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Outsourcing from manufacturing to software engineering

Strategic Use of Quality Inspection Process for SMEs

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Abstract

The transition from manufacturing outsourcing to software engineering outsourcing can be an appealing and challenging activity for all enterprises. A theoretical framework is proposed based on four items in this case study. The present study identifies problems in both manufacturing outsourcing and software engineering outsourcing. Relationships between these two sets of industrial problems are discussed to discover the possibility to apply manufacturing outsourcing solution to software engineering. The manufacturing outsourcing solution is demonstrated in detail, providing a solid foundation of exploring software engineering outsourcing solution. The theoretical framework reaches completion to the end of this study, and it appears to be possible to adapt manufacturing outsourcing solution to software engineering outsourcing operations.

Keywords: *Manufacturing Outsourcing, Software Engineering Outsourcing*

1 Introduction

According to the global management consultancy PRTM and World Trade magazine, topics related to outsourcing rank at the top of business issues for an extensive range of organizations (Wery 2005). As defined by Alastair Reid (2005), outsourcing means paying and giving responsibilities to another corporation of experts for a particular purpose to achieve better quality and overall performance. Further confirmed by Helena et al. (2008), outsourcing is regarded as a process being contracted and delegated to a third party outside the boundaries of the firm. Globalization has expanded with an increasing speed in recent years, and has impelled companies to become more efficient and to position themselves strategically within the increasingly competitive market. Following a steady trend, to remain competitive in the market, more and more companies start to look at all business activities with an eye toward keeping the core functions in house and outsourcing other non-core functions (Djavanshir 2005). Outsourcing used to be the sole prerogative of Fortune 100 companies, however, this is no longer the truth in the current world of outsourcing. Companies of all scales are attempting to outsource a variety of their businesses to the far east on the assumption that the cheap labor helps reduce costs. However, this assumption is misleading companies to blindly copy the model and it can result in failures in their outsourcing activities and cost the companies serious money. In this paper, a Quality Inspection Process model, provided by a small sized production company called *Hexatronic*, will be evaluated for its employment in manufacturing outsourcing. On the assumption[1] that best practices of manufacturing outsourcing exist in real industry, the question that arise is "How to apply outsourcing from manufacturing to software engineering, making strategic use of Quality Inspection Process model?" Further, the Quality Inspection Process model will be revised for its potential contribution to software engineering outsourcing. The study is conducted with industrial involvement of two Swedish companies, *Hexatronic* and *Vici Industrial AB*, in Gothenburg, Sweden.

In most instances, pursuing overall cost savings is the primary driver and the most obvious benefit for outsourcing activities (Djavanshir 2005, Wery 2005). Outsourcing helps to focus on the core business and increase competitive advantage, which is seen as another evident benefit (Pistole & Bragg 2005, Reid 2005, Goth 1999). Furthermore, outsourcing is proven to lower risks by sharing the risks with long term outsourcing partners (Goth 1999, McDermott 1996). Comparing with large enterprises, small- and medium-sized(SMEs) organizations, those with fewer than 100 employees, are actually benefiting from outsourcing to carry out development in a short duration of time with minimal investment, and focus on the core business to enhance competitiveness (Reid 2005). Additionally outsourcing operation is not limited to manufacturing companies anymore, instead it is applied to a wide range of industries (Wery 2005). Appealed by the significant cost savings and easy access to updated technologies, a growing number of organizations are attempting to outsource software development to achieve operational and strategical goals (Huang & Jahyun Goo 2009).

What remains to be explored is how small- and medium-sized organizations could learn from manufacturing outsourcing best practices and therefore operate software engineering outsourcing strategically if there are commonalities. Mostly, researchers discuss outsourcing in general, or look at manufacturing outsourcing or software engineering outsourcing individually. Very few studies

1 The assumption is clarified in Chapter 5.1

have focused on what similarities and dissimilarities could be discovered from the two sectors manufacturing and software engineering of outsourcing and how these could help software engineering outsourcing to learn from manufacturing outsourcing.

A study of the strategies learnt from manufacturing outsourcing and the possibilities to apply these strategies into software engineering outsourcing is important for several reasons. First, identifying problems and solution in manufacturing outsourcing can help to reveal the understanding of overall outsourcing operations and the real situations of the outsourcing industry. Second, recognizing problems in software engineering outsourcing help to distinguish underlying similarities and dissimilarities between manufacturing outsourcing and software engineering outsourcing. Although outsourcing operations own a certain process and steps , it is evident that manufacturing industry focuses on the production within supply chain and cost reduction while software engineering puts more emphasis on technologies, knowledge, associated skills and people involvement. Third, adapting manufacturing outsourcing solution to software engineering outsourcing fashions a potential outsourcing panacea with improved practices as it extends from the production-oriented manufacturing industry into the more technology-driven domain of software engineering.

The purpose of this case study is to discover the strategic use of the Quality Inspection Process model for small- and medium-sized organizations to master software engineering outsourcing operations[2]. With the main objective to apply manufacturing outsourcing solution to software engineering outsourcing, several questions need be addressed in this study:

- What are the problems existing in manufacturing outsourcing and software engineering outsourcing?
- Do the problems in these two kinds of industries have some common characteristic?
- How is the Quality Inspection Process model used in manufacturing outsourcing?
- How can the Quality Inspection Process model be applied to software engineering outsourcing?

2 Related Research

According to Roger Wery (2005), “the most strategic decision management will make in the next year is to move business outsourced”. To discover insights about key drivers in outsourcing, PRTM & World Trade magazine fashioned a survey, interviewing 180 persons of different positions from a number of industries in several countries. Roger Wery (2005) states that a broader “make or buy” review is usually associated with outsourcing decisions. Based on different types of business activity and the particular industry, Roger Wery emphasized two cases. In the case, when an organization is looking for an outsourcing partner to improve performance, achieving overall cost saving is the primary driver (Wery 2005). However, Roger Wery also reminds that the complex coordination required in outsourcing could have a negative impact on time to market, and cost a high initial price (Wery 2005). In the other case, when a company is willing to open facilities in select locations, the main driver is an attractively priced talent pool (Wery 2005). In summary, Roger Wery indicates that the key core competency in the future is the ability to master outsourcing operations. This paper concludes the two most common key drivers of outsourcing operations for organizations with a particular purpose in mind.

“Outsourcing may be widespread, but few enterprises are fully aware of the process implications and steps”, say Goncalo Monteiro Duarte, Peter Sacket and Stephen Evans (Duarte et al. 2005). In the paper, the outsourcing process is broken down into seven specific and ordered phases: analysis and planning; supplier selection; contract negotiation; transfer the activity; outsourcing and supplier management; performance system construction and end of contract (Duarte et al. 2005). This paper is strongly recommended for pioneers in outsourcing as it gives detailed background information about outsourcing and provides detailed guidelines for each outsourcing phase.

Alastair Reid (2005) looks at how small business can make use of outsourcing opportunities, when the market is broadly dominated by large enterprises. For small business, outsourcing helps the company focus on its core business, and save money, time and effort (Reid 2005). Therefore, the company gains more resources to concentrate on the strength, and becomes more competitive in the market. Linda Pistole and A. Bragg (Pistole & Bragg 2005) further explores how to make IT outsourcing work for small enterprises. This paper focuses on costs which is considered as the dominant factor for small- and medium-sized enterprises. These two papers have small- and medium-sized organizations as their specified target audience which is the same as the intended target of this research, and explain how small- and medium-sized organizations' approaching outsourcing could be beneficial for the organizations.

Resulted by the growing price pressure and increasing market competition, there has been a steady trend of manufacturing outsourcing to selected low cost regions in recent years (Suonsilta 2004, Dowling 2004). Reino Suonsilta argues in his paper that the Far East model might not be the manufacturing panacea for all instances, since perceived cost saving can be eroded attribute to many external conditions, such as high freight forwarding and communication overhead (Suonsilta 2004). Furthermore, Caroline Dowling (2004) points out the fact that “millions of dollars are wasted every year because companies fail to take a broader view of their supply chains beyond manufacturing”. She appeals companies to implement a full-picture analysis and develop a manufacturing strategy that is tailored to their unique and specific needs (Dowling 2004). Dr Tim Baines (2004)

2 This purpose statement is based on (Creswell 2009)

puts forward a challenge, faced by many manufacturers, that of how to appreciate the value of the company's strategic position in a move to uphold competitiveness. The outcome of his research is a new concept called 'competitive space', which aims at appreciating the strategic positioning of companies and managing competitive space with structured decisions (Baines 2004). To give a complete and explicit example, Christian Verstraete (2004) describes a case study at HP who started to apply manufacturing outsourcing around 1995. HP followed a strategic outsourcing activity, with the key objective of preferential assurance of supply and cost reduction (Verstraete 2004). What HP mainly gained from this strategic intention is global strategic partnerships with few suppliers. Benefiting from these relationships, HP successfully increased the flexibility of its supply chains, reduced the reaction time to business events, and became a more adaptive enterprise in the competitive market. This group of research papers indicates the truth of manufacturing outsourcing by identifying different risks and challenges, which contributes the most in the later Chapter Problems in Outsourcing.

Not limited to manufacturing industries, outsourcing has shown its advantages when applied into other areas, for instance, software engineering. Organizations of all scales start to seriously consider keeping only core business in house and shifting other IT activities outsourced (Goth 1999, Djavanshir 2005). Reza Djavanshir (2005) declares that outsourcing does offer cost saving in terms of the low labor cost, however, outsourcing also raises unpredictable risks associated with complexity. Software engineering outsourcing helps firms to be flexible and to quickly respond to constantly changing market and customer requirements, which is the key factor to success in today's IT industry (Djavanshir 2005). It is suggested for companies to identify risks, and make accurate assumptions in their outsourcing strategy based on collected information (Djavanshir 2005). Greg Goth also states that IT outsourcing permits companies to improve core competencies and share risks with outsourcing partners (Goth 1999). Greg Goth points out a major outsourcing risk, “a shortage of skilled IT workers and an extremely competitive marketplace have caused some vendors to spread personnel too thin, relative to the number and complexity of projects they have”. Vendors forming alliances offering customer one-stop convenience appears as an interesting phenomenon in this paper. This supports the good of a combination of established outsourcing providers and start-ups, as the established companies provide a bigger market and the smaller companies offer innovative applications (Goth 1999). Summarized by Greg Goth (1999), quick adaptation is the key to survive in the current IT outsourcing industry. These research papers are aware of the trend that companies are attempting IT outsourcing for certain benefits, however, also being threaten by different risks and challenges. The information in these papers offers inspirations and references for problems in software engineering outsourcing discussed later.

