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# KAIKAKU IN PRODUCTION TOWARD CREATING UNIQUE PRODUCTION SYSTEMS

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MÄLARDALEN UNIVERSITY
SWEDEN

School of Innovation, Design and Engineering

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Akademisk avhandling

som för avläggande av teknologie doktorsexamen i industriell ekonomi och organisation vid Akademin för innovation, design och teknik kommer att offentligen försvaras fredagen den 27 september 2013, 10.00 i Filen, Eskilstuna.

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MÄLARDALEN UNIVERSITY
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Abstract

In the business environment characterized by the severe global competition and the fast-paced changes, production functions of manufacturing companies must have a capacity of undertaking not only incremental improvement, Kaizen, but also large-scale improvement that is of a radial and innovative nature here called "Kaikaku" (Kaikaku is a Japanese word meaning change or reformation).

Moreover, production functions especially those located in high-wage countries must be proficient in radical innovation in production to maintain their competitive advantages. They must to be capable of creating new knowledge and constantly developing and implementing radically new production technologies, processes, and equipment which make their production systems more "unique". Here, a unique production system means a production system that is valuable for the company's competition, rare in the industry, difficult for competitors to imitate, and difficult for them to substitute.

Kaikaku is not a new phenomenon in the industry, and much research has been done on how to manage large-scale changes in Kaikaku. However, the previous research has rarely focused on the relation of Kaikaku and creating unique production systems, especially in the perspective of Kaikaku as a means to create such systems. The objective of the research presented in the doctoral thesis is to propose how to undertake Kaikaku so that it contributes to creating unique production systems. To fulfil the objective, one five empirical studies were conducted. In the empirical studies, data were collected through literature review, interviews, participant-observation, and action research. Both Japanese and Swedish manufacturing companies were studied.

General conclusions of the research are summarized as follows. In order to undertake Kaikaku so that it contributes to realizing unique production systems, the intent and commitment to realize such systems must be present at the strategic level of the organization. Organization structures and resources need to be prepared to support the mentioned kind of Kaikaku. A process of Kaikaku can be a less linear and systematic but more cyclic and emergent process which can be seen as a series of unfolding smaller improvement or development projects that are undertaken during Kaikaku to achieve overall objectives. In each projects exploration and organizational learning are facilitated. The research also has found a specific direction of how to develop a production system in order to make the system more unique. Finally, in the research, a production-process design method that is helpful to create unique production lines, cells, and equipment has been found and studied.

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# Abstract

In the business environment characterized by the severe global competition and the fast-paced changes, production functions of manufacturing companies must have a capacity of undertaking not only incremental improvement, Kaizen, but also large-scale improvement that is of a radial and innovative nature here called “Kaikaku” (Kaikaku is a Japanese word meaning change or reformation).

Moreover, production functions especially those located in high-wage countries must be proficient in radical innovation in production to maintain their competitive advantages. They must to be capable of creating new knowledge and constantly developing and implementing radically new production technologies, processes, and equipment which make their production systems more “unique”. Here, a unique production system means a production system that is valuable for the company’s competition, rare in the industry, difficult for competitors to imitate, and difficult for them to substitute.

Kaikaku is not a new phenomenon in the industry, and much research has been done on how to manage large-scale changes in Kaikaku. However, the previous research has rarely focused on the relation of Kaikaku and creating unique production systems. Kaikaku can be an effective means to create such systems. The objective of the research presented in the doctoral thesis is to propose how to plan and implement Kaikaku so that it contributes to creating unique production systems. To fulfil the objective, five empirical studies were conducted. In the empirical studies, data were collected through literature review, interviews, participant-observation, and action research. Japanese and Swedish manufacturing companies were studied.

General conclusions of the research are summarized as follows. In order to achieve Kaikaku so that it contributes to realizing unique production systems, the intent and commitment to realize such systems must be present at the strategic level of the organization. Organization structures and resources need to be prepared to support the mentioned kind of Kaikaku. A process of Kaikaku can be a less linear and systematic but more cyclic and emergent process which can be seen as a series of unfolding smaller improvement or development projects that are undertaken during Kaikaku to achieve overall objectives. In each projects exploration and organizational learning are facilitated. The research has also found a specific direction of how to develop a production system in order to make the system more unique. Finally, in the research, a design method that is helpful to create unique production lines, cells, and equipment has been found and studied.

# Sammanfattning (In Swedish)

På dagens globalt konkurrensutsatta marknad präglad av snabba förändringar behöver tillverkande företag kompetens för att, i tillägg till inkrementella förbättringar, Kaizen, även kunna genomföra storskalig förbättring av radikal och innovativ karaktär, Kaikaku, i sina produktionssystem. (Kaikaku är ett Japanskt begrepp som innebär förändring eller reformation).

Dessutom måste tillverkande företag vara skickliga på radikal innovation för att kunna bibehålla sin konkurrenskraft, särskilt de företag som är belägna i höglöneländer. De måste vara kapabla till att skapa ny kunskap och konstant utveckla och implementera ny produktionsteknik, utrustning, och metoder för att på så sätt göra sitt produktionssystem alltmer ”unikt”. Unikt i detta hänseende innefattar radikalt innovativt och nytt ”bortom forskningsfronten” inom området, och innebär att det är svårt för konkurrenter att imitera.

Kaikaku är inget nytt fenomen utan mycket forskning har bedrivits tidigare med fokus på hur man realiserar stora förändringar. Dock så har denna forskning väldigt sällan fokuserat på relationen mellan Kaikaku och skapandet av unika produktionssystem, något Kaikaku kan vara ett effektivt medel för att uppnå. Målet med forskningen i doktorsavhandlingen är att presentera hur man kan genomföra Kaikaku så att det bidrar till att skapa unika produktionssystem. För att uppfylla målet så har fem empiriska studier genomförts. Inom de empiriska studierna så har data samlats in genom litteraturstudier, intervjuer, deltagande observationer och aktionsforskning. Såväl Japanska som Svenska tillverkande företag har studerats.

Allmänna slutsatser från forskningen är följande. För att kunna genomföra Kaikaku på så sätt att det bidrar till realisering av unika produktionssystem så måste såväl intention som engagemang för att realisera denna typ av system vara förankrad på en strategisk nivå i organisationen. Organisatoriska strukturer och resurser måste vara redo att stödja denna form av Kaikaku. Kaikakuprocessen tenderar att vara mindre linjär och systematisk, och istället mer cyklisk och framväxande. Detta kan beskrivas som en serie med förbättrings- och utvecklingsprojekt iscensatta för att bidra till att uppnå de övergripande målen. I varje projekt främjas såväl utforskande som lärande. Forskningen har också identifierat en specifik riktning för hur produktionssystem kan utvecklas till att bli än mer unika. Slutligen så har en metod för design av produktionsprocessen identifierats, vars syfte är att hjälpa till att skapa unika produktionsliner, -celler, och -utrustning.

# Acknowledgements

Many say that getting Ph.D. degree is a journey without a clear map. It has been very true to me. The research journey has been like a recursive process of drawing a map from scratch, finding a goal in a dense fog, and creating my own path to get there. The journey has been sometimes tough and lonesome and other times it has been joyful and rewarding. It has been shared with many people and I could not come this far without their involvement and help. I would like to express my gratitude to everyone who has been a part of the journey.

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I would like to thank all my colleagues, especially the members of the Kaikaku team: Professor Mats Jackson, Professor Tomas Backström, Professor Yvonne Eriksson, Bengt Köping Olsson, Jens von Axelson, Daniel Gåsvaer, Jennie Schaeffer, Nina Bozic, and Lina Stålberg. The multidisciplinary team we have created has been truly inspiring and influential to my research work. I wish such collaboration will continue to be active in the research institution. I am grateful to all who participated in the case studies. They have given valuable input to the research work. I have always enjoyed discussing various topics related to the research with them.

Finally the journey cannot be carried out without the support of my family especially my wife Sara. Before starting the research we had no child but now we have five- and three-year old children. Time files! Her and my parents have been very supportive to my work. I would also like to thank my children Hugo and Olivia. They have been very helpful to make me take my minds off the research work.

Västerås in August 2013

Yuji Yamamoto

# Appended papers

This thesis is based on the following papers.

Paper A Yamamoto, Y. and Bellgran, M. (2013) “Four types of manufacturing process innovation and their managerial concerns”, *Forty Sixth CIRP Conference on Manufacturing Systems*, Setúbal, Portugal.

Paper B Yamamoto, Y. and Bellgran, M. (2010) "Fundamental mindset that drives improvements towards lean production", *Assembly Automation*, Vol. 30, No. 2, pp.124-130.

Paper C Yamamoto, Y. and Bellgran, M. (2009), "Production management infrastructure that enables production to be innovative", *16th Annual International EurOMA Conference*, Göteborg, Sweden.

Paper D Yamamoto, Y. and Bellgran, M. “Manufacturing process innovation initiatives at Japanese manufacturing companies” (under revision for Journal of Manufacturing Technology Management).

Paper E Yamamoto, Y. and Bellgran, M. (2013) “Manufacturing process improvements using value adding process point approach”, *22nd Annual conference of The International Association for Management of Technology*, Porto Alegre, Brazil.

Paper F Yamamoto, Y. (2013) “Proposal of a deliberate discovery-learning approach to building exploration capabilities in a manufacturing organization”, *23rd International conference on Flexible Automation and Intelligent Manufacturing*, Porto, Portugal.

# List of papers not included in the thesis

Yamamoto, Y. and Bellgran, M. (2008), "Guidelines for increasing skills in Kaizen shown by a Japanese TPS Expert at 6 Swedish Manufacturing Companies", *The 18th International Conference on Flexible Automation and Intelligent Manufacturing*, Skövde, Sweden.

Yamamoto, Y., Bellgran, M., and Jackson, M. (2008), "Kaizen and Kaikaku– Recent challenges and support models", *Swedish Production Symposium SPS 2008*, Stockholm, Sweden.

# Table of contents

# CHAPTER 1 – Introduction

*This chapter introduces the research presented in this thesis on the topic of improvements in production that are of a radical and innovative nature, called Kaikaku. The chapter begins with a description of the circumstances of today's manufacturing industry that raises the need for Kaikaku in production and the importance of developing competitive production systems. This is followed by addressing the challenges and opportunities in the research of Kaikaku. Based on these challenges and opportunities, the research objective and research questions are formulated. Further, the delimitations of the research are described. Finally, an outline of the thesis is presented.*

## 1.1 Research background

In today's business environment, the pressures on manufacturing companies to compete on the global arena have increasingly intensified. Demands and expectations from customers on manufactured products have increasingly become diversified and sophisticated. Production functions of manufacturing companies have to meet those demands and expectations with higher quality, greater efficiency, increased flexibility, and shorter lead time from order to delivery. Moreover, the current business environment is characterized by a high velocity of change. Speed of change in global economies, industries, and companies has increased to ever-greater extent. Production functions are challenged to manage and benefit from, for example, high fluctuations of production volumes and product variances, shorter product life cycles, shorter lead time of product realization, rapid technological advancement, corporate mergers and acquisitions, changes of laws and regulations, changes in dynamic global supply chains, and changes in energy and raw material prices. In order to maintain competitiveness in production under these circumstances, manufacturing companies must establish necessary conditions to gain and sustain a high speed of improvement in production.

Traditionally, production functions have focused on the incremental improvement often called Kaizen to maintain competitiveness. Kaizen often involves small-step improvements based on existing production systems. While proficiency in Kaizen is an important element of obtaining a high speed of improvement in production, in today's business environment relying only on Kaizen may not guarantee a sufficient pace of improvement. Production functions must have a capacity to undertake large-scale improvement that is of a radical and innovative nature and combine it with Kaizen so that they strengthen each other. The research presented in this thesis refers to large-scale improvement that is of a radical and innovative nature as *Kaikaku.* Kaikaku in production is the main topic of the research.

Kaikaku involves fundamental rethinking and radical redesign of existing production systems, which brings about a necessity for or opportunity of viewing production in a holistic, long-term, strategic, and management perspective. Radicalness in Kaikaku provides room for actively adopting new production technologies, equipment, and operational procedures. Kaikaku can be initiated as a reaction to an urgent situation of a company, for instance an economic crisis. On the other hand, it can also be initiated to anticipate necessary changes in the future. Due to the holistic and radical nature of Kaikaku, the concept does not only involve redesign activities of production systems; it also encompasses envision or revision of production strategies and implementation of changes in all complex and interrelated technological, human, and organizational dimensions (Davenport, 1993).

Kaikaku is not a new phenomenon in the manufacturing industry. Many production functions have conducted and experienced various kinds of Kaikaku efforts involving, for instance, major changes in production equipment, material and information flows, work organization, and management systems. Implementing lean production, which has been a major movement in the manufacturing industry (Netland, 2013), is also a kind of Kaikaku. As the boom of implementing lean production implies, Kaikaku is often realized by adopting solutions available externally. Such solutions are, for instance, packaged organization-wide improvement initiatives such as lean production and Six Sigma, off-the-shelf production equipment or IT systems, or other solutions developed by competitors or external vendors. Achieving Kaikaku with a reliance on solutions that have been proven effective in the industry is understandable in the perspective of avoiding risk of failure and saving costs of developing and validating these solutions. However, realizing Kaikaku by importing or imitating externally available solutions may not be sufficient to maintain long-term competitiveness in production, especially for production functions located in high-wage countries (Smeds, 1997). For those functions, it has been increasingly hard to compete with internal or external competitors in fast-growing countries, for instance in East and South East Asia. Lower labour costs and economic growth in these countries have attracted domestic and foreign investment. Taking advantage of the active investment, these competitors are rapidly gaining competitiveness by actively absorbing, for example, latest production technologies and production management practices (Goedhuys and Veugelers, 2012). In order for production functions in high-wage countries to be continuously valuable for manufacturing companies, these must be capable of actively creating new knowledge as well as constantly developing innovative production technologies, equipment, operational procedures, etc. that make their production systems more unique in the industry. Here, 'unique' in this thesis connotes being valuable for the company's competitiveness, rare among competitors, difficult for competitors to imitate, and difficult for them to substitute (Barney, 1991). A production system is a socio-technical system (Hubka and Eder, 1988). A unique production system means that not only the technical part of the production system is unique but also the social part. The latter means that individuals, groups, and organizations possess unique capabilities for performing specific tasks, for instance realizing innovation in production.

The importance of creating unique production systems can be further emphasized by introducing an industrial example, the production challenges of several Japanese manufacturing companies. In 2009, the author of this thesis had the opportunity to interview senior production managers at several Japanese manufacturing companies. The managers acknowledged that the companies made conscious efforts to make their domestic factories more unique in the industry. They perceived that emerging competitors in East and South East Asia were a serious threat to the factories in Japan. They were particularly afraid of the competitors' speed of gaining competitiveness. Since those competitors are geographically close to Japan, the managers saw that it became hard for the domestic factories to survive as far as the role of the factories was only to produce goods and improvements at the factories were similar to those at the competitors. They argued that making the factories in Japan the centres of production development where unique solutions were constantly developed, experimented with, and used was one of a few ways for those factories to be valuable for the companies for a long time. The production challenges described above seem to be relevant to many production functions located in high-wage countries. For instance, several articles have reported that European manufacturing companies are facing similar challenges (e.g. Geyer, 2003; IVA, 2005; Thomas et al., 2012), although the necessity of creating unique production systems can vary among companies depending on their business and manufacturing strategies, types of products they make, location of their production functions, etc.

## 1.2 Problem statement

Kaikaku is not a new research field scarcely studied. In academia, Kaikaku corresponds to a production-focused version of *Business Process Reengineering (BPR)*, alternatively called *process innovation*. Process innovation, generally defined as "fundamental rethinking and radical redesign of business processes to achieve dramatic improvement in key performance measures" (Hammer and Champy, 1993), became a popular theme of research in the early 1990s. Since then, a large amount of research on process innovation has been conducted. One of the mainstreams of the process innovation research is to describe the nature of process innovation and propose a definition of it (e.g. Harrington, 1995). Another mainstream of the research is to develop a life-cycle model of process innovation that usually contains normative phases and steps to be undertaken (e.g. Motwani et al., 1998). The other mainstream is analysing and suggesting success factors for process innovation (e.g. Herzog et al., 2007). For more specific kinds of process innovation such as implementation of lean production, a large number of books, articles, and consultancy materials have been published or developed to support the implementation.

Most of the previous research on process innovation mentioned above has focused on the question of how to successfully manage radical and large-scale changes in a structured and systematic way. This is understandable considering that such changes are usually more complicated than small and incremental ones and that they tend to require a large amount of investment, which motivates managers to minimize the risk of failure. Due to the large amount of the research devoted to addressing this question, little room seems to be left for research on how to plan and execute process innovation in a systematic way. However, more research opportunities can be identified when one considers how process innovation can contribute to creating unique production systems. In this thesis, the term Kaikaku is used instead of process innovation, in order to emphasize the potential of radical improvement to contribute to creating such systems.

Kaikaku can contribute to making the technical part of production systems more unique. Kaikaku itself is an innovation effort that introduces new machines and/or new work procedures to production systems. However, Kaikaku can be undertaken in an even more innovative way so that innovative technical solutions are actively created that collectively make the systems more unique. As mentioned earlier, in the manufacturing industry Kaikaku is often realized with a reliance on existing solutions that are not particularly unique in industry. In the research on Kaikaku, considerably little attention has been paid to how to realize Kaikaku so that more unique solutions can be created (Feurer et al., 1996; McAdam, 2003).

Kaikaku can contribute to making the social part of production systems more unique. It especially contributes to increasing *organizational capabilities for innovation*. These capabilities or in short innovation capabilities are broadly defined as abilities to create and realize innovative outcomes on a routine basis (Olsson, 2008). They are largely embedded in the collective skills and knowledge of people and social routines in the organizations (Hayes and Pisano, 1994). Researchers have identified the positive effect of Kaikaku on innovation capabilities (e.g. Riis et al., 2001), although the effect seems to be less regarded in the industry. Hayes and Pisano (1994) state that an effort of radical improvement is often seen as a one-shot project or a quick fix to a specific problem, rather than as a means to the broader goals of selecting and developing unique capabilities. Perhaps manufacturing companies are aware of the positive effect mentioned, but they do not take conscious and proactive measures to enhance the innovation capabilities during Kaikaku. While researchers stress the importance and potential of active capability building during Kaikaku, few studies have been done on how to practically undertake Kaikaku so that it enhances innovation capabilities.

## 1.3 Research objective

The aim of the research presented in this thesis is to advance the research on Kaikaku especially focusing on how Kaikaku can contribute to creating unique production systems. The research objective is formulated as follows:

> *The objective of the research is to propose how to facilitate improvement in production that is of a radical and innovative nature, called Kaikaku. The proposal should help preparation and execution work in Kaikaku at manufacturing companies so that Kaikaku contributes to realizing unique production systems.*

## 1.4 Research questions

In order to fulfil the research objective, two research questions are posed. As mentioned in an earlier section, a production system includes a technical part and a social part. The first research question is related to the technical part. In order for Kaikaku to contribute to making the technical part of a production system more unique, it can be realized in an even more innovative way so that it generates unique technical solutions that in turn make the system more unique. It is important to investigate what factors related to Kaikaku contribute to creating such solutions and then consider proper utilization of those factors. Therefore, the first research question is formulated as follows:

> **RQ1:** How should Kaikaku be realized so that it can generate solutions that make the technical part of a production system more unique?

The second research question is related to the social part of a production system. In the present research, building innovation capabilities is especially focused as a way of making the social part of the production system more unique. In an earlier section it was mentioned that Kaikaku is a valuable opportunity to actively build innovation capabilities. Similar to the first research question, it is important to identify factors that enhance innovation capabilities during Kaikaku and consider proper utilization of the factors. Therefore, the second research question is formulated as follows:

> **RQ2:** How should Kaikaku be realized so that it enhances innovation capabilities that make the social part of a production system more unique?

## 1.5 Delimitations

The research presented in this thesis focuses on Kaikaku in production in the manufacturing industry. Production functions located in Japan and Sweden have particularly been considered as study objects. This is because the author of this thesis has good access to these objects and also because the author is generally interested in comparing production in those two countries. In terms of production, these countries have different cultural backgrounds but face similar challenges. For instance, factories in these countries are under strong off-shoring and relocalization pressure due to the high labour costs.

The present research assumes situations where production functions experience an implicit or explicit need for initiating Kaikaku. When to initiate Kaikaku is an important question that can be influenced by the companies' business environments, strategies, available resources, timing of new product introduction to the market, timing of renovation or relocation of the factories, etc. However, the research does not deal with the question of when to initiate Kaikaku in detail, because that question is more related to strategic decision making rather than how to realize Kaikaku.

In order to achieve fast-pace improvement in production, it is critical to combine Kaizen and Kaikaku in an effective way so that they strengthen each other (Boer and Gertsen, 2003). It is an important question how production functions can establish organization structures and procedures that enable combining Kaizen and Kaikaku effectively. However, the research does not deal with this question because the main focus of the research is on Kaikaku itself.

A production system can be associated with different system levels, for instance a factory, a part of a factory such as a production cell or line, or a group of factories connected through supply chains. In this thesis, a production system generally corresponds to a factory. Therefore, the research presented has its focus on Kaikaku at the factory level.

Major improvements of performance measures in production may be achieved by changing things outside of the production system. For instance, changing product structures into more modularized ones may significantly impact on the performance in production (Karlsson, 2002). Radical improvement in production by changing things outside of the production system is critically important for manufacturing companies. However, the present research focuses on possible changes in productions systems including the interfaces between those systems and their external systems.

## 1.6 Outline of the thesis

This thesis consists of six chapters. The second chapter introduces definitions of the terms used in this thesis and also theories on which the present research is based. The third chapter describes and discusses the research methodology employed in the research. In the fourth chapter, the empirical evidence collected during the research is presented. In the fifth chapter, the collected evidence is analysed in order to fulfil the objective of the research. Finally, in the sixth chapter, discussions and conclusions are presented.

# CHAPTER 2 – Theoretical background

*During the research presented in this thesis, it became evident that the term Kaikaku is described differently in books and articles as well as by researchers and practitioners with whom the author of this thesis discussed Kaikaku during the research. This chapter presents definitions of the terms used in this thesis and also theories that the current research is based upon. The term production system is defined, then the Kaikaku concept is introduced based on the literature. Challenges in the research of Kaikaku are addressed, and theories related to the addressed challenges are introduced and discussed. Finally, a summary of the chapter is made.*

## 2.1 Production system

In the research on production, activities of making products are often described from a system perspective. In this section, the terms production and production system are defined.

A literal meaning of the word production is "the action of making or manufacturing from components or raw materials" (Oxford, 2003). The International Academy of Production Engineering (CIRP) provides a more specific definition of production: "the act of physically making a product from its material constituents, as distinct from designing the product, planning and controlling its production, assuring its quality" (CIRP, 2004). CIRP further defines the term manufacturing as "all functions and activities directly contributing to the making of goods" (CIRP, 2004). Manufacturing in this definition includes a broader scope of activities than production, such as product development. However, in practice, researchers and practitioners frequently use manufacturing and production as synonyms, or manufacturing to mean a subset of production or vice versa. In this thesis, production and manufacturing are considered synonyms and the definition of production proposed by CIRP (2004) is applied to these terms.

Production is often viewed as a complex activity involving various elements such as materials, machines, humans, methods, and information. These elements need to be organized so that production generates desired outcomes. In a large-scale improvement in production, changes can be made in any elements of production and their interrelations. Furthermore, changes can be made in any support activities for production, for instance production planning and control, quality assurance, maintenance of machines, improvement of operations, labour management, etc. A holistic perspective is necessary to analyse and organize production and its related activities. In the research on production, a system perspective is frequently applied for this purpose. A system is a collection of elements which are interrelated in an organized way and work together towards the accomplishment of a certain logical and purposeful end (Wu, 1994). Based on the need of considering not only the actual act of producing but also other activities that support production, a production system is defined as follows:

> *A production system is a collection of facilities, humans, and information that are interrelated in an organized way and work together to make products from their material constituents.*

In this definition, a production system includes any activities and facilities directly or indirectly needed to make products from raw materials. As mentioned in Chapter 1, in this thesis a production system corresponds to a production plant.

A production system can be described in different ways depending on the perspectives of observers. Three system aspects are frequently considered when describing a production system, namely functional, structural, and hierarchical aspects. In the functional aspect, a system has its function of transforming certain inputs into outputs. In the structural aspect, a system consists of a set of elements interlinked by relationships. In the hierarchical aspect, a system includes one or more subsystems and is part of a more comprehensive system called a super system (Seliger et al., 1987). In the literature on production, various models of a production system have been presented (e.g. Hubka and Eder, 1988; Rösiö, 2012). In this thesis, a production system is understood based on the model presented by Hubka and Eder (1988) (see Figure 2.1). Hubka and Eder (1988) identify four subsystems that affect a transformation process from raw materials to products: human, technical, information, and management systems. In this thesis, these four subsystems are understood as follows:

- Human system: humans who exert any effect on the transformation process, for instance shop-floor workers, supervisors, engineers, administrators, and higher management.
- Technical system: artifacts that exert effects on the transformation systems, for example tools, jigs, machines, workbenches, and computers.
- Information system: data, programs, knowledge, etc. that are used in the production system.

- Management system: a system that acts indirectly to drive the transformation process. It provides coordinated direction of the production system to achieve a desired end.

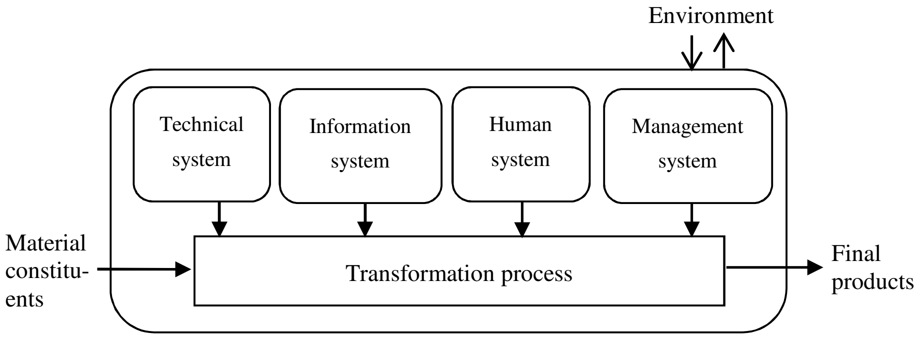



**Figure 2.1:** Description of a production system based on Hubka and Eder (1988).

Although not described in Figure 2.1, these four subsystems are interrelated to each other. Further, a production system is an open system that affects or is affected by its environment, for instance its climate and geography or the business systems of the company.

A production system is also a socio-technical system. A part of the system is a society that consists of humans or groups of humans recognized by common occupations and purposes, and organizations within which these humans act (Hubka and Eder, 1988). The other part of the system is a collection of artifacts created based on technology. In this thesis, it is considered that the technical system and the transformation process shown in Figure 2.1 are related to the technical part of the production system, the human and the management systems are related to the social part, and the information system is related to both parts.

The word *process* can be defined in this subsection. A process is a set of logically related tasks performed to achieve a definite outcome (Davenport and Short, 1990). A process can be large or small. A process can be the entire set of activities intended to make a product from its materials or a single administration or production process, for instance receiving an order forecast from a customer or fitting two parts together in an assembly operation.

## 2.2 Kaikaku

In this section the concept of Kaikaku and theories related to Kaikaku are introduced mostly based on the literature.

