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A MODEL FOR EVALUATING AND IMPROVING COLLABORATIVE PRODUCT DEVELOPMENT

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1 Introduction

Trends within the manufacturing industry indicate an increased demand on the European industry to improve product and process development efficiency. Production is today in many cases moved abroad to low-wage countries. We can expect product development to follow, thus undermining national economies in Europe. The outsourcing trend makes collaboration and relations cross company borders as well as internally between departments important, and are becoming critical in the battle to stay and increase competitiveness.

The topic of this paper is success factors within collaborative product development (CPD). The objective is to present a model for evaluation and improvement, based on both theory and a case study. The research questions are: how, why and which critical factors influence internal and external collaboration within product development. The model is suitable for evaluating the product development in a project, and subsequently act upon it, in form of actions of improvements.

2 Facing the outsourcing trend

To stay competitive within European manufacturing industry product- and process development capabilities have to be improved. Production will continue to be moved to low-wage countries if nothing is done. Increased international competition demands improved collaboration between actors within industry to get hold of larger projects that not only include single products but whole systems. In order to stay competitive, companies need to continuously interpret their business environment and adapt to new demands. There is a need for new methods, tools, and procedures to improve the product development work. Design and production of products involve co-ordinated organizations, which develop and change during product development [1]. Storing, structuring and communicating information and knowledge between production and product development is thus rapidly becoming one of the company's most important processes for future competitiveness. Furthermore, the gap between academic research and industrial practice has to be bridged [2]. This can be done by developing tools and methods based on well-known and familiar design methods, e.g. Quality Function Deployment (QFD) (see [3]). The ambition of this research is to develop a tool, familiar for managers, for analysing and evaluating the product development work within a project.

The success factors and improvements which will be presented are a result of several studies conducted in various industrial companies and a synthesis of reviewed literature. The aim is to present relevant factors to address and to improve when dealing with CPD. There exists previous research within the area e.g. Cooper [4] has published a number of articles on the subject: *critical success factors in product development*. Also, O'Donnell and Duffy have made extensive research on design performance and definitions of its measurements, efficiency and effectiveness [5] (further see [30]). What is essential in this paper is the attempt towards an understanding of how people experience and apprehend the system around them and how they affect or are affected by the processes that are executed in the system. Thus, the model presented, aims to help companies evaluate their product development from a broader view and make organization improvements presumed from the results of the evaluation.

This paper will review related literature and research, including a present an existing framework. A complementary case study will be presented and discussed. The paper sums up in conclusion and needed future works.

3 Method and scientific approach

The main methodology used in this paper has been case study research (see [6]). The case studies have comprised industry companies that develop and manufacture products and involving a collaborative context. Such context may include being part of an industrial network, or having an organization that it is divided into organizational functions with complex internal collaboration. The case studies have been conducted with a systems approach, aiming to explain a particular effect by analyzing driving forces with a person or within a system [7]. The system approach is useful when dealing with engineering design research and inter-organizational research, due to the art of the science and its systems of components and relations among them.

This paper is built upon previous research which is complemented with a case study with qualitative data. During the case study necessary data has been collected through ideographical research interviews [8]. These forms of interviews were chosen on behalf of its purpose, to mainly search for qualitative information but with few additional syntheses in quantified form. Thus, it considered to suit the case study well. The objective with these interviews was to survey people's experience, knowledge and apprehension regarding proposed dimensions and underlying success factors. Coherence between success factors and degree of collaboration in projects has been searched for. Apart from these findings, the individual's most personal experience and opinions regarding how to succeed with CPD are also searched for. An interview guide was used during the interviews and notes were taken freely by two interviewees.

3.1 Building a useful model using a QFD-application

Because of the objective's nature in this paper, to present a model suitable for evaluating the product development in a project and subsequently act upon it, the results have to be presented in an understandable way. Companies fins academic research hard to use and therefore have problems adopting the recommendations [2, 3]. We have chosen to use a QFD-application to present the results from research, with the purpose of making the results more comprehendible. QFD is a methodology that successfully has been implemented and used in many companies, thus quite well known. QFD may not only be used for securing quality of a product but is useful when comparing competitors´ products. It may also be used for other

applications such as evaluating concepts or evaluating suppliers (for more info about QFD-applications see [9]).

4 Mapping success and failure in product development

A lot has been written concerning influences on successful product development, less about how industry really should implement and use this important research in their daily work.

