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*Is customer involvement in product development driven by high product complexity and/or high production cost?*

**Abstract**

This study of the relation between two factors that might explain why the Swedish wood component manufacturing industry use customer involvement in product development to a very small extent, failed to give high complexity and high production cost interesting predictory value in explaining the limited role of customer involvement in product development.

In a complementary study, although with a small response rate, of the much more complex machine industry for the wood component industry even indicated that product complexity negatively impact customer involvement.

**Key words**

Production cost, product complexity, customer involvement, product development, B2B.

**Background**

Capitalism has two opposing tendencies; the general law of competition, driving towards perfect competition and commodities on the one hand and the strive of each individual company to differentiate its products to reap the monopoly rent of monopolistic competition, oligopoly or monopoly; Ricardo (1817), Marx (1862), Schumpeter (1907) and Sraffa (1960). The fundamental differentiation is innovation and new product development.

But why do companies in many industries ”accept” ”commoditization” of their products; not making enough efforts to invent or develop new products?

Research has showed that customer involvement is crucial for successful new product development; Von Hippel & Urban (1988), Pitta *et al* (1996), Matzler & Hinterhuber (1997), Lagrosen (2005). In spite of this many companies refrain from customer involvement. Why? Interviews with key persons in the extremely commoditized Swedish wood component indicated that important factors behind this laxity could be the low product complexity and the low value added.
New product development in the wood industry is essential. Organizations have been created both in Sweden and abroad, to find ways to improve and change product development, Forest Tech Europe (2008), VINNOVA, “Woodwisdom”. Competitive advantage through product development is believed to end in the wood product industry, due to a non-moving market; but this market stagnation might be just as well explained because there are few real innovations; Wood material science & engineering (2008).

The relationships between Swedish forest industry and their suppliers are not well developed. Specialization often leads to expertise and innovation, but the wood component suppliers are normally not specialized. Communication between companies and suppliers is limited and ineffective. In the forest industry innovations are rare, Fredriksson (2003). The Swedish wood manufacturing industry is facing intensified global competition. In many companies (especially smaller ones, struggling for survival), it is an imperative to find new ways of development to increase profit; Ekberg (Technology University of Luleå).

The Swedish glued edge pine panel industry has decreased. According to Bengt Friberg at the Swedish Wood & Furniture Association (Trä & Möbelförbundet), the market has dropped with 17% the 1st half of 2008 compared to 2007. Due to foreign competition, the 30 Swedish companies in 1995 have now become 6. The glued edge pine panel industry had a stronger position a couple of years ago, when the quality of the Swedish wood was well renowned and demand from international markets increased. However, the quality of foreign competition has improved, and the advantage that Swedish companies had have disappeared. Friberg argues that the future lies in raw material processing; it is crucial to differentiate: Specialization, technical improvements and design thinking can put the Swedish industry in the lead again.

Despite efforts, a substantial part of all product development projects fail; resulting in the launch of products not accepted by the market, thus wasting resources. Reasons are bad communication and low customer involvement. Product failure is costly and time consuming; doing it right the first time can keep a company alive and give it competitive advantage, Matzler & Hinterhuber (1997).
If customer involvement can affect product development in a positive way, conditions that affect the choice to involve customers are of interest. Are product complexity and the value-added important factors? The particularities of the product dictate not only the kind of technology a company have, but also the purchasing behavior of the buyers; Richard & Xiaohuba (2004). So, does product complexity and/or value added also influence if the company chose to involve customers in product development?

2. Theory

The ultimate test of innovation is consumer response; Pitta et al (1996). To meet the need of customers, companies require technical competence, integration competence and market/business knowledge. Successful product development depends on understanding the customer; Lagrosen (2005). Using customers’ needs and wishes as a starting point in product development increases creativity in the product development process; Esbri (2008).

It would consequently be of value to investigate the drivers of customer involvement in product development. Customer involvement is crucial in product development; Von Hippel & Urban (1988), Lagrosen (2005), Pitta et al (1996), Matzler & Hinterhuber (1997). Findings about the product and productions aspects driving the involvement of customers, would help companies to know how their competitors would use product development as a differentiation strategy. It will map how the wood industry and its suppliers function and might lead to an awakening about the necessity to develop new products.

