The companies used different levels of postponement. The product configuration point in Alpha and Gamma were situated in the assembly plant, whereas in Beta it was in regional hubs. Also the level of product customization varied. Alpha and Beta offered option-oriented products (parametric), whereas Gamma offered standard products, a few of them with a color or casing option.

In product creation projects Alpha made use of co-location of designers and industrial engineers, in Gamma this held only for mechanical parts since all electronic production were outsourced. Beta often made use of a ramp-up plant, where R&D and Operations were co-located. After ramp-up, production was replicated to several other production plants.

Comparing the timing of CE, Beta involved Operations to make feasibility studies even before the product creation projects were launched, Alpha had cross-functional architecture teams, and Gamma invited industrial engineers to sign-off on product architectures defined by industrial designers and design engineers. The interface device therefore varied from product concept (Beta), to product architecture (Alpha) and to product specifications (Gamma).

In Alpha, 'demand chain design' was being implemented as a track in the company's product creation model. In Beta this had been the case for some years, and process owners were appointed for product creation projects. In Gamma, the demand chain creation was not a formal business process.

Besides the differences in product characteristics and demand chain setup, some more significant differences in considering and handling the interface were observed. In Alpha, the project manager of a product creation project conferred with an internal logistics consultant. Beta appointed a person from logistics to the project team. In Gamma, people from production considered logistics issues. At the same time Beta was the only company deploying logistics target setting for products, and metrics for evaluating product architectures. In both Gamma and Alpha the primary focus of CE was DFM/DFA, and demand chain costs were calculated as a fixed percentage of the material and labor costs. Beta had a "delivery and service capability creation" organization, an organization developing and maintaining both DFX-tools and delivery and service capability for use in product creation projects. In the expert panel analysis of the case study results, Beta managers made a very strong point that DFX methods and tools do not sufficiently bring forth the process management view. DFX are about product design principles, metrics and design targets. "Delivery and service capability creation" (Beta terminology) becomes increasingly important when a product creation project proceeds. It is essentially about capability creation to deliver the products once they are brought to the market.

In order to fully exploit mutual leveraging between products and demand chains, Beta had moved away from a monolithic demand chain concept (one-size-fits-all) to utilizing different business models for different types of products. For core network products they delivered directly from assembly plant to installation site, whereas for base stations they delivered from a regional hub close to the customer. For the different business models different DFL-targets were set, refining concurrent product and demand chain creation in the company. Demand chain creation was not explicitly addressed as a formal task or discipline in Gamma. In Alpha, one demand chain design was used for all products, but the company has actively started to analyze potential advantages of using focused demand chains.

Table 3. Differences in managing the product and demand chain creation interface.

	Alpha	Beta	Gamma
Customization level	Parametric	Parametric	Standard offer
Order Penetration Point	Assembly Plant	Regional Hub	Assembly Plant
Interface device	Product Architecture	Product Concept	Product specifications
Logistics participation in product creation	Product creation team consults logistics	Logistics represented in product creation team	Logistics is covered by production engineers
Demand chain design	One demand chain for all products	Focused demand chains	One demand chain for all products
Use of DFX	- DFM/DFA - DFL being implemented	- Specific tools for DFX - Delivery & Service Capability Creation to go beyond DFX	- DFM/DFA - No DFL

DISCUSSION OF FINDINGS

From the above cross case comparison it can be concluded that the product / demand chain interface is handled differently in the three companies. In Gamma, a good fit can be ascribed to co-location and local heroes, skilful employees that take responsibility of the interface. Beta ensures this by standardized routines and specific tools. In Alpha the situation seems to be moving from the one in Gamma towards the one in Beta.

A straightforward conclusion could be that the three cases are situated along a continuum, from practically not managing the interface between product creation and demand chain creation, to strongly focusing on creating fit between products and demand chains. If so, it could be suggested, that concurrent product and demand chain creation is a capability (Teece et al 1997) that companies can master at different levels. From this perspective, Alpha and Gamma may consider to take Beta's practice and performance as the target and aim at reaching the same level of integration/concurrency as in the Beta case. An important question would be, what Alpha and Gamma should "carry over" and what they should omit? Next, what is there for Beta to learn and unlearn?

This 'right path' idea, however, has its challenges. First of all, all three companies are successful in the marketplace, so why should Alpha and Gamma deploy the same amount of resources as Beta? Secondly, Eisenhardt & Martin (2000) state that development of capabilities usually begins from different starting points, and takes unique paths. Therefore, fully knowing that with the data from only three case studies we cannot build a "theory" or a decision making tool for managers, we organized our learning into a model that we propose to guide future research. It is also suggested to be a useful frame for managers when organizing their strategic decision-making concerning the factors that need to be considered as “given”, and the factors that can serve as a useful basis in elaborating strategic choices in the particular context.