4.1 An existing framework for CPD

This paper is based on a framework presented by Elfving [10]. The framework highlights five parts of CPD between small companies as critical tasks that have to be fulfilled; (i) to have a mutual strategy and common goals, (ii) to know the importance of the requirement specification, (iii) to have a foundation of trust between involved actors, (iv) to have a functioning communication tool and, (v) to have a dynamic product development process suitable for the company. The framework was developed with specific emphasis on small firms. What has been discovered thereafter is that the proposed framework also relates to larger organizations. Much of the findings relate to the size of a specific project and the degree of collaboration within that project, rather than the size of the firm. Therefore, the conclusions by Elfving [10] may also be useful for larger organizations. The CPD framework assumes that most companies and networks of companies has a defined product development process and is working accordingly, successfully or not. The framework suggests dynamic product development (DPD) by Ottosson (see [11]) as a suitable process for small companies, companies that often already have dynamic organizations with elements of intuition and feeling in product development (intuition and feelings see [12]). The DPD process may not suit all companies; therefore the issue concerning choice of most suitable process is left to be answered by each company. Each and every company carries unique and varying conditions applicable to the product development.

In more detail; to succeed with product development, there is a need for mutual strategies, such as a product strategy, within and between collaborating companies. It is also most important to have mutual goals. Communication tools are especially important when dealing with integrated product development. The concurrent engineering process is largely about how information is processed and comprehended within and between organizations with the help of information systems. It is required to have a functioning communication tool that is accessible even for those who do not have much experience of such tools. A communication tool, e.g. a virtual workspace or virtual factory [13], that is accessible, comprehensible, and correct, will enhance collaboration. Nevertheless, the main success factor for collaborative product development in these cases [10] is found within the area of trust among individuals and among organizations. Company manager sees trust as crucial for the survival of networks. Without trust the collaboration will fail. To obtain trust it is most important that all actors are introduced to one another early on in the process to create trust and to take all the actors' aspects into consideration when developing products, e.g. when establishing requirement specifications, etc. (further see *Creating trust*). Collaboration between departments or organizations becomes easier through early implementation of production requirements in the specification [10].

4.2 The need for a deeper understanding of concepts

To get a holistic view of previous research within the area and synthesis it into a useful model some specific fields have to be explored. Further, some general definitions and explanations

of concepts connected to the area, and known success factors within product development, are presented based upon literature and previous research.

Collaboration in many aspects - People have always, in some way, collaborated and built relationships to survive. The relationships may be between individuals or between groups of individuals; what is essential is that humans interact. For hundreds of years collaboration has been used within business and organization management - favours and favours in return. In modern society there have been increased interests in how to manage different kinds of relationships within and among organizations, i.e. internal and external collaboration.

Internal collaboration can be referred to as the interaction between individuals and functions within an organization, e.g. the collaboration between the design department, the manufacturing department, and the sales department. An overall conclusion from studies is that collaboration enhances success in many different ways [14]. There are many theories concerning success factors dealing with internal collaboration, especially in forms of cross-functional teams, such as; communication, expertise, creativity, leadership, organization, resources, and methods or strategies for handling conflicts etc. ([15, 14] et. al).

External collaboration has mainly focused on buyer - supplier relationships and how to manage these forms of collaboration [16]. However, the more complex products are, the more complex the relationships become [17]. Collaboration among companies has developed into a powerful tool to increase competitiveness, especially within complex and turbulent environments. Therefore, today there are numerous forms of external collaboration, such as; main and sub-supplier collaboration, alliances, networks (see [18]) or other forms of *full going partnerships, external development* where the development of a product is owned by mutual partners (see [19, 13]).

Main and sub-supplier collaboration - Many main suppliers are reforming their operations, moving towards more external contracting as their key activities. Sub-suppliers become more important as they develop and produce an increasing amount of the components for an end product. As a result, the main supplier becomes reliant upon the sub-suppliers' knowledge within certain areas. Projects are being carried out where suppliers have full responsibility for the development of a product; i.e. *development projects with suppliers integrated* (see [20]). It is therefore obvious that the customer/supplier interface now plays a key role in the design and development of new products [21]. This results in sub-suppliers influence on products' price, performance, and quality to an ever-increasing degree.