3 Industrial Contacts

The first industrial contact is a small Swedish public production company called *Hexatronic*, and it is selected as case 1. The first interview was conducted on the 9th of March, with the president of *Hexatronic* responding. According to the respondent, the company is outsourcing everything they can, only keeping people inside. *Hexatronic* started outsourcing with the main motivation of reducing cost, and now achieve an approximately seven million dollar yearly profit. In short, the respondent agreed that the main factor for their success in outsourcing is the friendly relationship they have with their suppliers. They built the relationship with trust and open mind in a long term strategy, and they succeeded to benefit from this long term partnership. The respondent offered the Quality Inspection Process model as their solution to their manufacturing outsourcing problems.

The second industrial contact is a medium sized company called *Vici Industrial AB,* and it is selected as case 2. They are mainly the supplier of rocker arm system for big truck companies, such as Volvo Trucks and Scania. An interview with *Vici Industrial AB* was conducted on the 21st of March. Although *Vici Industrial AB* is not using a model exactly named Quality Inspection Process, they have similar emphasis over their manufacturing outsourcing activities. According to the respondent, *Vici industrial AB* is the supplier for Volvo Trucks and Scania, but they also buy components from their suppliers. In other words, *Vici industrial AB* plays the role of outsourcing supplier, but also has experience in being a client. As a result, the interview data gathered from *Vici Industrial AB* confirmed the data collected from the first interview with *Hexatronic*, and at the same time raises attention from some unique angles of viewpoints in outsourcing operations standing on the other side of the regular outsourcing relationship. The respondent from *Vici Industrial AB* stressed the importance of a win-win condition for both parties in the contract, and made explicit illustration on how do they measure performance and track progress using different diagrams.

4 Research Design

This section describes the research method be used in this research and the reason for the choice. Moreover different data sources gathered are identified, followed by the specific approach for analyzing data.

4.1 Qualitative Research

The inquiry was based on the design of qualitative research in which an interpretation of what people see, hear and understand is made (Creswell 2009). One of the reasons is that qualitative research provides ways of gathering information by directly interacting with people and observing how they behave, which is distinct from quantitative research testing theories with measurements. The goal of this research is to learn about the problem of a

particular area existing in industry and to address the problem with potential solutions, which is the key idea behind qualitative research. As resources were limited, qualitative research helped gather information by supporting multiple sources of data, observations, interviews, documents, and audio-visual materials. It also provided a guideline for conducting an inductive process of organizing data into increasingly more abstract units of information (Creswell 2009).

To discover how to apply outsourcing solutions from manufacturing industry to the software engineering industry, the author intends to make use of the research methodology of pragmatism. Although according to Creswell (2009), pragmatism is a philosophical underpinning for mixed methods studies, the author uses pragmatism methodology for this qualitative research in this paper attribute to various limitations of time, resources and personal experiences. Pragmatism methodology has an absolute concern with applications and solutions, emphasizes the research problem, and make great efforts to understand the problem (Creswell 2009). As the author is exploring the problem and attempting to address the problem, pragmatism methodology tends to be profitable typically in this study.

Case study approach is considered as the strategy of inquiry of this qualitative research. Case study approach is used for researchers to explore in depth an event, activity, or process (Creswell 2009). As a strategy of inquiry, case study approach offers a systematic way of looking at events, collecting data, analyzing data, and documenting study findings. This study intends to deal with a complex activity, outsourcing, in great-depth, which has a match with the focus of case study approach on understand a contemporary phenomena within some real-life context (Yin 2003). Using case study approach in this study helps the author collect various sources of data over a bounded period of time, and deepens the author's understanding of the specific and complex case along with the main problem domain of outsourcing. Case study approach promotes the desire to understand complex social phenomena, and in this study strengthens the concern with the research problem and solutions. According to Yin (2003), case study approach is preferred in examining contemporary events, and involves mainly two sources of evidence: direct observation of the studying events, and interviews of the involving persons. As the author mainly gains data from interviews and documents from two organizations, this study tends to make full use of the unique ability of case study approach to deal with a full variety of evidence, documents, interviews and observations.

4.2 Data Sources

The primary data source for this research was the interviews materials conducted with two companies, *Hexatronic* and *Vici Industrial AB*. The two interviews were based on the same set of interview questions, small changes were made with *Vici Industrial AB* since it plays the role of supplier in outsourcing client-supplier relationship while the other one as client. With permissions of the respondents, the interviews were recorded to increase the rehearsability and reprocessability (Maruping & Agarwal 2004) of the conversation. The data collected from these interviews greatly increased the understanding of the problem domain and knowledge of the real industrial situations. Different sources of data collected in this research is summarized together with their advantages and limitations in Table 1 below.

Moreover a Quality Inspection Process model for handling quality with six different perspectives was provided by Hexatronic. This specification illustrates six detailed areas of what the industry concerns: inputs, material/equipment, skills/training, method/techniques, measurement/assessment and outputs. Therefore, it contributes to a better understanding of how the client can ensure and assess quality with supplier with an explicit framework.

4.3 Data Analysis

Following qualitative procedures, the data analysis was an ongoing process which required continuous reflection about the data (Creswell 2009). In this research, data collected from the two interviews were continuously

Data source	Data Collection Type	Advantages of the Type	Limitations of the Type
President at Hexatronic	Interview	Real industrial contacts with ample experience of outsourcing	Subjective opinions may affect objective reality
Market manager at Vici Industrial AB	Interview	Real industrial contacts with ample experience of outsourcing	Subjective opinions may affect objective reality
Quality Inspection Process specification	Document	Valuable information	Internal document may not follow the standard
Recorded tapes for interviews	Audio-visual material	Rehearsable, reprocessable	Data may be interpreted out of context

Table 1 *Qualitative data sources based on Creswell (2009) methodology*

analyzed for manufacturing problems and manufacturing solution which largely enhances the substantiation of this research. The data analysis procedure aims at making sense out of text and imaging data (Creswell 2009). Based on the three steps data analysis procedure in qualitative research suggested by Creswell (2009) and inspired by Allan's (2003) findings about a detailed illustrated and executable data analysis procedure with well defined codes, concepts and categories, this research applied a five steps data analysis procedure.

1. Organize the data from various sources and prepare for analysis. After each interview, the interview data was transcribed and typed into digital format as early as possible.
2. Read through the data and mark out key points. This step made preparation for the following steps. In this research the author was using Key Point Coding according to Allan (2003). In the transcripts the author identified the points as important and highlighted in bold font, and gave an identifier. For instance the first key point in the first study case appears as Px1.
3. Key point coding. In this step, all key points were listed, marked and given a corresponding code which is described in a short phrase.
4. Emergence of concepts. The codes from step three were then analyzed and those with a common concern were then grouped together to emerge a concept, which is of a higher abstract level of commonality.
5. Emergence of categories. This step grouped concepts, those with a common concern. Further commonalities found are called categories.

The ultimate goal of this data analysis procedure is to investigate the categories and the connections between them, and to find out what kinds of manufacturing outsourcing problems the companies are facing and how they are solving the problems. Since two interviews took place subsequently, the second study case's key points are compared with the first study case's so far established concepts and categories. Therefore the findings appear to be accumulated and be reflected based on the adjustments to categories.

4.4 Theoretical Framework

The theoretical framework of this study focuses on four major items, manufacturing outsourcing problems, software engineering outsourcing problems, manufacturing outsourcing solution, and software engineering outsourcing solution as revealed by Figure 1. Each item will be studied, and the relationships between items will be stated.

To illustrate the possibility of adapting manufacturing outsourcing solution as software engineering outsourcing solution, manufacturing outsourcing problems and software engineering outsourcing problems will be identified. Manufacturing outsourcing problems will be abstracted from the interviews and related research. Also software engineering outsourcing problems will be referenced from related research. These two sections of problems will be compared and analyzed to see if any common characteristic exists. The next stage of this study will be the exploration of how the manufacturing outsourcing industry is solving problems. Understanding of manufacturing outsourcing solution offers the ability to apply manufacturing outsourcing solution to software engineering outsourcing industry. It includes the results of data analysis. At last, potential software engineering outsourcing solution will be argued and discussed.

In the end of this paper, a full version of theoretical framework will be provided. The four items in the framework will be displayed with study findings, and relationship between items will be clarified.