Little research has been made of the forest product industry; Hovgaard & Hansen (2004). Not much is known about its innovation practices and its product development. What is known is mainly about the furniture industry; an industry driven by fashion and end customer preferences. Product development in industrially oriented sectors may differ and must be investigated further. The future success of forest industry products ought to be centered on new products, new processes and the use of new raw materials; Hovgaard & Hansen (2004).
2.1 Commodity products
A large portion of the Swedish forest products are commodities. A commodity has the same features as other products in the market, the difference lying in the price of the product. The fact that buyers mainly consider the price of the product leads to a limited information flow between suppliers and customers. The lack of information flow influences the commodity producer negatively. If the needs and wants of the final customer do not reach the supplier, they will probably not be able to satisfy those needs; Johansson (2004). Without innovation, industrial markets risk ending up with commodity products; McQuiston (2004).

2.2 Product complexity
According to Richard & Xiaohuba (2004), manufacturers of complex products in the environmental industry context, started to realize that early customer involvement in product development effectively decreases market uncertainty, production cost and time-to-market.

Eppinger & Novak (2001) divide product complexity into:
1. The number of product components to specify and produce.
2. The number of interactions to manage between these components, named parts coupling.
3. The degree of product novelty.

In Eppinger & Novak (2001) it is argued that product complexity is driven by a number of factors; choices in performance, technology and product architecture.

2.3 Added value and Production cost/unit
High added value on the product makes it easier to put resources to product development. It is also indication of the (potential) profit; it is therefore unlikely that companies would answer direct questions about the value added. However, in commoditized markets with low complexity products, the value added is low. Ceteris paribus with a comparable value-added percentage, production cost would give indication of the absolute value-added. We supposed that a question about production cost would be less invasive. The production cost is an important variable when choosing
overall corporate strategies. The cost of the product dictates the lower boundary price the product will have and is therefore crucial to keep as low as possible, Sloman & Hinde (2007).

2.4 Product development

According to Ulrich & Eppinger (1995, p. 2), product development is defined as “...the set of activities beginning with the perception of a market opportunity and ending in the production, sale and delivery of a product.”

According to Gounaris et al (2001) industrial goods companies are not as market oriented as consumer goods companies, including less considering cultural needs and general behavior. Not being market oriented is a result of having engineers and R&D oriented rather than marketing oriented managers; Hlavaecck (1980). As a result, more value is given to technical rather than selling aspects. A reason why industrial companies are more sales oriented than market oriented could be that buyers build long-term relations with suppliers; Gounaris et al (2001), Gansean (1994). Industrial companies pay more attention to product technology and how to achieve competitive advantage through technological superiority than to the product itself. The relation is “locking up” the buyer with the supplier; the former is not reevaluating the relationship. To gain competitive advantage, companies ought to be market oriented, using design, implementing market research and strategic marketing; Gounaris et al (2001).

Product development can be either radical or incremental. Incremental product development modifies already existing products or adds features to them. The development process focuses on current customer preferences. Those preferences will be the basis for product modification. It is essential for companies working on volatile markets to develop products to compete with new product lines; Ulrich & Eppinger (2000). Radical product development focuses on new business through product and/or processes that change the economies of a business; the target is a new market, Ettlie et al (1984).
2.5 Process development

According to Pisano (1994) the fundamental challenges of process development are quite similar across industries; despite differences in specific activities. Process development starts with the targets for process performance: Unit cost, capacity, quality levels, critical tolerances or other operating characteristics. The goal is to find a process that either optimizes the efficiency or produces the product to a lower cost. Integrated problem solving is essential for successful process development. There are three stages in the process development: Process research, pilot development and commercial startup.

The process research stage defines the basic structure of the process. The main idea is to describe the architecture and a holistic view of the process rather than explaining it in detail. This stage would in product development be called concept development.

In the pilot development stage the process is scaled up to some intermediate scale, selecting re-creation parameters, as timing, temperature and pressure. This would optimize the efficiency of the process. The stage relies on data on how production actually runs, rather than theories as in the previous stage.

The commercial start-up, involves not only scaling up the process to a functional stage, but also adapting it to the plant where the product will be produced. In this phase unanticipated problems often arise.

2.6 Customer involvement

Sandén (2007) states the customer involvement can be defined in two ways;

1. Customer involvement includes all communication with the customer in relation with the product development process.

2. The company tries to identify needs which the client is not aware of. It also attempt to investigate needs that are difficult to concretize. The most important advantage with customer involvement is to identify these latent needs.
Kaulio (1998) defines three types of customer involvement; Product development for the customer, product development with the customers and product development by the customers.

Product development for the customer.
This approach focuses on products that are designed on behalf of the customers. Data on users, general theories and models of customer behavior are used as a basis for the design. The approach includes specific studies of customers, such as interviews or focus groups. The product development process is based on customer data. Quality function deployment is a customer involvement method for the customer. Quality function deployment is defined as “A system to secure that customer needs drive the product design and production process.” Customers are only involved in the initial face of the product development process. The thoughts and preferences of the customers are interpreted by designers and put into product characteristics, Sullivan (1986). The designer is the driver of product development and the customer is only a source of data.