The timing for involvement of sub-suppliers is critical for the main supplier. Generally, sub-suppliers could be involved in four different phases in the product development project, with different roles to play [22]. Early involvement is often applied when the main supplier provides a certain knowledge or skill. The role of the sub-supplier in the concept phase could be active, with discussions about specifications, functions and interfaces, or a more passive role for evaluation purposes. Later selection of suppliers is often used when the main supplier finalises a complete specification or functional specification, which results in less potential for sub-suppliers to influence the design.

Handling requirements - The design process requires efficient communication and management of requirements. Decisions made early in the design process have a great impact on the committed costs of the project. Design changes in the later phases due to poor decision-making can be very expensive. In particular, the inappropriate decisions regarding the production of the product could potentially be very expensive. The engineering process requirements become one of the company's most important priorities.

The design of a product often starts with some general project objectives and a set of stakeholder needs. The stakeholders (internal or external) act according to their interest and use their power to influence the product in the direction they desire. An important internal stakeholder is production. In order to get a well-balanced product, it is necessary to take a broader approach, not considering only end-users, but also all the other stakeholders throughout the product's life cycle [23]. The stakeholders' different needs will be translated into more detailed requirements and constraints. The stakeholder production will generate requirements that will have impact on the product and the products production. However, production requirements are very important and should not be seen as a constraint to what the designer can do but rather as an enabler to realize the product [24].

There is a need for production requirements to have a better coupling to the business strategy and product strategy of a company. This can be done if key targets for products within production are developed in regards to the business strategy, and then implemented in the requirement specification of the projects [25].

The importance of a mutual strategy and building common goals - Strategy as a tool for success is widely spread and may be described as a set of plans and policies by which a company aims to gain advantages over its competitors. Generally a strategy includes plans for products, and the marketing of these products to a particular set of customers [26].

Sometimes, time and energy are lacking within a company when it comes to developing a distinct business strategy with appurtenant goals and measures. Therefore, it is possible that these companies are also without a product or manufacturing strategy [10]. The emphasis today within manufacturing industries often is to work reactively by being operationally efficient rather than strategically effective. Managers must begin to think and act strategically instead of only in a reactive manner [27]. Strategic decisions involve making trade-offs, thus the essence of strategy is choosing what not to do. Without trade-offs there would be no need for choice, thus no need for strategy. Without strategies, the process of developing products is hard to perceive. Often, when it comes to collaboration the lack of a mutual product strategy caused difficulties in the product development process. Individuals or collaborating organizations head towards differing goals, using different roads. Without a well supported strategy or defined common goals, involved actors will end up with no product at all. As a manager of a small company explain how to think strategically: "– *To grow, we need to get hold of the large elephants, not the small birds*!". Lack of these kind of mutual product strategies causes difficulties. A product strategy and a strategy of communication are needed [19, 13]. Organizations should put effort in actions concerning building and setting of goals. However, the task to build and develop support for common goals within a project with people from diverse functions or different companies is not an easy task.

Creating trust - Creating trust is an important issue in business relations in general [28, 18], and CPD specificly [10, 12]. Trust does not only happen to a relation, although this is what many people may believe. The concept of trust is well studied, especially within economics, social, and organization theory [28]. Relational contracting, networks, strategic alliances and horizontal co-operation within industry have increased in both number and variety. Together with the increased complexity and uncertainty in business environments those relations force inter-organizational trust. The trend is evident; trust is being seen as a precondition for success. Although the need for trust has increased due to the extensive development of collaborative relations has become even harder to develop and maintain trust within and among organizations. Dealing with product development today, demands trustworthy relationships, especially involving teams of any kind; virtual, distributed, cross-functional etc. Building trust is essential in manufacturing networks with member companies with common

goals for developing and manufacturing products [10], and not least within a larger organization with separated functions, e.g. design, production, marketing, and sales.

There are several types of trust. Interpersonal and inter-organizational trust is those most related to manufacturing industry and product development that occur among individuals or among organizations. Interpersonal trust is based on familiarity and developed in earlier interactions between persons or involvement in a social group. Inter-organizational trust refers to trusting the behaviour of a corporate actor [28]. To find a trustworthy partner there is often a need for sending out signals of trustworthiness, such as reputation, brands, and adherence to standards. In the development of products the signal of trustworthiness can e.g. be recognised in a sub-supplier relation, a sub-supplier which has been recommended by others or maybe has adopted a particular standard thus can be seen as more trustworthy. Provided established communication this enables building of trust.