## 2.2.1 Definition of Kaikaku

A literal meaning of the Japanese word Kaikaku is reformation, drastic change, or radical change. In Japan the word is used in various settings. For instance in a political setting, terms such as gyosei-kaikaku (administrative reform), seiji-kaikaku (political reform), and zeisei-kaikaku (fiscal reform) can be frequently found in newspapers. In the industrial production setting, Japanese manufacturing companies use the word when they take more radical approaches to improvement in production than Kaizen. Kaizen is a well-known term and is generally defined as incremental and continuous improvement (e.g. Imai, 1986). In books and articles, Kaikaku is often described in contrast to Kaizen. For instance, Imai (1986) states that Kaizen strategy maintains and improves working standard through small and gradual improvements, while Kaikaku calls for radical improvements as a result of large investments in technology and/or equipment. Kondou (2003) describes that Kaizen is a process for improving existing operations by applying conservative changes, while Kaikaku is a process to attain dramatic results by replacing existing practices with new ones. Womack and Jones (1996) and Liker (2004) refer to Kaikaku as radical improvement and Kaizen as incremental continuous improvement. At a general level Kaikaku seems to be commonly understood as a radical approach to improvement. However, at a more detail level, Kaikaku is explained differently among researchers and practitioners. Examples of different explanations of Kaikaku found in the literature are shown in Table 2.1

**Table 2.1:** Different explanations of the Kaikaku concept

| Authors | Description of Kaikaku |
|---|---|
| Imai (1986) | A technology-driven abrupt change conducted by a small number of champions. |
| Wakamatsu and Kondou (2003) | An accumulation of daily Kaizen leads to Kaikaku. Kaizen is a means of Kaikaku. |
| Ikaida (2007) | An accumulation of numerous improvement activities. A varied and wide-ranging activity. Needs to be implanted into everyone as a DNA. |
| Womack and Jones (1996) | Radical activity to eliminate waste. Transforming batch production to flow production. |
| Uno (2004) | Fundamental change towards the ideal state, discarding the conventional way. |
| Shibata and Kaneda (2001) | System improvement where a new working method is introduced. |
| Kondou (2003) | A process to attain dramatic results by replacing existing practices with new ones. Important to obtain new knowledge as well as to acquire new methodologies that are externally available. |
| Bodek (2004) | Kaikaku is an equivalent term to “Kaizen Blitz”, which is |

| | |
|---|---|
| | an improvement in a specific area with the aim of delivering a large gain in a short period of time. |

For instance, while Imai (1986) associates Kaikaku with a technology-driven change, Ikaida (2007) describes Kaikaku as a varied and wide-ranging activity. Further, Imai (1986) describes that the change in Kaikaku occurs abruptly, whereas some other authors express that Kaikaku is achieved in a more gradual manner. For example, Wakamatsu and Kondou (2003) say that Kaikaku is achieved through exhaustive execution of Kaizen. Norman (2004) mentions that Kaikaku is more commonly referred to as “Kaizen Blitz” in the USA. Kaizen Blitz is an intensive improvement event within a limited period of time ranging from a few days to a few months. It is driven by a small group of people, and it focuses on a limited area in operations (Bicheno, 2004).

Another approach to understanding the concept of Kaikaku is to analyse how companies actually use the word. During the research presented in this thesis, a study was conducted that included an analysis of 65 case reports describing radical improvement activities in production at Japanese manufacturing companies.[1] The companies called the activities Kaikaku or Kakushin.[2] The analysis was helpful to understand what kind of activities the companies refer to as Kaikaku. General characteristics of Kaikaku in the reports are summarized in Table 2.2. In the table, these characteristics are compared with those of Kaizen found in the literature.

**Table 2.2:** General characteristics of Kaikaku realized in the Japanese companies in the reports compared with characteristics of Kaizen found in the literature

| **General characteristics of Kaikaku realized in the Japanese companies** | **Characteristics of Kaizen in the existing literature** |
|---|---|
| Fundamental change aiming to achieve radical improvements in operational performance | Incremental and small-step changes |
| Large-scale and wide-ranging activity | Small-scale and narrowly-focused activity |
| Deliberate activity initiated from top or senior management | Autonomy-encouraged activity |
| Discrete effort which has a definite period of time | Continuous effort |
| Involving stretched target setting | Ongoing and incremental targets |

Kaikaku at the mentioned Japanese companies generally intended fundamental reconsideration of the existing production systems including the pro-

[1] The study was not conducted to define Kaikaku but had another purpose. However, the data obtained from the study are useful when discussing the definition of Kaikaku here. The study is a part of the research presented in this thesis and will be explained further in Chapter 3.
[2] Kakushin means innovation in Japanese. Since Kaikaku and Kakushin are frequently used as synonyms at Japanese companies, in this thesis these words are considered equivalent and only Kaikaku is used.

duction processes and facilities as well as the mindset and behaviour in the organizations, aiming at achieving drastic improvements in performance measures in production. Kaizen usually involves small-step and incremental changes based on the existing ways of handling production (Brunet and New, 2003). Kaizen can also bring about fundamental changes when accumulated over time (Orlikowski, 1996). However, it is more often considered as an opportunity rather than a necessity.

Kaikaku in the reports tends to entail large-scale changes involving wide-ranging activities. Changes were made in, for instance, production processes, pieces of production equipment, culture in organizations, manufacturing strategies, leadership styles, information systems, and management processes. In some cases, the scope of the change was not only the production systems but also all production functions or the whole company. In the reports Kaikaku often involved implementation of lean production. It has been recognized that an implementation of lean production often brings about a paradigm shift of the company towards a lean enterprise (e.g. Iwaki, 2005; Smeds, 1994). In contrast, Kaizen usually focuses on a narrowly defined area of a system, for instance a production cell or a part of a production line.

As mentioned previously, some researchers and practitioners consider that Kaikaku and Kaizen Blitz are synonymous. However, due to the large-scale change nature of Kaikaku, Kaikaku is distinguished from Kaizen Blitz in this thesis.

In the reports, Kaikaku was a deliberate effort initiated by top and senior management and required a strong direction from the management. Since Kaikaku often changed the processes that involved different groups, divisions, or departments in the organizations, coordination and direction from the high-level management were needed. Kaikaku can be characterized as a top-down approach, but this does not necessarily mean that changes are never collaborative and participative. In the reports, many of the Kaikaku efforts were initiated by the management, but actual changes were driven by employees at lower levels of the organization. In the literature on Kaizen, the concept is frequently considered as a bottom-up approach. Kaizen is often encouraged by management but individual Kaizen activities are often conducted autonomously and in a less coordinated manner between improvement groups (Berger, 1997).

Kaikaku was a discrete effort that had a definite time period with specific targets to be achieved at the end of the period. Therefore, Kaikaku was typically seen as a large project or an initiative (in the following the word initiative is mostly used). A Kaikaku initiative often contained smaller projects conducted at different points of time during the overall initiative. The time frames of the Kaikaku initiatives ranged from a few months to a few years. On the other hand, Kaizen is normally seen as a continuous effort, which indicates the embedded nature of the practice in a never-ending journey towards quality and efficiency (Brunet and New, 2003).

Kaikaku activities often included significantly stretched targets, for instance, halving production lead time, doubling productivity, reducing the area of shop floor used for production to half its size, etc. Such stretched targets were usually set by the management in order to provoke people in the organization to question the current state of the operations and the shared mindsets and behaviours. In Kaizen, targets are often ongoing and incremental. They are often incorporated into monthly or yearly quality and productivity targets (Imai, 1986).

The general characteristics of Kaikaku described above resemble those of *business process reengineering*, alternatively called *process innovation.* In this thesis, these terms are considered synonyms and process innovation is used throughout. Process innovation is an improvement activity focusing on various business processes in an organization, for example processes in product development, production, customer acquisition, logistics, management, and planning. Process innovation typically focuses on large processes that range across more than one group, division, or department and aims to fundamentally rethink and dramatically improve existing processes (e.g. Davenport, 1993; Hammer and Champy, 1993). Process innovation became a popular theme of research in the early 1990s. Since then, a large amount of research has been undertaken. Earlier approaches to process innovation had an information-technology focus, developed from a mechanistic view of the organization, or promised multiplicative improvement such as improvement by a factor of ten (Herzog et al., 2009). Later, approaches to process innovation have evolved and become more holistic (Speier et al., 1998). The focus in process innovation has been directed not only towards information technology but towards any technological and organizational enablers of changes. A more organic view of organization, which is often emphasized in the theories of change management and organizational learning, has been applied to process innovation. The radical tone of process innovation has also been somewhat tempered (Guha et al., 1997).

In the literature on process innovation, a number of articles and books discuss the nature of process innovation and propose definitions of it (e.g. Davenport, 1993; Hammer and Champy, 1993; Harrington, 1995). The nature of process innovation frequently mentioned in the literature is radical improvement, fundamental rethinking of the existing way of working, large-scale change, and cultural and structural change, which is essentially similar to the characteristics of Kaikaku described above. Therefore, in this thesis, Kaikaku is considered equivalent to process innovation in production. Here, Kaikaku is defined based on one of the most widely accepted definitions of process innovation proposed by Hammer and Champy (1993):

*Kaikaku is a large-scale improvement that involves fundamental rethinking and radical design of systems and processes related to production, with the primary purpose of achieving dramatic improvements in the performance of the production system which is frequently measured in terms of cost, quality, speed, and flexibility.*

One of the reasons why the term Kaikaku is still used is briefly mentioned in Chapter 1. The reasons will be explained further in Section 2.3. In the above definition, the main purpose of Kaikaku is to improve the performance of a production system. However, the scope of change in Kaikaku is not limited to the production system. It can include changes in any processes or systems related to production, for instance processes between sales and production and corporate management processes. The definition implies that Kaikaku is a radical measure, but it does not necessarily mean one big jump. It can also be a result of many smaller changes that are undertaken in concert and reinforce each other towards a radically new form (Smeds, 2001). New process design change may be radical but its implementation may be more incremental (Andreu et al., 1997; Stoddard et al., 1996).

### 2.2.2 Process of Kaikaku

Due to the equivalence of Kaikaku to process innovation, the theoretical basis of Kaikaku resides in the theories of process innovation. In the literature on process innovation, various methodologies have been developed and proposed (e.g. Coulson-Thomas, 1994; Davenport, 1993; Guha et al., 1993; Harrington, 1991). Those methodologies often include or are represented by a high-level process that covers a life cycle of process innovation. A process is normally divided into several phases and steps, each of which comprises activities, methods, tools, and important factors that a methodology recommends to undertake, use, or consider. A number of high-level processes of process innovation have been presented in the literature, and there are even reviews of those processes (e.g. Al-Mashari and Zairi, 2000; Motwani et al., 1998). Each of the high-level processes differs in the number of phases and steps and activities within those phases and steps. However, at a general level, these processes are similar and commonly include preparation, redesign, and implementation stages as presented in Figure 2.2. In this thesis, the process of Kaikaku is considered as the one shown in Figure 2.2.

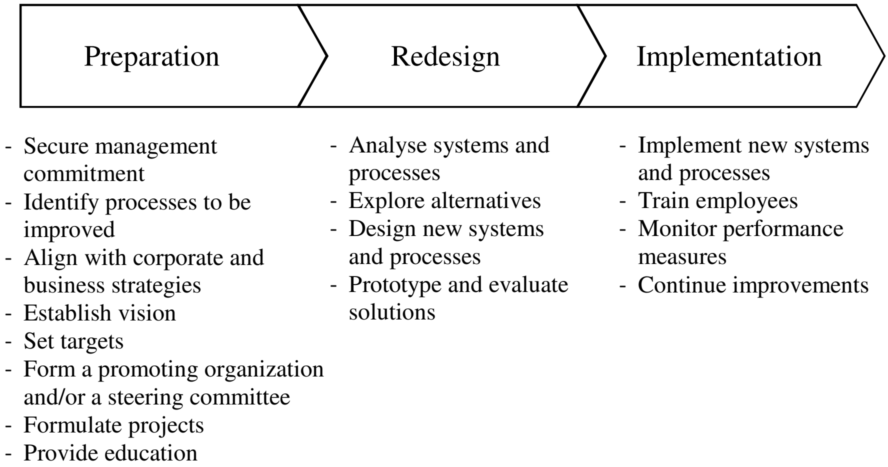



**Figure 2.2:** A high-level process of Kaikaku.

As mentioned earlier, Kaikaku usually includes smaller projects which are executed at different points of time during Kaikaku. Each smaller project also includes the three stages in Figure 2.2 on a smaller scale.

For more specific kinds of Kaikaku, for instance an organization-wide implementation of lean production or Six Sigma, researchers and practitioners have developed step-by-step approaches to the implementation. For example, Magnusson et al. (2003) proposed a 12-step Six Sigma deployment model. These steps are grouped into four stages referred to as getting started, education, measurement, and improvement. Womack and Jones (1996) suggested a framework of implementation of lean production that includes four phases called get started, create a new organization, install business systems, and complete the transformation. Each of these phases contains a number of specific steps.

The above-mentioned methodologies of process innovation and the step-by-step approaches to the organization-wide improvement initiatives provide structures to radical improvement activities. On the other hand, the normative perspectives in those methodologies and approaches seem to be based on the assumption that a change can be managed and controlled through well-thought-out and analytical-driven planning exercises. Such approaches to Kaikaku are called deliberate approaches (Mintzberg, 1987). There are criticisms to the deliberate approach. For instance, too much focus on planning makes a process more rigid and thus less flexible to deal with contingencies (Hines et al., 2004). Mindset and behaviour changes cannot be managed or controlled and rarely follow a plan (Balogun and Hope Hailey, 2008; Drew et al., 2004). Domination of plan and control leaves little room for employees to learn and exert their creativity (Edmondson, 2008). Researchers who address the risk of too much reliance on the deliberate approach often advocate the so-called deliberate-emergent approach (Mintzberg, 1987; Riis et al., 2001; Smeds, 1994; 1997). Kaikaku is essentially a deliberate effort, since it is a large-scale improvement that requires initiation from top or senior management. However, in a deliberate-emergent approach, even though Kaikaku initiatives are initiated and their targets are set by the management, how to achieve the targets is largely left to employees to discover through experiments and learning. Edmondson (2008) highlights the benefits of the deliberate-emergent approach by comparing it with the deliberate approach (see Table 2.3. In her article, the deliberate-emergent and the deliberate approach are termed "execution as learning" and "execution as efficiency", respectively.)

**Table 2.3:** Comparison of two types of execution (Edmondson, 2008)

| **Execution as efficiency (deliberate approach)** | **Execution as learning (deliberate-emergent approach)** |
|---|---|
| Leaders provide answers. | Leaders set direction and articulate the mission. |
| Employees follow directions. | Employees (usually in teams) discover answers. |
| Optimal work processes are designed and set up in advance. | Tentative work processes are set up as a starting point. |
| New work processes are developed infrequently; implementing change is a huge undertaking. | Work processes keep developing; small changes, experiments, and improvements are a way of life. |
| Feedback is typically one-way (from boss to employee) and corrective. | Feedback is typically one-way (from boss to employee) and corrective. |
| Problem-solving is rarely required; judgment is not expected; employees ask managers when they are unsure. | Problem-solving is constantly needed, so valuable information is provided to guide employees' judgments. |

The deliberate-emergent approach has also its drawbacks. A change process can be less systematic, linear, and controllable. The benefit of the approach is largely intangible and therefore hard to evaluate with traditional calculation methods such as return on investment. The deliberate and deliberate-emergent approaches in Table 2.3 can be considered opposite ends of a spectrum with an infinite range of options in between. In reality, Kaikaku initiatives include both approaches with a different degree of emphasis.

## 2.2.3 Success factors for Kaikaku

A number of researchers and practitioners have presented and discussed various factors for successful implementation of Kaikaku which are typically identified through interviews, surveys, observations, and literature reviews (Coulson-Thomas, 1994; Guimaraes and Bond, 1996; Herzog et al., 2007; Jarrar and Aspinwall, 1999; Paper and Chang, 2005). It seems that there is no significant difference among the articles and books about the success factors for Kaikaku. Typical factors are, for instance, top management's involvement and commitment to success, clear articulation of visions and goals, alignment with strategies, formulation of project organization, information sharing, and acknowledgement of the importance of human and organizational enablers. Table 2.4 lists success factors frequently mentioned in the literature.

**Table 2.4:** Success factors for Kaikaku frequently mentioned in the literature

| |
|---|
| Top management's commitment to project success |
| Initiation, leadership, and support from top- and senior-level management |
| Motivation by customer demands and competitive pressures |
| Alignment with strategy |
| Clear articulation of visions and goals |
| Focus on a few critical processes |
| Development of a defined project organization |
| Formulation of cross-functional team |
| Information sharing and continuous communication |
| Resources for education and training |
| Performance measurement and continuous monitoring |
| Middle management's "buy-in" |
| Ownership and empowerment of employees |

The high-level process of Kaikaku and the success factors mentioned in the previous and current subsections imply that different kinds of *levers* can be recognized in Kaikaku. Here, levers denote means that drive Kaikaku towards its desired end. Some levers are related to strategic issues, for instance aligning Kaikaku with the company's strategies. Some other levers are related to organization or team structures. In this thesis, six kinds of levers are recognized as described below. These levers have often appeared in various process-innovation methodologies or frameworks suggested by practitioners and researchers (Al-Mashari and Zairi, 2000; Jarrar and Aspinwall, 1999; Motwani et al., 1998; Paper and Chang, 2005; Valiris and Glykas, 1999).

- Strategic levers: means that are of a strategic nature and often delivered at a strategic level of the organization, such as goals, visions, management's commitment, etc.
- Technological levers: technological means used to achieve a desired end in Kaikaku.
- Process levers: means related to how to process Kaikaku. A process lever can be a high-level process such as that shown in Figure 2.2, or a process of a more specific activity.

- Structural levers: means related to organizational structures and formulation of teams and groups.
- Cultural and human levers: means related to organizational cultures, knowledge, skills, and motivation of people in the organization.
- Method and tool levers: problem-solving or opportunity-finding methods, techniques, and tools used to achieve a desired end in Kaikaku.

### 2.2.4 When to initiate Kaikaku

As mentioned in the first chapter, the topic of when to start Kaikaku is not within the scope of the current research. However, a discussion of the topic is still important to understand the concept of Kaikaku.

In the literature on Kaikaku, it is frequently mentioned that Kaikaku should be initiated only when there is an explicit need for fundamental rethinking of the current way of working, or when necessary changes are hard to be achieved through Kaizen. Since the risks of Kaikaku are usually larger than those of Kaizen in environments in which companies are not under severe competition or in which their basic business practices are not in question, companies should better avoid undertaking such a radical approach to improvement (Davenport, 1993). A company could achieve its goals through Kaizen, but when the pace of change is too slow, the company may have no choice but to resort to drastic changes or reform (Stewart and Raman, 2007). When the progress of Kaizen begins to stagnate or when the need for improvement surpasses the scope of a gradual improvement, a radical improvement can be introduced (Lee and Asllani, 1997).

Kaikaku can be initiated as a reaction to an existing situation that a company must deal with immediately, such as an economic crisis of a company. However, it can be introduced proactively by anticipating, for example, market trends, the competitive position of the company, or emerging technologies in the future. Researchers and practitioners commonly emphasize the importance of a proactive approach to Kaikaku (e.g. Hammer and Champy, 1993; Terziovski et al., 2003).

Exactly when to initiate Kaikaku and how quickly it needs to be realized should be determined in a strategic context (e.g. Balogun and Hope Hailey, 2008; Davenport, 1993). Various external and internal factors of a company can affect the decision of when to initiate Kaikaku. Examples of external factors are market trends, requirements from customers, movements of competitors, and availability of new technologies or new production methods. Internal factors are, for instance, the financial situation of the company, the company's business and production strategies, performance of the current production system, speed of improvement in production, the organization's readiness for change, plans for introducing new products, and plans for relocation or renovation of factories.

Perhaps due to the fact that a variety of factors affect the decision on when to initiate Kaikaku, only a few analytical methods have been developed that help to estimate the optimal point at which Kaikaku should be initiated (Lee and Asllani, 1997). It seems that the decision of when to initiate Kaikaku still largely resides in the subjective judgment of senior-level management based on various quantitative or qualitative information.

### 2.2.5 Kaikaku, innovation, and uniqueness

Kaikaku is closely related to the words innovation and innovativeness. The relation can be defined here. In the literature on innovation, it is widely accepted that innovation is the implementation of new and valuable ideas, large or small, that have the potential to contribute to organizational objectives (Schroeder et al., 1989). It is also broadly accepted that innovation can be classified into two levels in the dimension of novelty in changes, namely incremental and radical innovation. Incremental innovation involves modification, extension, or reinforcement of existing processes and systems without changing their essential concept (Dewar and Dutton, 1986). Radical innovation, which can be labelled in several other ways such as discontinuous, disruptive, or breakthrough innovation, is a fundamental change and involves development of new processes and systems that are distinctly different from the existing ones (Dewar and Dutton, 1986). In addition to the binary classification of innovation, Tidd et al. (2005) and Kleinschmidt and Cooper (1991) have further classified radical innovation into two levels, moderate and radical innovation. According to these authors, moderate innovation involves the generation of outcomes that are new to the specific company but not new to the industry (more specifically, to a certain sector of the manufacturing industry such as automobile, telecommunication, etc.), while radical innovation relates to the generation of outcomes that are new to the industry, in other words, new to the state of the art. In this thesis, the classification of moderate and radical innovation is adopted. However, the term moderate innovation is referred to as “local innovation” in this thesis in order to emphasize the point that the novelty in this type of innovation is limited to a specific company. Further, in this thesis, innovativeness is generally related to the technical part of a production system and not to the social part.

Innovation and innovativeness as discussed above can be related to Kaizen and Kaikaku as shown in Table 2.5. Innovation discussed here involves two dimensions: scale (large or small) and innovativeness (incremental, local, or radical). Kaizen corresponds to small-scale incremental innovation.[3] Kaikaku is related to large-scale innovation, and in this thesis two kinds of

[3] Large-scale incremental innovation may also be called Kaizen or alternatively total quality management, TQM. However, in this thesis no particular name is given to this kind of innovation.

Kaikaku are distinguished which are called locally and radically innovative Kaikaku. Locally innovative Kaikaku occurs when Kaikaku largely involves adoption of solutions that are new to the specific company but not new to the industry, while radically innovative Kaikaku occurs when Kaikaku largely involves development and/or adoption of solutions that are not only novel to the specific company but also new to the industry.

**Table 2.5:** Relation of innovation and Kaikaku

| | Incremental innovation | Local innovation | Radical innovation |
|---|---|---|---|
| Small scale | Kaizen | Small-scale local innovation | Small-scale radical innovation |
| Large scale | Large-scale incremental innovation | Locally innovative Kaikaku | Radically innovative Kaikaku |

In Chapter 1 the word *unique* is given a more specific meaning than the one that can be found in a dictionary, “existing as the only one or as the sole example” (Oxford, 2003). As mentioned in the same chapter, unique in this thesis connotes being valuable for the company’s competitiveness, rare among the competitors, difficult for the competitors to imitate, and difficult for them to substitute (Barney, 1991). This definition of unique is made based on the literature on general management, especially the resource-based view of companies. In the literature, researchers commonly agree that unique company resources[4] are vital sources for gaining sustained competitive advantages (Barney, 1991; Gagnon, 1999; Hayes and Pisano, 1994; Teece et al., 1997).

A production system can be seen as one of a company’s resources. A unique production systems means that the technical and/or social part of the system is unique. In this thesis, the social part being unique is equivalent to the organization possessing unique capabilities for performing certain tasks.

The relation between innovation and uniqueness can be considered. These two terms are closely related but are not equivalent. Innovative solutions are not necessarily unique. Results of local innovation can be valuable but may not be rare. Results of radical innovation can be valuable and rare but may be imitable or substitutable by competitors.

### 2.2.6 Four types of Kaikaku

As a concluding section of introducing the concept of Kaikaku, a model of four types of Kaikaku developed in the present research will be introduced. The current section has revealed that Kaikaku involves a variety and a wide range of activities, from local to radical innovation, from technological to

[4] Company resources are generally defined as anything that the company owns (Barney, 1991). More detailed definition of the term resource is presented in Subsection 2.5.2.

cultural changes, and from abrupt to gradual changes. This variety seems to lie behind the various descriptions of Kaikaku as presented in Table 2.1. In order to understand the concept of Kaikaku in a more structured way, a model that classifies Kaikaku into four types was developed. The model is presented below. How the model was developed as well as discussions on the model are presented in Appended paper A.

The model is shown in Figure 2.3. The horizontal axis of the model represents the classification of Kaikaku in terms of innovativeness of change in Kaikaku. As mentioned in the previous subsection, two kinds of Kaikaku are defined in this dimension, locally and radically innovative Kaikaku.

The vertical axis of the model represents the classification of Kaikaku in terms of subject of change. Based on the structural and infrastructural groups of the manufacturing decision categories proposed by Wheelwright (1984), two kinds of Kaikaku are defined below.

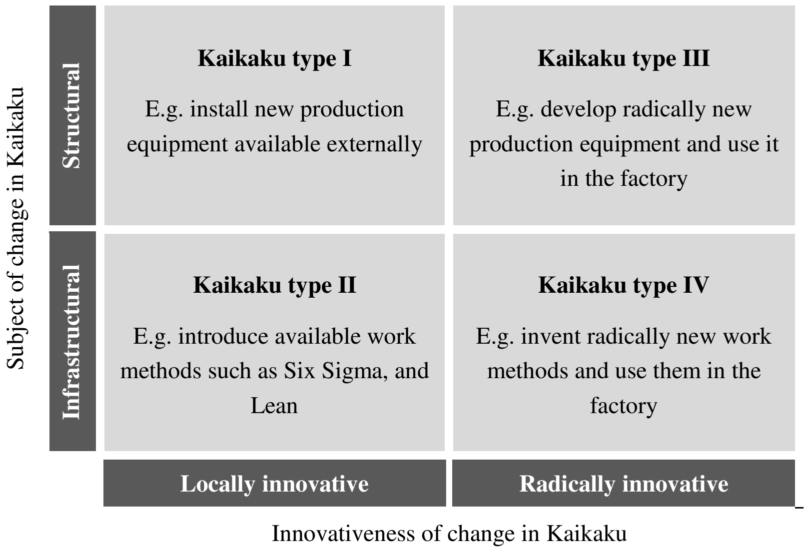



**Figure 2.3:** A model of four types of Kaikaku.

*Structural*: Basic changes take place mainly in the structural area shown in Table 2.6. This kind of change tends to require substantial capital investment when altered, is often difficult to reverse or undo once it is in place, and thus tends to have a long-term impact. It is often carefully planned by a limited number of people, such as strategic planners or production engineers.

*Infrastructural*: Basic changes take place mainly in the infrastructural area shown in Table 2.6. Such changes do not tend to require a large capital investment at a single point of time. Instead, they tend to require continuous and consistent efforts, and a cumulative impact of on-going efforts leads to realizing a major change. This type of Kaikaku is more "soft-oriented" since it often involves basic changes in the way of working. Employees' active involvement and consistency in the patterns of their conduct are considered important.

**Table 2.6:** Subject of change in the structural and infrastructural areas

**Structural area**

- Production capacity – volume per year
- Plant network design – size, location, focus
- Production technology – equipment, automation level
- Vertical integration – direction, extent

**Infrastructural area**

- Human resources – pay system, evaluation system
- Production planning/control – inventory, order system, batch size
- Quality control – defect prevention, monitoring
- Cost control – cost accounting, cost planning
- Material control – flow, layout
- Maintenance – routines, monitoring
- Organization – structure, culture

Four types of Kaikaku are defined below. Industrial examples of each type of Kaikaku are also presented.