Product development with the customers.
This approach is focusing on the customer, using data on customer preferences, requirements and needs. Concepts and prototypes of solutions to customer needs are presented to customers so that they can tell if it would really be a solution to their needs. The approach uses a formal dialog with the customers.

Concept testing is one of the methods categorized under “product development with the customer”. The method involves the customer in the early stages of the product development. It is mostly used for consumer packaged goods and durables, but also for industrial products. To facilitate the response of the customer the presentation of the product should offer a realistic description of the proposed product, using sketches, mock-ups and prototypes. To receive reactions on its functions and features, customers evaluates product ideas and the firm implements changes needed; Moore (1982).

A second method is beta testing. The beta test is applied in the latter stages of the product development process and aims at determining if the product satisfies customers. The beta test is commonly used in software engineering and is a type of field test, including the collection of information, using observations or historical studies. It is
recommended that beta testing is not be the only method to get feedback from the customers, as the reflections of the customers would be given too late in the product development process; Dolan & Matthews (1993).

A third method is user-oriented development; it is a human factors/ergonomics engineering approach to product design. A systematic analysis of the relation between user, product, task and environment leads to an initial problem analysis. The analysis focuses usage requirements, rather than product features. Several prototypes are field-tested on customers and then modified by designers. The designer plays a crucial role in this method. The field of applications is diverse, including the design of military outfits, interior design and hand tools; Kaulio (1998).

Product development by the customers.
This approach is focusing on customer participation; the customers do not only share their problems, needs and wants, but participate actively in finding solutions. Customers have a more active role and are engaged in the process of developing solutions to their needs. It is done using small focus groups, not one-to-one interviews. Two customer involvement methods included here are;

Consumer idealized design; a method emphasizing customer involvement in the conceptual design stage. It is the second stage of the design process, where the physical solutions have to fit the design specifications; Hsu & Woo (1998). It focuses on early customer involvement, by using an exercise similar to focus groups. Participants are carefully picked from the target market. To achieve the best result the group should be as diverse, as possible. The basic idea behind the approach is to get the customer to forget existing products and ignore the feasibility of the design. Each session begins with a blank piece of paper. The role of the customer is to identify the basic requirements and actively find new solutions to their own needs; Cianciante & Magdisson (1993).

A second method is the lead user method. Von Hippel & Urban (1998) argue that the lead-user method is the best way to get solution data. Lead users are faced with needs that often will become general. Lead-users face them months or years before the bulk of the market. Lead-users are positioned to benefit massively by finding a solution of those needs. The lead-user method is carried out in a four-step process:
1. Specifying lead user indicators.
2. Identifying lead user groups.
3. Generating concepts or products with lead users.
4. Testing lead user concepts on ordinary users

Figure 1. Customer Involvement Methods, after Kaulio (1998)

Success in product development through customer involvement
If used correctly customer involvement give competitive advantage. Alam (2002) describes the benefits of customer involvement in product development as follows:

1. Reduced cycle time. To compete in a fast moving market it is often important that the development process is fast.
2. User education. The user can be educated about the use of the product and its attributes.
3. Rapid diffusion. An early marketing push of the product can lead to earlier acceptance on the market.
4. Improved public relations can be accomplished before the product hits the market.
5. Long-term relationship can be created through producer-user relationships.
6. Superior and differentiated services, customer involvement can lead to products with unique benefits and better value for the user.

Negative aspects of customer involvement
Companies not involving customers, often excuses themselves by the cost; both indirect and direct costs. The number of clients is relevant; can a company please all? Lagrosen (1995) mentions as a reason given for not using customer involvement is having too few clients.

According to Alam (2002) reasons for not using customer involvement are:

1. The organizational structure and culture hamper customer involvement and make companies reluctant to its benefits.
2. Customer involvement is difficult and complicated.
3. Perceived increased workload, demanding more resources in time and money.
4. Perceived increased uncertainty of the project, as client behavior is unknown.
5. Customers might steal the product ideas.
6. Customers do not have the right knowledge.
Each company has to weigh the positive and the negative aspects and decide what is best for them. The aspects must be analyzed economically and weighed against increased profits; Alam (2002).