Trust has an indirect impact on a products outcome. Trust contributes to the commitment to a project, however, it is not a driving force for reducing cycle time in product development. Thus, it does not contribute to improve project speed [29]. Trust is built upon good communication between partnering companies. Without trust a network will fail. As a company manager says; ”*You have to build trust and faith. It will create better co-operation*.” and; “*It is not an alternative to fail communication within product development.*” Network members can influence the communication by agreeing upon what kind of relation they have with the other members. Good communication is essential in product development, especially within distributed teams or networks where actors are missing an important means of communication such as the spontaneous informal physical meetings [19, 13].

There are numerous ways to improve trust and collaboration between product and process development: - Participants in product development projects should sit together, different departments should not be afraid to let go of resources. - Increase collaboration among departments other than product development projects, joint actions, other development projects etc. - Do not make decisions if not all representatives, from all involved departments are present. - Formulate joint principles and strategies for future development [25].

General success factors - Much has been written about success factors for product development. There exist a large amount of success factors, depending upon the author, the factors differ somewhat. Balanchandra and Friar [30] have made an extensive survey and mapped success factors in product development literature. After reviewing over 60 articles, a study as to whether there exists any general agreement about factors leading to success was conducted. Four major categories and 72 factors were found. The major categories were *market*, *technology, environment* and *organization*. The most critical factors were found in the organization category. Other authors have latter addressed critical factors of product development [31, 32]. Factors that must be managed are *executive direction*, *project team*, *innovation strategies*, *internal factors,* and *external factors,* etc. They emphasize securing the management support, having the “right”-people needed, having the appropriate strategies and, understand the environment. Other categories are also presented: *organizational factors*, *development process factors*, *marketing and new products characteristics*, and *skills and capabilities* [31, 32].

Successful product development - Successful product development is here defined according to the PDMA organization (2005-03-14) as: *a product that meets its goals and performance expectations. Product development success has four dimensions. Three dimensions at the project level: financial, customer-based, and product technical performance. The fourth dimension is new product contribution to overall firm success.*

5 A model for evaluating successful product development

Based on the described framework in chapter 4, and previous research, an initial theory was developed on how different factors influence projects including collaborative features. The factors were divided into five dimensions; *organization*, *strategy*, *requirements and goals*, *process*, and *tools*. Earlier research findings have indicated that projects with different levels of collaboration are more or less dependent on different success factors, e.g. [25, 33]. Five types of projects with different levels of collaboration were specified; *internal development projects*, *industrialisation projects*, *development projects with suppliers involved*, *development projects with suppliers integrated*, and *development projects with full going partnerships, external development*. These dimensions and projects were arranged in a matrix with the purpose to recommend points of action for improving a company's product development, see figure 1. Further, findings from a case study and previous research were used for developing the matrix into a more complete model for evaluating product development.

5.1 Exemplification by an industry case

To supplement earlier findings there is a need for good examples. A complementary case study was conducted especially addressing the model and to survey people's experience, knowledge and apprehension regarding proposed dimensions and underlying success factors., Coherence between success factors and degree of collaboration in projects has been searched for (for details about data see [34]).

The case study involves a large company within the mechanical and mechatronic industry. The company has internal marketing/sales, design and production departments with high degree of interaction among them but with some difficulties to manage the collaboration. The company was a good case due to its ongoing efforts to cope with CPD, with emphasis on internal collaboration between production and design department. Despite physically separated production and design departments, development of products has been carried out in a collaborative manner with especially improved early involvement of the production organization. Effort has been directed towards education, recruitment of new knowledge and experience in production technology and project management, and improved product development models.

The case study was based on ideographical research interviews involving managers (for production, design, and marketing), project leaders, project participators, and internal evaluators. Questions were asked and freely discussed around the different dimensions and success factors, together with the different types of projects. The discussion also dealt with how and why to improve addressed factors in different situations. In this way a profound understanding of the different factors´ impact on projects in a collaborative context, and what can be done to improve the possibility for success in product development, was created. The interviews were later summarized through sentence reduction and, interpreted and analysed. Further, this part of the paper is presenting the interviews, summarized and concentrated, and a discussion of dimensions, and underlying success factors.