5 Problems in Outsourcing

As clarified in the theoretical framework, problems in both manufacturing outsourcing and software engineering outsourcing need to identified and analyzed. In this

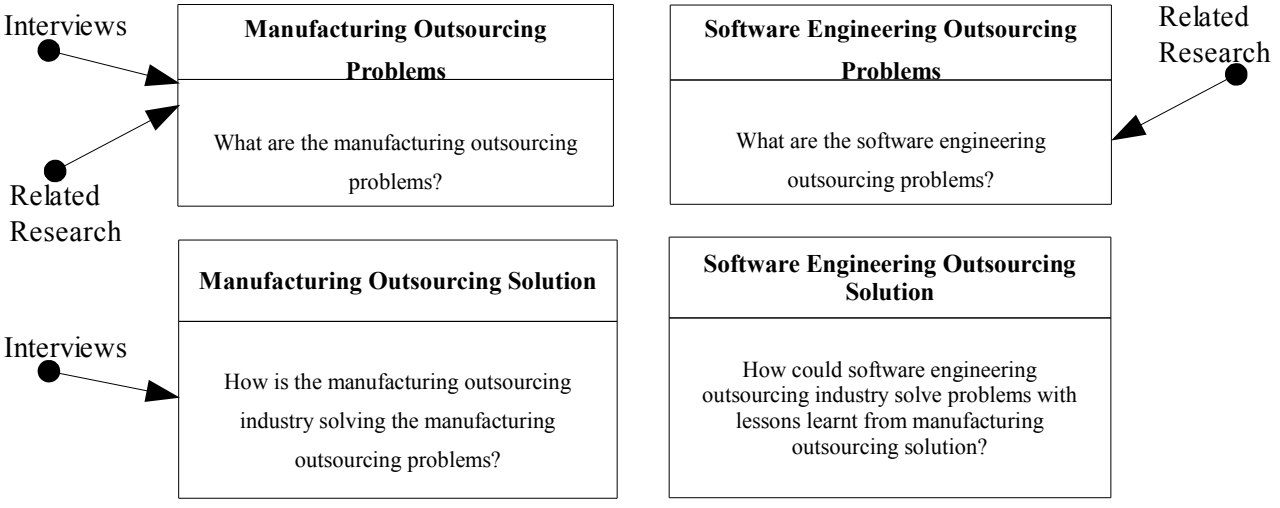

Figure 1 *Theoretical Framework*

chapter, manufacturing outsourcing problems will be referenced from related research and interviews. Software engineering outsourcing problems are then interpreted. Discussions about the relationships between the two sets of problems are specified in the last section of this chapter.

Although recently increased competition has an impact on the fact that companies of all scales are under pressure to give away responsibilities of some business activities and leave themselves free to concentrate on their core business, few companies have learnt to make judicious use of outsourcing strategies. In other words, many companies fail to tailor outsourcing strategies to their own unique and specific needs, instead blindly following the majority.

Although the two terms "outsourcing" and "offshoring" are usually used as ambiguous or analogues, the term "outsourcing" has an absolute distinction from the term "offshoring" in this research. Outsourcing has a particular emphasis on the entire governance and performance of both the organization itself and the third party firm, while offshoring pays special attention to the location of main operations (Helena et al. 2008). Outsourcing activities can be performed either onshore or offshore, however, this is excluded of the scope of this research.

Indicated by Scheller (2005), outsourcing can be divided into five major sectors: customer service operations, information technology, backroom operations, engineering services, and manufacturing operations. Each sector requires different levels of professional proficiency, and associates with different main supporting countries (Scheller 2005). Obviously, software engineering is part of the sector information technology. In this study, only sector manufacturing operations and sector software engineering will be concerned.

5.1 Manufacturing Problems

The sector manufacturing operations is regarded as the one first applied in reality and most widely spread in industry. The assumption that manufacturing outsourcing best practices exist in real industry is formed based on the fact that manufacturing outsourcing is the one being applied the first and the most successful (Dowling 2004, Suonsilta 2004, Verstraete 2004). Many companies are moving manufacturing to far east, considering the cheap labor source as the most appealing and important factor to reduce cost. However, they are missing an insight into other factors in determining whether a product should be outsourcing manufactured, and which can easily cost companies serious money (Verstraete 2004, Dowling 2004, Baines 2004).

Supply chain networks exist within all companies manufacturing operations (Baines 2004). Manufacturing outsourcing deals with supply chain networks. Therefore, to be able to drive down costs and increase profits, a company must know how to manage the supply chain (Dowling 2004). Based on Baines's (2004) research, there are basically four sets of interfaces within the supply chain network. Baines (2004) states that "each interface can be thought of as consisting of a boundary between those production-related activities carried out internally, and those offered by external organizations". With this objective to discover the similar sets of interfaces and analogous problems in software engineering in mind, the following is the study for problems occurring at different interfaces in supply chain for manufacturing operations. Table 2 makes a summary of the outsourcing problems in manufacturing industry together with their belonging interfaces discussed in this section.

As shown in Figure 2, there are four interfaces existing between the organization and three other external participants. Interface A, which is considered as the one been most recognized, exists between the organization and the external participant for outsourced activities, for example fabrication. This interface concerns about the upstream supply chain for raw materials and components (Baines 2004). As well as having many business opportunities, this interfaces provides high possibility for potential problems.

The most vital problem within interface A is the relationship between the two parties. Pantano (2005) indicates that "it is traditional in nature and suffers from a long history of troubled industrial relations which makes new technology introduction highly political, bureaucratic and overly complex". The relationship between the organization and the contract manufacturer is facing challenges and should be emphasized.

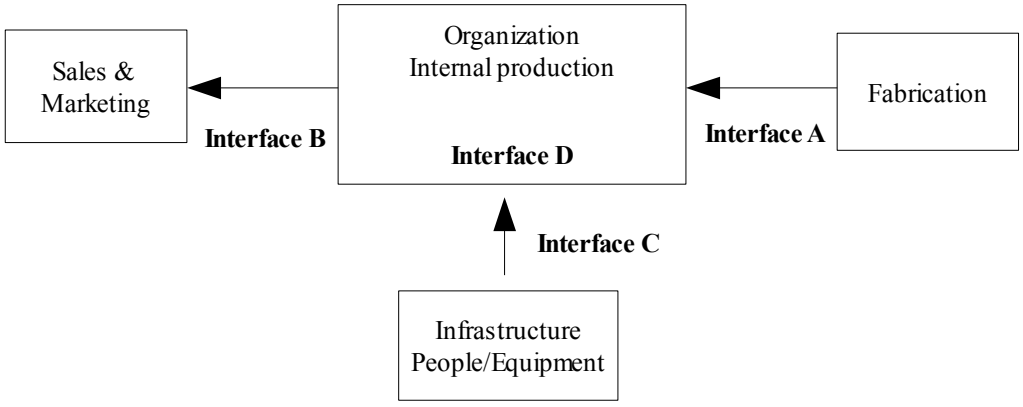

Figure 2 (Baines 2004) *Simplified view of a manufacturing organization within its supply chain networks.*

Moreover, as a result of the difficulties of generating knowledge and technologies, how to promote and transfer knowledge, technologies and skills becomes one problem. Most commonly, the contract manufacturers only concentrate on the production of their own components. They make products, but miss the knowledge of what is inside. These kinds of loss of valuable 'know-how' could easily threaten the product deadlines, and at the same time increase development cost (Pantano 2005).

Another problem usually emerge within this interface is how to effectively solve problems during production. When only one organization is involved, it is easy to detect where the problem may encounter and identify why it may happen. However, when several organizations are involved, it dramatically enhances the difficulties of knowing the appropriate information (Verstraete 2004).

Interface B exists between the organization and customer-involving activities. It is often regarded as the domain of sales and marketing (Baines 2004). Within this interface, the emphasis is the customer and market which are directly and closely connected.

A major problem is to understand how the organization is competing in the current market and to decide what activities need to be given away based on the market condition (Baines 2004). If the organization makes decision without evaluating its position in the market, its capacity of competition could be greatly eroded. For instance, if the market requires a fast reaction time, as many organizations are doing now, it is critical to move the manufacturing as close to the market as possible.

Interface C exists between the organization's internal production and its infrastructure. The infrastructure consists of people, facilities, tools and equipments that collectively constitute the manufacturing capability of the organization (Baines 2004).

The most outstanding problem appearing on this interface is the expensive tool issues. To lower the inevitable cost on tool issues, early rectification would be beneficial, as well as recognizing the expertise of manufacturing personnel who deal with tools and equipments on a daily basis (Pantano 2005).

Interface D exists within the organization, which differs from the other three interfaces that exist between the organization and another external participant. This can be considered as a form of horizontal integration and depends on the range of the products to some extent (Baines 2004).

Since this interface exists within the organization, maintaining visibility and flexibility are the two major problems. As more than one organizations are actively participating, a loss of visibility should be realized (Verstraete 2004). As a manufacturing strategy needs to tailor the company's need to the ever changing market, remaining flexible becomes risky and essential (Dowling 2004).

5.2 Software Engineering Problems

Following previous manufacturing outsourcing problems, software engineering outsourcing problems will be identified. These problems are mainly abstracted from multiple previous existing research.

Interface	Problem
Interface A between the organization and the external participant for outsourced activities	How to improve and maintain the long historical and troubled industrial relations How to promote and transfer knowledge, technologies and skills How to effectively solve problems during production when many organizations are involved
Interface B between the organization and external participant for customer-involving activities	How to evaluate the current market and well position the organization based on the market condition
Interface C between the organization's internal production and its infrastructure	How to lower the inevitable and expensive tool issues
Interface D within the organization	How to enhance visibility in the complex supply chain as more than one organizations are participating How to enhance flexibility in the changing market for unique and specific organizational needs

Table 2 *The set of outsourcing interfaces and problems emerged over outsourcing sector Manufacturing*

The information technology outsourcing sector is growing with a steady speed as it is catching more and more attention, especially from small- and medium-sized enterprises. A big portion of this sector is software engineering. Software engineering outsourcing provides the appeal of having operation cost savings, access to the latest technologies with little investment, and fostering innovations (Reid 2005, Djavanshir 2005). When requirements are explicated, deliveries are formulated, risks are mitigated, and competition is warranted, software engineering outsourcing works best (Reifer 2004). However, many companies are still doubting and some have already experienced difficulties and failures. Table 3 sums up software engineering outsourcing problems being described as following.

The most common causes for problems are unclear expectations, poor communications, and dissipating interests (Reid 2005). These certainly lead to problems in relationships between the IT organization and the software provider, which has a direct and intricate impact on the outcome of the outsourcing activities. When realistic expectations and goals for both parties are neglected to be clearly defined, misunderstandings and suspicions easily take place because of a missing common vision between the two parties.

One significant problem in software engineering outsourcing remains the risk that technologies need to be transferred in a more concentrated time frame and with a more strategic structure. Outsourcing offers the benefit of gaining new technology without having to invest in developing new systems, however, at the same time boosts the difficulties of successfully transfer knowledge. Rather than happening incrementally, software engineering outsourcing requests technology and knowledge transfer to be achieved within a relatively concentrated time frame (Lacity & Rottman 2008). Therefore optimal strategies and testing methods should be explored as one way to mitigate the risk.