*Kaikaku type I (structural – locally innovative)*: The primary intention of this type of Kaikaku is to introduce basic changes in the structural area. This type is mostly achieved by importing solutions externally available.

Many industrial examples of this type of Kaikaku can be found in the literature. For example, Schroeder and Congden (1995) describe cases of radical improvements at several foundries where drastic improvements in production capacities were achieved by purchasing and installing off-the-shelf automatic molding machines.

*Kaikaku type II (infrastructural – locally innovative)*: This type of Kaikaku intends to introduce fundamental changes in the infrastructural area. This type is realized mostly by importing solutions externally available.

Many lean transformation projects often fall into this type. In those transformations, radical improvements in the production lead time were achieved by fundamental changes in, for example, production flows, production control systems, and organization structures and cultures.

*Kaikaku type III (structural – radically innovative)*: This type of Kaikaku introduces basic changes in the structural area and largely involves development and implementation of radically innovative solutions.

An example of this type of Kaikaku in industry is Kaikaku at the Takaoka plant in Toyota described by Stewart and Raman (2007). Toyota introduced a number of new-to-the-industry pieces of equipment to the plant, such as compact dies for the plastic injection molding and slim industrial robots for the spot welding assembly. These pieces of equipment contributed to a 50 per cent reduction in production lead times and the length of production lines (Stewart and Raman, 2007).

*Kaikaku type IV (infrastructural – locally innovative)*: This type of Kaikaku mostly involves basic changes in the structural area and development and implementation of radically new solutions.

An industrial example of this type of Kaikaku is the trolley-pull production created at Ricoh United (Tanaka, 2005). This manufacturer changed from a conveyer line to a unique production line consisting of connected trolleys pulled by an electric motor. This enabled the line length to be synchronized with the production volume. As a result of this new system, lead time and in-process stock were reduced by 80 per cent.

It should be noted that the classification of Kaikaku presented above is only conceptual. In reality a Kaikaku initiative can be related to more than one type of Kaikaku. Locally and radically innovative Kaikaku can be considered as two ends of a continuum. A Kaikaku initiative can be placed somewhere in between these two ends.

The model can explain the various descriptions of Kaikaku shown in Table 2.1. As mentioned previously, Imai (1986) says that Kaikaku is a technology-oriented and abrupt change conducted by a small number of champions, while Wakamatsu and Kondo (2003) argue that Kaikaku is an accumulation of exhaustive executions of Kaizen. By using the model, it can be explained that Imai (1986) refers to Kaikaku in the structural area, while Wakamatsu and Kondo (2003) refer to Kaikaku in the infrastructural area.

## 2.3 Challenges in the research on Kaikaku

In the previous section, the concept of Kaikaku was introduced. Kaikaku is not a new area of research. On the contrary, Kaikaku corresponds to process innovation in production, and a large amount of research has been conducted in the area of process innovation. As Motwani et al. (1998) summarized based on the literature review of 133 articles on process innovation, one of the mainstreams of the research is to describe the nature of process innovation and provide definitions of it (e.g. Davenport, 1993; Hammer and Champy, 1993; Harrington, 1995). Another stream is to provide normative proposals for, for instance, success factors for implementation of process innovation (Coulson-Thomas, 1994; Guimaraes and Bond, 1996; Herzog et al., 2007; Jarrar and Aspinwall, 1999; Paper and Chang, 2005). Still another stream is to develop conceptual models or methodologies to support process innovation (e.g. Coulson-Thomas, 1994; Davenport, 1993; Guha et al., 1993;

Harrington, 1991). For more specific kinds of Kaikaku, for instance implementation of organization-wide improvement initiatives such as lean production and Six Sigma, a large number of books, articles, and consultancy materials have been published or made to support the implementation (e.g. Bicheno, 2004; Drew et al., 2004; Iwaki, 2005; Magnusson et al., 2003; Womack and Jones, 1996).

A large part of the above-mentioned works has been devoted to analysing, structuring, and proposing how to successfully manage large-scale and radical changes in a structured way. Kaikaku needs structure considering that it involves complex changes not only in a technical dimension but also in organizational, human, and strategic dimensions. Kaikaku often requires a large amount of investment, which motivates managers to minimize the risk of failure. The research on Kaikaku seems to have made significant contributions to providing structures for planning and execution activities in Kaikaku. Consequently, there seems to be little room left for studying how to manage changes in Kaikaku in a systematic way.

On the other hand, as mentioned in Chapter 1, in the light of how Kaikaku can contribute to creating unique production systems, there can be more opportunities to study Kaikaku. This has led to formulating the two research questions (RQ 1 and 2). RQ 1 is about how to realize Kaikaku so that it can generate more radically innovate solutions that make the technical part of the production system more unique. RQ 2 is about how to realize Kaikaku to enhance innovation capabilities, which contributes to making the social part of the system more unique. The theoretical foundations related to RQ 1 and RQ 2 are presented in the next section and the subsequent section, respectively.

Further, in the first chapter it was mentioned that the term Kaikaku is used instead of process innovation in order to emphasize the potential of Kaikaku to contribute to creating unique production systems. Another reason for using the term is that Japanese companies are generally known for their emphasis on long-term capability building (e.g. Nonaka, 2007), and that there are analyses stating that production systems in Japan are becoming more unique as a result of the companies' explicit efforts to maintain their competitive advantages in production (e.g. Kimura and Takano, 2005).

## 2.4 Kaikaku for higher innovativeness

The Kaikaku process is subject to a range of internal and external factors that affect the likelihood of Kaikaku generating radically innovative solutions. Rothwell (1992) distinguishes what he terms "project-related factors" and "corporate conditions" that set the context in which projects are undertaken. In this section, these two kinds of factors are referred to as Kaikaku process factors and organizational factors, respectively. Here, organizational factors are only limited to those internal to a company. In the following subsections, theories related to organizational and process factors are introduced.

### 2.4.1 Organizational factors

In the research on innovation management, there is a strand of research based on the premise that social practices of people in an organization constitute the basic ingredient of innovation (Prajogo and Ahmed, 2006). The main focus of this strand of research is to identify characteristics of organizations that are conducive to innovation. Various characteristics have been identified in the research. Tidd et al. (2005) have summarized these characteristics and relate them to ten different themes as shown in Table 2.7. The characteristics described by Tidd et al. (2005) are relevant to any type of innovation (incremental, local, or radical innovation). On the other hand, McLaughlin et al. (2008) and Tushman and O'Reilly III (1997) describe characteristics of an organization that are especially related to incremental and radical innovation (see Table 2.8).

**Table 2.7:** Components of the innovative organization (Tidd et al., 2005)

| Component | Key features |
|---|---|
| Shared vision, leadership, and will to innovate | Clearly articulated and shared sense of purpose, strategic intent, top management commitment |
| Appropriate structure | Organization design that enables creativity, learning, and interaction |
| Key individuals | Promoters, champions, gatekeepers, and other roles that energize or facilitate innovation |
| Effective team working | Appropriate use of teams, at local, cross-functional, and inter-organizational level, to solve problems |
| Individual development | Long-term commitment to education and training to ensure a high level of competence and the skills to learn effectively |
| Extensive communication | Within and between the organization and outside. Internally in three directions – upwards, downwards, and laterally |
| High involvement in innovation | Participation in organization-wide continuous improvement activity |
| External focus | Internal and external customer orientation. Extensive networking |
| Creative climate | Positive approach to creative ideas, supported by relevant motivation systems |
| Learning organization | High levels of involvement within and outside the company in proactive experimentation, finding and solving problems, communication and sharing of experiences and knowledge capture and dissemination. |

**Table 2.8:** Characteristics of organizations proficient in incremental and radical innovation, based on McLaughlin et al. (2008)

| Incremental innovation | Radical innovation |
|---|---|
| Formalized | Contingent |
| Centralized | Decentralized |
| Systematic | Loosely structured |
| Efficiency-oriented | Supporting experimentation |
| Homogeneous | Heterogeneous |
| Older and experienced | Younger and entrepreneurial |
| High inertia | Focus on discovery |
| Risk-avoiding | Risk-taking |
| Managing and controlling | Autonomous and high trust |

The above-mentioned innovation research implies that the likelihood of Kaikaku generating radically innovative solutions is higher when the organization is better configured to support radical innovation. Although researchers have identified the characteristics of an innovative organization, these are often derived from the analysis of product or service development organizations. A limited amount of study has been conducted to investigate characteristics of production-related organizations that are supportive to radical innovation.

### 2.4.2 Kaikaku process factors

Principles, methods, techniques, tools, or practices to be adopted in the process of Kaikaku can increase the chance of generating innovation solutions. In the research on process innovation, researchers have identified several practices that contribute to increasing the chance mentioned. Practices frequently mentioned in the literature are setting stretched targets, forming cross-functional teams, analysing and designing processes from a holistic perspective, and designing processes with fewer constraints, a so-called "clean-slate approach" (Davenport, 1993; Hammer and Champy, 1993).

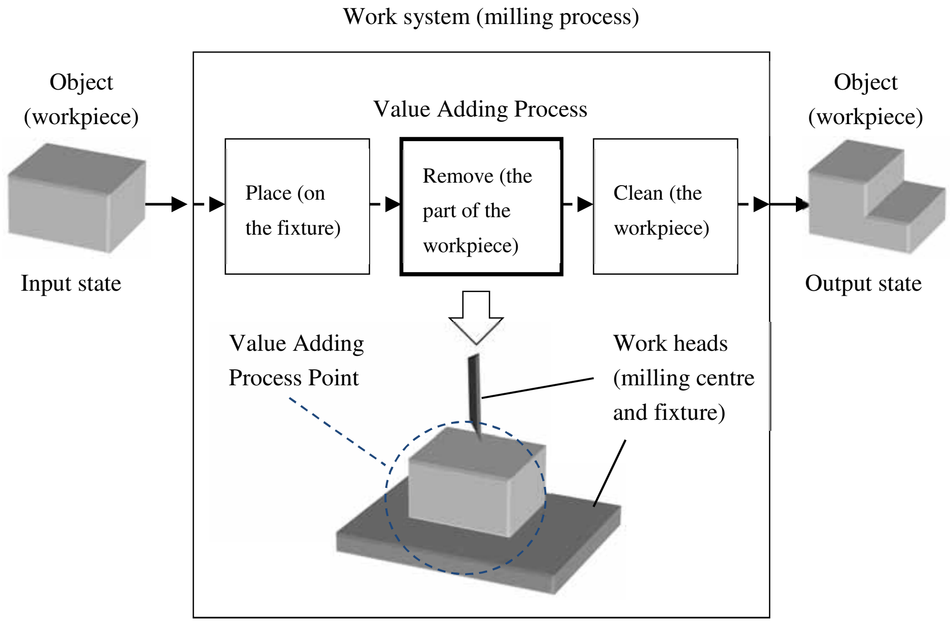
Creativity is an important dimension in large-scale and radical changes (McAdam and McIntyre, 1997). Creativity is a human process that enables a person to think outside the pre-assumed scope of what would be expected (Sundström and Zika-Viktorsson, 2009). Creativity should be distinguished from innovation, because creativity encompasses the creation of new and valuable ideas while innovation is the implementation of them (Couger, 1995). Without creativity being systematically incorporated in thinking patterns of teams and individuals, these tend to retreat to the comfort of incrementalism when encountering the necessity of creating new processes and systems (McAdam, 2003). Kettinger et al. (1997) and Couger et al. (1994) proposed using a variety of creative problem-solving techniques in the process of Kaikaku. Examples of these techniques are brainstorming, force field analysis, nominal group technique, and wishful thinking technique. Too much focus on control, structure, and efficiency in the process of change can affect creativity negatively (Ekvall, 1993). A change process should therefore be flexible and encourage autonomous ways of working with clear accountability for outcomes (Buckler, 1996).

Designing production systems or their subsystems with fewer constraints (a clean-slate approach) is important when seeking unique solutions. Such an approach enables designers to be free from the current solutions and their underlying assumptions and constraints and explore a wider range of alternatives. Various methodologies and methods that have been developed to support design work for production systems or their subsystems can be used to redesign with a clean slate. Examples are production-system design methodologies based on systems theories (e.g. Hubka and Eder, 1988) or axiomatic design theories (e.g. Almström, 2005). To solve more specific design problems in the production system, design methods such as layout design, group technology, and job design, Value Engineering (e.g. Younker, 2003), and Work Systems Design (Nadler, 1967) have been developed in the field of operations management and industrial engineering.

In addition to the above-mentioned practices, approaches, methodologies, and methods, the research presented in this thesis found a particular design method that can contribute to creating unique production lines, cells, and pieces of equipment. The method is used by several Japanese manufacturing companies but is explained only in a few books and articles written in Japanese (Nakamura, 2003; Shinoda and Nakamura, 1996; Shinoda and Niwa, 2000). Consequently the method is rarely known internationally. Since this method was applied in a case study during the present research, the rest of this subsection is devoted to explaining the method and comparing it with other similar design methods. The method particularly focuses on the points where value is added to materials in production processes. The method is called differently in Japan, for instance, *kakouten* (process point) approach or *nomo-koto* (thing-process) analysis. In this thesis, the method is referred to as the Value Adding Process Point (VAPP) approach.

### Basic concept of the VAPP approach

In this thesis, the VAPP approach is explained based on a book written by Nakamura (2003), because it provides the most comprehensive description of the method. A literal meaning of value adding process point is the same as "process point" denoted in a Total Productive Maintenance (TPM) tool, Process Point Analysis (JIPM, 1996): an area or space where a tool contacts a workpiece and transfers force or other kinds of energy to the workpiece in order to transform the workpiece into a desired shape. However, in the VAPP approach, the value adding process point is defined in a more extended way than its literal meaning. In this paper the definition is explained by using a milling process as an example (see Figure 2.4). The VAPP approach is partially based on the systems theory. A certain production process can be seen as a work system whose task is to transform materials, energy, or signals from a certain state (input) into a desired state (output). In the VAPP approach, materials that are to be the whole or parts of the final products are in focus, because value is added to those materials. In the approach these materials are called *objects*. In the example in Figure 2.4, the milling process is considered as a work system whose task is to transform a specific shape of the workpiece (the object) into a desired shape.




*A Value Adding Process Point*: An essential mechanism for realizing the VAP, described by objects, work heads, interactions among the objects and work heads, and conditions for quality conformance at the VAP.

**Figure 2.4:** The basic concept of the VAPP approach, an example of a milling process.

A transformation process from inputs to outputs normally includes more than one partial process. Among the partial processes, there should be one or a few processes that cannot be eliminated regardless of any means to accomplish the task of the work system. In the VAPP approach these ineliminable processes are the ones in which value is added to objects. In the approach these processes are referred to as *Value Adding Processes (VAPs),* and other partial processes as non-VAPs. VAPs and non-VAPs are expressed by describing what actions are carried out on the objects and the actions are expressed by verbs. In the milling example in Figure 2.4, the partial processes are placing the workpiece on the fixture, removing the designed part of the workpiece, and cleaning the workpiece. The VAP is the second partial process.

In the milling example, the VAP is realized by the milling centre contacting the workpiece and transferring the necessary force to it. At the same time the fixture contacts the workpiece to hold its position. In the VAPP approach, physical entities directly contacting objects and transferring/receiving force or other kinds of energy to/from the objects in order to realize a VAP are referred to as *work heads*. The milling centre and the fixture are the work heads in the example. How work heads interact with objects at a VAP significantly influences the output quality of a work system (in the milling example, the output quality can be measured by, for instance, dimensions and surface roughness of the milled workpiece). Certain attributes of the objects and work heads (e.g. hardness, shape, heat conductivity) and certain controllable parameters affecting the interaction among them (e.g. turning speed of a work head) need to be considered in order to ensure the output quality. In the VAPP approach, those attributes and parameters are called *conditions for quality conformance*.

It can be inferred that objects, work heads, interactions among them, and conditions for quality conformance at a VAP (or VAPs) are key elements of a work system. A *Value Adding Process Point* (VAPP) is an essential mechanism for realizing a VAP. A VAPP consists of objects, work heads, interactions among them, and conditions for quality conformance at a VAP. A VAPP can be described by using those elements. In a simpler expression, a VAPP is what is essentially done at a value-adding process in a work system.

The terms used in the VAPP approach can be explained again by using another example: a task of assembling two plastic parts snap-fitted by fingers. In this example, objects are the two plastic parts, and VAPs are "aligning the two parts" and "fitting the two parts". The work heads in both VAPs are fingers. In the second VAP, pressure applied from fingers to the plastic parts and shape and hardness of the parts can be the conditions for quality conformance. The VAPP in the second VAP can be described that fitting of the two plastic parts with a certain shape and hardness is made by fingers applying a certain pressure to those plastic parts.

**Designing and analysing a work system using the VAPP approach**

The VAPP approach is an approach to designing and analysing a work system with a specific focus on VAPPs. Nakamura (2003) suggests a basic procedure for designing a work system focusing on VAPPs:

- Identify objects and define the task of a work system.
- Identify the VAPs in the work system.

- Decide work heads and interactions among the objects and work heads at the VAPs. Identify conditions for quality conformance at the VAPs.
- Design physical structures that enable the VAPPs. Add non-VAPs if necessary. Design structures that enable the non-VAPs.

The VAPP approach aims at realizing a simple work system as much as possible. A simple work system is a system in which VAPs are realized with few physical entities, little energy, time, and information. Nakamura (2003) provides a general principle to achieve a simple work system. The principle is to conceive one of two specific ideal states. One is a state in which the task of a work system is accomplished only with VAPs. An image of this state is that the objects in a work system realize the VAPs by themselves without any external influence. Another is a state in which the task is realized only with VAPPs, in other words, with the objects, the work heads, and the interactions among them. Nakamura (2003) also provides some complementary guidelines for achieving a simple work system. Examples are:

- Compact VAPs. Consider if VAPs can be done at the same time and place.
- Minimize the frequency of *holder* change. Here, holders are things that maintain an object(s) at a certain position(s), for instance hands, jigs, tables, pallets, containers, and conveyer bands. The less frequently holders are changed in a work system, the less complicated the system tends to be.
- Choose appropriate work heads and identify conditions for quality conformance at the VAPs. Well-designed work heads and well-controlled VAPs can reduce the number of non-VAPs, such as finishing, cleaning, inspections, etc.

In an analysis of a work system focusing on VAPPs, Nakamura (2003) suggests using several perspectives. Examples are shown below:

- Compare the amount of time, space, energy, and physical entities used at VAPPs and the amount of those used in the work system. For instance, when a factory is a work system, the amount of time, space, energy, and physical entities used at the factory is much larger than the amount used at the VAPPs.
- Focus on objects and follow how they are handled in a work system. In a factory for instance, the value should be continuously added to the objects until they become the finished products. In reality however, the objects are frequently moved up, down, to the left or right, and turned or rotated between the VAPs.
- Identify the frequency of holder change in a work system.

**Comparison of the VAPP approach with other design methods**

The VAPP approach pays close attention to objects, their transformation processes, and physical entities that enable these processes. The approach is not a method for designing the entire production system, because it does not include, for instance, design of human and management systems. The approach is a method for solving specific design problems in the production system as those developed in the field of operations management and industrial engineering. The approach follows design procedures similar to the previously mentioned production system design methodologies and the design methods Value Engineering (VE) and Work System Design (WSD), in a way that the approach and these methodologies and methods first identify solutions in an abstract and functional domain then seek for physical embodiment. The VAPP approach is particularly close to WSD, since both methods recommend conceiving an ideal state in which the task of a work system is realized with only the minimum required resource expenditure. Although the VAPP approach shares several commonalities with those design methodologies and methods, the approach has some distinct features. These features are the following:

- Explicit pursuit of a simple work system
- Identification of work heads and conditions for quality conformance
- Perception of waste: anything but VAPP(s) is waste

The VAPP approach consciously pursues the realization of a simple work system and it provides a few guiding principles for it. VE and WSD also recommend generating simple design solutions. However, these methods do not emphasize the importance of simplicity as explicitly as the VAPP approach, nor do they provide guiding principles for achieving a simple work system. Design For Manufacturing and Assembly (DFMA) has a clear emphasis on achieving simple product designs, which in turn can reduce the complexity of how to produce them. DFMA also provides a number of design guidelines for achieving this. In terms of the emphasis on simplicity, DFMA is similar to the VAPP approach, but DFMA is a method for designing products and not for designing a part of a production system.

Identification of work heads and conditions for quality conformance is not apparent in the mentioned design methodologies and methods. Well-designed work heads and a proper control of the interaction between objects and work heads can reduce the number of non-VAPs and increase the output quality of the work system. Systematically recognizing work heads and conditions for quality conformance can be a help for a proper choice of work head and control of the interaction mentioned.

In the VAPP approach, VAPPs are considered necessary in the work system but any other physical entities in the work system are regarded as waste. This perception of waste is slightly different from the common notion of waste, which is typically defined as “any activity that consumes resources but adds no value as specified by the customer” (Womack and Jones, 1996) or “process or material that does not add value to a good or service from the viewpoint of the customer” (WebFinance). The common definition of waste tends to direct one’s attention to wasteful activities or processes but does not always specify exactly what physical entities add value or not. On the other hand, the waste defined in the VAPP clearly specifies what physical entities are wasteful. The perception of waste in the approach tends to help to pay more attention to waste in production equipment (e.g. tools, workbenches, devices, and machines). Production system design methodologies (e.g. one suggested by Hubka and Eder, 1988) and VE evaluate the efficiency of a certain process by calculating the ratio of output value of the process and cost necessary to realize the process. The awareness of cost can lead to reducing waste in the production equipment, but the notion of anything but VAPPs being waste may provoke a more radical approach to reducing waste than simply reducing the cost.

## 2.5 Kaikaku for building innovation capabilities

As mentioned in Chapter 1, Kaikaku can be viewed as a valuable opportunity to develop the organization so that it becomes more supportive to innovation. Researchers in the field of management, innovation management, and operations management frequently use the term *organizational capabilities for innovation*, or in short *innovation capabilities*, when discussing developing an organization towards an innovative one (e.g. Bessant and Caffyn, 1997; Peng et al., 2008; Teece et al., 1997). In the following subsections, the terms and theories related to innovation capabilities are introduced. Previous research on how to build these capabilities is then introduced and discussed.

### 2.5.1 Organizational capabilities for innovation

The notion of organizational capabilities has been developed by management researchers, particularly those who advocate the resource-based view of the company (e.g. Teece et al., 1997). Organizational capabilities for innovation can be broadly defined as abilities to create and realize innovative outcomes on a routine basis (Olsson, 2008). As many management researchers propose, organizational capabilities can be described by bundles of *organizational routines* that utilize clusters of *resources* to achieve desired outcomes (Peng et al., 2008). Organizational routines are the way things are done or patterns of activities (Ketokivi and Schroeder, 2004). These routines encompass both standard formal procedures and patterns of behaviours not explicitly guided by written rules and policies (McLaughlin et al., 2008). Resources refer to tangible and intangible assets in an organization that could be put into productive use (Teece et al., 1997). Resources can be physical assets, stocks of knowledge, human capital, capital resources, etc. The notion of organizational capabilities as bundles of routines is helpful to understand and explain how those capabilities can be built, which will be discussed more in the next subsection.

Researchers in innovation management often use the terms *exploitation* and *exploration* capabilities as major components of innovation capabilities (e.g. Boer and Gertsen, 2003). Exploitation can be captured by terms such as modification, refinement, choice, efficiency, implementation, and execution, while exploration includes notions such as search, variation, risk-taking, experimentation, play, flexibility, and discovery (March, 1991). In the literature on innovation, it has been frequently argued that incremental innovation largely depends on exploitation capabilities, while local and radical innovation requires exploration capabilities (Benner and Tushman, 2003). However, exploitation capabilities also positively influence radical innovation, and vice versa. In this thesis, the relationship between exploitation and exploration capabilities and incremental, local, and radical innovations is understood as illustrated in Figure 2.5.

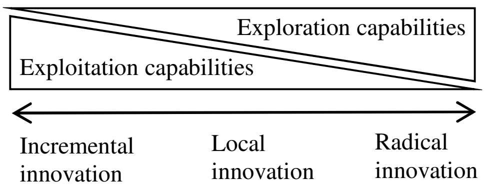



**Figure 2.5:** Relationship between exploitation and exploration capabilities and incremental, local, and radical innovation.

An organization with well-developed capabilities for exploitation does not mean that it excels at exploration. Rather, these capabilities tend to inhibit exploration (Dougherty and Hardy, 1996). Because of the inherit tension between exploitation and exploration, researchers have suggested to develop the exploitation and exploration capabilities at different parts of an organization, for instance, the former capabilities at operating departments and the latter at a R&D department (Tushman and O'Reilly III, 1997). However, there is a growing argument in the literature that any departments and groups in an organization should excel at both exploitation and exploration and be able to shift between them as needed depending on the situation that the departments and groups are facing (Boer and Gertsen, 2003). Traditionally production-related organizations have been more configured to exploitation and have developed exploitation capabilities because they have a long history of exercising incremental improvements. In order to build innovation capabilities for a higher level, the challenge for many production-related organizations is to proactively build exploration capabilities across the organization.

### 2.5.2 Building organizational capability for innovation

As mentioned earlier, the notion of organizational capabilities as bundles of routines is helpful to understand and explain how those capabilities can be built. The notion implies that capabilities cannot be acquired by an individual or a group exercises certain procedures once. The procedures have to be repeated in the organization until they become routines. Therefore, building organizational capabilities cannot be achieved overnight and thus requires a long-term perspective. Due to the need of repetition, capability building resembles the process of becoming an athlete (Bessant and Caffyn, 1997). Bessant and Caffyn (1997) describes the similarity as follows;

> *…it (capability building) is like becoming a marathon runner – the idea is relatively simple and you may become motivated to try it. However, the process of actually competing requires that you go through a process of gradual training, changing some of your behaviors and trying new ones out, repeating and rehearsing… Your performance will gradually improve… and eventually you will be able to complete the first marathon… but the training does not stop there…*

While a process of individual training may be controllable, Fujimoto (2007) asserts that the process of organizational capability building is far less controllable. The process can be characterized as emergent, less linear, and less systematic (Fujimoto, 2007). In addition, researchers commonly discuss that the process is fundamentally one of organizational learning, in which unfamiliar routines are often first articulated and then reinforced over time (Bessant and Caffyn, 1997). Therefore, persistent organizational learning is essential for promoting organizational capability building (Fujimoto, 2007).

Organizational learning is a process of improving actions through better knowledge and understanding (Fiol and Lyles, 1985). Argyris and Schön (1978) differentiate between three kinds of organizational learning: *single-loop*, *double-loop*, and *deutero learning.* According to Argyris and Schön (1978), single-loop learning occurs when an organization or a group modifies existing practices in response to errors without changing shared values and standards in the group or the organization. When these shared values and standards are questioned and modified, it is called double-loop learning. Deutero learning is about learning how to carry out single and double-loop learning, in other words, it is about learning how to improve and innovate. Therefore, deutero leaning is the most relevant type of learning to build innovation capabilities.

The theories introduced above imply that exploration capabilities can be emergently built through active deutero learning in the organization. The implication raises an assumption that such active deutero learning needs to be embedded in Kaikaku, in order for Kaikaku to contribute to building innovation, especially exploration capabilities. However, as to how to practically facilitate deutero learning during Kaikaku, little research has been conducted.

## 2.6 Summary of the theoretical background

In this chapter, many terms, concepts, theories, and previous studies have been introduced and discussed. The theoretical foundation of the present research mostly lies in process innovation research. However, the present research has extended its foundation towards innovation management research, management research especially concerning the resource-based view of the company, and a particular design method for production systems. Below, the main points of this chapter are listed.