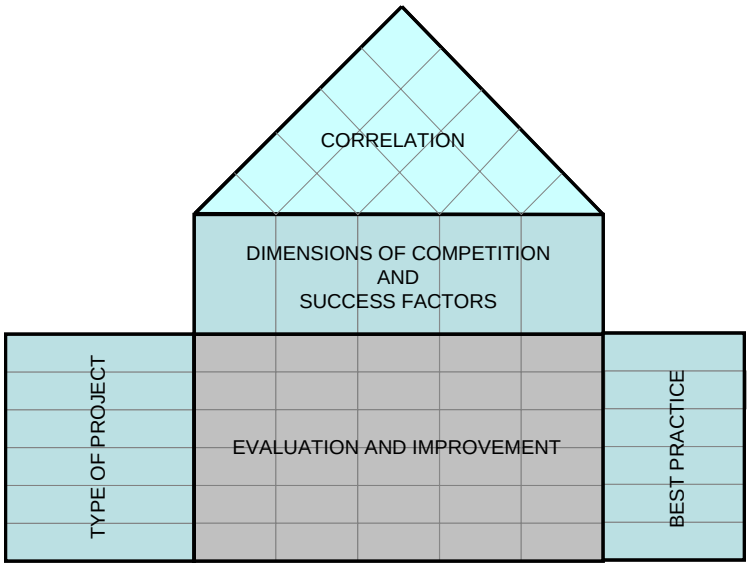

Figure 1. Outline of the proposed model including five elements.

Organization - During interviews the *team* arose as an important success factor. The respondents emphasized the importance of having a product development team that is focused and dedicated throughout the entire project. The social aspects are pinpointed as very important. Difficulties are also addressed particularly when working cross-functionally bringing different ways of working from different functions, e.g. differences in how to lead and manage projects between production and design departments. To improve such success factor there is a need for more intensified collaboration in cross-functional team, with low involvement of consultants, to keep the team as homogeneous as possible, with dedicated persons. Continuity is the key. *Geographical location* of the project team is pointed out as important to create auspicious conditions for product development. Only by placing a team together in a project room, lots of effort is being spared and the communication eased. Decisions and steering of projects, clarifying of rights, duties, and authority are important and may be summarized as *project management*. There is a need for a strong uniting project organization, where the project leader has mandate to take decisions, about the budget, resources, and the project team. The project leader has to know the process; the product development process as well as the production process. One respondent describes the sometimes hopeless situations with the words:

"*Many people want to be a project leader because it's fashion*!"

It is easy to forget that it takes a lot to be a good project leader; everyone is not suited for the task, even if the trend (in media, during education, at work) tells us that you "at least" should be a project leader. Early involvement of the production department in the product development is a key issue for success, which is also the case with *degree of collaboration* of customers in the development process. It is most important that the production department takes on the responsibility to make producability goals an integrated part of the development of a product.

Strategy - The choice of technology base, or *platform*, is a strategic decision for a company, and implies common technical solutions, tools and methods. In this way both the development and production are able to handle variants and changes in a better way.

"*If the product is smart from the beginning it will enable changes of it*!"

When planning for the future, as the development of a platform, the company believes in the future. Strategy shows how the company is reasoning. Today it is common to underestimate the impact clear strategies have in product development. Often, there exists a mutual strategy, but it is not communicated, accepted, nor supported by the group. It is most important to have *support* from management, project leaders etc. In this case, assemblers and other staff working with manufacturing of the product do not have problems adapting to and supporting a strategy. The *way of working* with the strategy is important. The strategy has impact on product development, and it is influencing the product development early on in the process. Product requirement shall in most cases connect to the overall strategy. Working with planning, operation, and communication is strategically important. Requirement specifications are characterized by the strategy if it is a satisfactory specification. Interviews highlight the importance of having strategy as a beacon; a beacon that escorts. A practical example of what may be parts of such beacon is modularisation, late customer order point, better products, or cheaper products.

"If you are going for a low-cost product you can't begin with a Mercedes, you have to begin with a Skoda!"

A *product plan* is based upon a strategy, and is the basis for commitment of resources. It should be a helpful tool to develop and produce the best product. Interviews indicate that the product plan is not built on long-term decisions which complicate the product development.