Another frequently cited problem is about handling conflicts between the IT organization and the software provider. To operate successfully in outsourcing, you must learn how to avoid conflicts (Reifer 2004). The software solution provider owns the power of decision-making and project-execution (Bhat et al. 2006). When involving two organizations and having a split between the two with different objectives and goals of achievement, inconsistencies and conflicts naturally occur. If the two eventually fail to agree on a shared goal, it is of high possibility of delay in delivery or the delivery of software not tailored to the needs.

When facing requirements related issues, one question is always asked “what is needed in the market?”. As a result, assessing the maturity of a particular market becomes a challenging problem in the early stage of outsourcing activities. An immature market manifests itself in a vulnerable business environment that greatly enhance risks of all matters. On the contrary, what could be gained from a mature business environment is not only technological infrastructure but also modern business standards and processes (Djavanshir 2005).

For a software engineering outsourcing manager, what special management skills are essential? A different mind set is absolutely required, since situations, for example globally distributed teams, a manager would deal with could be totally different or overly complex.

As multiple parties' engagements are involved, multiple tools are sometimes used in the meanwhile. However, using multiple tools that do not integrate with each other can possibly cause problems like loss of data or wasteful rework (Bhat et al. 2006).

Ensuring integration to operate smoothly, one problem that how to establish a basis and what suitable interfaces should be defined between participants need to be addressed (Duarte et al. 2005). Companies have experienced the failure when the supplier can not be integrated into the host organization's own process, typically bringing overrun budgets or unsatisfactory deliveries. If suitable interfaces for multiple stakeholders could be well defined from the beginning, indications of potential problems would appear earlier and problems would be resolved earlier and easier.

Software Engineering Outsourcing Problems
• How to eliminate misunderstandings and suspicions when nurturing relationships
• How to transfer technologies in a more concentrated time frame and with a more strategic structure
• How to strategically avoid and effectively solve conflicts and problems between two parties
• How to assess the maturity of a particular market
• What special skills are essential for a software engineering outsourcing client manager
• How to master using multiple tools without loosing data or duplicate work
• How to establish a basis and what suitable interfaces should be defined between multiple participants

Table 3 *Problems emerged over outsourcing sector Software Engineering (part of Information Technology)*

5.3 Relationships[3]

Now that the author have specified the set of interfaces and problems in supply chain networks of manufacturing outsourcing and the problems in software engineering outsourcing, it becomes apparent that the manufacturing outsourcing problems and software engineering outsourcing problems may be generic to a set of interfaces which could be an abstract representation of the manufacturing outsourcing interfaces. Before discovering the abstract representation of outsourcing interfaces, it is useful to make a general observation of the outsourcing problems.

3 The framework of this section gains enlightenment from (Zachman 1987)

Comparing previously defined manufacturing outsourcing problems and software engineering outsourcing problems, there appears to be six common subjects of outsourcing problems. Problem subject one, partnership, expresses as to improve and maintain the long historical and troubled industrial relations in manufacturing outsourcing, while as regards to eliminate misunderstandings and suspicions in relationships in software engineering outsourcing. Problem subject two, knowledge transfer, relates to promote and transfer knowledge and technologies in manufacturing outsourcing, while further exploring how knowledge transfer can be done in a more concentrated time frame with a more strategic structuture in software engineering outsourcing. Problem subject three, problem solving, involves solving problems effectively among multiple organizations in manufacturing outsourcing, while involving avoid conflicts between two parties in software engineering outsourcing. The remaining three problem subjects: market, tools/staff, and performance are concluded in the same fashion.

Succeeding the six outsourcing problem subjects are the general representation of outsourcing interfaces which is regarded as an abstraction of the manufacturing outsourcing interfaces. There are three fundamental stakeholders in all outsourcing activities, the owner, the supplier, and the customer. The owner is the organization who is the initiator of an outsourcing operation, acting as the 'client' party in a client-supplier outsourcing relationship. The supplier is the one actually accomplishing the outsourcing activities that are defined by the owner. The customer represents all potential users from a broad perspective, being considered as the original source of requirements. Hence, two interfaces naturally arise to the surface, one as interface between the owner and the supplier, the other as interface between the owner and the customer. Taking a closer look at the owner organization, it can be divided into two segments with different responsibilities: the main body caring about the overall outsourcing process management, and the infrastructure supporting the main body as a basis with tools and staff. A third interface emerges between the main body of the owner organization and the infrastructure of the owner organization. The last interface exists within the main body of the owner organization, being considered as a form of horizontal integration while several projects are running simultaneously. Given this general set of interfaces within outsourcing operations, it is relatively straightforward to identify the analogical interfaces in software engineering outsourcing. Table 4 indicates the software engineering analogues.

A significant observation regarding these outsourcing interfaces and outsourcing problem subjects is that these six outsourcing problem subjects all take place at any interfaces of the four. Problem subjects those with engagement of more than one organization, partnership, knowledge transfer, and problem solving are most commonly happen at the interface between the owner and the supplier. Problem subject market is mostly connected to the interface between the owner and the customer. Problem subject tools/staff come up at the interface concerning the infrastructure of the owner. Problem subject performance occurs at the interface within the owner organization.

Table 4 summarizes the general set of interfaces in outsourcing operations, along with the interfaces be exclusive in manufacturing outsourcing and software engineering outsourcing. Also problem subjects take place at each interface are outlined.

Generic	Manufacturing	Software Engineering	Problem Subjects
Interface A between owner & supplier	between the organization & the external participant for outsourced activities	between the IT organization & external software solution provider	• Partnership • Knowledge Transfer • Problem Solving
Interface B between owner & customer	between the organization & external participant for customer-involving activities	between the IT organization & external requirements provider	• Market
Interface C between owner's main body & owner's infrastructure	between the organization's internal production & its infrastructure	between the IT organization's internal operation & IT staff and software tools	• Tools/Staff
Interface D within owner's main body	within the organization	within the IT organization	• Performance

Table 4 *The set of interfaces and problems emerged over outsourcing sector Manufacturing, along with analogs in outsourcing sector Software Engineering(part of Information Technology)*

6 Solutions in Manufacturing

Previously on problems in outsourcing, four interfaces in manufacturing operations and most common problems for each corresponding interface are expounded. Therefore, on the next stage the fact that how do manufacturing companies actually solving real problems in the practical industry needs to be discovered. This chapter illustrates how the company Hexatronic and Vici Industrial AB are dealing with real challenges in their outsourcing activities.

Revealed by the result of data analysis, the emerging categories [See appendix A] of the interview data demonstrate a match of the problems existing in the real industry and the ones defined in previous chapter. A Quality Inspection Process model is provided by Hexatronic as their solution for inspecting the overall outsourcing process with diverse aspects shown as Figure 3.

The Quality Inspection Process model consists of six sections surrounding the core Process. As pointed out by the owner, the president of company Hexatronic, this model covers the six most important aspects in outsourcing process and conveys the concepts by one single drawing. This model owns the ability to let people feel comfortable to talk, hence, offers the possibility to find root causes for problems in outsourcing operations.

6.1 Inputs

The first section "Inputs" contains the question "What triggers the process?". This is usually considered as the starting point of an outsourcing activity. What to be outsourced is the most important question to be addressed, being closely relevant to the "Make or Buy" decision in the early stage of outsourcing process.

To decide what business activities could be outsourced, it is a must to know the current market needs and the organizational position in the increasingly competitive market. As a result, the section "Inputs" raises up the concern for the manufacturing problem "how to evaluate the current market and well position the organization based on the market condition" that is shown in Table 2. To be the winner of a battle, you need to have a good knowledge of your enemy and also yourself. If a company can better understand how it is competing in the market, it can more intellectually define its position in the market and naturally make adaptations to meet the market.

Clarified by Hexatronic, the market has been their first concern when started outsourcing in the 90's. Hexatronic has successfully spotted the suitable 'market window' for itself and has made strategic use of it. As a fairly small company, Hexatronic evaluates the market, and then make use of those unique angles in the market which are relatively trifling for big companies to notice. Hexatronic makes a good example itself of how critical it is for a firm to learn the capability of evaluating the market and appreciating the firm's strategic position objectively.

6.2 With What

The second section "With what" has a highly concern about what resources are needed. The resources are defined typically as tools, machines, equipment, fixtures, and raw materials those make up the fundamental basis for the initiatives of outsourcing activities. Without the appropriate machines and raw materials, definitely,

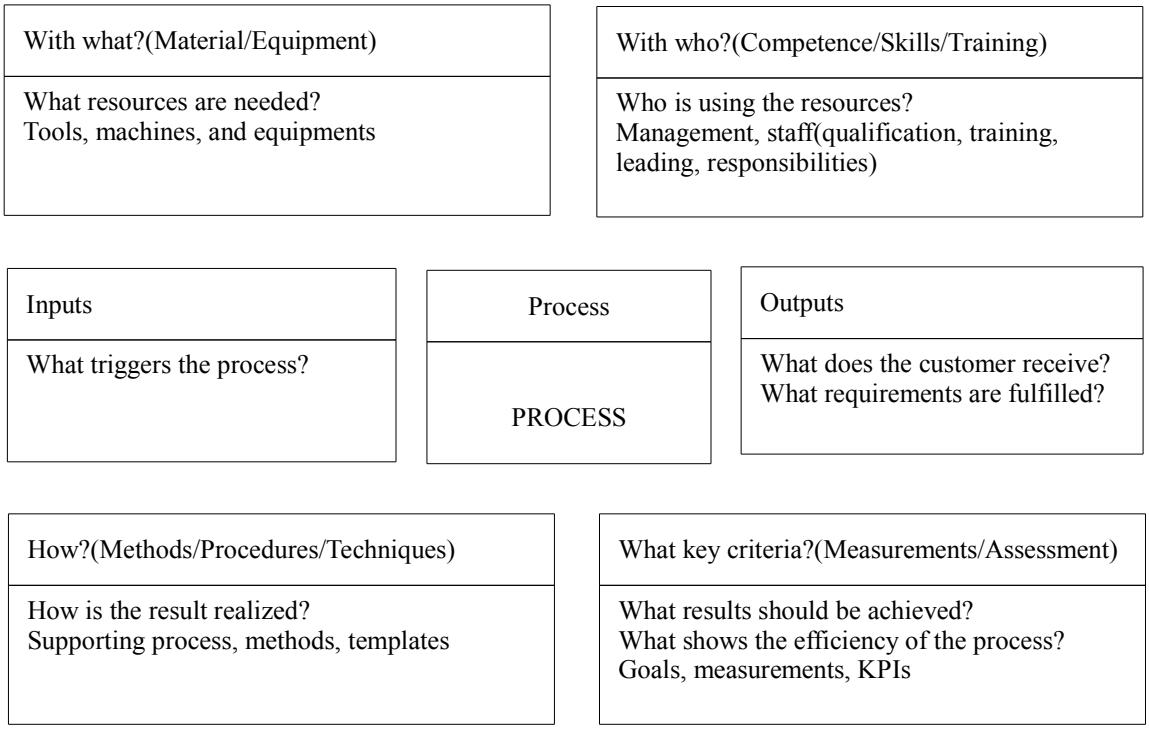

Figure 3 *(Hexatronic) Quality Inspection Process model*

manufacturing can not perform properly since the most basic requirements are not fulfilled.