- Kaikaku is essentially similar to process innovation. Therefore, Kaikaku is defined based on the definition of process innovation.
- A unique production system is defined as a production system that is valuable for the company's competitiveness, rare in the industry, difficult for the competitors to imitate, and difficult for them to substitute.
- Much research has been done on Kaikaku, but little on the relation of Kaikaku to creating unique production systems. In this thesis, the term Kaikaku is used instead of process innovation to highlight the relation.
- The chance of Kaikaku generating radically innovative solutions is higher when the organization is configured to be supportive to such innovation. A limited amount of research has been done on what production organizations supportive to radical innovation in production look like.
- There are practices, approaches, methodologies, and methods that can be used in the process of Kaikaku to increase the chance of generating radically innovative solutions. The Value Adding Process Point approach is introduced as a relatively unknown design method to support creating unique production lines, cells, and equipment.
- Kaikaku can be seen as a valuable opportunity to build innovation capabilities. Previous research implies that active deutero learning should be embedded in the process of Kaikaku. However, previous research has not developed sufficient knowledge of how to practically facilitate deutero learning in Kaikaku.

# CHAPTER 3 – Research methodology

*This chapter describes and discusses the research methodology employed in the research presented in this thesis. In the first part of this chapter, from Subsections 3.1 to 3.5, it is discussed generally how the present research was methodologically approached and what methodological concerns were taken into consideration. Then Subsection 3.6 describes operationally how the research was conducted in detail. Lastly, the quality of the present research is estimated.*

## 3.1 Research approach

The objective of the present research is to analyse and propose how Kaikaku can be carried out so that it contributes to realizing unique production systems. The objective can be approached in various ways, and the choice of approach can significantly affect processes, results, and validity of the research. Kaikaku in production is a social and complex activity involving changes in all interrelated strategic, technological, human, and organizational dimensions. Thus, the research on Kaikaku required a holistic perspective. The research also needed close attention to the context of Kaikaku, since how Kaikaku could be realized was likely to be affected by various contextual factors such as available financial and human resources, strategies, and organizational cultures. Furthermore, it was necessary to obtain a deep insight into a "soft" side of a production system, for example, mindsets and behavioural patterns of individuals, groups, or organizations, in order to answer the research questions posed in this thesis. It was considered that the research objective would hardly be achieved by the research approach called *quantitative research*. In quantitative research, statistical and mathematical techniques for quantitative data processing are central, and researchers are required to be detached from the research objects (Gummesson, 2000). The present research employed a research approach in contrast to the quantitative approach, i.e. *qualitative research*. Qualitative research is characterized by collection and analysis of non-numeric data and usage of a personal interpretive process to understand the reality (Gummesson, 2000). Qualitative research is an appropriate approach when investigators want to understand the meaning, context, and process of certain phenomena that cannot be explained properly by quantitative research (Maxwell, 2005). Qualitative research also helps investigators to obtain holistic perspectives and insights into dynamic systems (Patton, 1990).

In Chapter 2, it is mentioned that a limited amount of knowledge has been developed that is relevant to the research questions. Therefore, it was considered that the present research should focus mainly on theory building and less on theory testing. The lack of existing theories implied that theories should be built based on the data obtained from *empirical studies*. In this thesis, an empirical study means a way of gaining knowledge or building theories by means of direct and indirect observation or experience (Bryman and Bell, 2007).

## 3.2 Research design

Every type of quantitative research has an implicit, if not explicit, research design (Yin, 1994). Because a design always exists in research, it is important to make it explicit so that its strengths, limitations, and consequences can be clearly understood (Maxwell, 2005). The present research was designed with reference to several articles and books on qualitative research methodologies, especially those written by Maxwell (2005), Yin (1994), Yin (2011), Blessing and Chakrabarti (2009), Gummesson (2000), Bryman and Bell (2007), Coughlan and Coghlan (2002), and Eisenhardt (1989). At a general level, recommendations and methodological concerns discussed in those documents are similar and can be related to what Maxwell (2005) terms as five components of qualitative research design: *goals* (research objectives), *conceptual framework*, *research questions*, *methods* (data collection and analysis methods), and *validity*. The recommendations and methodological concerns are related to, for instance, how to define research objectives and questions, how to select participating companies, groups, or individuals in studies, how to establish relationship with the participants, and how to collect and analyse empirical data. In the design of the present research, these recommendations and concerns were taken into consideration.

Maxwell (2005) illustrates the relationship of the five design components as shown in Figure 3.1. These components form an integrated and interacting whole, with each component closely tied to several others rather than being linked in a linear sequence. Maxwell (2005) further emphasizes that it is rarely possible or even inadequate to plan qualitative research in a linear fashion as a one-dimensional sequence of steps from problem formulation to conclusions. Any component of research design may need to be reconsidered or modified during the research in response to new developments or to changes in some other components. With his statements in mind, the components of the research design in this research were iteratively reviewed and redesigned during the course of the research.

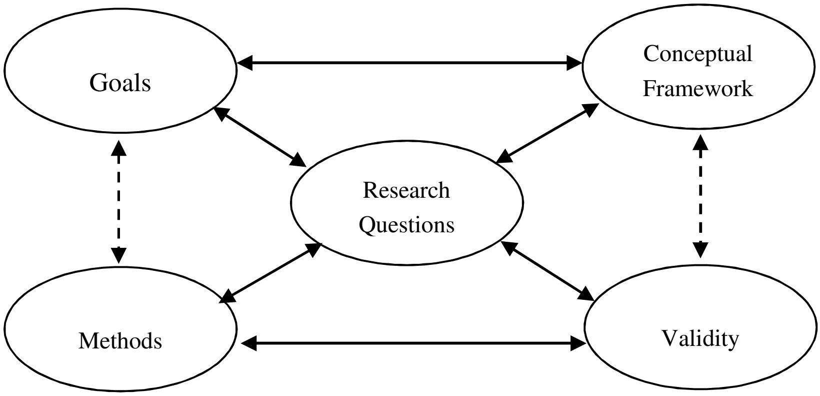



**Figure 3.1:** An interactive model of research design (Maxwell, 2005).

## 3.3 Gaining access

When researchers directly collect field-based data, they must gain and maintain *access* to study objects. Access refers to ability or permission to get close to study objects, to really be able to find out what is happening (Gummesson, 2000). As Gummesson (2000) asserts that access is the number one challenge in qualitative research, gaining access was considered one of the most important methodological concerns in the present research. Gaining access was a difficult task, and the possibility of access to study objects significantly affected the design of the present research. To answer the research questions, it was thought desirable to directly observe or participate in multiple Kaikaku initiatives with an explicit emphasis on achieving unique production systems. However, it was found that such initiatives were generally rare. The author of this thesis (hereafter called *the researcher*) made efforts to find and gain access to such initiatives in Sweden using his personal contacts or contacts that could be obtained through the research institution that the researcher belonged to, but he could gain a significant level of access to only one Kaikaku project. The difficulty in finding and gaining access to desirable study objects motivated the researcher to seek study objects also in Japan. As mentioned in Chapter 2, various articles, magazines, and newspapers in Japan indicated that many Japanese manufacturing companies made explicit efforts to make their domestic factories unique (e.g. Kimura and Takano, 2005).

## 3.4 Empirical data collection

During the research, five separate empirical studies were conducted. In the literature on research methodologies, several variations of empirical studies can be recognized, such as case study, action research, ethnography, etc. (Yin, 2011). In the present research, each of the five empirical studies employed one of the three variations *research synthesis*, *case study*, and *action research*. These variations involve different ways of collecting empirical data. While reasons for these variants being employed in the present research are given in Section 3.6, this section briefly introduces these three variations and explains generally how the data were collected within those variations. Note that detailed explanations of how the data were collected in the empirical studies will be presented in Section 3.6.

### 3.4.1 Research synthesis

A research synthesis is a specific kind of literature review. It aims to draw overall conclusions from past empirical studies by summarizing the hypotheses or empirical data made or collected in those studies (Cooper, 1998). One of the five empirical studies was a research synthesis in which empirical data were collected from published reports describing Kaikaku initiatives. According to Whittemore and Knafl (2005), the process of a research synthesis can be conceptualized into five steps: problem identification, literature search (data collection), data evaluation, data analysis, and presentation. In the data collection step in the research synthesis, decisions on how to collect data were made explicit to ensure methodological rigour. By referring to Cooper (1998), two kinds of decisions were made explicit. One was about how reports were gathered. Decisions were made as to what reference database was used, what search terms were used, and reports of what years were searched. The other kind of decisions was about how to judge the relevance of reports to the topic of interest. Decisions were made as to what characteristics of reports should be used to determine the relevance or exclusion of the reports, and whether the decision on the relevance should be made by title, abstract, or full text of the reports.

### 3.4.2 Case study

A case study is an empirical inquiry into a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin, 1994). Four of the five empirical studies were case studies. In case studies, empirical data may come from six sources: documents, archival records, interviews, direct observation, participant observation, and physical artifacts (Yin, 1994). In order to increase the credibility of collected empirical data, data collection from multiple sources, often called *triangulation,* is recommended (e.g. Eisenhardt, 1989). In the case studies conducted in the research, empirical data were collected from multiple sources.

Selection of cases is an important aspect of case studies. Eisenhardt (1989) states that case selection can be based on *statistical sampling* or *theoretical sampling*. In statistical sampling, cases are chosen randomly from the chosen population. It is often useful to test or verify theories based on statistical evidence. In theoretical sampling, alternatively called *purposeful sampling* (Patton, 1990), cases can be deliberately selected to help generate, replicate, or extend theories (Meredith, 1998). Since the present research focused on theory building, purposeful sampling was considered appropriate in the case selection. However, the issue of the access mentioned previously significantly affected the case selection.

### 3.4.3 Action research

Action research can be seen as a variant of case study, but while a case-study researcher is often an independent observer, an action researcher is an active participant in the process of change (Westbrook, 1995). Action research is generally defined as an approach to research that aims both at taking action and creating knowledge about that action (Coughlan and Coghlan, 2002). A prominent advantage of action research is the possibility of obtaining concrete experience in testing concepts, hypotheses, and theories through the immediate feedback that the research intervention receives (Westbrook, 1995). In the present research two of the five empirical studies involved the researcher's active intervention in improvement activities at a company.

Two distinct features of action research affected the empirical data collection in these two studies. One feature is that in action research changes occur not only within the client systems but also within the researchers themselves (Herr and Anderson, 2005). In the two empirical studies mentioned above, data were not only those obtained from interviews, observations, and documents but also self-reflections of the researcher. The other feature is that action research is essentially an emergent process in which a series of events gradually unfold (Coughlan and Coghlan, 2002). Due to this emergent nature, action research often progresses with the cycle of planning, acting, observing, and reflecting (Herr and Anderson, 2005). In one of the two empirical studies, data were collected by following this cycle.

## 3.5 Analysis of empirical data

Analysis of empirical data is one of the most difficult and the least developed aspects of empirical studies (Eisenhardt, 1989; Maxwell, 2005; Yin, 1994). Nonetheless, every investigation should start with a general analytic strategy (Yin, 1994). In the present research, the way of analysing the collected data was generally similar among all the variations of the empirical studies. The empirical studies followed Yin (2011) five-phase cycle of data analysis: *compiling*, *disassembling*, *reassembling*, *interpreting*, and *concluding*. These phases can be recursive, which means that while an analyst is in one phase, he or she may go backward or forward at the same time (Yin, 2011). Each phase is briefly explained below.

*Compiling*: At the first phase of the cycle, collected empirical data are organized in a systematic fashion, for instance by typing hand-written records in electronic form with consistent use of words and terms. The organized data are easily found and accessed during the later phases of analysis.

*Disassembling*: The organized data are broken down into smaller pieces of data. A label or "a code" can be assigned to a group of similar pieces of data. Coding in qualitative research does not strictly follow a rigorous set of rules as it does in quantitative research (Maxwell, 2005).

*Reassembling*: Some broader meaning of the data may emerge during the disassembling phase. The disassembled data are then rearranged and recombined into some meaningful forms, for example lists, hierarchical arrays, matrices, conceptual maps, flowcharts, etc. In the empirical studies, matrices were created when analysing data from multiple cases. Hierarchical arrays were created, often by using sticky notes, when within-case analyses were done.

*Interpreting*: The reassembled data are interpreted. Some broad patterns or logics may be identified, such as similarities and differences among the data, conformance or disagreement between theories and data, and explanation of the observed phenomena or events.

*Concluding*: Conclusions are derived from the previous phases. A conclusion is some kind of overarching statement or series of statements that raises the findings of a study to a higher conceptual level or a broad set of ideas (Yin, 2011). Research and practical implications are examples of such statements.

Apart from the above-mentioned analysis, which was typically done after the completion of the data collection, memos that were ongoing commentaries about self-reflections on the collected data were kept on record during the data collection in the empirical studies. Such memos helped to undertake analysis along with the data collection. The memos included impressions and reflections on, among other things, the observations and interviews, or initial ideas on concepts or theories.

Here it is perhaps appropriate to clarify the term *empirical findings* used in this thesis. It means a set of raw empirical data (in another word, evidence) relevant to the purpose of the study. In addition, it also means results of any of the first three phases of the analysis presented above.

## 3.6 Research process

The previous sections have described how the present research was generally approached. This section provides a description of how the research was conducted in detail.

### 3.6.1 The research setting

In the second chapter, it is mentioned that an organizational setting affects a process of Kaikaku. Likewise, the process of the present research was influenced by the setting in which the research was undertaken. Before explaining the process of the research, the research setting will be described.

The present research can be divided into two periods. The first period was for completing the licentiate thesis and the second was for the doctoral thesis. In the first period, the research was a standalone project and was not a part of a larger research project. What mostly influenced the research process during the first period was that the researcher had an opportunity to work with a Japanese consultant who had long experience of practising the Toyota Production System (TPS). Working as an assistant to the consultant for about one and half years gave an opportunity to conduct an empirical study and also provided the researcher with a concrete experience of Kaikaku and deeper understanding of lean production.

In the second period, the present research became a part of a larger research project that included four more Ph.D. students. The common theme of the larger project was how to support Kaikaku, but each Ph.D. student had a specific topic of interest under the common theme.[5] The larger project was considered as a multi-disciplinary project, since three Ph.D. students including the researcher were from the production research group in the research institution, while the other two were from the innovation management research group. One day every month, a dialogue seminar was held. In the seminars the Ph.D. students and their supervisors discussed various topics relevant to Kaikaku and exchanged their opinions and ideas about studies conducted in the project. The dialogue seminars influenced the process of the present research in a way that the researcher became more interested in the innovation research. Two of the five empirical studies were conducted with the help of the innovation research group.

In addition to the multi-disciplinary efforts in the research institution, the larger research project intended to establish close collaboration with manufacturing companies. Prior to the initiation of the large project, five manufacturing companies were contracted as collaborating companies in the project.

[5] Each of the four students focused on one of the following research topics: how to maintain a high speed of improvement in production, how to develop a methodology that supports radical improvement in production, how spatial design can contribute to realizing innovation, and how to develop individuals to be competent in innovation.

These companies were selected by the research institution. The intention of the collaboration was for these companies to undertake Kaikaku initiatives while the researchers should assist the initiatives and at the same time use them as study objects. The preselection of the collaborating companies made it easier for the researchers to have a high level of access to those companies. On the other hand, there were risks that desirable empirical data might not be obtained from those companies. In fact, Kaikaku did not occur at any of those companies, although a few radical improvements at a subsystem level occurred. Consequently, the researcher worked with one of the collaborating companies to try out certain methods or ideas relevant to the present research.

### 3.6.2 The research process

During the present research five empirical studies were conducted. The process of the research was not a systematic and linear one in which these studies were all planned in advance. On the contrary, the process can be characterized as an emergent process in which, being affected by the research setting mentioned above, a series of those studies successively unfolded during the course of the research. Although each of the studies had a rather different study objective, they were conducted in reference to the research questions. An overview of the empirical studies is shown in Table 3.1. An overview of the research process is presented in Figure 3.2.

**Figure 3.2:** The research process.

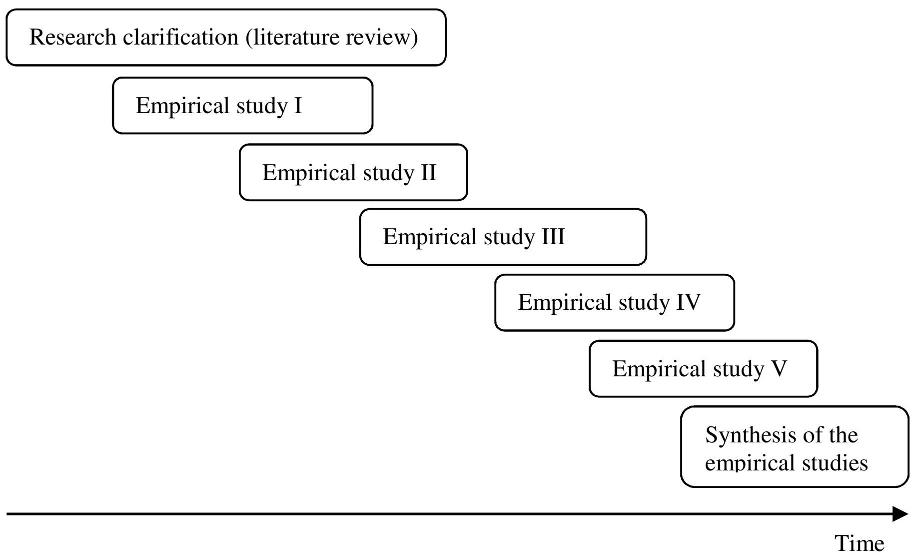


**Table 3.1:** An overview of the empirical studies conducted during the research.

| **Empirical study** | **I** | **II** | **III** | **IV** | **V** |
|---|---|---|---|---|---|
| Main question | How were the lean transformations driven by the experienced TPS consultant? | What do production organizations striving to realize radical innovation look like? | How do Japanese companies undertake Kaikaku initiatives? | How to use the VAPP approach in practice | How to facilitate building exploration capabilities |
| Relevant RQ | RQ 2 | RQs 1 and 2 | RQs 1 and 2 | RQ 1 | RQ 2 |
| Type of study | Case study | Case study | Research synthesis | Action research | Action research |
| Unit of analysis | Kaikaku initiatives, lean transformations in particular | Production organization | Kaikaku initiatives in Japan | Use of the VAPP approach | Process of capability building |
| Main sources of empirical evidence | Participant observation | Interviews | Reports describing Kaikaku initiatives | Participant observation. Data generation by intervention | Participant observation. Data generation by intervention |
| Number of companies involved | 2 | 9 | (Review of 65 Kaikaku reports) | 1 | 1 |
| Data analysis techniques | Within-case analysis, pattern matching | Cross-case analysis, tabulation | Cross-case analysis, tabulation | Within-case analysis | Within-case analysis |
| Relevant Appended paper | B | C | D | E | F |

The remainder of this subsection explains how the research unfolded and also how each of the empirical studies was conducted in detail.

**Research clarification**

The research started with a research clarification based on general questions such as what Kaikaku is and how Kaikaku can be supported. In order to understand features of Kaikaku and identify areas of focus in the research, an initial literature review was conducted. The review was of an open-ended nature and continued until an early phase of the second period of the research began. The reviewed articles and books were related to various research fields such as process innovation, operations management, production system design, industrial engineering, lean production, TPM, TQM, Six Sigma, operations strategy, corporate strategy, change management, and organizational learning. It was eventually found that the basic concept of Kaikaku was essentially similar to the one of process innovation, and that much research had been done on how to efficiently manage changes in Kaikaku. On the other hand, less research had been done as to how to use Kaikaku so that it contributes to realizing unique production systems. The identification of niche areas of Kaikaku research led to formulating the research questions presented in this thesis. The initial literature review also resulted in identifying the four types of Kaikaku presented in Subsection 2.2.6 and in Appended paper A.

**Empirical Study I**

The researcher's collaboration with the Japanese consultant mentioned in Subsection 3.6.1 created an opportunity to conduct Empirical Study I (ES I). The study was conducted when the consultant facilitated implementations of lean production (hereafter called lean transformations) at two Swedish manufacturing companies. The consultant had practiced TPS for more than 20 years and had instructed TPS at more than 150 companies with 2,800 persons globally. The consultant's way of driving the lean transformations was relevant to the second research question. During the transformations he did not provide many prescribed solutions to the client companies. Instead, the consultant largely focused on deliberately creating situations in which members of the companies had to discover solutions by themselves though experiments. Such an approach provoked the members to collectively build capabilities necessary to achieve lean production. The purpose of ES I was to obtain a deep understanding of the consultant's way of driving lean transformation.

The Swedish companies mentioned were medium-sized companies. One of them, here called company A, has approximately 150 employees. They produce precision casting goods for automotive, industrial equipment, and infrastructural industries. The other company, named company B, has about 130 employees making electrical products mainly for infrastructural industry. Improvement in production was not particularly significant at these two companies before the transformations were initiated. The lean transformations started in September 2007 and September 2008 at companies A and B, respectively. The duration of the consultant's involvement was one and half years at company A, and six months at company B. During this period the consultant and the researcher visited the companies approximately one week per month.

The researcher was an assistant to the consultant and at the same time a participant observer of the lean transformations. Empirical data were collected from various sources, including actual participation in improvement events, interviews with presidents, production managers, engineers, shop floor leaders and operators, as well as frequent conversations with the consultant, which especially helped to understand the thinking behind his behaviours, decisions, and actions during the lean transformations. The analysis of the collected data was mostly done by writing memos during the data collection. Van Maanen (1988) suggests that field notes should be an ongoing commentary about what is happening in the case study, involving both observations and an analysis of them, preferably separated from each other. Adopting Van Maanen's suggestion, a sheet with two columns was created. In the left column the collected data were presented, and the reflections on the collected data were written in the right column. By iterating the data collection and analysis, a mechanism of how the consultant drove the lean transformations was gradually identified. ES I is presented in Appended paper B.

**Empirical Study II**

As mentioned in Chapter 2, the likelihood of Kaikaku generating radically innovative solutions is higher when an organizational setting is supportive to radical innovation. Although much research has been done to identify characteristics of organizations supportive to radical innovation, a limited amount of study has focused on production organizations. The purpose of Empirical Study II was to investigate production organizations striving to realize unique production systems and to identify what organizational setup (i.e., structures, processes, systems, strategies) was relevant to the realization of such systems.

Desirable study objects in this study should be production organizations that had created unique production systems or made organizational efforts to create such systems. Such objects did not have to be in the process of Kaikaku, because the unit of analysis in this study was an organizational setup that should not be much dependent on specific Kaikaku initiatives. Since the researcher could not find and gain access to desirable study objects in Sweden, he sought for study objects among Japanese manufacturing companies. It was generally difficult to gain access to companies remotely located from the research institution. The researcher relied on a personal contact to find study objects. The contact, a senior researcher at a Japanese research institution, established access to five Japanese manufacturing companies for interviews, using his own contacts and knowledge of what companies could be suitable for the study. All of the companies were large, and four of them were in the automotive industry. A brief profile of the companies is shown in Table 3.2. Interview respondents were senior managers related to production and production engineers. The interviews were carried out by the researcher from March to April 2009.

Although all of the interview respondents answered that the companies were making organizational efforts to make their domestic factories unique, the selection of the companies can be criticized as a convenient selection. However, based on Weiss (1994) arguing that there are situations in which a convenience sampling is the only way to proceed especially when study objects are rare or difficult to gain access to, the difficulty in gaining access in this study may to some degree justify the selection of the companies.

Prior to the interviews, an interview template was created based on the literature on innovative organization (e.g. Dobni, 2006; McLaughlin et al., 2008; Tidd et al., 2005). The template included a series of guiding questions related to four general categories:

- Manufacturing strategy
- Organization structure at production function
- Education systems at production function
- Involvement of shop floor employees in innovation

It was assumed that production engineering functions would play an important role in creating unique production systems. Therefore, questions related to roles and structures of production engineering functions were included in the interview questions.

Empirical evidence from the five companies might be dependent on specific contexts of the companies, such as national culture, geographical locations of the factories, and the companies' competitive situations, etc. To understand production organizations in another context, interviews were also conducted at four Swedish manufacturing companies. A profile of those companies is shown in Table 3.2. Since these companies did not take organizational efforts to make their production systems unique and they were chosen simply based on the ease of access, the data obtained from those Swedish companies were treated only as reference.

In the analysis, the collected data were assembled in a matrix array with interview items in rows and companies in columns in order to undertake a cross-case analysis. By trying to identify patterns among data in the matrix, an organizational setup relevant to creating unique production systems was identified. ES II is presented in Appended paper C.

**Table 3.2:** Profiles of the companies.

| Company | Business sector | Number of employees (Non-consolidated) | Company based in |
|---|---|---|---|
| Company C | Automobile | 31,000 | Japan |
| Company D | Air conditioning equipment | 7,100 | Japan |
| Company E | Automobile parts | 3,600 | Japan |
| Company F | Automobile & industrial vehicles | 11,700 | Japan |
| Company G | Automobile & truck parts | 33,600 | Japan |
| Company H | Construction equipment | 16,400 | Sweden |
| Company I | Motor & generator | 400 | Sweden |
| Company J | Automobile & truck parts | 6,000 (consolidated) | Sweden |
| Company K | Automobile parts | 900 | Sweden |

### Empirical Study III

The researcher desired to obtain further understanding of how manufacturing companies actually undertake Kaikaku initiatives in regard to the research questions. Due to the lack of access to directly observable Kaikaku initiatives, it was decided to collect and analyse a large number of reports describing Kaikaku initiatives at Japanese manufacturing companies. The objective of Empirical Study III was to answer 1) what in the Kaikaku initiatives described in the reports contributed to making the technical parts of the production system more unique, and 2) what in those initiatives contributed to building innovation capabilities.

There were mainly two reasons why Kaikaku initiatives at Japanese companies were collected and analysed. One reason is that, as mentioned earlier in this thesis, Japanese companies were generally known for their emphasis on long-term capability building (e.g. Nonaka, 2007), and more Japanese companies made explicit efforts to create unique production systems (Kimura and Takano, 2005). The other reason was that it was possible to search for and obtain a large number of reports with rich descriptions of Kaikaku initiatives through reference database services in Japan.

The reports were collected through CiNii, one of the largest reference database services in Japan for Japanese publications. Initially, a title search was undertaken using search words like “seisan kakushin”, “seisan kaikaku”, “kojo kakushin”, and “kojo kaikaku” (seisan and kojo are Japanese words meaning manufacturing and factory, respectively). Articles published during and after the year 2000 were searched in order to reject Kaikaku initiatives that might not reflect the recent business environment. More than 350 articles were found by the title search. When reading the titles or abstracts, the articles with little relevance to the study were rejected. After the initial screening, 93 articles were left. By reading the full texts of these articles, the articles that did not provide sufficient descriptions of the Kaikaku initiatives were eliminated. After the second screening, 65 articles remained for the formal review. The 65 articles are listed in the Appendix of Appended paper D. Eleven of these articles described Kaikaku initiatives at SMEs with less than 300 employees. Other articles reported Kaikaku initiatives at large companies.[6]

In order to meet the objective of the study, two rounds of analysis were conducted[7]. In the first round, it was thought that the objective could be met by first obtaining an overview picture of Kaikaku initiatives from the selected articles and then analysing this picture in the perspective of the questions stated in the objective. The first round was conducted as follows. When the articles were reviewed, notes were taken regarding what the companies did during the initiatives, and how and why they did so. It was eventually found that the notes could be related to nine emerging themes: reasons of initiation, objectives, strategic focus areas, how initiatives were driven at an organization level, solutions generated, how these solutions were generated, how the implementations were achieved, results of the initiatives, and success factors. A matrix of these themes in columns and the respective Kaikaku initiatives in rows was created in order to conduct a cross-case analysis. An overall picture of the Kaikaku initiatives was created by clustering all of the notes related to each theme (see Tables 1 to 5 in Paper D). By analysing the overview picture, patterns or trends among the initiatives relevant to the questions mentioned were identified.