Requirements and goals - Within projects there are problems concerning the inability to set *measurable goals*. Interviews indicate that there is a need for fewer and more measurable goals, and to prioritize and concretize requirements to simplify the development. Goals and requirements are central when developing products. All parties must make them *common*. The respondents describe an immediate need to make the process dealing with the requirements continuous. You always have to know the purpose of the requirement to be able to make the right decisions. Decisions have to be well prepared. However, the preparation must not be more complicated than specifying a checklist. In questioning goals and the process of setting them, you may never take success for granted and move the goals forward to an unreachable level. The product must be in focus and there must be a holistic view of its process.

Process - It is important to decide where, by whom, and on which level decisions are made. Looking into the *decision making process* in studied company it is clear that decisions are not made at the appropriate time. Designers are designing based on idea sketches, not based upon evaluated, supported concept as it should be. People feel that they are missing a process or model to follow despite there exist a well documented product development model. Again they feel a beacon is needed. The problem is that it consists of hundreds and hundreds of papers that no one ever cares to read. People operating in the product development process ask for a management system that everyone agrees upon and which includes methods, checklists etc. Simple tools that are overlooked today.

Tools - The tools that are being used in the organization today are in themselves okay. However, the focus is on the fact that the tools have been used, not the actual accomplishment, less on the result of the tools. Thus, a twisted view of how and way the tools are being used is developed and maintained. It is really important to ask oneself *why am I using this tool?* and *what do I want to accomplish with it?*. It may seem as obvious and natural to ask these questions. It is commonsense. The fact remains, companies fail to do so, why?

Trust - Some interesting findings concerning trust, specific for the company, together with some general apprehension, are summarized further. Trust is important among individuals, among organizations. As it applies to methods it is important for the project ability to develop products, the collaboration between production department and design department. Trust is vital when it comes to making decisions, and executing them. To create trust you have to feel like you are participating in a project, in a group, etc. To get people and organizations to participate you have to make them *communicate*, and create a feeling of "us". This can be done just by arranging seminars, or going away with the project group for a day or two. Building a trademark. However, there have to be resources reserved for activities or occasions when the goal is to create trust. Collaboration is an important part in the concept of trust and vice versa. There must be trust between design and production; the organization and the supplier; the project group and the project leader, and trust in ideas and products that are developed. In the case in point, trust was extremely important in the collaboration with the sub-suppliers that had developments' responsibility for specific parts. Trust may create false security. As a respondent said:

"Without figures and an appropriate analysis, misleading decisions are sometimes made. Trust may create false security."

However, competence infuses trust, thus competence and knowledge are main enablers for trust. Trust is built on a long term basis but is quickly undermined.

Type of projects - The main outcome from the interviews about project types did mostly concern the three project types with highest degree of internal collaboration; *internal development projects*, *industrialisation projects*, and *development projects with suppliers*. Interviews verified the previous division of projects. Some examples appeared of how such projects could look like. An internal development project could concern ongoing research, which often is quite sensitive to external observation. An industrialisation project may involve customization of products. Development projects are development in collaboration with supplier. Supplier is not entire responsible of a product.

6 Discussion of results

The complete model consist of five different elements (see figure 2), all represented according to the QFD-principle. The five elements are; *project type*, equivalent with the customer's requirement in a QFD-matrix. *Dimensions of competition and success factors*, equivalent with the products characteristics. *Evaluation and improvements*, equivalent with the relations. *Best practice*, equivalent with the market. And last, *correlation*, equivalent with the roof to the house of quality.

Type of projects - The five project types are set as *internal development projects*, *industrialisation projects*, and *development projects with involved suppliers*, *development projects with integrated suppliers*, and *development projects with full going partnerships*. The findings from the case study and the previous studies show no need for revising the project types.

Dimensions - Based on the findings, the first proposed dimensions of competition were revised (compare to [4, 30, 31, 32]). Organization which was proposed as the first dimension is a wide concept, and was narrowed. The interviews indicated that this dimension was more about *project management* rather than organization in general. The findings show that success within product development is more about the *team*, how the team is managed, and how

people are involved in the team. To improve such success factor there should be a more intensified collaboration in cross-functional team with low involvement of consultants. Keep the team as homogeneous as possible with dedicated persons to the finish line, and continuity is the key. The dimensions are also about the *degree of collaboration* and the *geographical location*. The second dimension was strategy, but was revised to *strategy and goals*, with the underlying success factors, *choice of technology*, *product planning*, and *shared visions*. Recommended improvements could be done within product planning and how to connect product requirement to the overall strategy. Planning, operation, and communication is strategically important. Involved actors have to share goals and visions, and management has to show support for the development.