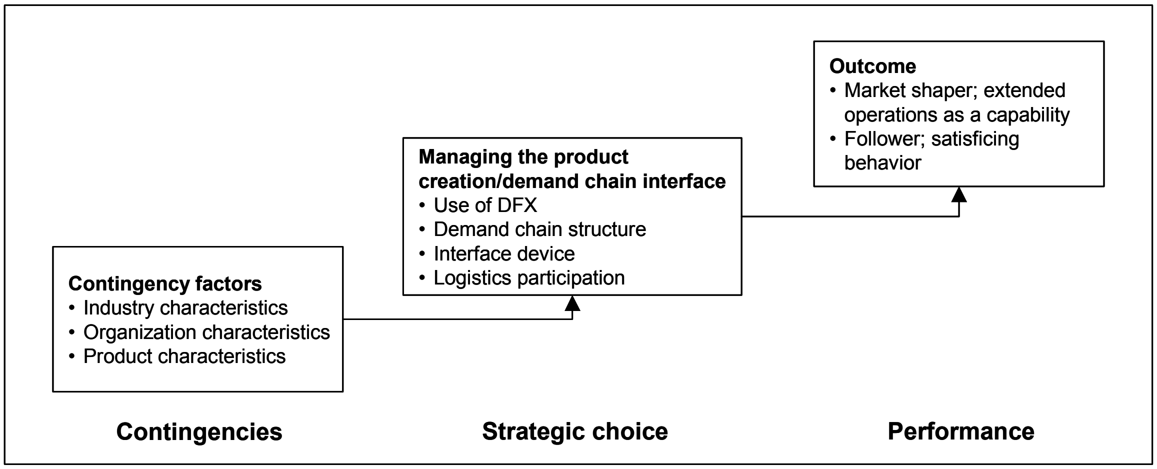

Figure 1: Framework of contingencies and strategic choice in managing the interface between product creation and demand chain creation.

Contingency factors
The external pressure from the industry, the organizational characteristics and many of the product characteristics are institutional factors for the product creation / demand chain interface. As such, they cannot be changed from within the interface. In here we take a perspective that many of the fundamental product characteristics are such that they should be taken as given in the creation of logistics solutions.

Beta’s industry environment has a higher ‘clockspeed’ than Alpha’s or Gamma’s. Because of the much larger organization they probably also have a higher organizational complexity to manage. These contingency factors define the different starting points for the three case organizations to manage their product creation / demand chain interface. However, the environmental contingency factors cannot alone explain the differences in the way different companies perform in managing the interface. There are several factors that serve as a basis for making strategic choices in managing the interface, closer to the actual practice than the contingency factors.

Strategic choice
Companies can make choices in how they manage DFX, how they structure their demand chain, how do they define the devices they use for managing the interface and how logistics participates in the product creation process. The use of DFX ranges from Gamma not using it, to Alpha starting to implement the method during the course of this research project, to Beta going beyond traditional DFX to “delivery and service capability creation”. Demand chain structure can clearly be altered by choice. Choices can be made in the order penetration point and having either a universal demand chain or several focused chains. Interface devices range

from product concept to product architecture to product specifications. Choices can also be made in the logistics participation to product creation.

By placing "strategy" in the core of the 3D concurrent engineering framework, Fine recommends fit between products, processes, supply chain and the overall business strategy. According to Sanchez (2001), dynamic capabilities are building blocks in the strategy theory, alongside with resources and competencies. The case study results indicate that all the three case companies were handling the interface, but in different ways. Therefore, we consider concurrent product and demand chain creation a capability to be nurtured and capitalized on. Rather than saying that capabilities exist in an organization or not, the question is at what maturity level do they exist.

Performance: is there space for satisficing behavior?
From the interviews in Beta it became clear that they feel a strong external pressure to ensure good fit between products and demand chain. The pressure stems from the very high industry clockspeed of the telecommunications industry and from very low margins leaving little space for demand chain cost. In Alpha and Gamma, the focus is on creating superior products to niche markets with seemingly lower relative pressure. Still, they feel competitors in their footsteps imposing them to continuously reshape their market, i.e. to set new standards for customer value in their products. Thus, the three case companies have different external pressure.