The first round of analysis brought some answers to the questions, but the researcher thought that more answers could be obtained by another way of analysis. The second round of analysis was conducted as follows. In the second round, the reports were re-reviewed with the purpose of identifying the data directly relevant to the questions mentioned above. By following Yin's (2011) five-phase cycle of data analysis, the data identified were reassembled according to the questions. The results of the reassembly are presented in Section 4.3. The reassembled data were used for the analysis presented in Chapter 5.

**Empirical Study IV**

One of the findings from ES III was that several Japanese companies employed a unique approach to designing manufacturing processes in the Kaikaku initiatives. This approach is introduced as the VAPP approach in Subsection 2.4.2 and the basic concept of the approach is explained in the

[6] Some may argue whether this study can be called an empirical study. The author of this thesis sees it as an empirical study, because the reports selected for the review had rich descriptions of Kaikaku initiatives, most of which were written by members of the companies who were involved in the initiatives. It was considered that those descriptions were equivalent to documentary information, which is a source of evidence in empirical studies, according to Yin (1994).

[7] The results of the first round of analysis are presented in Appended paper D. However, the results of the second round are presented only in this thesis.

same subsection. As mentioned in this subsection, the approach has been rarely known internationally, and a small amount of practical information on how to apply the approach has been presented in the scarce literature on the approach. Considering the rareness of the study on the VAPP approach and the potential of the approach being used in Kaikaku at a larger number of companies, the researcher decided to explore the VAPP approach. The purpose of Empirical Study IV (ES IV) was to obtain knowledge of how to use the VAPP approach in practice.

In the study, the researcher attempted to obtain knowledge in three ways. One way was to review the literature. Several articles describing application examples of the VAPP approach at companies were found in the same reference database as that used in ES III. However, most of those articles only partially described how the approach was used at the companies. Another way was to gain access to the companies that used the VAPP approach. Access could not be established except to one person who practised the approach. This person was an ex-senior manager at a Japanese automobile and industrial equipment manufacturer. When he visited Sweden in 2011, the researcher asked him a general question about how managers at the company trained young production engineers to be more innovative. Then he started to explain the VAPP approach and also gave an example of how the approach was used. Although the information obtained from him was useful for the study, it was still not enough to satisfy the purpose of the study. Therefore, the study mostly relied on the third way of obtaining practical knowledge of the approach: conducting an action-oriented study in which the approach was applied at companies.

Criteria of suitable companies for the action-oriented study were that 1) managers at companies were receptive to the VAPP approach, 2) the locations of companies were not far away from the research institution, because frequent visits to companies were expected, and 3) the VAPP approach was to be applied in the context of Kaikaku. However, no company met these criteria. One company, one of the collaborating companies for the large research project mentioned in the previous subsection, met the first two criteria. It was decided to apply the VAPP approach at this company (hereafter called company L). Although the approach was not applied in the context of Kaikaku, it was expected that knowledge obtained from the study could be examined later in the context of Kaikaku. Company L was a medium-sized company developing, manufacturing, and selling electrical products for industrial use. The operations in the factory mostly consisted of assembly, for instance circuit board assembly and product final assembly.

Since books and articles related to the VAPP approach were written only in Japanese, the researcher took an active role in applying the VAPP approach at the company. During the periods of the study from January to June in 2011 and from February to June in 2012, there were four separate opportunities to apply the VAPP approach at four different shop floor sections in the factory. At the first three opportunities, the researcher acted as a designer who analysed the assembly lines and cells at the shop floor sections and proposed design recommendations by applying the VAPP approach. At the fourth opportunity, the researcher was a facilitator of a workshop where participants of the workshop applied the VAPP approach to improve their operations. In the events, the researcher was involved in the design but not in the implementation. Members of the company decided what parts of the design they wanted to implement and when and how to implement them.

Due to the explorative and experimental nature of the study, the four events were not planned in advance but in succession. Considering that action research was an emergent process with a deliberate execution of the cycle of planning, acting, observing, and reflecting (Coughlan and Coghlan, 2002; Herr and Anderson, 2005), the study followed the process inspired by the experiential learning cycle put forward by Kolb and Fry (1975) (see Figure 3.3).

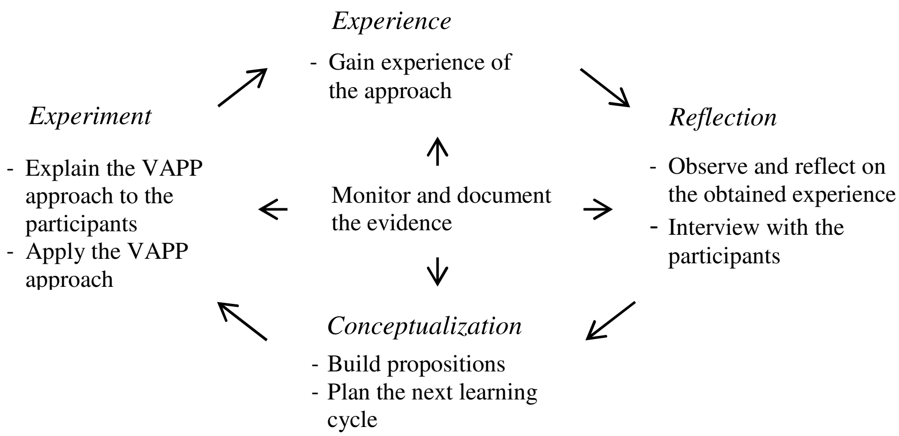



**Figure 3.3:** The action-oriented study process inspired by Kolb and Fry's (1975) experiential learning cycle.

The experiential learning cycle consists of experience, reflection, conceptualization, and experiment. One cycle corresponds to one application event in the study. The case study started with experiment instead of experience. At the experiment stage, the researcher or participants in the study applied the VAPP approach. At the experience stage, the researcher or the participants gained the experience of the approach. This was followed by the observation of the process and outcomes of the application; then the experience and observation were consciously reflected on. Reflection is a critical part of experiential learning because it integrates action and research (Coughlan and Coghlan, 2002; Raelin, 2000). The researcher reflected on his experience and observation regarding the application. Interviews were held with the participants in order to understand their experience of and reflection on the application. Finally, at the conceptualization stage, ideas, concepts, or propositions were built based on the previous stages. A plan for the next cycle was also discussed with the production manager. Actions, comments, drawings, ideas, sketches, reflections, etc., made during the learning cycles were empirical evidence. They were kept on record during the study. ES IV is presented in Appended paper E.

**Empirical Study V**

The second research question is how to realize Kaikaku so that it facilitates innovation capability building. As mentioned in Chapter 2, innovation capabilities mainly consist of exploitation and exploration capabilities, and building exploration capabilities is an important challenge for production functions. At the later phase of the present research, an assumption was made that the capabilities could be built in a similar way to how the Japanese consultant mentioned drove the lean transformations. During the transformations, the consultant deliberately created the need for improvement in different groups in the companies and at different points of time, in order to keep the momentum of the organizational changes towards lean production. It was inferred that deliberately and constantly creating the need for exploration was also necessary for the active development of exploration capabilities. Based on the inference, the researcher devised what is here named as "a deliberate discovery-learning approach to building exploration capabilities" (the definition of the approach will be presented in the next chapter).

The approach was still a hypothesis and should therefore be verified based on empirical evidence. One way to collect such evidence was to observe production organizations practising the approach, but it was difficult to find and gain access to such organizations. Therefore, an action-oriented study in which empirical data would be collected by applying the approach in production organizations was considered a way to evaluate the hypothesis. There were two challenges when conducting the study. One was that the approach was still a general guidance; there was no concrete guide on how to apply the approach in practice. Such a concrete guide needed to be developed. Another challenge was the limited amount of time available for the study. Perhaps it would take at least a year to evaluate the effectiveness of the approach, but only about six months were available for the study, because the idea of the study emerged in a late phase of the present research. Therefore the researcher decided to conduct a pilot study with the purpose of obtaining initial verification of the approach mentioned.

Empirical Study V (ES V) was conducted with this purpose. Since the study started with a hypothesis, a deductive approach including four steps shown below was adopted.

1. Define the approach

2. Develop a process that guides how to apply the approach in practice
3. Apply the approach at one or more case companies with the help of the process developed
4. Analyse the evidence collected from the third step to evaluate the effect of the approach

Criteria for companies suitable for the empirical study were similar to those in ES IV: 1) managers at companies were eager to build exploration capabilities in production organizations and open to experimenting in an untested way of building the capabilities, 2) companies should not be distant from the research institution, because frequent visits to the companies were expected, and 3) the approach was to be applied in the context of Kaikaku. Similar to ES IV, it was difficult to find a company meeting those criteria. Company L was the only one that accepted collaboration. The company accepted it probably because the researcher and members of the company had already established trust and an open relationship during ES IV. The company did not conduct a Kaikaku initiative when the study was undertaken. However, it was expected that the knowledge obtained from the study could be later examined and related to the context of Kaikaku.

The process developed at the second step of the empirical study included three steps: 1) initiating an event in which individuals or groups had to be explorative in order to cope with certain challenges, 2) observing and reflecting on the event, and 3) identifying and implementing organizational support for exploration (a detailed description of the process will be presented in Chapter 4). From August to December 2012, the researcher initiated the process in four groups in the company. In total approximately 40 managers and employees participated in the study. The researcher was mainly involved in the preparation and initiation of the first step in the process. Undertaking the rest of the process was left to the participants.

A few months after the initiation of the first step of the process, the researcher interviewed the participants to hear about what happened after the initiation of the first step and what they thought important for building exploration capabilities. The evidence collected from the interviews was analysed in order to meet the purpose of the study. ES V is presented in Appended paper F.

**Synthesis of the empirical studies**

Each of the five empirical studies had its own objective and thus the analysis in each study was done to meet this objective. The results of the analysis are presented in the respective papers appended in this thesis. At the final phase of the present research, the empirical evidence collected from all the empirical studies was reanalysed collectively to meet the objective of the present research: to propose how to realize Kaikaku so that it contributes to creating unique production systems.

RQ 1 (or RQ 2) was about how to realize Kaikaku to make the technical (or social) part of a production system more unique. In Chapter 1, it is mentioned that it is important to investigate what factors in Kaikaku contribute to making these parts of the production system more unique, in order to answer the research questions. Therefore, in the reanalysis mentioned, two specific questions were posed: 1) What is important in Kaikaku to make the technical part of a production system more unique?, and 2) What is important in Kaikaku to facilitate building innovation capabilities? The analysis was conducted in order to answer these questions.

Further, in Subsection 2.2.3, it is mentioned that levers in Kaikaku (defined as specific means that drive Kaikaku towards its desired end) can be classified into six kinds, for instance, strategic levers, structural levers, and technological levers. It was thought that the classification mentioned could be useful in analysing the evidence in a structured way.

Consequently, the analysis was conducted in the following way. Pieces of the empirical evidence collected from the five empirical studies were placed into the matrix of the two questions mentioned in columns and the six kinds of levers in rows. Pieces of the evidence in each cell were analysed to answer the questions. Based on the results of the analysis, a proposal of how to realize Kaikaku so that it contributes to creating a unique production system was created. The results of the analysis and the proposal are presented in Chapter 5.

## 3.7 Discussion of the quality of the empirical studies

In the literature on qualitative research methodologies, three criteria for evaluating the quality of the research are commonly recognized: validity, generalizability, and reliability. In the following subsections, the quality of the empirical studies conducted in the present research is discussed in terms of the three criteria.[8] In the empirical studies, several measures were taken to build quality into the studies. A summary of the measures taken in those studies is shown in Table 3.3.

**Table 3.3:** A summary of measures to increase the quality of the empirical studies.

| | ES I | ES II | ES III | ESIV | ES V |
|---|---|---|---|---|---|
| **Validity** | | | | | |
| Long-term field involvement | x | | | x | |
| Rich empirical data | x | x | x | x | |
| Triangulation | x | x | | x | x |
| Participants' validation | x | | | x | x |
| Explicit enactment action-reflection cycle | | | | x | |

[8] A discussion on the quality of the whole research will be presented in Chapter 6.

| | | | | | |
|---|---|---|---|---|---|
| Discussion with research colleagues | x | x | x | x | x |
| **External validity** | | | | | |
| Rich data for analytical generalization | x | x | x | x | |
| Multiple-case study | x | x | | | |
| Rich description of case for transferability | | | | x | x |
| **Reliability** | | | | | |
| Explicit work procedures | x | x | x | x | x |
| Documentation of data in detail | x | x | x | x | x |

### 3.7.1 Validity

Validity in qualitative research is about the degree to which theories, models, concepts, discussions, and conclusions accurately reflect and present the real world (Gummesson, 2000). A valid study can be achieved by proper collection and interpretation of data (Yin, 2011). According to Maxwell (2005), major threats to validity are reactivity and bias. Reactivity is the influence of researchers on the study objects or their settings. In the present research, reactivity was not avoidable especially in the participant-observation study (ES I) and the action-oriented studies (ES IV and V). In those studies, minimizing the researcher's influence was not considered a goal for the studies. Instead, it was thought important for the researcher to be aware of how his interventions might affect the circumstances under study and how this could influence the validity of the studies.

The other major validity threat, bias, refers to the investigator's selectivity in collecting and analysing data (Maxwell, 2005). In the empirical studies, the researcher tried to reduce the risks of bias and other validity threats, such as misinterpretations of data, by employing several measures (see Table 3.3).

A common measure was triangulation. In all of the empirical studies except the research synthesis (ES III), the data were collected from multiple sources.

A large amount of empirical data can prevent from drawing mistaken conclusions from the study because such conclusions are less likely to be uniformly supported by the amount of data (Westbrook, 1995). A large amount of empirical data was collected especially in ES I and III. On the other hand, as mentioned in the previous section, the amount of empirical data obtained in ES V was limited. Therefore, theories from this study are less grounded and should be treated as working theories that can be a basis for future research.

According to Westbrook (1995), subjectivity is a major source of bias, and thus it is the main methodological weakness of action research. Action researchers need to be open to presenting their inference, opinions, and viewpoints to the collaborating organizations in order to reduce subjectivity (Coughlan and Coghlan, 2002). Subjectivity can be reduced by conscious and deliberate enactment of action-reflection cycles (Coughlan and Coghlan, 2002; Herr and Anderson, 2005). Iteration of such a cycle creates the variety of modes of communication between researchers and the collaborating organizations though which any misunderstandings or wrong assumptions have multiple opportunities to get exposed and corrected (Westbrook, 1995). In the action-oriented studies, especially ES IV, the researcher consciously enacted the cycles of the experiential learning as presented in Figure 3.3 in order to enhance the open dialogues and reflections shared with the participants of the studies.

Other than the above-mentioned measures, the researcher constantly discussed the methods and results of the studies with research colleagues, which also contributed to improving the validity of the studies. Overall, it is assumed that the validity of the studies is not optimal but acceptable as far as the limitations of the studies are made explicit.

### 3.7.2 Generalizability

Generalizability, also called external validity, is about whether findings of the study are generalizable beyond the immediate cases studied (Yin, 1994). Yin (1994) distinguishes two types of generalization: statistical and analytical generalization. Statistical generalization infers a population on the basis of collecting a large number of samples. Analytical generalization is based on in-depth studies that involve exhaustive investigations of certain phenomena. The empirical studies except ES V were in-depth studies of the phenomena of interest, including the collection of a reasonable amount of empirical data. Therefore, it is assumed that analytical generalization is possible from those studies. In ES II and III, Japanese manufacturing companies were studied. When discussing the generality of the results from those studies, contextual factors of the study objects must be considered.

Generalizability can be strengthened by conducting multiple-case studies (Meredith, 1998). ES I and II were multiple-case studies. On the other hand, ES IV and V were single-case studies. Generalizing the results from those studies is particularly challenging. Herr and Anderson (2005) recommend that in such studies researchers should regard *transferability* instead of generalizability, in which findings are not generalized but rather transferred from a sending context to a receiving context. Sufficient descriptions of the contexts and findings of the case studies permit the readers to assess generality of the cases or make comparisons with their own or other reported situations (Westbrook, 1995). In the single-case studies, efforts were made to strengthen transferability.

### 3.7.3 Reliability

Reliability means that two or more researchers studying the same phenomena with similar purposes should reach approximately the same results. In order to achieve higher reliability, it is important to make as many steps as operational as possible and to conduct research as if someone was always looking over your shoulder (Yin, 1994). It is also important to document collected data in detail and organize them in a structured fashion so that, if needed, a reviewer can visit those data and assess whether the same or similar conclusions can be drawn from the data. In the empirical studies conducted in the research, the researcher tried to make the study procedures as explicit as possible. For instance, in the research synthesis (ES III), the procedures of the literature search, selection, and analysis were made explicit. In the interview study (ES II), the interview template was created and verbal information was written down or recorded if allowed. In an action-oriented study (ES IV), the process of experiential learning cycles was prepared when entering the interventions. Field notes were constantly written down in ES I, IV, and V. Even with the above-mentioned efforts, the researcher perceived that achieving high reliability was a challenging issue, especially when the studies involved the researcher's interventions in the case companies. The researcher's previous experience in improvement in production, his cultural background, values, skills in communication, etc., affected the generation, collection, and interpretation of empirical data. Therefore, it is assumed that limited reliability is inevitable in those studies.

# CHAPTER 4 – Empirical findings

*This chapter presents empirical findings obtained from the five empirical studies conducted in the research presented in this thesis. A large part of empirical findings is also presented in the appended papers. However, some parts are presented only in the main text of this thesis.*

## 4.1 Empirical findings from Empirical Study I

The purpose of Empirical Study I was to understand the way of driving lean transformations practised by the Japanese consultant mentioned in Chapter 3. Empirical evidence was collected through the researcher's (the author of this thesis) participant observations of two lean transformations at two medium-sized Swedish manufacturing companies (companies A and B).

During the empirical study, companies A and B realized radical improvements in production. For example, the production lead time at company A was reduced by 35 per cent. This was achieved by drastic changes in production flows, production planning, batch sizes, management structure, organization culture, etc. At company B, the lead time of the assembly and test processes was reduced from a few days to a few hours. This was achieved mainly by changing from batch production to one-piece flow.

The outcomes of these transformations may not be particularly different from other lean transformations in the industry. However, how the consultant drove these lean transformations was relevant to the second research question. At the beginning of the transformations, a general directive of improvement (e.g. the lead time shall be reduced by half, or the number of internal defects shall be reduced by half) was issued. However, the Japanese consultant was reluctant to make detailed plans. He said, "I can make a rough plan, but I have never experienced any lean transformations that followed any detailed plan". Furthermore, his advice, comments, and behaviour appeared spontaneous, with little consistency. Examples of improvement events described below illustrate his behaviour and actions during the lean transformations. More examples of the improvement events can be found in Appended paper B.

*Example of improvement, event I*: When analysing one production process at company A, the consultant thought that there was too much buffer stock.

It was because they produced in one-week batches. After a quick investigation showed that it was possible to produce in daily batches, he suggested removing the buffer stock completely, except for the amount needed for the daily batches. The shop floor supervisor and the operators showed confusion and an unwillingness to reduce the stock. The consultant however insisted that they do it anyway, saying that they would find a way to manage the reduced amount of buffer stock.

*Example of improvement, event II*: At company A, there was a tension between the two departments production planning and production. Production planning felt that production did not follow the plans. At the same time, production felt that many production orders started based on a prognosis, and frequent priority changes of the orders caused chaos in production. Due to the lack of trust in production, production planning tended to start production orders in greater volume and as early as possible in order to offset the risk of delivery delay to the customers. This increased work in progress, WIP, and lead time. It also increased the process complexity that made actual WIP and lead time even longer. The consultant told production planners that if they tried to reduce the risk of delivery delay by starting production orders in greater volume and earlier than necessary, the competency of production would never improve. They were advised to try to start only confirmed orders and, moreover, to start as late as possible. Taking actual value added time of their products into consideration, the consultant saw that lead time could be much shorter. He instructed them to reduce the lead time by 30 or 50 per cent in their planning system immediately, and to start production orders later in accordance with the shortened lead time.

*Example of improvement, event III*: At company B, an assembly section made a layout change to create a flow production. Then the consultant instructed the production manager to carefully observe how operators assembled the products. He said, “Layout change is just a first step. Now, observe the assembly process carefully and find any factors that disturb the repeatability of the operation. All the disturbances you may find are potential risks of quality problems. The disturbances can be because of lack of assembly instructions, poor product designs for assembly, insufficient operator training systems, inappropriate fixtures or jigs, inadequate positions of parts feeding, malfunctions of testers, lack of parts, defect parts, competence of supervisors, and so forth. The lead time can be shortened by the layout change, but identifying and correcting all those disturbances is another important reason for this layout change.”

It is probably difficult to understand the relevance of the above-presented evidence to the second research question. Therefore, as an exception, interpretation (analysis) of the evidence obtained is presented in the rest of this section, with the purpose of clarifying the relevance mentioned.

By observing improvement events such as those presented above, it was found that there was consistent thinking behind the consultant's comments and behaviours. In his way of driving the lean transformations, he did not focus much on providing solutions or teaching lean concepts, tools, and techniques to the employees of the companies. Instead, he was mainly concerned with how to constantly create situations where people at the companies feel the need for improvement. He strongly believed that creating the need for improvement was the central driver of lean transformation. The consultant's way of driving lean transformations can be described as follows:

> *Occasionally by force he created situations where people in an organization had little choice but to feel the need for improvement. The situations were created by setting requirements that bring different problems up to surface. Through letting people in the organization discover solutions to the surfaced problems in a learning-by-doing manner, the operational performances were improved and at the same time people learned skills, knowledge, techniques, and thinking necessary to achieve lean production.*

The image of the above-mentioned way of driving lean transformation can be explained by "the Japanese sea model" as shown in Figure 4.1. This is commonly used to explain why stock levels need to be reduced in lean production. The principle of this model is that a high water level (i.e. stock level) hides various problems underneath. Problems such as lack of parts, production of defect parts, and machine breakdowns are absorbed by the stock and do not affect the operation directly. Consequently, these problems are not likely to be recognized with any sense of urgency. On the other hand, when the stock level is reduced, the problems start to directly affect the operation. This provokes the need for various improvement activities. The activities can be related to quality, work standard, maintenance, leadership, product design, and so on, depending on the problems that appear on the surface.

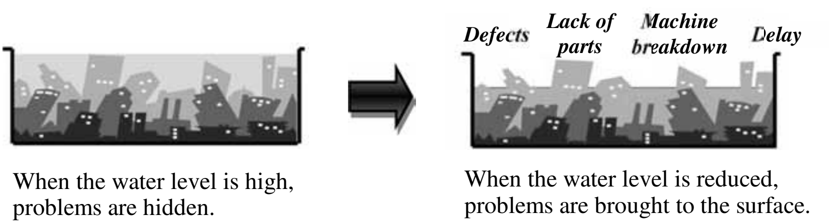



**Figure 4.1:** The Japanese sea model.

The above-mentioned water level can be any other parameters that can be changed to create the need for improvement, for instance space for stock and production lead time. It was found that the consultant constantly and deliberately reduced the water level at different parts of the organization at different points of time to create a momentum of improvement cycles towards lean production. Lean techniques (e.g. 5S, standardized work, Kanban) or other improvement methods can be provided only based on the needs.

In the described way of driving lean transformation, there is little sense to make a predetermined and detailed transformation plan, because necessary interventions in the course of the transformation are largely dependent on the problems that emerge on the surface. Each improvement cycle can be structured but the whole transformation process is of an emergent nature. The process can be described as an unfolding series of improvement events triggered by the consultant. The process is consequently less linear and systematic, and therefore it is more difficult to predict exactly what outcome will be obtained when. The uncertainty is especially high at the beginning of the transformation. However, a notable advantage of the presented way of driving lean transformation is that it includes a process of collective *discovery learning* (Buckler, 1996) in which people are encouraged to find a way to discover solutions through experiments. Such learning provides opportunities for employees to learn how to improve and occasionally how to innovate, which in turn enhances innovation capabilities.

## 4.2 Empirical findings from Empirical Study II

The purpose of Empirical Study II was to investigate production organizations striving to realize unique production systems, and to identify what organizational setup was relevant to the realization of such systems. Empirical evidence was collected through interviews with five Japanese manufacturing companies that make organizational efforts to create unique production systems. Interviews were also conducted at four Swedish manufacturing companies as reference cases.

Below a summary of the collected evidence is presented in accordance with the four general categories of questions asked during the interviews. As shown in Subsection 3.6.2, the categories are manufacturing strategy, organization structure at production function, education systems at production function, and involvement of shop floor employees in innovation. A more detailed description of the evidence can be found in Appended paper C.

*Manufacturing strategy*: Strategic roles of the production functions in companies were inquired into in the interviews. The respondents from the five Japanese companies commonly answered that the production functions in Japan played and would continue to play significant roles in sustaining the companies' competitive advantage. These companies assign their domestic production functions as global production development centres where new production processes, new production equipment, and new work methods are developed, tested, implemented, and refined. At the same time, the functions were considered a global centre of human resource development where managers and employees were educated, trained, and actively engaged in development work so that they became capable of realizing the kinds of technical solutions mentioned. Further, the respondents from the Japanese companies mentioned that innovation or developing unique solutions in production is one of the important roles of the functions. A respondent from one of these companies presented a picture of how different parts of the production organization should be integrated to create a competitive production organization (see Figure 4.2). In the picture, the importance of innovation in production is explicitly stated. As for the Swedish companies, two of them assigned their domestic factories as master plants, but the respondents from these companies did not emphasize the role of production as strongly as those of the Japanese companies.

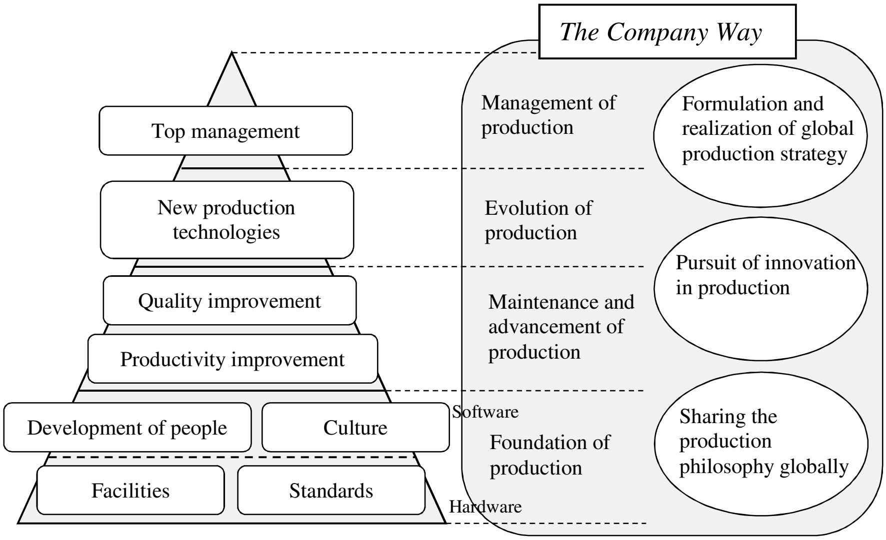



**Figure 4.2:** A structure of production management at one of the Japanese companies presented by an interview respondent (translated by the author of this thesis).