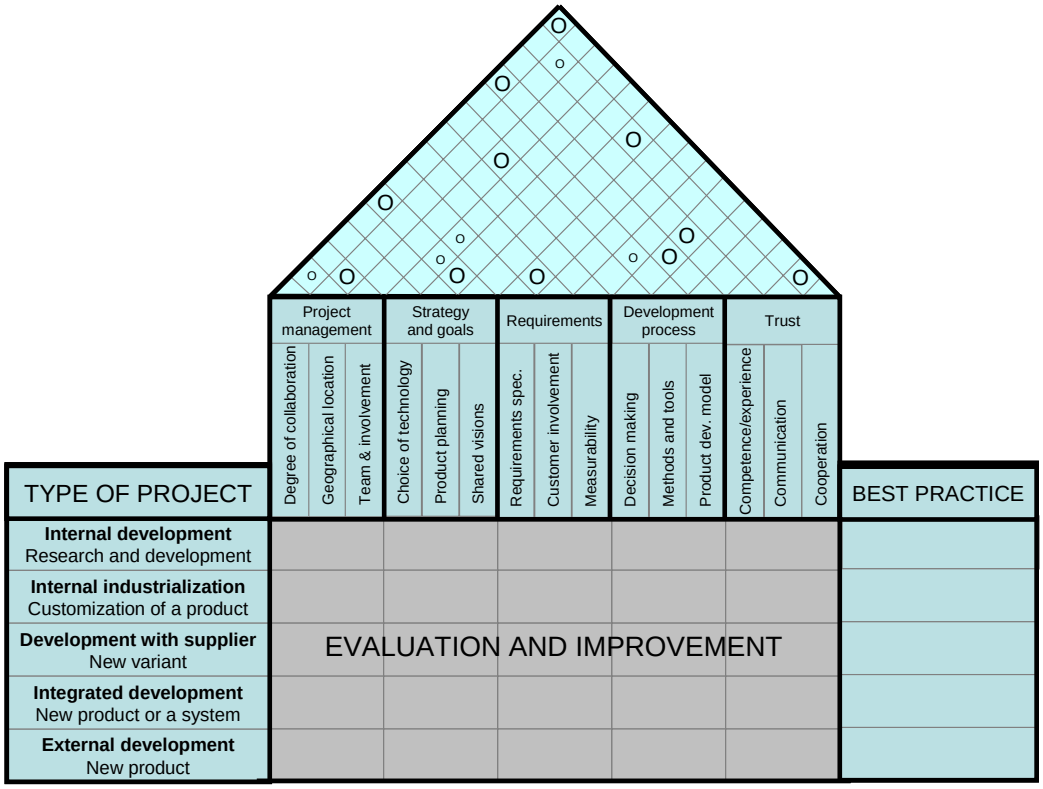

Figure 2. A model for evaluating collaborative product development consisting of five elements.

Because of the strategy revisions, the third dimension became *requirements* with *requirements specification*, *customer involvement*, and *measurability* as success factors. The interviews indicate that there is a need for both fewer and more measurable goals, and priorities requirements to simplify the development. Decisions have to be well prepared. However, the preparation must not be more complicated than specifying a checklist. The process is found to be very important when looking for success in CPD. The dimension *development process* is suggested to consist of three success factors; *decision making*, *methods and tools*, and *product development model*. It is important to decide where, by whom, and on which level decisions are made. Today decisions are not made where they should have been made. People operational in the product development process ask for a management system that everyone agrees upon and includes method of working, checklists etc., simple tools that are overlooked today.

Trust stretches over all dimensions, and is an enabler for success. However, its importance requires its own dimension. Factors influencing trust are *competence/experience*, *communication*, and *cooperation*. To improve trust organizations may simple arrange seminars, or go away with the project group for a day or two. Thus, there have to be resources

reserved for activities or occasions when trust may be created. Trust is built on long term basis, nevertheless it can be quickly undermined. Trust may be created by a trustworthy and comprehensible organization or group of people.

Best practice - The best practice is found within literature and previously conducted research. There is a lot done within the area describing where to put focus in the organization. Best practice makes a difference when enacted with actions of improvements.