When considering tools and equipments, expensive tool issues can not be denied. Therefore the section "With what" catches people's attention for the problem "how to lower the inevitable and expensive tool issues". To bring down the problem radically, tools and equipments need to verified as good quality. This might cost a high price initially, however, will greatly help save money from a long-term development view. To eliminate the problem caused by the lack of knowledge of the tool, expertise who read the tool instruction with all the details and deal with tools on a daily basis are recommended to be cultivated and trained.

Mentioned more than once by Vici Industrial AB, the second respondent organization in this research, "to produce quality, we must buy and use good equipments and machines". The organization has imported robot machines from Germany for assembly line work. The machines do the work accurately, reduce the staff number needed in the factory, and naturally cut down the budget. Hexatronic also underlined that they must have equipment to guarantee production and verify quality. They use equipment mainly for measuring, which largely safeguards the quality to some extent.

6.3 With Who

The third section "With who" lies particular emphasis on who is using the resources. In short, most human beings' perspectives are in the range of this section's consideration, for instance, management, staff training, leadership and personal responsibility.

As it concerns human beings' perspectives, it turns out to be related to the problem "how to improve and maintain the long historical and troubled industrial relations". Partner relationship has proven to be a determinant factor in outsourcing operations. While thinking of who you are working with, you need to think about how to establish a relationship with your partner. Because differences exist in a variety of aspects, as culture, working behavior, education level, quick adaptations are essential to build the relationship between partners. To maintain a long term relationship, that is regarded as the key to success, each party has to truly respect and trust the others' engagement.

Hexatronic keeps a friendly relationship with its suppliers for more than ten years. They have the same partner for a long time, and in return get a lower price offered by the supplier. Although business is still business, the respondent stressed that they became real friends with their outsourcing suppliers, which counts on the indubitable need for trust. They always have discussions in an open environment to be honest to each other. For the success of their relationship, they never tried to change a culture, instead, they merged two different cultures. By frequently visiting each other, they nurture both working relationship and friendship between two parties.

Furthermore, the section "With who" answers the question "how to promote and transfer knowledge, technologies and skills" partially. Distinct from other business activities, manufacturing outsourcing activities request two parties to work cooperatively, sharing knowledge, technologies and skills. Dr Victor Pantano (2005) says "For the much heralded knowledge economy to thrive, the barriers to sharing have to be broached." To benefit from outsourcing, there is an absolute need for transferring knowledge, technologies and skills. Sharing knowledge provides an easy access to technologies and skills, and saves time on investing a new technology with minimal effort. In the meanwhile, sharing without barriers greatly gives a hand to improve partner relationships.

Knowledge transfer is carried out well by Hexatronic based on the friendly long term relationship it has with its suppliers. They communicate conventionally, using diverse communication tools. They travel constantly, maintaining the relationship and at the same time achieving congruence in all vital decisions. They teach each other with their best practices, helping others solve potential problems. Hexatronic enjoys the friendly relationship with its suppliers, and benefits from the comprehensive knowledge sharing.

6.4 How

The fourth section “How” pays special attention to how the result is realized. Methods, procedures and techniques, those support the manufacturing outsourcing operation, should all be identified. The range of these tactics could be varied, from a simple checklist to a complete process.

Since this section “How” focuses on the strategic tactics applied during the manufacturing outsourcing process, it certainly contributes to the problem “how to effectively solve problems during production when many organizations are involved”. When multiple organizations are collaborating, it is important that roles and responsibilities are clearly specified. Also to reduce misunderstandings, expectations for each party should be clarified in the beginning of the manufacturing outsourcing process. The most vital tactic should be realized during outsourcing process is getting a win-win condition. Both parties must gain profit. In the negotiation stage, as long as both parties can win profit, a good working relationship can be maintained. It helps solve the problem smoothly, and further strengthens the relationship.

Indicated by both Hexatronic and Vici Industrial AB, they earn money and their supplier or client earn money at the same time. They seldom go to serious negotiation table, instead, if there is profit or price reduction each party takes 50% equally. Once Vici Industrial AB ran into conflicts with its client in the situation that they were losing money because the client changed their requirements. As solved without breaking the partnership, Vici Industrial AB received a longer contract for the production offered by the client.

Furthermore, the section “How” also prompts the question

“how to promote and transfer knowledge, technologies and skills”. As discussed in the earlier section, there is a recognized need to transfer knowledge. Strategies for knowledge transfer are also essential. Tools can be relied, however, not the only way to transfer knowledge. Key personnel can be assigned for a specialized knowledge, and be responsible for spreading out the knowledge.

Take Vici Industrial AB as an example, they bought machines from their German supplier. Therefore a German engineer is sent to Vici to help build up the machine and provide full and accurate instructions. Hexatronic also has staff who travel frequently to their supplier, inspecting how the supplier is working and, more important, exchanging experiences and knowledge. As a small sized firm, Hexatronic works with small companies to exchange valuable market information which is considered to be easier than working with large enterprises.

6.5 With What Key Criteria

The fifth section “With what key criteria” attaches importance to what results should be achieved. It advocates the use of key criteria that measures and shows the efficiency of the process. Measurements need to be visualized to enhance the visibility and performance of manufacturing outsourcing process.

The ultimate goal of measuring is to improve quality and performance, therefore, interprets the problem “how to enhance visibility and flexibility in the complex manufacturing outsourcing process”. Key Performance Indicator is a widely used measurements to help an organization define and evaluate process towards the organization's goal. These key performance indicators must be the key to success. They must truly reflect the organization's current situation. They must show progress to the organization's long term goals. They must obtain the ability to be measurable. Applying these well defined measurements can clearly check out the process progress and visually display the performance.

Provided by Vici Indubitable AB, they use Statistic Process Control to monitor the process to be stable or adjust the process. Also they make use of The Capability Index diagram, showing the capability of delivering compared with customer demands. These diagrams offer statistics of certain items within a certain period, providing possibilities for the organization to adjust the process and conduct improvements. Hexatronic uses Service-Level Agreement to verify both themselves and their suppliers. By using these measurements, they gain more reflections from the process and then own the ability to improve the process.

6.6 Outputs

The sixth section “Outputs” mainly concerns “what does the customer receive?”. This is usually the end point of an outsourcing activity, and sometimes the starting point for the next stage of outsourcing activities.

Since this section emphasizes on what the customer receives in the end, it is related to the problem of evaluating the market and positioning the product. To remain competitive in the market, the output of the manufacturing outsourcing activities needs to fulfill the customer requirements and keep its unique features.

Hexatronic owns outsourcing activities for their products and also those products that are commonly existing in the market. But they slightly change the design for particular purposes, for instance a product with smaller size or additional ports. Therefore the product gains competitiveness in the market by having special properties for special purposes.

7 Discussion

Based on the conclusion of the previous discussion about software engineering outsourcing sharing a common set of operational interfaces and problems with manufacturing outsourcing, it appears to be feasible to apply manufacturing outsourcing solution to software engineering outsourcing problems. To be able to make use of the manufacturing outsourcing solution in software engineering outsourcing area, the Quality Inspection Process model calls for modifications. The software engineering outsourcing solution of this study provides a theoretical guideline based on the author's personal thoughts.

As the potential outsourcing solution for software engineering, this Quality Inspection Process model remains the same framework as the original manufacturing outsourcing solution, but intends to place emphasizes on different items. The software engineering solution Quality Inspection Process model, as Figure 4, consists of six sections those are the same as the original manufacturing outsourcing solution Quality Inspection Process model but with different key words and leading questions. The model aims at catching attention for the six most important aspects in software engineering outsourcing, and as a result being conscious of latent problems.

7.1 Inputs

The first section “Inputs” remains the same as it is originally for manufacturing solution, addressing the question “what triggers the process?”. Each software has its distinguishing features that allows the software to gain a firm presence in the increasingly competitive market. Before giving responsibilities away to a third party software provider, one point needs to be considered thoroughly, does the market have high maturity but low saturation for the outsourced software development?

On one hand, the maturity of the market has to be assessed. A market with high maturity indicates that the market has the ability to provide technological infrastructure and modern business support. Therefore, the outsourced software development has an easy access

to well equipped facilities and up to date technologies. On the other hand, the market also needs to have low saturation of this type of software. If the market has high saturation of the software, it means that the same product or product with similar features has already been developed again and again. Therefore, the outsourced software application is loosing its competitive edge in the market on the existing applications. In a word, assessment of the market conditions, including its maturity and saturation, is considerable vital before making the software engineering outsourcing decisions.

7.2 With What

The second section "With what" takes software tools into account, and answers the question "what software tools are needed?". While in software engineering outsourcing, the party who develops the software has the freedom to choose the suitable tools. However, this greatly gives rise to the possibilities of expensive tool issues with regard to a loss of data or duplicate work caused by the usage of multiple tools. The situation would run out of control during the delivery time if some tools can not be integrated or even some tools fail to coexist with others.