2.7 State of the art

**Dominating theory**


**Emerging theory**

In a study examining the effects of environmental contexts, such as technological turbulence, Richard & Xiaohuba (2004) found that customer involvement in product development is positively predicted by product complexity and formalization and negatively by decentralization. The role of product complexity and the implementation of customer orientation have received little attention in literature; Richard & Xiaohuba (2004), supported by Biligin (2006) and Ngamkroekjoti (2008).

2.8 Research Questions

This article intend to give validation to the emerging theory of Richard & Xiaohuba (2004) and/or propose a new theory about value added (here measured by high production cost and/or high product complexity and high production cost combined as variables positively predicting a higher degree of customer involvement in product development.

**Model for analysis**

Many firms do not involve customers in their product development. Why? Can it be shown that high customer involvement is driven by high product complexity and high production cost?

The model demonstrates the possible effect of product complexity and/or production cost and the variables combined could have on customer involvement in product development. The success of product development will not be investigated in this thesis, but is the intended end-result of using customer involvement.

**Hypothesis**

\[ H1: \text{High product complexity, } CO, \text{ positively predicts the use of high customer involvement, } CI, \text{ in the product development; } CI=a*CO+z. \]

\[ H2: \text{High value-added (production cost), } VA, \text{ positively predicts the use of high customer involvement in the product development; } CI=b*VA+x. \]

\[ H3: \text{High production cost and high product complexity together positively predicts the use of high customer involvement; } CI=a*CO+b*VA+y. \]

**Figure 2.** Research Model.

**3. Method**

The study was made with surveys sent per e-mail. Most respondents were contacted by phone. The investigated population are the Swedish wood component suppliers.

**3.1 Sampling/selection**

The Swedish Wood and Furniture Association (Trä och möbelförbundet,) have 63 wood component suppliers registered today; excluding packing, pallets and wood carpentries’
suppliers. We also excluded companies mostly selling end products to end consumers. Of these 63 companies we have spoken to 55 on the phone, to which the survey was sent. The remaining 8 was not reached. We received 36 surveys. However the internal losses where important; only 50% of the surveys where testable.

3.2 Pre-study
We made a pre-study, interviewing some industry representatives, to get a deeper insight into how the companies conduct product development and to better understand the concepts involved. One of the interviews was with Per and Johan Andersson at Thomas Frick AB, a wood machine supplier. The second interview was conducted with a wood component supplier, ESS ENN. To ensure that the survey questions were properly phrased and understood, we tested them in these interviews. The interviews gave information on different types of suppliers, which would improve the understanding of the answers to the survey.

To obtain information about the current situation on the Swedish glued edge pine panel market, we also made a telephone interview with Bengt Friberg at the Swedish Wood & Furniture Association.

3.3 Operationalization

Customer involvement
Customer involvement is clearly important. The main question is whether customer involvement is used in product development. It is important to know as it is a building stone of the hypotheses. Sub-questions 1.3 and 1.5 are based on the theory of Alam (2002). The reasons why companies use or do not use customer involvement are important for the analysis. It could tell us how the companies think about customer involvement in product development. Sub-question 1.1 refers to the five different methods of customer involvement.

To operationalize customer involvement, we used Kaulio's (1998) categories:

1. None.
The company does not use customer involvement in product development.
2. **Product development for the customer.**

This approach focuses on products designed on behalf of the customers and not letting the customer influence the actual product development in an active way. Customer visits, product customization, conversations and consultations fall under the product development for the customer approach.

3. **Product development with the customer**

This approach is focusing on the customer, using data on customer preferences, requirements and needs. Concepts and prototypes of customer needs are presented so customers can tell if they would be solutions to their needs. The approach is used to keep a formal dialog with customers. Product testing and product development meetings are categorized under product development with the customer approach.

4. **Product development by the customer.**

The approach is focusing customer participation; the customers do not only share their problems, needs and wants, but participate actively in finding a solution. Customers have a more active role and are engaged in the process of developing solutions to their needs.

**Production cost**

The question is asked to see the total cost of the product. It is crucial for hypothesis 2 as it predicts that production cost per unit is a variable for choosing customer involved product development. The question is based on Anderson’s (2008) the theory of cost price. We have operationalized production cost in an interval scale.

The different production costs were be classified accordingly:

*Group 1: ≤10 SEK
*Group 2: 11-100 SEK
*Group 3: 101-1000 SEK
*Group 4: 1001-10,000 SEK
*Group 5: 10001-100,000 SEK
*Group 6: 100,001-1,000,000 SEK
*Group 7: ≥1,000,000 SEK

**Product complexity**

1.1 How many components does this product consist of?

1.2 When was this product launched?

1.3 How many work operations are need to complete the production process?
These three questions have a common purpose to determine the product complexity. Product complexity is the main theory and basis for hypothesis 1. The questions are composed according to the definition made by Eppinger & Novak (2001). How many work operations that are needed, is asked to find out the interrelation of the components; a crucial factor in measuring product complexity, Eppinger & Novak (2001).