Simon (1981) ponders on "satisficing" as the real-world's alternative to academia's objective of "perfection". Since optimal solutions most often are out of reach, firms turn to 'good enough' solutions. This might explain the difference among the three cases: without any direct competitors (product substitutability) Beta could be able to act as Alpha or Gamma (satisficing), and vice versa if Alpha and Gamma had close competitors and as tough competitive industry environment as Beta they might need to act as Beta (pursuing perfection). It might be that the lesser the pressure, the more room for complacency.

CONCLUSIONS

Mendelson & Pillai (1999) link the operational performance of a company with the pace of the industry it operates in. By measuring the clockspeed, managers are said to be able to benchmark across industries and decide what capability (level) their company needs in order to survive in their particular market. The starting points for developing capabilities are different due to institutional factors, and so is the space in which companies have to choose their paths. But within that space there are strategic choices. In the three cases the differences in handling the product / demand chain interface may arise from different starting points, and from the different paths taken by the companies.

The three cases show some practical elements in handling the product / demand chain interface that companies in similar industries can be inspired from. However, the way different companies need to develop their capability in this area is contingent on the factors related to industry and market place in which the company operates, on organizational characteristics, and on the product architectures. We suggest concurrent product and demand chain creation as a capability to be nurtured and capitalized on by companies. In this pursuit, companies have a set of choices to make when aiming at success in their industry. Further research is needed to validate if the proposed relationships between contingencies, strategic choice and performance hold more generally.

REFERENCES

Boothroyd, G. & Dewhurst, P. (1994), *Product Design for Manufacture and Assembly*, Marcel Dekker.

Concurrent Engineering Research Center (1992), Process issues in implementing concurrent engineering in DICE, *CERC Technical Report Series CERC-TR-RN-93-003*, West Virginia University, Morgantown, WV.

Childerhouse, P., Aitken, J., Towill, D. (2002), Analysis and design of focused demand chains, *Journal of Operations Management*, vol. 20, pp. 675-689.

Eisenhardt, K. & Brown, S. (1998): Time Pacing: Competing in markets that won't stand still, *Harvard Business Review*, vol. 76, No. 2, pp. 59-69

Eisenhardt, K. & Martin, J. (2000): Dynamic Capabilities: What are they?, *Strat. Mgmt. J.*, 21, 1105-1121

Fine, C.H. (1998): *Clockspeed: Winning Industry Control in the Age of Temporary Advantage*, Perseus Books

Fisher, M. (1997): What is the Right Supply Chain for Your Product? *Harvard Business Review*, 97205, 105-116

Heikkilä, J. (2002), From supply to demand chain management: efficiency and customer satisfaction, *Journal of Operations Management*, vol. 20, pp. 747-767

Lawrence, P. & Lorsch, J. (1967), *Organizations and Environment*, Harvard University Press, Cambridge MA.

Mendelson, H. & Pillai, R.P. (1999), Industry Clockspeed: Measurement and Operational Implications, *Manufacturing and Service Operations Management*, vol.1, no. 1

Paashuis, V. and H. Boer, Organizing for concurrent engineering: an integration mechanism framework, *Integrated Manufacturing Systems*, Vol. 8, No. 2, pp. 79-89, 1997

Ruffini, F.R.A., Boer, H., Riemsdijk, M.J. (2000), Organisation design in operations management, *IJOPM*, 20, 7

Sanchez, R. (2001), Product, Process and Knowledge Architectures in Organizational Competence, in *Knowledge Management and Organizational Competence*, Oxford

Simon, H. (1981), *The sciences of the artificial*, MIT Press, Cambridge, MA

Smulders, F.E.H.M., H. Boer, P.H.K. Hansen, E. Gubi and K. Dorst (2002) Configurations of NPD-Production interfaces and interface integration mechanisms, *Creativity and Innovation Management*, Vol. 11, No. 1

Teece, D.J., Pisano, G., Shuen, A. (1997), Dynamic Capabilities and Strategic Management, *Strategic Management Journal*, Vol. 18, no. 7, pp. 509-534

Ulrich, K. (1995), The Role of Product Architecture in the Manufacturing Firm, *Research Policy*, Vol. 24

Ulrich, K. & Eppinger, S. (2000), *Product Design and Development*, McGraw-Hill

Vollmann, T.E., Cordon, C. (1998), Building successful customer–supplier alliances. *Long Range Planning*, vol. 31, no. 5, 684–694.

Vollmann, T.E., Cordon, C., Heikkilä, J. (2000), Teaching supply chain management to business executives. *Production and Operations Management Journal,* vol. 9, no.1