As to how manufacturing strategies are formulated and implemented, no significant difference was found among the nine companies. At the companies, corporate or business strategies are created. Then a few years of long-term manufacturing strategies are formulated. Yearly action plans are made and specific projects are organized based on the manufacturing strategies.

A notable difference between the Japanese and Swedish companies was that the Japanese companies emphasized the importance of developing their own unique production equipment as a way to differentiate their production systems from those of the competitors. Four of the Japanese companies also had a specific concept in equipment development. These companies made efforts to develop simple, slim, and compact equipment. On the other hand, respondents from all the Swedish companies reported that they preferred relying on external suppliers for equipment development. A respondent from one of the Swedish companies said that the company usually bought standard machines and devices in consideration of costs and availability of spare parts.

*Organization structure at production function*: Organization structures especially of production engineering functions were investigated in the interviews. The Japanese companies divided production engineering functions into support functions for factories and production development functions. A production development function here means a function specialized for developing future production technologies, production equipment, production lines and cells, etc. A respondent from one of the Japanese companies said that such a separation was needed, otherwise the production engineers tended to be drawn into daily problem-solving tasks for the shop floors. Two of the Swedish companies also made such divisions.

One of the questions related to organization structure was the ratio of production engineers to shop floor operators. The question was asked in order to understand the amount of resources that the companies generally allocated to production engineering functions. While eight of the nine companies had a ratio between a few per cent and fifteen per cent, one Japanese company had a considerably high ratio of 28 per cent. This company had developed its own industrial robots, and the number of robots used at the domestic factories was higher than that of the operators (the number of the operators was about 10,000).

Compared to the Swedish companies, the Japanese companies had larger production development functions, but at the same time they had challenging targets to achieve. For example, they were required to develop future production systems that would reduce production lead time or production costs by half, to develop production equipment with half of the usual payback time, or to develop automation systems with the number of actuators used in the system being reduced by half.

Interview respondents were asked about the cooperation between product development and production engineering functions. While most of the nine companies used design reviews as facilitation of the cooperation, three of the Japanese companies had additional mechanisms to enhance the cooperation. For instance, one of these companies organized a so-called “next product generation team”, which consisted of engineers from both product development and production development functions. The team simultaneously developed future platforms of products as well as future production systems. A respondent from this company showed a picture of how the next product generation teams that had been organized since the early 1970s constantly developed innovative production systems. Further, at this company, production development engineers are free to move their workstations to any other departments or business units, depending on the project that they are involved in. Another company organized a special department coordinating production engineers, product development engineers, and factory staff and operators in order to drive large improvement projects in production. Respondents from this company showed an example of how the department drove a project that led to the creation of unique internal logistic solutions.

*Education systems in production function*: The respondents were asked about how people in the production organizations were trained and educated. A tendency was that the more a company considered the strategic importance of the production, the more the company made systematic efforts to educate production engineers and shop floor workers. As for the training of the production engineers, most of the companies studied trained production engineers based on learning by working. Two Japanese companies having a large number of production engineers had developed central training systems.

As for training of shop floor workers, most of the Japanese and Swedish companies had systematic training schemes. Skill matrices were commonly used among the companies studied. Some of the Japanese companies organized or encouraged entering internal or external skill competitions in order to foster skill development of the operators.

*Involvement of shop floor employees*: In the interviews it was investigated how shop floor employees contributed to realizing unique production systems. The respondents from all of the Japanese companies reported that their knowledge and skills were essential to realize such systems. A respondent from one of those companies said that without the shop floor employees' skills in making problems tangible, analysing them, and giving feedback to production engineers, new production processes and equipment could not mature and exert their full potential. Another company had created fully automated reconfigurable assembly lines. A respondent from the company said that the lines could be operated only by highly skilled operators who had deep knowledge of the equipment used in the lines and could identify and correct disturbances in the lines quickly.

Many of the respondents of the Japanese companies said that the companies had long experience in lean production and that the shop-floor employees were highly skilled in maintaining and improving operations. At the same time, they recognized that improvements at the shop-floor level rarely went beyond an annual ten per cent increase in key performance measures. Such improvements were still critically important for the companies because they brought a large amount of cost saving every year, but it was said that improvements larger than that usually required engineering-driven improvements.

## 4.3 Empirical findings from Empirical Study III

The purpose of Empirical Study III was to answer 1) what in the Kaikaku initiatives described in the reports contributed to making the technical parts of the production system more unique, and 2) what in those initiatives contributed to building innovation capabilities. 65 case reports describing Kaikaku initiatives were gathered and two rounds of data reassembly were conducted (see Section 3.5 about data reassembly).

The first round of data reassembly led to the creation of an overview picture of the Kaikaku initiatives. The picture is presented in Appended paper D. In this section, the result of the second round of data reassembly is presented. The result is not presented in that appended paper.

The data (i.e. pieces of descriptions and comments about the Kaikaku initiatives presented in the reports) relevant to the first question are shown in Table 4.1. It was found that the data were related to five themes: strategies and goals, pursuit of ideal states, development of production technologies and equipment, cross-functional teams, cultures and mindsets, and other factors (see Table 4.1).

**Table 4.1:** A summary of the data relevant to what in the Kaikaku initiatives contributed to making the technical parts of the production system more unique.

*Strategies and goals*

- The goal was to create simple and slim production lines by reducing lengths, areas, and investment costs to one third. The intention was to generate unprecedented ideas and stimulate collective efforts to achieve the goal (Shirai, 2007).
- Together with performance goals, the restriction on the investment cost (1/30 of existing solutions) stimulated creativity even more (Kishimoto and Fujita, 2009).
- Creating a factory as a global centre of advanced production technology development was a part of the initiative (Watabe, 2010).
- "Challenge the impossible" was a part of the roadmap of the Kaikaku initiative. The paradigm shift from incrementalism was thought necessary (Matsuo, 2007).

*Pursuit of ideal states*

- Fixtureless assembly was considered ideal when designing new assembly lines (Kawakami and Kobayashi, 2005).
- Approaching ideal states with a clean slate was preferred to improvement based on the existing systems (Sawa, 2007).
- Value-engineering thinking was adopted. It implied seeking solutions from their ultimate purposes without relying on conventional solutions. Ideal states were considered from a holistic perspective (Maruyama, 2008).
- An ideal assembly line was pursued by focusing on VAPPs (Tanahashi, 2009).
- Focusing on VAPPs and theoretical ideals enabled creating solutions that were thought impossible before (Fujimoto, 2009).
- "Anything but VAPPs is waste" was considered in the equipment design, which led to creating simple but unique production equipment (Sawa, 2007; Shirai, 2007).

*Development of production technologies and equipment*

- Development of unique production technologies was considered a way to sustain competiveness in production. The development resulted in creating modularized automation assembly lines (Watabe, 2010).
- Reconfigurable automation assembly lines were developed (Yoshida and Fujiwara, 2007; Banzai and Watanabe, 2007).
- “Lean equipment” – simple, compact, and low-cost equipment that was inlined and synchronized with takt time – was developed to differentiate the production systems from those of competitors (Akita, 2004; Sawa, 2007; Enomoto, 2007, Takahashi, 2001; Yoneya 2001).

*Cross-functional team*

- A cross-factory support group was created. The group included an ideation team consisting of experts from different functions and a development team for supporting advanced production equipment development (Shirai, 2007).
- Production engineers and operators worked as a team to develop and implement novel production equipment (Kawakami and Kobayashi, 2005; Tanahashi, 2009).
- Future products and future production systems were simultaneously developed, which led to creating a reconfigurable automation line (Watabe, 2010).
- Product development and production engineering worked together to develop automated assembly lines and cells (Banzai and Watanabe, 2007; Watabe, 2010; Yoshida and Fujiwara, 2007).

*Cultures and mindsets*

- The culture of advocating experimenting, admiring challengers, and tolerating failures helped to overcome highly difficult challenges (Ozawa, 2006).
- A positive attitude and persistency in the group contributed to creating solutions that had been thought impossible at the beginning (Kawakami and Kobayashi, 2005; Kishimoto and Fujita, 2009).
- The initiative was undertaken with a “do it first” mentality (Nakagi, 2004).

*Other factors*

- Education for in-house production equipment development was organized (Enomoto, 2007).
- An internal exhibition of production-related innovative solutions was held. Awards were given to employees who created highly innovative solutions (Sawa, 2007).

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In the following the data shown in Table 4.1 are briefly explained. Setting stretched targets was common among most of the Kaikaku initiatives described in the reports. However, a few companies set even harder and nearly unattainable targets, such as those shown in Table 4.1, to stimulate creativity even more and also to provoke collective efforts to achieve the common goals. At one company, such a target was set with the purpose of driving people in the organization to leave behind the incrementalism prevailing among them and be more explorative and active in realizing innovation in production (Matsuo, 2007).

Several companies in the reports pursued different kinds of ideal states as a way to generate novel solutions. In a report it is stated that pursuing ideal states helps designers and problem solvers to be free from conventional solutions and ways of thinking (Maruyama, 2008). Some companies used the VAPP approach, which is also one of the ways to pursue ideal states.

Some companies focused on developing advanced production equipment in the Kaikaku initiatives, with the intention of differentiating the production systems from those of the competitors. For instance, a company developed reconfigurable automation assembly lines consisting of robot modules which could be added to or removed from the lines depending on product variations and volume (Yoshida and Fujiwara, 2007). Some other companies made efforts to develop so-called lean equipment – simple, compact, and low-cost equipment that could be placed in the production lines and synchronized with the takt time – in their Kaikaku initiatives. This kind of equipment was well described in one of the reports written by Yoneya (2001). The report mentions that conventional pieces of equipment used to be designed for manpower saving and high-speed processing. However, they became obstacles to realizing one-piece flows. They were often too large to be placed at one-piece flow lines, and the speeds of these machines were too high to synchronize with the takt times of the lines. Therefore, the company developed small low-cost pieces of equipment that could be placed in the lines and synchronized with the takt time. Some reports state that developing lean equipment was also a way to establish sustained competitive advantages in production (e.g. Takahashi, 2001). All of the production equipment mentioned was developed in-house.

Several reports mention that cross-functional teams contributed to creating innovative solutions. For instance, at the company reported by Shirai (2007), cross-functional teams were created to assist in generating unprecedented ideas and developing unique production equipment. The teams consisted of experts from different functions. One of the teams was to support ideation and the other to support development of production equipment.

In addition, it is mentioned in some reports that the culture of advocating experimenting, admiring challenges, encouraging persistence, and tolerating failures helps to generate solutions that company staff thought impossible to create at the beginning of the projects.

The data relevant to the second question are shown in Table 4.2. As shown in the table, it was found that the data were related to eight themes: innovation capability building as a part of the objectives, innovation efforts energized by doing, cycles of innovation capability building, experimentalism, providing opportunities for innovation capability building, roles of top management, supporting organizations, follow-up and rewards, and other factors.

**Table 4.2:** A summary of the data relevant to what the companies did during Kaikaku to build innovation capabilities.

*Innovation capability building as a part of the objectives*

- Radical improvement in production and development of organization and human resources were equally emphasized and undertaken simultaneously (Akita, 2004; Hora, 2003; Nakagi, 2004; Noguchi, 2007; Yoneya, 2001).
- To reenergize innovation efforts was one of the purposes of the initiative (Hamada, 2003; Yoshida and Saito, 2008).
- To increase the speed of improvement was one of the objectives (Nagai et al., 2001).
- Kaikaku was a means to increase employees' motivation for realizing innovation (Shiina, 2009).
- Continuous participation of all employees in breakthroughs and innovation was a part of the strategic visions or roadmaps under which the initiative was undertaken (Fujita, 2005; Tanahashi, 2009).

*Innovation efforts energized by doing*

- Experiencing radical improvements (e.g. production lead time reduced to one tenth) brought employees a sense of achievement and can-do spirit, which gave them motivation for further improvements (Fujita, 2005; Hirose, 2005; Nakagi, 2004; Noguchi, 2007; Omori, 2009; Takahashi, 2001; Watai, 2004).
- Through undertaking radical improvements, behavioural changes in the employees occurred. They had changed from a conservative type – preferring to maintain the status quo and avoid changes, to an innovative type – favouring questioning the status quo and conducting experiments (Kamata, 2000; Mishima, 2004; Yoshida and Saito, 2008).
- Employees' skills in improvement were increased through the initiative (Kamata, 2000; Shimoda, 2004).

*Cycle of innovation capability building*

- Employees in the organization identified challenges, overcame them, and then gained a sense of achievement. Top management admired their efforts, which increased the motivation for improvement even more. By iterating this process, motivation and skills for improvement were increased (Yoneya, 2001).
- Explorative improvements develop people. The more people could achieve such improvements, the more difficult challenges they could address. Iterating this improvement cycle as fast as possible was the key for the initiative (Kamata, 2000).
- People in the organization iterate improvements that involve the exploration of unknown and non-experienced areas. The continuous effort for the exploration strengthens the organization (Matsuo, 2007).

*Experimentalism*

- The initiative was undertaken with the motto of "do it first" (Hirose, 2005; Mishima, 2004; Nagai et al., 2001; Nakagi, 2004).
- Action and speed were the highest priority in the initiative (Akita, 2004).
- Explorative improvements undertaken with a "do-it-first" attitude generate outcomes that can be analysed and reflected on. They may result in failures, but people could learn from them and prevent the same mistake from occurring again (Kamata, 2000).

*Providing opportunities for innovation capability building*

- Intensive improvement events were regularly initiated expecting participants to learn team work, analytical skills, and the "do-it-first" behaviours (Sasaki, 2009).
- To mobilize the employees, goals were set that often seemed impossible at a first

glance but possible if everyone made significant efforts (Akita, 2004; Sasaki, 2009).

- Organizational capabilities for innovation were improved by identifying challenges and having the employees work on them in a learning-by-doing manner (Horio, 2008).
- Three elements were important to constantly realize innovation: providing opportunities for innovation, increasing the motivation for innovation, and developing the skills and knowledge in innovation. It was found that the first one was the most important element (Horio, 2008; Sasaki, 2009).
- In-house equipment projects were launched. The projects were not only for reducing costs but also developing skills for equipment development. The deep understanding of the equipment was also beneficial for effective maintenance (Anonymous, 2009).

*Roles of top management*

- Top management periodically inspected the shop floors to keep the momentum of improvement (Taniguchi, 2009).
- Top management's active involvement in improvements, its leadership, and behavioural changes of middle managers were important to create the tempo in improvement (Yoneya, 2001).
- It was important for top management to communicate the importance of capability building and share capability-building objectives with employees (Horio, 2008).

*Supporting organizations*

- An improvement support team was created. The team was intended for increasing the speed of improvement, by providing technical support to the improvement of material handling, jigs, fixtures, devices, etc. (Taniguchi, 2009).
- A group for promoting organizational development was created in the initiative (Horio, 2008).

*Follow-up and rewards*

- An evaluation and reward system was created to increase motivation of the cycle of improvement (Horio, 2008).
- Progress and results of the improvements were shared in the organization and presented at a meeting attended by the top management (Taniguchi, 2009).

*Other factors*

- Education and training for developing improvement skills was organized (Taniguchi, 2009; Yoneya, 2001).
- An initiative was undertaken with the motto of "a change of individuals leads to a change of workplaces, and the change of workplaces leads to a change of organizational cultures" (Hamada, 2003; Hora, 2003; Taniguchi, 2009).

Many of the reports reviewed mentioned the importance of building innovation capabilities during Kaikaku. Some companies set increasing the capabilities as one of the objectives in Kaikaku. Some other companies had achieving high proficiency in innovation as a long-term strategic goal and considered Kaikaku as an important step to realize that goal (Fujita, 2005; Tanahashi, 2009).

Most of the Kaikaku initiatives in the reports were executed as a series of smaller improvement or development projects that were carried out in a coordinated way to achieve the overall objectives. Several managers involved in the initiatives recognized that achieving radical improvements motivated the employees to undertake more difficult improvement. Experiencing or directly observing radical improvements (e.g. reducing production lead time to one tenth at a certain area of the shop floor) brought employees a sense of achievement and can-do spirit (Noguchi, 2007). The president of one of the companies in the reports commented that behavioural changes in the employees occurred through making radical improvements. They had changed from a conservative type – preferring to maintain the status quo and avoid changes, to an innovative type – favouring questioning the status quo and conducting experiments (Kamata, 2000).

Further, in several reports managers observed that the employees' skills, knowledge, and motivation for innovation had increased as an improvement cycle was iterated. For example, a director of one of the companies in the report commented that people in the organization visualized wastes, solved the problem, gained a sense of achievement, and repeated this process again (Yoneya, 2001). Through this cycle people increased their capability for innovation, and the performance of the operation was also improved. The director believed that this cycle was the most important element of the Kaikaku initiative. In another report, a manager of a company pointed out that explorative improvements made with a bold spirit might result in failures, but people could learn from them and prevent the same mistake from occurring again (Kamata, 2000). He stated that such improvements developed people. The more often people could achieve such improvements, the more difficult challenges they could tackle (Kamata, 2000). In one of the reports, it is stated that the iteration of such a cycle changes individuals, which leads to changing the climate of workplaces, which in turn leads to a change in organizational cultures (Hamada, 2003).

In several reports, it is recognized that the capability building required continuous efforts. In the Kaikaku initiatives various things were done or considered important in order to keep the momentum of iterating the kind of cycle mentioned. A number of reports have shown that the do-it-first mentality, top management involvement in innovation efforts, teams that support problem solving, and follow-up and reward systems contributed to keep the momentum mentioned (Mishima, 2004; Nagai et al., 2001; Taniguchi, 2009; Horio, 2008).

In several Kaikaku inititatives, constanly providing employees with opportunities to realize innovation was considered important for building innovation capabilities. Horio (2008) and Sakaki (2009) stated in the reports that three elements were important to constantly realize innovation: providing opportunities for innovation, increasing the motivation for innovation, and developing the skills and knowledge in innovation. Horio (2008) asserted that the first one was the most important element.

## 4.4 Empirical findings from Empirical Study IV

The purpose of Empirical Study IV was to obtain knowledge of how to use the VAPP approach in practice. As mentioned in Chapter 3, the researcher attempted to obtain the knowledge from three sources: published reports describing how companies used the VAPP approach, an interview with a person who practised the approach, and an action-oriented case study in which the researcher used the approach at case company L.

From the first source, several reports were found. A summary of the descriptions in the reports as to how the approach was used at the companies is shown in Table 4.3.

**Table 4.3:** A summary of how the VAPP approach was used at the companies (information obtained from the published reports).

| Company (Source) | How the VAPP approach was used |
|---|---|
| Sekiso (Kato, 2008) | A routine was established in which engineers had to consider at least three alternative work heads for every VAP when they designed equipment. The company also made an effort to identify and document the work heads and the conditions for quality conformance at each VAP in the factory. These activities contributed to maintaining a high level of manufacturing quality as well as reducing investment cost in pieces of equipment by half. |
| Fuji Univance (Shinoda and Kono, 1997) | Simple and low-cost production lines and equipment were developed by using the VAPP approach. The company made a chart that describes each of the VAPs in the factory. The principle of “compacting VAPs” was applied. One of the results was reducing investment cost of a new assembly line by 30 per cent. |
| Canon (Sawa, 2007) | A corporate-wide initiative was launched aiming to create new ways of realizing VAPs and at the same time to eliminate parts of the pieces of equipment that were not directly involved in the VAPs. A target was to reduce investment cost and size of pieces of equipment to one fifth. |
| Mitsuba (Tanahashi, 2009) | A novel way to design a new assembly line was devised. The new line was designed from the assembly completion and backwards, based on the thinking that assembly parts should be fed at the immediate points where the parts are disassembled. 25 per cent higher productivity was achieved in the new assembly line. The area of the new line was also reduced by half. |
| Toshiba (Harada and Adachi, 2000) | The company promoted the development of so-called “value-adding process-point-focused equipment” – simple and low-cost equipment consisting of the least necessary functions and structures to realize the related VAPs. Slimming the requirement specification for the equipment was considered important to realize such equipment. |

Two of the companies in Table 4.3 used the VAPP approach in the context of Kaikaku. Most of the reports only partially described how the approach was used. On the other hand, a couple of the reports had more detailed descriptions. The report describing an application case at Mitsuba (Tanahashi, 2009) is one of them. At the company, which is an automotive supplier, a group of production engineers used the VAPP approach when designing a new assembly line. When they disassembled a finished product, they thought that waste would be at a minimum if all assembly parts were fed to the immediate points where the disassembly took place. With this consideration, they designed the assembly line backwards; they identified work heads and conditions for quality conformance from the assembly completion to the start of the assembly. This design approach was new for the company because production engineers at the company usually designed assembly lines from the beginning of the assembly and forward. As a result, productivity increased by 25 per cent in the new line, and the area used for the new line was less than half of the previous one.

A summary of how the approach was used at the case companies is summarized in Table 4.4.

**Table 4.4:** A summary of how the VAPP approach was used at the case companies.

| Company (Source) | How the VAPP approach was used |
|---|---|
| Company X (Interview) | The VAPP approach was used to develop a simple and low-cost piece of equipment. A conceptual design was made with the objects, work heads, and other supporting structures being successively sketched on a large piece of paper. Experts from different disciplines gathered to work on the conceptual design. |
| Shop floor Alpha, Company L (Case study) | An assembly process for the key components of the product was analysed by using the VAPP approach. The analysis was made with an explicit focus on the objects in the process. To assist the analysis, an analysis chart was created. Recommendations for the improvement were made by considering an ideal state, i.e. how to add a minimum amount of waste to the identified VAPPs. |
| Shop floor Beta, Company L (Case study) | An assembly process for the interface components of the product was analysed and improvements were proposed by using the VAPP approach. The analysis and a redesign of the process were made in the same way as at Alpha. It was found that the design using the VAPP approach required imagination and creativity. |
| Shop floor Gamma, Company L (Case study) | Design recommendations for a new assembly line for a new product family were made by adopting Mitsuba's way of designing an assembly line – designing backwards from the assembly completion to the beginning of the assembly. |
| Shop floor Delta, Company L (Case study) | Design recommendations for the packaging process were created in a workshop with the shop floor employees at Delta. They were asked to generate ideas for improvement by considering the ideal state mentioned above in this table. In the workshop, efforts were made to facilitate the participants' creativity. |

An application case at company X in Table 4.4 was presented by the interview respondent. The company is an automobile and industrial equipment manufacturer, and the respondent was an ex-senior manager of the company. In the interview he gave an example of how the approach was used at the company. In the example, production engineers were requested to make a conceptual design of a simple and low-cost machine that should make holes on car bodies. A workshop was organized in which the engineers first sketched an object (a part of a car body) in the middle of a large piece of paper. Then they sketched work heads (that would directly affect the object to create holes on it) around the object. Later they sketched structures that could realize the movement of the work heads. Then they sketched structures that could support the previously sketched structures. In this way, the sketch was continued until a conceptual design of the mentioned machine was created. Along with the conceptual design, notes on reliability, safety, operability, robustness, use of common parts, environmental impact, etc., were written on the same piece of paper. The interview respondent reported that production engineers tended to rely on existing solutions when they designed pieces of equipment but the VAPP approach helped them to focus on simplicity and think beyond the existing solutions.

Descriptions of how the VAPP approach was used at case company L is presented in detail in Appended paper E. However, an application case at the shop floor group Alpha can be introduced here as an example. Group Alpha was responsible for assembling key components of the products. The production manager requested the researcher to analyse the assembly process at Alfa and suggest design recommendations by applying the VAPP approach. By referring to Nakamura's (2003) suggestion as to how to use the approach in an analysis (presented in the second chapter), the analysis began with an explicit focus on the *objects* (the parts assembled at Alfa). How the objects were moved and processed was carefully observed. How often the objects changed the *holders* (the things maintaining the objects at certain positions such as hands, tables, pallets, and fixtures) was also observed. Then it was observed how the shop floor operators and the pieces of equipment were involved with the objects. When observed in this way, the objects were mostly moved, picked, or placed, without receiving much value-adding. Problems were identified by considering why the objects were handled in the observed manner. Later, ideas for improvements were generated by referring to the principle and guidelines for designing a simple work system explained in Subsection 2.4.2. As the principle suggests, the ideal states were conceived (the task of the work system being performed only by the VAPs or VAPPs). In order to structure and visualize the above-described analysis, an analysis chart was devised (see Figure 3 in Appended paper E). Based on the analysis, a conceptual design was created, again by referring to the principle and guidelines for a simple work system. In the conceptual design, the VAPs became closer to each other. The non-VAPs were reduced by about 40 per cent. The frequency of the holder changes was also reduced by more than 50 per cent. The conceptual design included an idea for a compact piece of equipment that was new to the company. The analysis result and the conceptual design were presented to and discussed with the production manager and a production engineer. They agreed on the problems identified in the analysis. They also appreciated most of the conceptual design except some details. They thought that the VAPP approach was an interesting analysis and design method, because the approach gave them a detailed insight into how the objects were handled at the shop floor and how they should be handled. Being inspired by the recommended design, the production engineer designed and implemented a new shop floor layout that enabled simpler material flows at Alfa. A prototype of the compact equipment mentioned above was developed. At the moment when the case study ended, the prototype was tested.

## 4.5 Empirical findings from Empirical Study V

The purpose of Empirical Study V was to obtain initial empirical evidence regarding the effect of "the deliberate discovery-learning approach to building exploration capabilities". The evidence was obtained by applying the approach at a case company. As mentioned in Chapter 3, the empirical study adopted a deductive approach with four steps:

5. Define the approach
6. Develop a process that guides how to apply the approach in practice
7. Apply the approach at a case company with the help of the developed process
8. Collect the empirical evidence and find an initial indication as to the effect of the approach

The results of the first two steps are presented in the first subsection. The collected empirical evidence is presented in the second subsection.

### 4.5.1 Development of the approach

As explained in Subsection 3.6.2, the approach mentioned above was mainly inspired by the way that the Japanese consultant drove the lean transformations. The definition of the approach was made by analogy with the mentioned way. The definition is shown below.[9]

> *An organization's exploration capabilities are built through leaders iteratively and deliberately creating situations where groups in the organization have to or can be more explorative. By creating such situations iteratively at different parts of the organization and at different points of time, people in the organization become more trained to think and act in explorative ways, and at the same time organizational*

[9] The approach defined above is a type of deliberate-emergent approach. In Appended paper F, a theoretical comparison is made with other possible approaches, for instance a more deliberate or bottom-up approach to building the exploration capabilities.

*support for exploration (e.g. the organization's strategies, formal structures, systems, and processes) is eventually identified and implemented based on the needs. Along with this, new concepts and solutions are also created, tested, and/or implemented.*

The approach defined above shows a general direction of how the exploration capabilities can be built, but it does not inform how to apply it in practice. Therefore, a process was developed that could guide how to apply the approach in practice. The process developed is shown in Figure 4.3.