Correlations - The purpose of the correlation matrix is to emphasize that different factors are closely connected. This correlation may differ depending of a company's nature however there are some correlations that are more broad and independent. The close connection between *communication* and *cooperation*, and *product development model* and *degree of collaboration* are examples (see figure 2). Correlations are, as we see it, depended of each case/project. Figure 2 shows an example where the larger circles indicate a stronger relation than the small circles. The empty squares indicate neglectable correlation.

Degree of importance - One of the most important findings and impetus of this paper is that the dimensions are of varying importance for the different types of projects (see figure 3). Depending upon the degree of collaboration, or project, some dimensions or success factors are of more or less importance. In some cases clear differences could be identified, e.g. the success factors shared visions and product planning under the dimension strategy and goals. Partnership or being member in a manufacturing network in order to have a mutual and shared strategy is hard to manage. More effort has to be put into these factors than when the project only concerns in-house collaboration. When running internal development projects the geographical location is found to be much more crucial than when running projects in partnerships or networks (because of the pre-understanding of that the second case will be much more problematic than the first case, thus the problem is taken care of earlier on in the process). This may seem contradictory because of the nature of networks, as they are often geographically clustered. However, during in-house development projects the geographical distance between involved team members has a greater impact on the outcome than in a more distributed project.

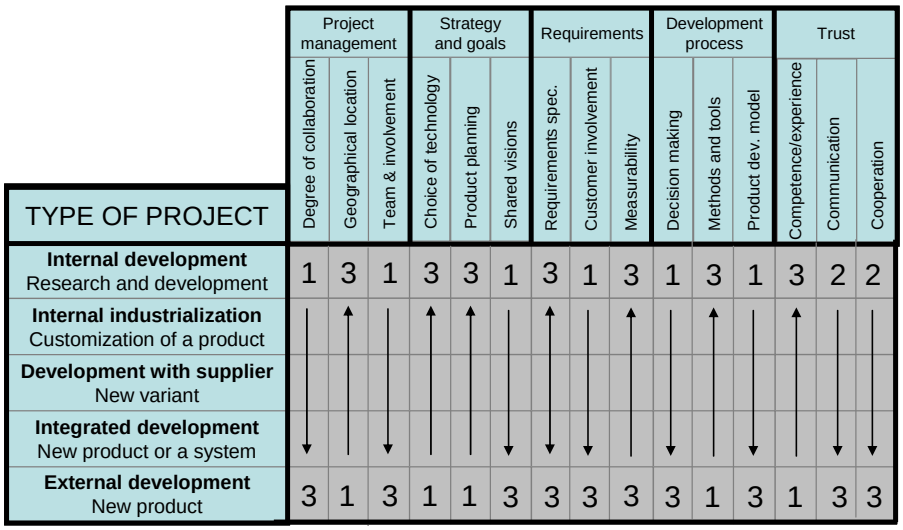

Figure 3. Indications of success factors' importance for different types of product development projects.

Still, the most efficient way to make a team function, is sitting together. Figure 3, shows a summary of the different success factories importance. The measures, 1-3 (where 3 is more

important than 1), are to be seen as estimated ratings and an indication of what research has shown.

6.1 Summary

The outsourcing trend within the manufacturing industry makes collaboration and relations cross company borders important and are becoming critical in the battle to stay and increase competitiveness. The conclusion is that companies need to analyse how and why collaboration is important for the organization, and investigate which critical factors influence such collaborative situations. Thus, the objective of the paper was to present a model that could serve as a tool for companies when evaluating and improving their product development. A model is presented in figure 2, which is built on previous research, literature review, and a case study, especially addressing the model. The model evaluates five dimensions; *organization*, *strategy and goals*, *requirements*, *development process*, and *trust*. The model is presented in a QFD-application for better usability. The dimension trust has been found to be crucial for successful collaborative product development. In spite of well-informed organizations there are difficulties improving and building trust.

7 Conclusions

This paper emphasizes the importance of continual development to stay competitive in the distributed market companies are facing today. There is no final answer to the question of how to be competitive and successful. Both product and processes need to be continuously developed. A product development project is defined based upon the humans involved in the project and the interactions between the involved. Thus, there is no right and exact way when dealing with humans' interaction. The model in figure 2 is not perfect, nor complete. To make it useful, manager have to put effort in evaluating the organization and thereafter make improvements according to and support of the model. Depending of the elements in a project, the results will differ. To further verify the summarized findings in this paper and underlying research, the model will be additionally tested and evaluated, hopefully also improved, in other projects, in other companies, thus achieve continuous development.

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