To solve the problem "how to master using multiple tools without loosing data or duplicate work" that is shown in Table 3, the criteria for software tool selection must be developed and conformed. Firstly, the software tool has to be easy to use. To provide easy access to later integration, the software tool used in this software engineering outsourcing use should be considered as a common platform. The software being developed is the focal point. Therefore, in place of putting extra effort in a complex tool, a software tool with clear interfaces and lucid instructions is the recommended choice. Furthermore if several tools have to be integrated for the software, interfaces need to be defined in the early stage, and be well reminded to developers through the whole development. This aims at eliminating the difficulties of integration, and preventing inconsistencies from the root.

Secondly, considering the fact that most outsourced software development activities locate distributively with the client, the software tool is required to support synchronization of work and version control. During the outsourced software development, the outsourcing client needs to check progress and verify the development constantly. But some outsourcing participants are struggling with the headache of how the verification work can be performed effectively. If the software tool in favor of a function support for synchronizing data between the software developer and the outsourcing client, it will largely save time and effort, and also reduce errors while moving the data. If the software tool keeps track of different version of the software source code, it will show its advantages of this function typically when detecting a bug in the software or when the software crashes.

Thirdly, a software tool with high extensibility appears preferable to those of low extensibility, especially under the condition of a long term outsourcing relationship. Purchasing a long term outsourcing partnership, a extendable software tool lightens the burdensome tasks at the initial stage of a second outsourcing project with the same outsourcing client. Depending on the real situations and specific customer requirements, previous project work might be reused partially for the new project, or could be the fundamental basis for the new project. As a

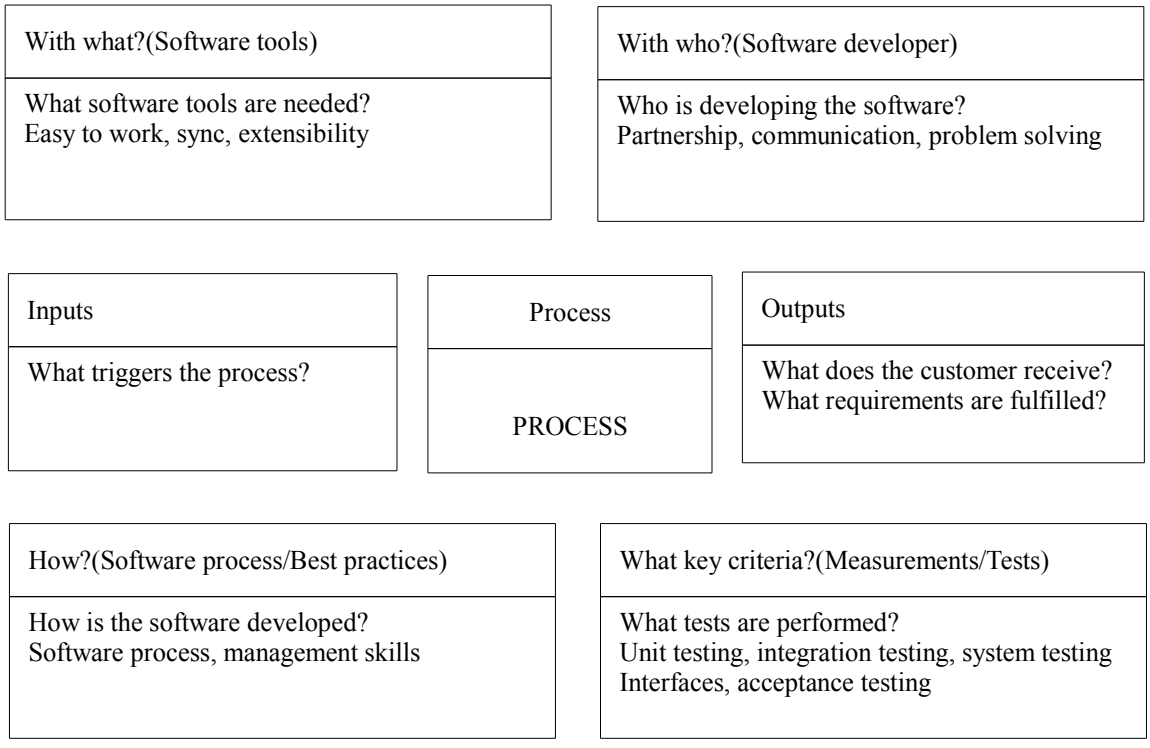

Figure 4 *Software engineering solution, Quality Inspection Process model*

result, it makes the most use of the limited resources, and gains more time by saving time for learning a new tool.

7.3 With Who

The third section "With who" obviously concerns about software developers, being aware of the question "who is developing the software?". Differ from the normal software development, outsourcing software development requires a slightly different mindset, and it is very much about managing partnership between the outsourcing client and the outsourced software developers.

This section draws attention to the problem "how to eliminate misunderstandings and suspicions when nurturing relationships". In software engineering outsourcing, the ultimate goal of the relationship is that the two participating parties can cooperate as a whole. However, in fact there is always a gap between the two with disparate objectives and goals of the operation and achievement. Realistic goals and constraints should be set, providing boundaries within which innovations can flourish. A clear vision should be settled as a norm, clarifying the direction in which both the two organizations need to move together. These declare practical expectations for both organization, and lead everyone to the same level of understanding of the work. As a consequence, the odds of the possibility of misunderstandings and suspicions emerging are lessened. In addition, sufficient communication is beneficial to clear up misunderstandings and suspicions, and further remain a good relationship. Resulted by geographical separation, formal communications through diverse communication tools might take place of face-to-face communication. Telephone meetings, video meetings, regular traveling and so forth are all good choices to convey ideas and decisions in software engineering outsourcing activities.

Moreover, this section also contributes to the problem "how to strategically avoid and effectively solve conflicts between two parties" in principle. Dealing with conflicts is regarded as one of the most important factors in outsourcing relationship. Instead of focusing on the problem, focus on solution is an effective tactic for solving conflicts between multiple organizations. The objective to focus on solution is the result of the environment in software engineering outsourcing. If each of the outsourcing participants limits his focus on the problem and only thinks about preserving his own benefits, the negotiation process would never come to an end and in the worst case rupture the partnership. Hence, the wise choice in this situation is getting a win-win condition for both parties. As long as both parties can gain profit, negotiation will come to a solution and the conflict is solved.

7.4 How

The fourth section "How" keeps a close watch on the tactics and best practices used for the outsourced software development. As the outsourced software development is mostly geographically separated, it is manifest to use special tactics and practices in the outsourced software development to resolve various difficulties resulted by the distance in both geography and organizational operations. The tactics and best practices mentioned here are not only used for a single party, but also used for managing collaboration between the client and the software provider.

To effectively solve problems between the two software engineering outsourcing parties, standard software processes need to be introduced on a technical perspective. There are a variety of software process models available, for instance waterfall model, spiral model, iterative development and so forth. Each of these software process models has its unique advantages and disadvantages. What is provided by these software processes are not only a set of standard and well defined phases that streamline the development process, but also proven and practical methodologies appropriate for different projects. It is critical to learn how to adopt a suitable software process to the real situation, or combine several software processes based on a certain purpose. Using a software process for the outsourcing software development offers strategic guidelines for the development and largely mitigates the effects of a broken process. Besides, to solve problems between two parties, exchanging experts and best practices is also one effective way to take full advantages of the limited resources in software engineering outsourcing. The two software engineering outsourcing participants have two different knowledge strengths, the client organization holding knowledge of customer requirements and business needs while the software provider holding the technical knowledge of developing the software. Therefore problems may occur because of a lack of knowledge in a particular area for one party over the outsourcing relationship. Exchanging experts and best practices is one of the most straight forward methods of moving the knowledge across the problem interfaces to effectively solve problems. The two participants teach each other, learn from each other, and help each other out.

Additionally, to transfer technologies in a more concentrated time frame and with a more strategic structure, some management skills are required to successfully perform this task. First of all, an outsourcing client manager needs to be conscious of the importance of project planning. Being the same as a normal project or manufacturing projects, the software engineering outsourcing client manager has the responsibilities to ensure that the right product is delivered on time. However, in a software engineering outsourcing environment, the manager needs to put extra attention on external factors those could have a negative effect on the project schedule, for example considerable traveling time. Secondly, essential negotiation skills are useful to an outsourcing client manager. While collaborating with the software provider, requirements and constraints are clarified, however, sometimes details of the

implementation or the profit need to be negotiated. Essential negotiation skills help the client manager settle the matter within a shorter period of time, and eliminate the risk of tainting the partnership with hostile negotiation. Last but not the least, a software engineering outsourcing client manager is required to have particular skills of verifying the work and adjusting estimation based on the feedback. The outsourcing manager needs to constantly verify the work performed by the software provider, not only checking if they are developing the required software but also reviewing the development progress. These frequent inspections allow the outsourcing manager to receive fast and accurate feedback from the outsourced software development, and consequently provide space for adjustments and modifications for the purpose of corrections or improvements.

7.5 With What Key Criteria

The fifth section “With what key criteria” takes notice of measurements and tests, focusing on a number of tests need to be performed within different phases of software development. In an outsourced software development, the most effective and direct measurement is reflected through testing with clearly indicated pass/fail criteria. On the whole, there are three basic levels of testing, unit testing, integration testing and system testing. Each level of testing is performed at different period of software development, and has its own goal and corresponding testing approach.

Integration testing plays an important role in a software engineering outsourcing environment. It accounts for forming separate units together within the software provider party, and moreover considers merging the software into the outsourcing client's own process. Clearly defined interfaces for integration should be confirmed with both outsourcing client and the software provider in the early stage of the development, in behalf of creating a condition for smooth integration in later development. This greatly decreases the possibilities that the software fails to be merged into the client organization's own process or product in the end of the development because of mismatched interfaces, which could be considered as a failure of software engineering outsourcing.