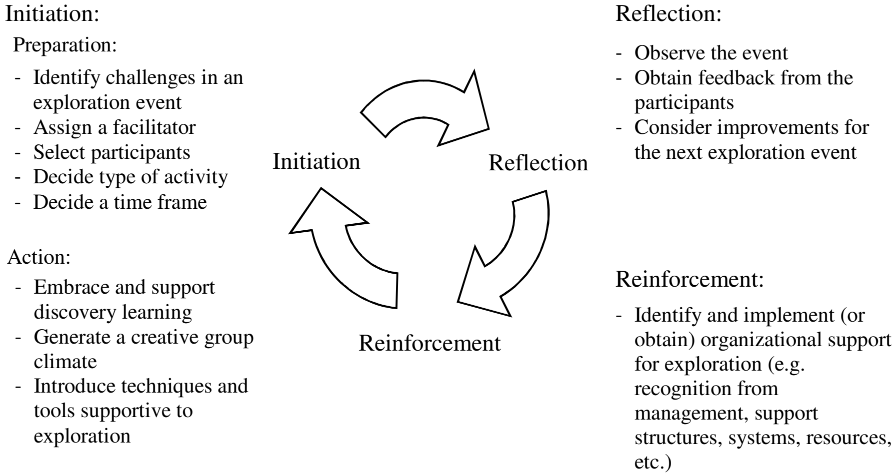


**Figure 4.3:** A process of how to apply the proposed approach in practice.

The developed process is a cyclic one, because, as mentioned in Subsection 2.5.2, building organizational capabilities resembles training that requires repetition (Bessant and Caffyn, 1997). The process was also inspired by Kolb's (1984) experiential learning cycle. This is because the mentioned approach and the experiential learning cycle have one thing in common: actions create opportunities for learning. The process consists of three steps, initiation, reflection, and reinforcement. At the first step, a situation is deliberately created where a certain group in an organization has to be more explorative and find solutions to problems or other kinds of challenges. In the process, such an occasion is called "an exploration event". At the second step, the exploration event is observed and reflection is made on the event. Improvements for the next exploration event are considered. At the last step, necessary organizational support for exploration (e.g. management's recognition, organization structures, financial and human resources) is identified and implemented. The process is intended for managers, leaders, and facilitators who drive the capability building. The idea behind the process is that continuous and deliberate iteration of the process causes evolutional development of the exploration capabilities; people in the organization gradually become more trained in exploration, and organizational support for exploration is eventually identified and implemented.

A more detailed explanation of how to execute the process is presented in Appended paper F. In this section, the first step, initiation, is explained further. The initiation step includes two substeps. At the first substep an exploration event is prepared. It starts with identifying challenges to be dealt with in the exploration event. Challenges should be bold enough to create the need for exploration with some sense of urgency. Challenges can be identified by considering the following:

- Increasing constraints (e.g. setting requirements such as doubling productivity and eliminating forklifts from the factory), and
- Removing constraints (e.g. designing equipment from a clean sheet of paper, designing manufacturing processes by conceiving an ideal state).

An exploration event includes idea generation, prototyping, and implementation. However, it can include only one or two of these activities. At the second substep, the exploration event is executed. Participants in the event are engaged in finding solutions for the challenges addressed in the event. At this substep, a group climate supportive to exploration (i.e. a climate embracing, for instance, playfulness, openness, mutual respect and trust, risk-taking, and experiment (McLaughlin et al., 2008)) can be created. Various creative problem-solving techniques, such as brainstorming and wishful thinking, can also be used.

### 4.5.2 Application of the approach

The process presented in the previous subsection was initiated at four different groups at the case company. As mentioned in Chapter 3, the researcher was involved in initiating four exploration events, with the purpose of exemplifying how an exploration event can be prepared and initiated. How to continue the rest of the process was left to the members of the company. After the initiation of those events, an additional exploration event was initiated by the company staff. A summary of the events is shown in Table 4.5. A few months after those events, the researcher interviewed the participants in the events to hear their reflections on the events and the rest of the process. It was also asked what they thought important to build exploration capabilities. A summary of the reflections is also shown in Table 4.5.

**Table 4.5:** The exploration events and the reflections of the participants.

| | |
|---|---|
| **Exploration event A:**[10] | **Improvement of a packaging process** |
| *Challenge:* | How to package the products with persons or machines touching the products and the packaging materials as little as possible. |
| *Activity & result:* | Ideas were generated in a form of creative workshop. The VAPP approach was used. Some ideas were implemented, and some other ideas were under development. |
| *Reflection:* | The participants felt that it was good to have an opportunity to purposefully think differently, since they had not done such activity before. The participants answered that the event provided a forum where they could show any idea, which afterwards made the participants more positive and open to improvement. |
| **Exploration event B:** | **Improvement of a manual assembly process** |
| *Challenge:* | How to assemble the components of the products with persons or machines touching the components as little as possible |
| *Activity & result:* | After a short discussion of possible solutions, the participants went to the assembly process where idea generation and prototyping were done simultaneously. After the initiation of the event, the participants continued the activity in the weekly improvement meetings. However, the improvement was not sustainable and the assembly process eventually went back to the previous state. |
| *Reflection:* | The participants understood that experiments could create more ideas. The improvement did not last because it was difficult to agree on different opinions about the improvement. A few participants felt that there was a lack of directives and coordination from the leaders when they had the disagreement. |
| **Exploration event C:** | **Reduction of walk distance at a part of the shop floor** |
| *Challenge:* | How to reduce the amount of walking at a shop floor area to one third. |
| *Activity & result:* | Ideas were generated in a creative workshop similar to the one in Exploration event A. New ideas were generated, and they were frequently discussed during the improvement meetings held afterwards. However, only a few ideas were realized. |
| *Reflection:* | The participants understood the importance of initiating an occasion such as an exploration event. Participants said that it was usually difficult to purposefully think differently in daily work. At the same time they felt that they needed more support and guidance on how to continue the event after the idea generation. As a result only a few ideas were realized. |
| **Exploration event D:** | **Generation of ideas for a future assembly process** |
| *Challenge:* | How to double the productivity of the assembly operation for the interface components. |
| *Activity & result:* | Ideas were generated in a similar workshop as in the previous events. A large number and a great variety of ideas were generated which helped to create an image of a future assembly process. |
| *Reflection:* | Several participants stated that it was an eye-opening experience. They |

[10] Note that Exploration event A is the same as the application of the VAPP approach at Delta in ES IV (see Table 4.4). The event served both ES IV and V.

| | |
|---|---|
| | knew that the operation was a difficult one to improve and thought that doubling the productivity was nearly impossible. However, many promising ideas were generated. A participant said that it was good to take a bold step sometimes, and then one could see more improvement possibilities. Participants agreed that it was important to have a discrete opportunity to think differently to avoid incrementalism, and that they would be more trained in exploration when an activity such as the event is undertaken frequently. |
| **Exploration event E:** | **Improvement of a specific packaging process** |
| *Challenge:* | How to eliminate the workload at a specific packaging process if we think anything is possible. |
| *Activity & result:* | The participants were from different functional groups. Various ideas were generated but two specific ideas were chosen for further development and prototypes were made. The ideas were implemented in the end. |
| *Reflection:* | The participants of the event felt that the event was successful since radically new ideas were generated and implemented. The production manager said that it was important to commit at the beginning of the event to providing financial and human resources to realize the chosen ideas. He said that he would like to continue to initiate activities such as exploration events to train employees to be better at innovation. |

Exploration event A was initiated to improve the productivity at the packing process. In the event, a workshop was organized for idea generation (how the workshop was prepared and executed is described in detail in Appended paper E). Some ideas were implemented after the workshop and some other ideas were under development at the time the participants in the event were interviewed. The participants generally appreciated the opportunity to consciously think differently, since they had not had such an opportunity before. Some of them said that the event provided a forum where they could discuss any idea, which later made the participants more positive and open to improvement.

Exploration events B and C were initiated to improve productivity at an assembly process and to reduce the walking distance at a certain area of the shop floor, respectively. Similar to the first event, many of the participants in the events understood the benefits of having an occasion to deliberately seek for unconventional solutions. Various new ideas were put forward in the idea-generation sessions, but only a few ideas were realized afterwards. Some of the participants said that they received little support and few directives from the managers concerning how to realize the ideas.

The challenge in Exploration event D was to generate ideas regarding how to double the productivity at a certain assembly operation. Many of the participants reflected that it was an eye-opening experience. They were unsure whether any useful ideas would be generated, since they knew that the operation was difficult to improve, due to the large variety of components assembled in the operation and the difficulty of automating it. However, a large number and a great variety of new ideas were generated, which gave the participants an impression that doubling the productivity was not entirely impossible. Similar to the previous events, the participants understood the importance of having an activity like the event. They said that they were used to thinking incrementally in their daily work, and that even if radically new ideas came out, they tended to be immediately dismissed with remarks such as “it will be difficult”. The participants also mentioned that they could be more trained in exploration when they frequently undertake activities similar to the event. Further, several participants understood the importance of involving one or a few persons in the event who had little relation to the problem addressed in the event. They said that these persons brought new perspectives to the problem solving and stimulated explorative thinking.

Exploration event D was to improve a part of the packaging process. The participants considered that the event was successful, because radically new ideas were generated and they were fully implemented. The production manager, who was one of the participants in the event, said that it was important to choose only a few ideas to work with and also commit at the beginning of the event to providing financial and human resources to realize the chosen ideas. He said that he would like to continue to initiate activities such as the events in order to train himself and the employees to be more proficient in innovation.

This chapter has presented the empirical evidence collected from the five empirical studies carried out during the research presented in this thesis. The evidence will be the basis for the analysis presented in the next chapter.

# CHAPTER 5 – Analysis and proposal

*This chapter is a synthesis of the empirical studies conducted during the research presented in this thesis. In this chapter, the empirical evidence collected in the empirical studies is analysed in the perspective of the research questions stated in the first chapter. Then a proposal is made regarding the research objective: how to realize Kaikaku in production so that it contributes to creating unique production systems. In the first section, the relevance of the empirical evidence to different types of Kaikaku is examined. In the second section, an analysis is made to answer specific questions related to the research questions. In the last section, the proposal is presented.*

## 5.1 Relevance of empirical evidence to Kaikaku

The five empirical studies conducted during the research presented in this thesis were planned and undertaken in reference to the research questions formulated in Chapter 1. At the same time, each of the studies had a more specific and rather separate theme. The empirical evidence collected in those studies is or can be related to one or more of the four types of Kaikaku presented in Subsection 2.2.6. Before analysing the evidence to propose how to realize Kaikaku so that it contributes to creating unique production systems, which is the objective of the research presented in this thesis, this section analyses how the evidence obtained in the empirical studies is or can be related to the four types of Kaikaku. Understanding the relation indicates whether the proposal that will be constructed in a later section is likely to be relevant to any type of Kaikaku or to a few specific types. The result of the analysis is shown in Figure 5.1. Each of the enclosed areas in Figure 5.1 illustrates how much evidence obtained in the respective study is or can be related to the four types of Kaikaku. Note that Figure 5.1 is an approximate estimation for the purpose of this chapter.

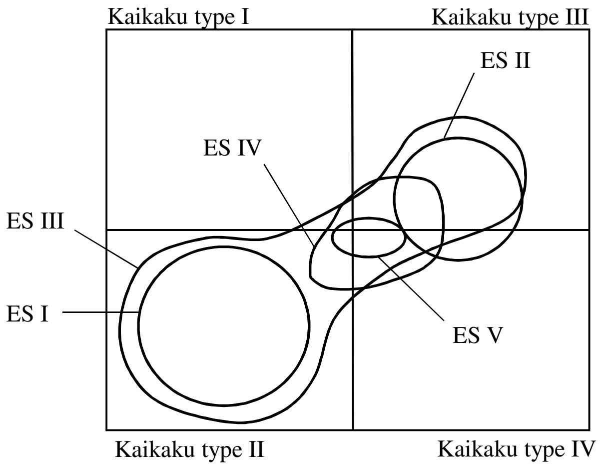


**Figure 5.1:** The relevance of the empirical evidence to the four types of Kaikaku.

In Empirical Study I (ES I), the empirical evidence was obtained from a long-term participatory observation of the lean transformations. Thus the evidence is related to type II of Kaikaku. The evidence obtained in ES II was about organizational setups at the companies striving for realizing radical innovation in production. The evidence can be related to radically innovative Kaikaku (types III and IV). It is more related to type III, because the companies studied made efforts to realize radical innovation in production by focusing on production technology and equipment. In ES III, the evidence was collected from the review of 65 Kaikaku initiatives. Approximately 70 per cent of those initiatives were related to type II, about 20 per cent to type III, and 5 per cent to type I and type IV. Empirical Study IV was about understanding how to use the VAPP approach. The evidence was obtained mostly without the context of Kaikaku. However, the evidence can be related to Kaikaku types II, III, and IV, because in the study the approach was found helpful to create unique production equipment, lines, and cells, but also to improve shop-floor operation without an explicit intention to create unique solutions. ES V investigated a specific approach to building exploration capabilities. The evidence was not obtained in the context of Kaikaku, but it can be assumed that it is relevant to any type of Kaikaku, because the specific approach can be used in any type.

Consequently, the empirical evidence obtained from those studies is mostly related to type II, less to type III, to a limited extent to type IV, and little to type I. It can be estimated that the proposal to be made in a later section is affected by this uneven distribution of the evidence across the four types of Kaikaku. Therefore, after the proposal is presented in the later section, it will be specified to which kind of Kaikaku the proposal is likely to be relevant.

## 5.2 Factors in Kaikaku that contribute to making production systems more unique

As a step before creating the proposal, in this section the evidence obtained from the empirical studies is analysed to identify factors in Kaikaku that are important for making production systems more unique. The evidence is analysed to answer the following two questions: 1) What is important in Kaikaku to make the technical part of a production system more unique? and 2) What is important in Kaikaku to enhance innovation capabilities? In this section, these questions are called *the first and the second question,* respectively. As mentioned in Chapter 3, the evidence is first sorted into the matrix of these questions in columns and the six categories of levers in Kaikaku (i.e. the strategic, technological, structural, process, cultural and human, and method and tool levers) in rows. Then the evidence in each cell is analysed to answer the questions. In the following subsections, the analysis is presented in relation to those levers.

### 5.2.1 Factors relevant to Strategic levers

In this subsection, the evidence found relevant to the strategic levers is analysed. The evidence obtained in ES II and III has shown that at the companies striving to create unique production systems, production plays a significant strategic role in gaining and maintaining the companies' competitive advantages. At these companies, creating such systems is especially relevant to the production plants located close to where the product development takes place. These plants are often considered as global centres of developing, experimenting, and implementing radically new production technologies, equipment, and work procedures. At the same time, they are also considered as centres of building capabilities that enable such development. The relevance of creating unique production systems and the strategic importance of those systems is understandable, since creating such systems requires a significant amount of financial and human resources. When the strategic importance is not high, the need of creating such systems is likely to be limited. Therefore, the following can be stated:

*It is an essential prerequisite to creating unique production systems that the strategic roles of those systems are significantly important for gaining and maintaining the companies' competitive advantages.*

The statement above is not directly relevant to the first and second questions. However, it is still important because without the prerequisite mentioned, it is less meaningful to consider how Kaikaku can contribute to creating unique production systems.

Further, from ES II and III it is found that at the companies striving to realize unique production systems, there was an explicit intent and commitment from the management to realize such systems. This implies that realization of such systems is more likely to be the result of a conscious effort rather than a result occurring by chance. The evidence is congruent with what is frequently stated in innovation management research. It has been stated that management's intent and commitment to innovation is one of the most important ingredients for an organization to constantly realize innovation (e.g. Dobni, 2006; Prajogo and Ahmed, 2006). ES III has shown that some companies set differentiating their production systems from those of competitors as one of the objectives in Kaikaku or express the intent in the companies' long-term production strategies and articulate that Kaikaku is an important step to realize the strategies. Some of those companies also emphasize the significance of radical innovation as an important part of activities in production. Considering the above evidence, the following can be stated regarding the first and second questions:

*In order for Kaikaku to contribute to creating unique production systems, strategic intent and commitment to creating such systems (or realizing radical innovation in production) must reside at the strategic level of the organization.*

*A way to relate Kaikaku to creating unique production systems is to set creating such systems as one of the objectives of Kaikaku, or express the intent to create such systems as one of the companies' long-term production strategies and emphasize that Kaikaku is an important step to realize the strategy.*

ES II and III have also shown that some companies communicate the above-mentioned intent and commitment by visualizing them in diagrams (e.g. Figure 4.1). Such visualization can be an effective way to communicate the intent and commitment to employees. According to Netland (2013), many manufacturing companies have created TPS-house-like diagrams, typically called X (company name) Production System or X Way, in order to communicate the company's effort to achieve operational excellence and continuous improvement in production. As Netland (2013) states, those diagrams rarely include achieving radical innovation in production or creating unique production systems as an important part of the effort in production.

The evidence obtained in ES III has shown that in several Kaikaku initiatives it was stated that developing innovation capabilities was one of the objectives in Kaikaku or that the initiative was a means to build the capabilities. Such a statement is important in the perspective of the second question, even though the importance of the capability building in Kaikaku is implied by relating Kaikaku to creating unique production systems. The importance of articulating capability-building objectives is also stated in the previous research. Riis et al. (2001) argue that process innovation should have dual objectives; one is to radically improve key performance measures, and the other is to increase innovation capabilities. Boudreau and Robey (1996) propose that making a capability-building objective explicit before entering redesign of processes can facilitate collective learning. Therefore, it can be stated in terms of the second question:

*Stating increasing innovation capabilities as one of the objectives in Kaikaku, or stating that achieving a high level of innovation capabilities is one of the long-term strategies and that Kaikaku is a means to realize the strategy can be an effective way to raise the importance of innovation capability building during Kaikaku.*

In ES III, an overall picture of 65 Kaikaku initiatives was created. When obtaining the overall picture, it was found that several companies had weak cultures of continuous improvement. Many of these companies launched the initiatives, for instance introducing lean production, as a means to establish a strong culture of continuous improvement. On the other hand, some other companies had already established cultures of continuous improvement before the initiatives. Such companies seemed to launch Kaikaku initiatives not only in order to radically improve key performance measures, but also to stimulate people in the organizations to be capable of realizing a higher level of innovation. It seems that these companies used Kaikaku as a stimulus to achieve a higher level of innovation capabilities. Different levels of innovation capabilities are shown in Table 5.1, which was compiled on the basis on the analysis of the mentioned overall picture and the literature on innovation (e.g. Bessant, 2003). In reference to Table 5.1, Kaikaku can be seen as a means to eventually achieve the highest level of innovation capabilities, *continuous innovation,* in which an exploitation of existing systems and an exploration of new systems are simultaneously pursued and effectively combined (Petersen et al., 2004).

**Table 5.1:** Four levels of innovation capabilities (also presented in Appended paper D)

| Level of capabilities | Characteristic behaviours or patterns |
|---|---|
| Level 1: Fire-fighting | Few or no improvements are made. A large amount of time is spent on correcting urgent problems continuously emerging. |
| Level 2: Local improvements | Operational processes are more stable than at level 1. Improvements are carried out at a local level but have little or no strategic impact. |
| Level 3: Strategic continuous improvement | A strong culture of continuous improvement exists in the organization. Improvements are linked to strategic objectives. Innovation can occasionally occur. |
| Level 4: Continuous innovation | Incremental and radical innovation are simultaneously sought for and effectively combined. A culture of and infrastructure for innovation is apparent in the organization. |

Understanding the different levels of innovation capabilities is useful for setting an objective regarding innovation capability building. It helps companies to assess the current level of the capabilities and to decide which level they want to reach in the future (Bessant, 2003). The importance of assessing the current level of innovation capabilities when setting a capability-building objective is also mentioned by Boudreau and Robey (1996).

Besides, joint evidence in the five empirical studies shows that setting challenging targets is an effective way to stimulate employees to leave behind conventional solutions and ways of thinking and search for new solutions. Such targets also stimulated different functional groups to work together to achieve their common aims. Further, it is found that setting such targets was also effective for building innovation capabilities, especially exploration capabilities. Such targets provided opportunities for members of organizations to obtain more knowledge and skills in exploration. In addition, such targets were set not only for an overall Kaikaku initiative but also for smaller projects carried out during the initiative. The importance of setting challenging targets in Kaikaku has frequently been mentioned in previous research on process innovation (e.g Davenport, 1993). However, it is especially important in terms of Kaikaku contributing to creating unique production systems. Therefore, the following is stated with respect to the first and second questions:

*Setting challenging targets is important not only for stimulating creativity but also for providing opportunities to build innovation capabilities.*

### 5.2.2 Factors relevant to technological levers

The evidence obtained from ES II and III shows that a number of Japanese companies particularly focused on development of production technologies and equipment as a way to differentiate their production systems from those of competitors. Some of the companies developed lean equipment (see Section 4.3), which is simple, slim, compact, and low-cost equipment that can be placed in production lines and cells and synchronized with takt time. Some other companies developed simple, slim, compact, but more advanced equipment, for example automated assembly lines that are modularized and reconfigurable to changes in product variations and volumes. The development of equipment mentioned above is in tune with lean production, for example with one-piece flow, small batch production, short change-over time, and takt time changes. Such equipment development can be considered as an advanced phase of lean production, as Iwaki (2005) states:

> *"…automation is often considered as the late stage of efficiency improvement in TPS. When the standardized work is well established, simple and cost-effective equipment is often enough to replace the elements of manual operation […] As the sophistication level of TPS increases, such equipment devel-*

*opment is quite effective. The state of equipment development in this direction is a key barometer to assess how much production has evolved after the introduction of TPS."*

It can be stated that advancing lean production with the help of production technology and equipment is a way that those Japanese companies adopted to make their production systems more unique. Considering the evidence mentioned above and the statement by Iwaki (2005), a specific direction of making production systems more unique can be conceived, as shown in Figure 5.2.

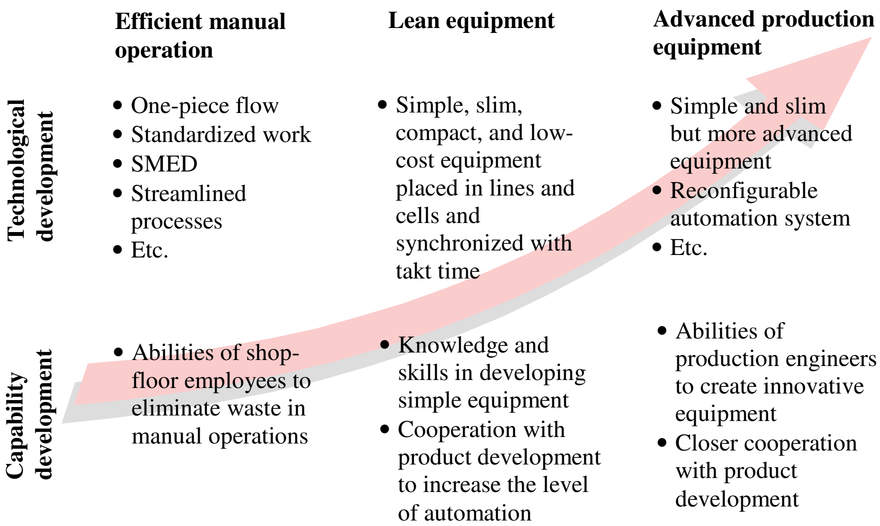


**Figure 5.2:** A direction of advancing lean production with the help of production technology and equipment.

The direction shown in Figure 5.2 includes three stages. At the first stage, as Iwaki (2005) and many other experts of lean production state (e.g. Ohno, 1978), production processes have to be streamlined and waste in manual operations has to be sufficiently eliminated before increasing the level of automation. At the second stage, elements of manual movement are replaced by simple low-cost machines. Lean equipment can be developed. In the third step, future efforts can be made to develop slim and compact but more advanced equipment (e.g. compact dies and slim industrial robots developed at Toyota (Stewart and Raman, 2007), see Subsection 2.2.6). Advanced automation systems may be developed, such as reconfigurable assembly automation systems.

The technological development mentioned cannot be achieved without the development of capabilities in the organization. To achieve the first step, shop-floor employees have to be proficient in carrying out lean production and continuous improvement. At the second step, knowledge and skills in developing lean equipment need to be developed. Product design may need to be in tune with automation. Close cooperation between product development and production is necessary in order to achieve this. At the third stage, production engineers need to be capable of developing innovative production equipment. Even closer cooperation between production and product development may be needed to develop such equipment.

The direction of development mentioned can be considered as one of the efforts in Kaikaku. However, the direction may not be relevant to all manufacturing companies. It should be noted that the direction is derived from the analysis of Japanese companies only. A reason why these companies have adopted this direction can be explained by the evidence obtained in ES II. As mentioned in Section 4.2, some of the interview respondents at the studied Japanese companies in ES II reported that those companies had a long history of practising lean production, and the improvements at the shop-floor level could reach at most less than ten per cent increase in performance measures. At the same time, the respondents said that competitors located in East and South East Asia were also active in lean production and rapidly increasing their competitiveness in production. They seemed to feel that developing unique production technologies and equipment and building the capabilities to promote such development is one of few ways for Japanese production to maintain competitive advantages. In the present research, the direction of development was not apparent at the Swedish companies studied. However, considering that technological competence has been and ought to be one of the competitive advantages of production functions in Sweden (Teknikföretagen, 2008), the direction mentioned can be a possible way for Swedish companies to make their production systems more unique. However, this development requires a significant amount of financial and human resources. To what extent these companies can make efforts in the mentioned direction is largely depending on the strategic roles of the production systems in the companies. The current analysis leads to the following statement related to the first and second questions:

*Advancing lean production in the direction described in Figure 5.2 can be a way to make production systems more unique, and it can be one of the efforts in Kaikaku. However, the degree of effort a company should make in this direction largely depends on the company's strategies.*

ES II and III have shown that the Japanese companies in these studies developed the mentioned kind of equipment mostly in-house. None of the collected evidence explains why these companies focused on in-house development. A possible explanation is that such equipment is largely company-specific and rarely available in the market. Another explanation is the general inclination of Japanese companies to internalize knowledge (Nonaka, 2007). According to Nonaka (2007), many Japanese companies believe that creation and accumulation of knowledge within the companies is a key to maintaining their long-term competitiveness. Whether the development should be made in-house or not seems to be a matter of the company's long-term strategy.

The pieces of production equipment discussed in this subsection are mostly mechanical systems and not information systems. In ES III, it is found that many Kaikaku initiatives includes development of information systems, for instance a system that enables monitoring and visualizing the progress of the operations in production in real time. However, in the research presented in this thesis, sufficient evidence was not obtained to analyse the relation between information technologies and the creation of unique production systems.

### 5.2.3 Factors relevant to structural levers

In this subsection, the evidence found relevant to the structural levers is analysed. The evidence from ES II, III, and V has shown that organizing cross-functional teams for development work and other kinds of problem solving increases the chance of creating radically innovative solutions. While the positive effect of such teams on innovation is well known in previous research on process innovation and innovation management (e.g. Davenport, 1993; Tidd et al., 2005), the empirical studies found several concrete examples of cross-functional teams and other ways to facilitate cross-functional work. The examples are listed below.

- A team consisting of product development engineers and production engineers that is intended to simultaneously develop a future product and a future production system
- A group specialized in driving projects that require close collaboration between product development, production engineering, and shop-floor operations
- A team consisting of experts from various functional groups that support ideation or development of production equipment
- A team consisting of product developers, production engineers, and skilled operators for developing an assembly automation system
- A problem-solving group that includes at least one person who has a deep insight into the problem area but is not directly responsible for the problem, with the intention of bringing new perspectives to the group
- Production engineers who are free to move their workstations anywhere in the company depending on the projects that they are involved in

In Kaikaku, different forms of cross-functional teams can be actively created for different purposes to increase the chance of creating unique solutions. Therefore, the following can be stated regarding the first question:

*Facilitating cross-functional work, including actively creating cross-functional teams during Kaikaku, is important for increasing the chance of creating unique solutions.*

Among the examples of cross-functional work listed above, the simultaneous development of future products and future production systems (e.g. "next generation team" described in Section 4.2) seems to be particularly effective in realizing unique production lines, cells, and equipment. If a company has not initiated such simultaneous development and there is an opportunity to do so, it can be experimentally initiated in Kaikaku.