Product complexity is divided into three parts, Eppinger & Novak (2001):
1. The number of product components to specify and produce.
2. The number of interactions to manage between these components, named parts coupling.
3. The degree of product novelty. The third question is substituted with the development pace of products within the company.

We have categorized product complexity in the following way:

**Low complexity**
The product consists of: 1-10 components.
The manufacturing process consists of: 1-25 work operations.
Number of developed products the last 10 years: 0-25 products

**Medium complexity**
The product consists of: 1-10 components.
The manufacturing process consists of: 1-25 work operations.
Number of developed products the last 10 years: ≥ 26 products.
The product consists of: 11-100 components.
The manufacturing process consists of: 1-25 work operations.
Number of developed products the last 10 years: 0-5 products.

**High complexity**
The product consists of: 11-100 components.
The manufacturing process consists of: 1-25 work operations.
Number of developed products the last 10 years: ≥6 products.
The product consists of: 101-1000 components.
The manufacturing process consists of: 0-10 work operations.
Number of developed products the last 10 years: 0-50 products.

**Very high Complexity**
The product consists of: ≥ 101 components.
The manufacturing process consists of: ≥ 0-10 work operations. Number of developed products the last 10 years: ≥ 51 products.

Based on the theory of product complexity by Eppinger & Novak (2001), we operationalize complexity based on a classification of the information on the number of produced products, work operations and components. The combinations of these three variables are used to distinguish three levels of complexity as visualized in the following matrix.

<table>
<thead>
<tr>
<th>Number of new products 0-5</th>
<th>Number of components 1-10</th>
<th>Number of components 11-100</th>
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<tr>
<td>Number of new products 0-10</td>
<td>operations 0-10</td>
<td>operations 11-25</td>
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<td>Number of new products 6-25</td>
<td>19</td>
<td>6</td>
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<td>Number of new products 26-50</td>
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<th>Complexity</th>
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*Figure 3. Complexity, number of firms*

4. **Empirical data**

4.1 **Survey results**

36 firms, 57.1% of a population of 63 wood component manufacturers in Sweden, answered our survey. Of the respondents, 87.5% have some kind of product development.

Wood component suppliers are likely to perceive themselves as customer focused companies. If the company’s perception is the same as the perception of their customers’ is not known.

*Customer involvement*

Most wood component suppliers perceive themselves as actively involving customers in the product development. 17.2% of the wood component suppliers do not use customer involvement.
Knowing what kind of customer involvement the suppliers use demonstrate the way they perceive “active customer involvement” and “customer involvement to some extent”. For the wood component companies “product development for the customers” is the most common.

The reasons for involving customers or not are important for the analysis. The most important for the wood component suppliers, is to create long-term relationship with the customers; 28.6%. Creating new ideas is also seen as important. Many wood component suppliers see customer involvement as a way to cut production time. The “Others” column includes: educating the customer, 11.8%, better PR, 4.1%. To secure direct demand from the customer and receive customer point-of-view each receive answers from 1% of the respondents. 25% of the companies that do not use customer involvement believe it is too difficult and complex.

5. Analysis
The Hypotheses were tested with regression analysis.
Hypothesis 1, Complexity: CI=+0,149*CO+0,511. The explanatory value is only 5%, The significance 0,362.

Hypothesis 2, Cost:CI=0,169*VA + 0,238. The explanatory value is low, only 12%. The significance is only 0,155.

Hypothesis 3, Cost & Complexity: CI=-0,137*CO+0,163*VA+0,306. The explanatory value of the model is small, only 17%. Of course, because of the small sample size the significance is only 0,256.

6. Conclusions
Back to the drawing table. Not only is the response frequency too low, but the explanatory value is low and the relationship between product complexity seems to be negative, contrary to our hypothesis. Why is that? We don’t think our operationalizations are wrong or bad. Rather the study, although limited, indicates that the emerging theories we based our hypothesis on where of limited value or even incorrect.

Future research
We also tried to study European and US manufacturers of machines for the wood component industry; an industry with much more complex products. However, we only got answers from 18 firms of a population of 80, 22.5%. The answers indicate that the relation might be much more complicated. As complexity grows, the involvement of customers seem to decrease again; possibly as their knowledge becomes less relative that of the manufacturers.

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7.1 Literature


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