Acceptance testing is one kind of system testing that involves customers. In software engineering outsourcing, system testing could be designed to break down into few acceptance tests, reducing difficulties of a complex system testing and risks of failing tests. The idea is to slice the system into a few blocks, and each block is tested together with customer. The difference between a defined block and a component being tested in the level of integration testing is about the functional property for the testing item. A component contains a particular function, and can be tested independently from other functionality. For the other, a block in system testing contains a version of complete property of system functionality. Consider a simple analogy, the system testing in software engineering outsourcing is consist of an iterative process of acceptance testings. Another reason for doing acceptance testing is to increase the outsourcing client's involvement. The development is frequently validated and verified by the outsourcing client who has sufficient knowledge of customer requirements and business needs. As a result, the software provider receives more immediate feedback from the outsourcing client and hence gains more time for improvements in the quality of the software.

7.6 Outputs

The sixth section “Outputs” remains unchanged from the manufacturing solution. It concerns the question “what does the customer receive?”. It offers means to verify what customer requirements are fulfilled and to assess how the software is competing in the market.

To verify what customer requirements are fulfilled, a simple checklist with a list of all defined requirements can be helpful. To assess how the software is competing in the market, market research about other existing software of similar functions and features can be conducted. Hence, extensive verifications and assessments provide a clear view of how the outsourced software remains competitive in the market.

As a whole, the software engineering solution Quality Inspection Process model covers six most significant aspects in software engineering outsourcing. Being a software engineering outsourcing solution, the Quality Inspection Process model considerably help with solving problems by bringing the questions forward itself. It highly ensures the success of software engineering outsourcing against either outsourcing being a broken process or outsourcing failing because of neglect of a particular problem subject.

8 Conclusion

This section makes a summary of the contribution of this study, and indicates the remaining points for future explorations.

8.1 Summary

It appears to be possible for small- and medium-sized organizations to make use of the manufacturing outsourcing solution, the Quality Inspection Process model, from the company Hextronic, and adapt it to be beneficial for software engineering outsourcing. Except the certain outsourcing operation process, manufacturing outsourcing and software engineering outsourcing do have something in common, which is indicated by a sharing of the same problem subjects. This highly grants the assumption that the manufacturing outsourcing solution can be applied into software engineering outsourcing. All in all, this study addresses the four questions listed in the beginning:

- Problems in manufacturing outsourcing and software engineering outsourcing are identified given in Table 2 and Table 3.
- Problems in manufacturing outsourcing and software engineering outsourcing share a general set of interfaces and six common problem subjects explained in Table 4.
- The manufacturing outsourcing solution, Quality Inspection Process, is detailed explained of its usage in industry discussed in Chapter 6.
- The Quality Inspection Process model is modified and adapted for use as software engineering outsourcing solution in Chapter 7.

To the end of this study, the theoretical framework exhibits a complete entirety as displayed in Figure 5.

8.2 Future Research

This research paper offers several opportunities for future research. First, this paper explores the strategic solution for software engineering outsourcing problems based on manufacturing outsourcing solution provided by industry. However, as mentioned earlier in this paper, software engineering outsourcing makes up a large portion of IT outsourcing. Therefore, there remains room for further exploration to apply the manufacturing outsourcing solution to software engineering outsourcing and then to IT outsourcing.

Second, the set of interfaces in outsourcing operations discussed in Chapter 5.3 is mainly developed on a basis of manufacturing outsourcing, and then it is used to confirm software engineering outsourcing. However, a third outsourcing sector could be discussed to validate the set of interfaces.

Third, the solution of software engineering outsourcing contributed by this research provides theoretical guidelines. However more practical data and analysis could be explored to proof the theoretical solution. It will be necessary to use the software engineering solution, the adapted Quality Inspection Process model, in the real industry with organizations doing software engineering outsourcing, and observe how the model could benefit the organizations.

Fourth, since the interviews in this research only involves small- and medium-sized organizations, the conclusion and contribution of this research intend to benefit small- and medium-sized organizations. There remains room for further research to discover solutions for organizations of all sizes.

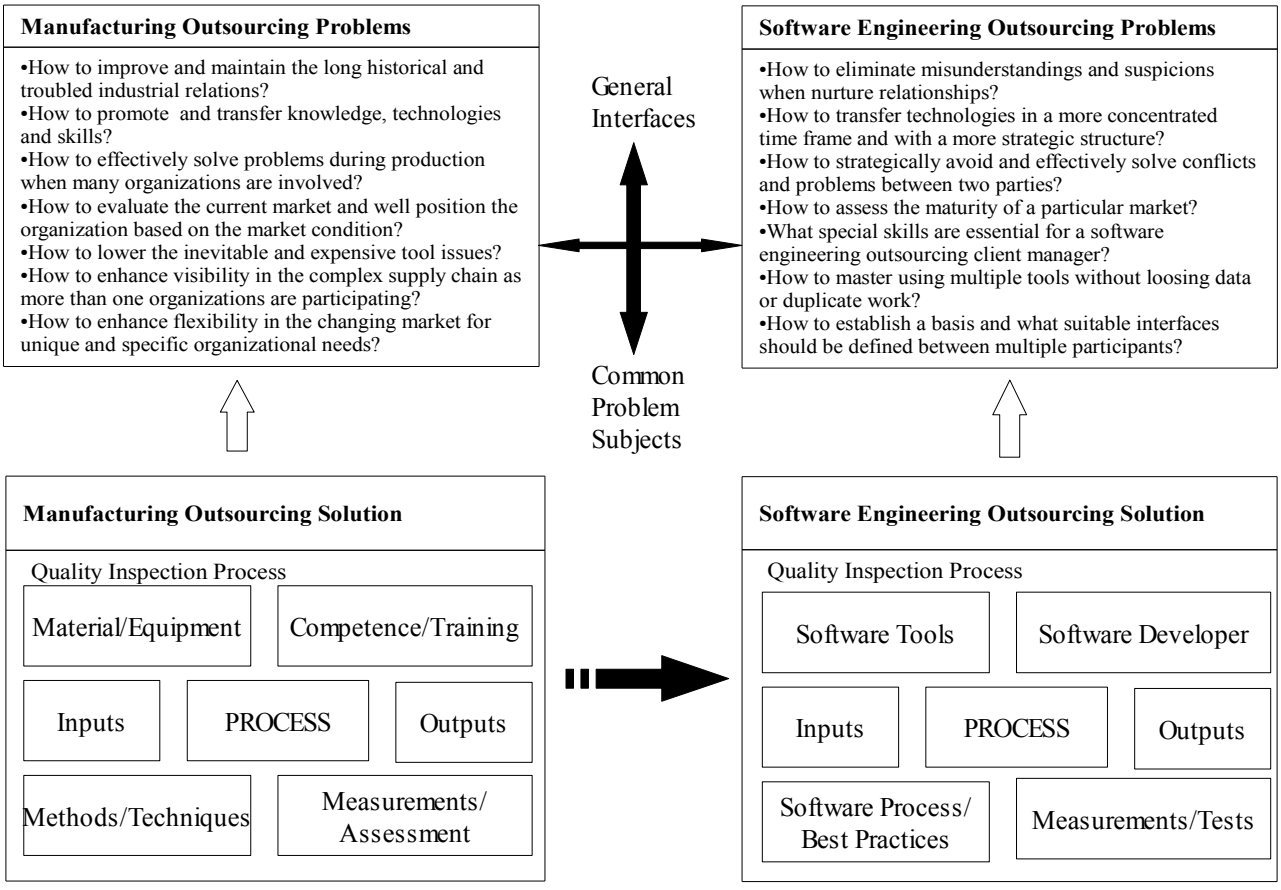

Figure 5 *Complete Theoretical Framework*

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APPENDIX Data Analysis Results

Study Case X, Vici Industrial AB[4]

Table 1-X: *Key points and codes from the data in Study Case X*

ID	Key Point	Code
Px1	We have many quality assessments, like TS, ISO	Quality assessment
Px2	we receive customer demands, with drawing and requirements	Customer requirements
Px3	We always have problems or discussions, depends on who is reading the contract	Misunderstanding
Px4	clients always want to discuss about price reduction	Contract discussion
Px5	If we can make a price reduction 2%. we tell our customers, they take 1%, and we take 1%	Both parties Honest
Px6	We need to buy and use equipments to produce quality	Equipments Produce quality
Px7	All drawings have measurements, tolerance limits	Measurement Requirements
Px8	We use CPK diagram, and SPC diagrams to visualize and measure performance	Measure performance
Px9	We do not do assemble test often, because we trust them	Trust Assemble test
Px10	If we see there is a problem in quality with the supplier, we visit them	Visit Quality problem
Px11	We have TS, a process called PPAP with 18 steps to check	PPAP Standard process
Px12	For each tool we need to specify quite much details	Tool specification
Px13	We have Quality MSA for employee training	Standard process Staff training
Px14	Be a second party audit, I have to go to visit the supplier	Visit
Px15	We have good relationship with both customers	Good relationship
Px16	Scania is much easier to work with	Easy to work
Px17	We have regular telephone meetings with the Design department	Communication
Px18	We have open discussions through phone	Communication Open discussion
Px19	We visit each other twice a year	Visit
Px20	Both parties need to be easy to work with	Both parties Easy to work Good relationship
Px21	We need to visit people, shake hands, look into the eyes	Visit Face to face communication
Px22	Good business requires good relationship	Good relationship
Px23	We need to have open mind, take up all issues even if it is bad	Open minded
Px24	We need to be frankly, tell them straight when we are not satisfied	Frankly

4 Resulted in the fact that case 2 Vici Industrial AB is comparably smaller than case 1 Hexatronic, the data is analyzed first.

ID	Key Point	Code
Px25	We need to have open books, where they can see our calculations which our clients always want to see	Open book Trust
Px26	We had two solutions for them	Focus on solution
Px27	Being an European company, we are more equal in the organization	European organizational environment
Px28	The US companies (our supplier) they are strictly in level	American organization environment
Px29	We can see the differences when we visit them	Organizational differences Visit
Px30	You must have good machines	Equipments

Table 2-X: *Emergence of concepts from codes in Study Case X*

Concept	ID
Specified customer requirements	Px2, Px7
Equipments used to verify quality	Px6, Px7, Px9
Negotiation and discussion	Px3, Px4
Win-win for both parties	Px5, Px20
Use of standards for process measurement	Px1, Px8, Px11, Px13
Indubitable need for trust	Px9, Px25
Essential visit	Px10, Px14, Px19, Px21, Px29
Focus on solution to solve problem	Px10, Px26
Be easy to work with helps build relationship	Px16, Px20
Good relationship considered necessary	Px15, Px22
Use of conventional communication	Px17, Px18, Px21
Staff training	Px13
Recognized need for good equipments	Px6, Px12, Px30
Importance of being honest and frankly in an open environment	Px5, Px18, Px23, Px24, Px25
Organizational differences exist	Px27, Px28, Px29
Misunderstandings exist	Px3

Figure 1-X: *Diagrammatical emergence of the category "Equipments verification"*

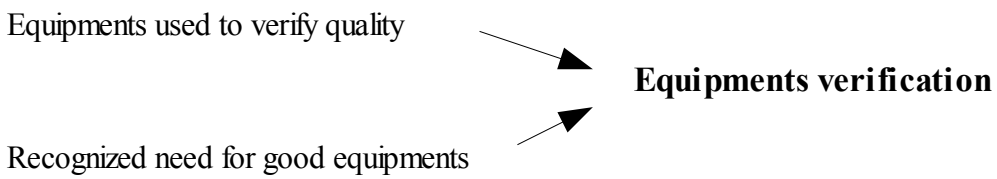


Figure 2-X: *Diagrammatical emergence of the category "Quality assurance"*

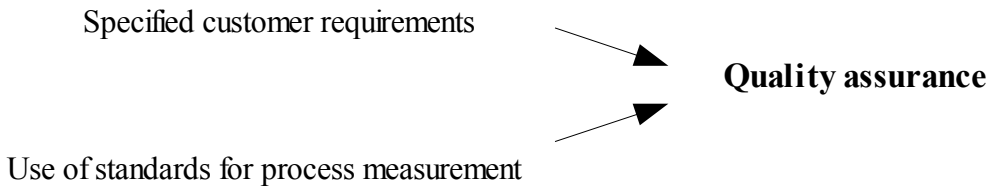


Figure 3-X: *Diagrammatical emergence of the category "Communication issues"*

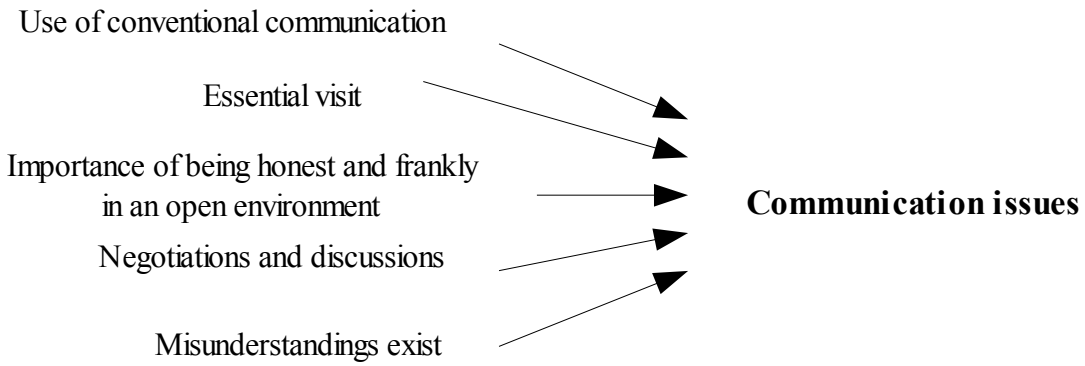


Figure 4-X: *Diagrammatical emergence of the category "Adaptations required"*

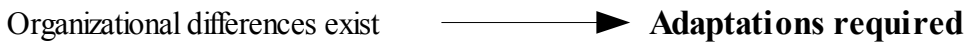


Figure 5-X: *Diagrammatical emergence of the category "Partner relationship"*

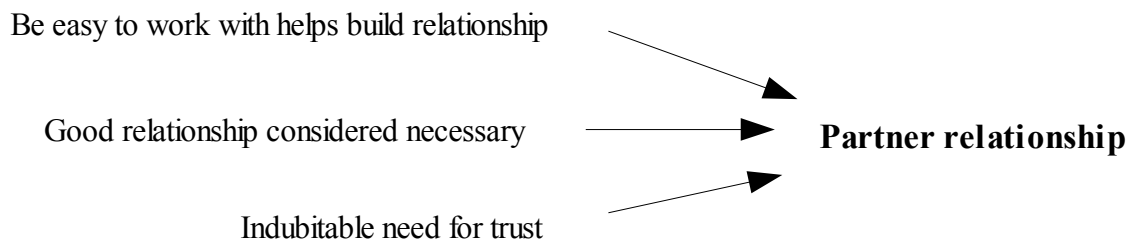
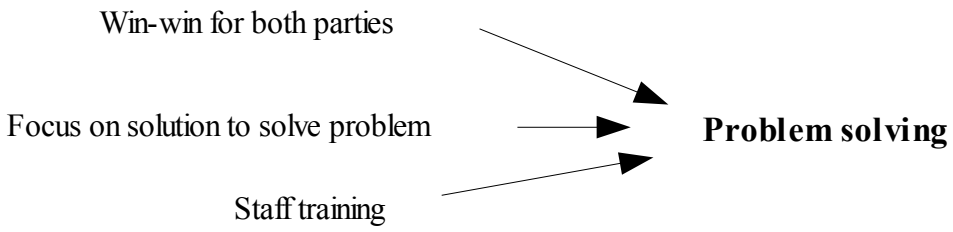


Figure 6-X: *Diagrammatical emergence of the category "Problem solving"*



Study Case Y, Hexatronic

Table 1-Y: *Key points and codes from the data in Study Case Y*

ID	Key Point	Code
Py1	The market has been our first concern.	Market concerns
Py2	It helps us to focus on our core	Focus on core
Py3	We have the same partner for a long time, at a lower price	Long term partnership
Py4	We earn money, they earn money at the same time	Both parties
Py5	We have deep discussion of what is required with customers.	Customer requirements Discussion
Py6	We get a bigger market with a lower price	Bigger market
Py7	We take the market window and make use of it	Market window
Py8	We follow all the specifications, IEEE, regulations regulated by the government and institution	Standards Regulations
Py9	We have people traveling for non-technical requirements	Traveling Requirements
Py10	There has to have the equipment to test, to verify	Equipment Testability
Py11	We have misunderstandings with our suppliers	Misunderstanding
Py12	We have so long relationship with our suppliers from 1993 till now	Long relationship
Py13	We can be honest to each other, we trust each other	Honest Trust
Py14	We do not need to pay advance to get the delivery because we have the credits	Trust credits
Py15	We have clear selling price and profit price	Open price
Py16	we are open-minded to each other	Open minded
Py17	We use Service-Level Agreement	Service-Level agreement
Py18	The purpose for this is to verify how we are, and they are in paper work	Service-Level agreement Verify both parties
Py19	For a new supplier, first we need to visit them twice at least before start working	Visit
Py20	We always get references of all information	References Information transform
Py21	We need to see how are people changing	People
Py22	People are sleeping with the quality	People Quality assurance
Py23	We kind of measure the performance by the speed of communication	Measure performance
Py24	We communicate by emails, phone, web-cam	Communication tools
Py25	We definitely experienced difficulties in communication since there are two different cultures	Communication difficulties Culture differences
Py26	There has been language problems	Language problems
Py27	Europeans are good at mixing things together	European culture
Py28	Asians are more strictly by lines	Asian culture

ID	Key Point	Code
Py29	We have really long-term friendship for 10 years	Long term relationship
Py30	We go traveling a lot	Traveling
Py31	We have social activities together	Social activities
Py32	Be nice to our suppliers	Good relationship
Py33	We are friends	Friendship
Py34	We merged the two different cultures.	Merge cultures
Py35	Everyone is in the middle	Everyone Round table principle
Py36	European have more friendly environment	European organizational environment
Py37	Asian have more strict levels and titles	Asian organizational environment
Py38	When you do not have the production in house, you are more competitive in the market	Competitive in market
Py39	We use Quality Inspection Process to find root causes for problems	Standards
Py40	We must protect our suppliers	Good relationship
Py41	We are on the same boat	Good relationship
Py42	Human beings are the most important	People
Py43	Do not try to change the culture	Culture differences
Py44	We work with smaller companies, they bring the market information back to us	Market information
Py45	For the first supplier, I talked to them, visited them, and taught them	Knowledge transform Training

Table 2-Y: *Emergence of concepts and categories from the data from Study Case Y*[5]

Category 1: Equipments verification	
Concept	**ID**
Equipments used to verify quality	Py10
Recognized need for good equipments	None
Category 2: Quality assurance	
Concept	**ID**
Specified customer requirements	Py5, Py9
Use of standards for process measurement	Py8, Py10, Py17, Py18, Py39
*Competitiveness with market concerns	Py1, Py2, Py6, Py7, Py44
Category 3: Communication Issues	
Concept	**ID**
Use of conventional communication	Py24
Essential visit	Py9, Py19, Py30

5 The concepts with * are the new concepts emerged for study case Y

Importance of being honest and frankly in an open environment	Py13, Py15, Py16
Misunderstandings exist	Py11
*Communication difficulties	Py25, Py26

Category 4: Adaptations required	
Concept	**ID**
Organizational differences exist	Py36, Py37
*Culture differences exist	Py25, Py27, Py28, Py34, Py44

Category 5: Partner relationship	
Concept	**ID**
Be easy to work with helps build relationship	Py32
Good relationship considered necessary	Py32, Py40, Py41
Indubitable need for trust	Py13, Py14
*Long-tern relationship	Py3, Py12, Py29
*Friendly relationship	Py32, Py31, Py33

Category 6: Problem solving	
Concept	**ID**
Win-win for both parties	Py4, Py18
Focus on solution to solve problem	None
Staff training	Py45
People importance	Py21, Py22, Py35, Py41
*Information transform	Py20, Py44, Py45