### 5.2.4 Factors relevant to process levers

In ES III, it was found that a majority of 65 Kaikaku initiatives were executed as a series of smaller improvement or development projects that were undertaken in a coordinated way to achieve the overall objectives. Several managers involved in the initiatives experienced that innovation capabilities were gradually improved as an improvement cycle was iterated. This process can be described in more detail as follows. Education and training were usually given at the beginning of the improvement activities. Problems or other kinds of challenges that required a certain degree of exploration were identified and solved. The results were visualized and shared in the organization. The problem solving often led to identifying further improvement opportunities. People who were involved in the improvements gained skills and knowledge about how to find solutions. At the same time they gained a sense of achievement and became motivated to face further challenges. Some improvements might fail but people could reflect on and learn from the failures. In this way, performances in production were improved and at the same time innovation capabilities increased. This coevolutional improvement of performance and innovation capabilities is illustrated in Figure 5.3. In the figure, one cycle of coevolution is called a learning cycle. This cycle can also be seen as a deutero learning cycle (Argyris and Schön, 1978).

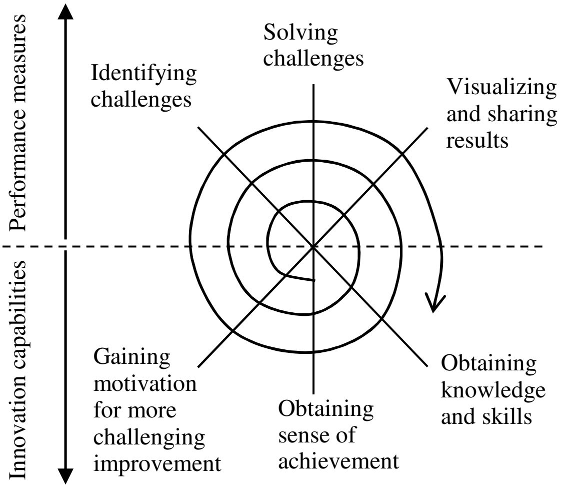


**Figure 5.3:** A coevolution cycle of performance improvement and building of innovation capabilities.

In the reports reviewed in ES III, several managers who were involved in the Kaikaku initiatives state that this coevolutional cycle is the most important element of Kaikaku. A similar cycle can also be identified in the lean transformations observed in ES I. As the transformations proceeded, people at the companies gradually learned how to improve, motivation for improvement was increased, and at the same time performance measures in production, for instance production lead time, were improved. The above evidence implies that the coevolution cycle is a key to building innovation capabilities during Kaikaku. Therefore, the following can be stated regarding the second question:

*It is essential for managers, leaders, or any others who drive Kaikaku to make sure that iteration of the coevolution cycle described in Figure 5.3 constantly occurs during Kaikaku when they desire to enhance innovation capabilities during Kaikaku.*

The iteration of the cycle does not occur naturally, and thus it has to be triggered. In the lean transformations observed in ES I, the cycle was triggered by iteratively and deliberately creating the situations where people in the companies had to feel the need for improvement. In many of the improvement events initiated during the transformations, "the water level" was reduced rather drastically (e.g. cutting the height of inventory shelves to half), which caused the members of the companies to leave the conventional way of thinking and discover new solutions. In ES V, the deliberate discovery learning approach to building exploration capabilities was tested at a case company. The amount of the empirical evidence obtained from ES V was limited, but the initial evidence has shown that by initiating the exploration events, many of the participants in the events understood the importance and potential of activities such as the events. Motivation for undertaking such activities also increased among them. Further, a manager of the case company said that he would like to continue to initiate such activities to train himself and the employees to be more proficient in innovation. Furthermore, the evidence from ES III has shown that in several Kaikaku initiatives, continuously providing employees with opportunities to realize innovation was considered important for building innovation capabilities. One of the reports reviewed in ES III mentioned that there are three elements facilitating innovation, providing opportunities for innovation, increasing the motivation for innovation, and developing the skills and knowledge in innovation, and that the first element is the most essential one (Horio, 2008). The above-mentioned evidence from ES I, III, and V implies that the iteration of the coevolutional cycle can be driven by initiating some kind of events in which people in the organization have to explore and discover new solutions. Therefore, the following can be stated regarding the second question:

*Iteration of the coevolutional cycle can be driven by repeatedly and deliberately creating improvement or development events in which people in the organization have to explore and discover new solutions. Such events can be created at different parts of the organization at different points of time during Kaikaku.*

In this thesis, the above-described way of driving Kaikaku with an emphasis on building innovation capabilities is called *the event-driven way of realizing Kaikaku and building innovation capabilities*.

The evidence obtained in ES I and V has shown that the coevolutional cycle may not occur only by triggering it. For example, in ES I, the Japanese consultant reduced the water level, but solving the problems resulting from reducing the water level was mostly left to the members of the client companies. Consequently, some improvement events were successful but others were not. The researcher (the author of this thesis) observed those improvement events and reflected that the success rate would have been higher if there had been more structure in those events. In ES V, several participants in the exploration events mentioned that many ideas were not realized because there was a lack of support and structure to realize them. The above evidence implies that the coevolutional cycle needs to be not only triggered but also structured and supported. Therefore, the following can be stated regarding the second question:

*In order to iterate the coevolutional cycle, the process within the cycle needs to be structured and supported.*

In ES III, it was found that there are various ways to support the coevolution cycle. Based on the evidence obtained from ES III and V, possible ways to structure and support the cycle are identified:

- Make sure that managers commit to providing financial and human resources to problem solving.
- Create a division, group, or team that supports problem solving, for instance, a team to support idea generation or to provide technical assistance in building production equipment.
- Create a group climate supportive to exploration, i.e. a climate that embraces the do-it-first mentality, playfulness, openness, mutual respect and trust, and risk-taking.
- Create follow-up and reward systems to structure the process of problem solving.
- Provide education relevant to exploration.

In order for managers to sponsor the event-driven way of realizing Kaikaku, it is important for them to understand that the overall process of Kaikaku is likely to be less systematic, less controllable, and more emergent, when the way mentioned is adopted. The process will be similar to the one of the lean transformations observed in ES I. The process appears to be an unfolding series of improvement or development events in which exploration is emphasized. Making a general plan is still important, because it helps to estimate necessary resources, assess possible risks, and create time pressure. However, managers have to be open to contingencies, since outcomes of each event are not fully predictable. Moreover, Kaikaku with the mentioned event-driven way involves a large amount of investment in organizational learning and consequently in intangible assets. The benefit of such investment is generally hard to evaluate with traditional calculation methods such as return on investment, and therefore some degree of managers' belief is needed in the decision on such investment (Alänge et al., 1998). Therefore, managers need to be aware that the cost and benefit of the event-driven way cannot be fully evaluated especially at the outset of a Kaikaku initiative.

### 5.2.5 Factors relevant to cultural and human levers

From the reports on the Kaikaku initiatives reviewed in ES III, it was found that an organization or group climate that advocates experiments, admires challenges, fosters playfulness, and tolerates failures contributed to generating innovative solutions. As mentioned in the previous subsection, such a climate is also important to iterate the coevolution cycle and build exploration capabilities. In ES IV and V, it was found that participants in the case studies felt more psychological safety in such a climate when they had to deliberately think differently and explore new solutions. As discussed in

Chapter 2, the importance of creating a climate supportive to innovation is frequently mentioned in the research on innovation management (e.g. McLaughlin et al., 2008; Tidd et al., 2005). The following can be stated with regard to the first and the second questions:

*Creating an organization and group climate during Kaikaku that fosters experiments, challenges, playfulness, and risk-taking and tolerates failures is important for facilitating exploration.*

### 5.2.6 Factors relevant to method and tool levers

In ES III, it was found that, in several Kaikaku initiatives, various forms of an ideal state were pursued to generate novel solutions. Examples of an ideal state found in the empirical study are that material and human movement should be at a minimum, material and information handling should be at a minimum, and assembly processes should be fixture-less. Pursuing ideal states has a similar effect to the clean-slate approach frequently mentioned in the research on process innovation (e.g. Hammer and Champy, 1993). It helps designers to leave behind conventional solutions and seek for new ones. The following can be stated regarding the first question:

*Various forms of ideal states can be pursued in Kaikaku that may increase the chance of generating unique solutions.*

The VAPP approach studied in ES IV was an analysis and design approach that helps to pursue a specific form of ideal state. The evidence obtained from the same study has shown that the VAPP approach contributed to making the movement of *objects* (materials to which the value is added in production) simpler and also making VAPs more interconnected and concentrated, which led to creating simple and compact production lines and cells. Furthermore, the approach helped to develop simple and compact equipment and also contributed to reducing investment cost in equipment. As mentioned in Chapter 2, one of the distinct features of the VAPP approach is to bring more attention to finding waste in equipment. This feature seems to have contributed to developing the kind of equipment mentioned. The above-described effects of the VAPP approach indicate that the approach is useful for advancing lean production in the direction mentioned previously. The evidence in ES IV has shown that the approach is not necessarily used in the context of Kaikaku. However, the approach can be more frequently used in Kaikaku, since Kaikaku seeks radical redesign of existing systems, and the approach supports such efforts. Consequently, the following can be stated regarding the first question:

*The VAPP approach can be used in Kaikaku and can be an effective way to create unique technical solutions. The approach is well in line with advancing lean production with the direction described in Figure 5.2.*

The purpose of ES IV was to obtain knowledge of how to use the VAPP approach in practice. The evidence from ES IV has shown that the ways to use the approach varied significantly among the companies (see Table 4.3 and Table 4.4). This implies that the VAPP approach is more like a mindset than a method and that a set of tools that supports a systematic use of the approach is generally underdeveloped. Therefore, users of the approach are likely to need to devise their own tools that suit the need of a specific company.

As mentioned in Chapter 2, the VAPP approach cannot be used to design a whole production system because it does not design, for instance, a human system or a control system. On the other hand, it is found that the use of the VAPP approach brings a specific priority in the design of a production system. In the approach, minimizing the movement of objects is firstly considered, and then minimizing the movement of human and machines are sought. At the same time, minimizing the amount of waste in equipment is considered. A simpler subsystem made in this way may require simpler control and maintenance systems. Consequently, use of the VAPP approach may lead to create a simpler production system as a whole.

Further, the evidence obtained in ES IV shows that the use of the VAPP approach brought new perspectives to its users. At one of the companies studied in ES IV, production engineers became more active in proposing ideas of simple and compact equipment to production equipment suppliers. At the case company in ES IV, production engineers obtained a deeper insight as to how objects should be handled in detail. At the same company, some of the shop-floor employees said that the principle of the VAPP approach that waste should be "added" to VAPPs (see Subsection 2.4.2 for more explanation) was new to them, because they were more used to thinking about how to reduce waste in the operations. An explicit focus on VAPPs is a unique feature of the VAPP approach, which is probably a reason why the approach often brought a new perspective to the users.

## 5.3 Proposal of how to realize Kaikaku so that it contributes to creating unique production systems

The analysis made in the previous section has led to identifying factors in Kaikaku that are important for or effective in making a production system more unique. These factors indicate what actions can be recommended in the process of Kaikaku to make the system more unique. These actions can be considered as specific levers in Kaikaku contributing to the uniqueness. The objective of the present research is to propose how to realize Kaikaku so that it contributes to creating unique production systems. A proposal can be made by integrating those specific levers in the process of Kaikaku.

When making a proposal by integrating those levers in the process of Kaikaku, it is found that the levers do not conflict with the high-level process of Kaikaku presented in Figure 2.2. Rather, the levers can be viewed as add-ons or supplements to the process that can be used when Kaikaku is realized with an emphasis on creating a unique production system. Further, these levers are relevant to one or more of the three stages of the high-level process (i.e. preparation, redesign, and implementation). The levers are also related to one of the six kinds of levers (i.e. strategic, technological, structural, process, cultural and human, and method and tool levers). Moreover, the analysis has implied that some of the levers are more related to making the technical part of a production system more unique and others to enhancing innovation capabilities. Other levers are equally related to both. Taking the above-mentioned aspects of the levers into consideration, an overview picture of the proposal is created as shown in Figure 5.4. In the figure the levers more related to making the technical part of a production system more unique are shown on the left side of the column titled as "Levers for making the technical part of the production system more unique". The levers more related to enhancing innovation capabilities are aligned to the left side of the column "Levers for enhancing innovation capabilities". The levers equally relevant to both are placed in the middle of these two columns.

Some remarks can be made on the proposal shown in Figure 5.4. The high-level process is a simplified description of the process of Kaikaku. Kaikaku usually consists of smaller projects that are carried out at different points of time to achieve their overall objectives. Each smaller project also includes the mentioned three stages on a smaller scale. The proposal is a synthesis of the empirical studies conducted during the present research and not a complete methodology with a comprehensive set of possible levers that can be used in Kaikaku to make the production system more unique. For instance, concerning method and tool levers, more methods, techniques, and tools can be identified than the pursuit for ideal state and the use of the VAPP approach. The reason of the incompleteness is discussed in Chapter 6. Furthermore, it is mentioned in Section 5.1 that the evidence obtained from the empirical studies is mostly related to Kaikaku type II, less to type III, to a limited extent to type IV, and little to type I. It is assumed that the proposal is relevant to realizing the following kinds of Kaikaku:

- Kaikaku types III and IV with the objective of making the technical part of the production system more unique
- Kaikaku type II with an explicit emphasis on building innovation capabilities
- Kaikaku that includes both the above. For instance, an earlier phase of Kaikaku is type II with an emphasis on building innovation capabilities, and a later phase involves type III.

In the following, an example of how Kaikaku can be realized so that it contributes to creating a unique production system is given. The example focuses on the third kind of Kaikaku shown in the above items. The purpose is to exemplify how the specific levers shown in Figure 5.4 can be utilized in the process of Kaikaku.

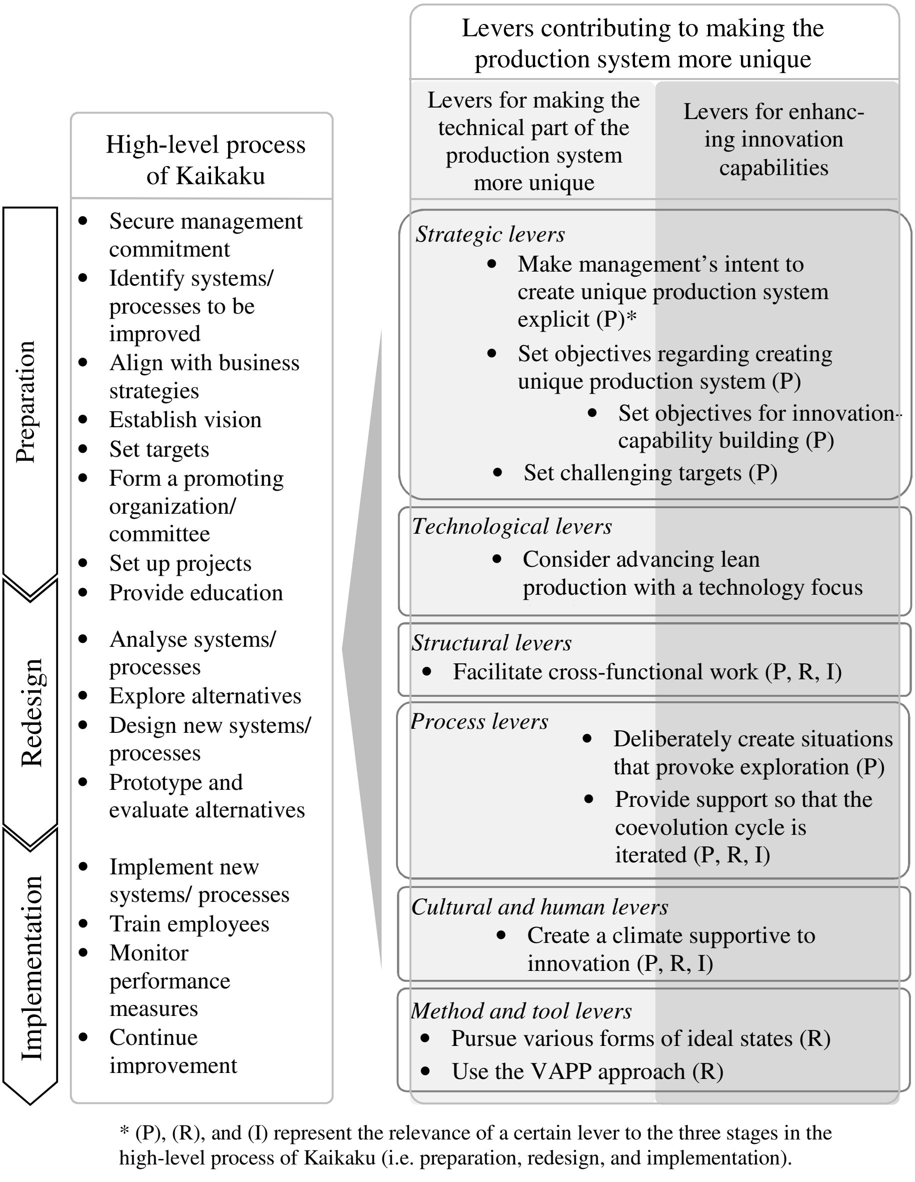


**Figure 5.4:** An overview picture of the proposal regarding how to realize Kaikaku so that it contributes to creating unique production systems.

At the preparation stage of Kaikaku, actions related to this stage shown in Figure 5.4 can be carried out. For instance, a vision is created for Kaikaku, and processes and systems to be improved are identified. In addition to those actions, managers, change leaders, or any other people responsible for driving Kaikaku (hereafter the word "managers" only is used) need to make sure that Kaikaku is realized in a strategic context of creating a unique production system. Intent and commitment to immediately or eventually create a unique production system need to reside at the strategic level of the organization. Creating such a system can be set as one of the objectives of Kaikaku, or managers articulate that Kaikaku is an important step or means to realize such a system in the future. The relevance of Kaikaku creating a unique production system can be presented in a roadmap or other kinds of vision diagrams, in order to communicate the relevance to the employees.

Further at the preparation stage, a general direction of how to develop the production system is considered. Advancing lean production with a technology focus (see Figure 5.2) can be considered as a way to make the production system more unique. An earlier phase of Kaikaku may focus on improving manual operations related to lean production, for instance streamlining the production process and eliminating waste in the manual operations. In a subsequent phase, development of lean equipment is focused on. Then, in a later phase more advanced equipment such as a reconfigurable automation system can be developed. Along with this technical development, the capabilities that enable it also need to be improved. For instance, the production engineering function is eventually strengthened or the collaboration between production and product development is gradually improved.

Setting stretched targets is commonly done in Kaikaku. It is especially important in terms of making the production system more unique. It stimulates creativity and at the same time provides an opportunity to learn how to explore and discover new solutions.

For the redesign and implementation stages, the event-driven way of realizing Kaikaku and building innovation capabilities can be adopted. When it is adopted, the overall process of Kaikaku is likely to be an unfolding series of improvement or development events with an emphasis on exploration. The overall process will be less systematic and more emergent, since outcomes of each event are not entirely predictable. Managers can make a general plan but have to be open to contingencies. These events are initiated by deliberately creating situations in which participants in the events have to explore and find solutions. When staging those events, managers need to provide necessary support, for instance financial and human resources, follow-up systems, reward systems, and education, so that the coevolution cycle is continuously iterated. In those events, a group climate supportive to exploration can be created. When the coevolution cycle is iterated, such a climate may be gradually disseminated throughout the organization. Cross-functional teams can be created to for those events. As mentioned in Section

5.2, various forms of cross-functional teams can be created for different purposes. Further, when designing new production processes or equipment, various kinds of ideal states can be pursued. The VAPP approach can also be used. The approach is particularly in tune with advancing lean production in the mentioned direction.

In the way described above, Kaikaku is executed until its objectives are fulfilled or it comes to the end of the defined time period. At the exit of Kaikaku, it is expected that performance measures in production are radically improved; at the same time, many of the technical solutions created during Kaikaku are unique and the innovation capabilities are improved so that the organization comes a step closer to the state of continuous innovation.

# CHAPTER 6 – Discussions and conclusions

*This chapter presents discussions and conclusions of the research presented in this thesis. First the generic value of the research is discussed. Then methodological discussions on the research are conducted. This is followed by answering the research questions and demonstrating the fulfilment of the research objective. Further, contributions of the research are discussed, and finally future research is recommended.*

## 6.1 General discussions

The previous chapters can be briefly summarized as follows. The research presented in this thesis started by recognizing the importance of Kaikaku in production as well as in creating unique production systems as a means to establish sustained competitive advantages in production. In Chapter 1, the research objective was set regarding how to realize Kaikaku so that it contributes to creating unique production systems. Chapter 2 concluded that making a unique production system means making the technical part of the system more unique and/or the social part of the system more unique. For the social part, increasing the level of innovation capabilities is focused on in the research. Having the research objective as a general direction, five empirical studies were conducted, each of which had a rather different topic of study. The methods employed in those studies are explained in Chapter 3. The empirical evidence collected from the studies is presented in Chapter 4. The evidence is analysed to derive a proposal regarding the research objective. The analysis and the proposal are presented in Chapter 5.

The generic value of the present research can be discussed. The research was undertaken on a niche area of the Kaikaku research. In Chapter 2, it is mentioned that Kaikaku is not a new phenomenon in the manufacturing industry and that much research has been done on this subject. In previous research, much focus has been on how to successfully structure and manage the process of large-scale change. On the other hand, few or no researchers have related Kaikaku to a broader strategic context of creating unique production systems. A part of the generic value of the present research is that it has shown how to realize Kaikaku in a way focused more on radical innovation and innovation capability building so that it contributes to realizing a unique production system.

The proposal presented in Section 5.3 includes the specific levers for making a production system more unique that can be used in the process of Kaikaku. The levers are derived from the empirical evidence collected in the research. In fact, many of those levers have already been identified in previous research. For example, making strategic intent for innovation explicit, organizing cross-functional teams, and creating an organization or group climate supportive to innovation, are moves frequently mentioned in the research areas of innovation management and process innovation. On the other hand, the following three levers are less discussed in the previous research and therefore they add more value to the present research: a specific direction of advancing lean production with a technology focus as a way to create unique production systems, the Value Adding Process Point (VAPP) approach, and the event-driven way of realizing Kaikaku and building innovation capabilities. Contributions of these levers to academia and industry will be discussed in a later section.

Concerning the generic value of the present research, discussions can be conducted as to who would be potential users of this thesis in the industry. In this thesis, it has been stated that striving to create unique production systems is not a strategy for every manufacturing company. The research has shown that the strategic roles of the production system in maintaining a company's competitive advantages must be significantly high in order to be able to strive for a unique production system. As mentioned in Chapter 1, in today's manufacturing industry, global competition has become so severe that it is difficult for production functions in high-wage countries to continue to be valuable for the companies. It can be stated that creating unique production systems is still a strategic choice relevant to many production functions in high-wage countries.

During the research, the author of this thesis (hereafter called the researcher) encountered some practitioners and researchers arguing that Kaikaku is not even necessary because it is a consequence of the failure of self-renewal and the inability to change as quickly as the environment (e.g. Smeds, 1997). The researcher argues that the reactive Kaikaku referred to in Section 2.2.4 should be avoided by any means; however, proactive Kaikaku has still its merit for companies, especially in the perspective that Kaikaku provides valuable opportunities for people in the organization to actively and collectively train themselves to be more proficient in innovation. The research has shown that many of the companies analysed used Kaikaku as a stimulus to step up the level of innovation capabilities.

At the same time, during the research, the researcher also received the impression that Kaikaku might be less relevant for the companies that had arrived at the highest level of innovation capability shown in Table 5.1, that is continuous innovation. The companies that the researcher thought had arrived at this level seemed to undertake radical improvement in production so frequently that members of the companies did not see them as Kaikaku any longer. At those companies, the difference between Kaizen and Kaikaku seems to be less apparent, discrete, or even relevant. These two improvement approaches seem to be merged into a single notion that practitioners often call Kaizen or continuous improvement but in fact is close to continuous innovation. It can be assumed that such companies have already created unique production systems and thus this thesis is less relevant for them. On the other hand, for companies at lower levels of innovation capabilities shown in Table 5.1, this thesis is still relevant.

## 6.2 Methodological discussions

Methodological discussions on the five empirical studies carried out in the present research are mostly conducted in Chapter 3. In this section, discussions are presented on the methods that the research has generally employed.

In Section 5.3, it is mentioned that the levers in the proposal are not comprehensive. There are a few reasons for this incompleteness of the proposal. They are relevant to the research methodology. One of them is that the present research has not intended to create a comprehensive proposal or methodology with a complete set of levers. Such a methodology might have been created with the help of previous research. However, the author decided to focus only on the levers that could be derived from the empirical evidence collected in the present research.

Another reason is that the present research has focused on obtaining practical knowledge in specific areas rather than broader but less concrete knowledge. For example, concerning the method and tool levers, more methods, techniques, and tools than the VAPP approach could have been collected and included in the proposal. However, in the research it was decided to focus on studying the approach to obtain practical knowledge on how to use the approach, instead of searching for and collecting other possible techniques and tools relevant to the proposal. A similar argument can be applied to the event-driven way of realizing Kaikaku. Although there should be other ways to build innovation capabilities during Kaikaku, the present research focused on the event-driven way to obtain practical knowledge about this.

Yet another reason can be related to the access issues discussed in Section 3.3. As mentioned in that section, it was generally difficult to gain a significant level of access to the desirable study objects, which were directly observable Kaikaku initiatives with a strong emphasis on immediately or eventually creating unique production systems. Consequently, some of the empirical studies focused on smaller and more specific topics (e.g. the VAPP approach), because it was more feasible to find collaborating companies with such focused topics than a broad topic like Kaikaku.

Some more methodological issues can be discussed. Some may argue that the separation of the research questions (RQ1 and RQ2) is not meaningful, because the answers to RQ1 are also relevant to RQ 2, and vice versa (this will be mentioned in more detail in the next section). The researcher argues that the separation has still been meaningful, especially at the outset of the research. Those two questions gave different perspectives and foci in collecting and analysing empirical evidence.

Some readers of this thesis may argue that the identified levers are not necessarily used in the context of Kaikaku and that they can also be used in general efforts to create unique production systems regardless of the Kaikaku context. If this is true, they may wonder why the research needed to link Kaikaku to creating unique production systems. It can be discussed that the first argument is probably true. The levers can seemingly be used without the context of Kaikaku, although this is only an assumption and not analysed in the research. An answer to the second argument is related to how the research interest evolved during the research. At the beginning of the research, the main interest was how to support the process of Kaikaku. Then the interest evolved and expanded to a question of how Kaikaku can contribute to making production systems more unique.

In conclusion, together with the quality of the empirical studies assessed in Section 3.7, it can be established that the methodology of the research is reasonably sound, although there are limitations such as those discussed in this section.

## 6.3 Conclusions

In this section the research questions are answered and the fulfilment of the research objective is discussed.

The research questions regarding how to realize Kaikaku so that the technical part of a production system becomes more unique (RQ1), and how to realize Kaikaku so that it enhances innovation capabilities (RQ 2). In this thesis, the answer to these questions is to use the levers identified and presented in Chapter 5 in the process of Kaikaku. As shown in Figure 5.4, the levers are related to the categories of strategic, technological, structural, process, cultural and human, and method and tool levers. Each of the identified levers is relevant to different phases of Kaikaku. Using the levers related to "levers for making the technical part of the production system more unique" is equivalent to the answer to RQ 1. Likewise, using the levers related to "levers for enhancing innovation capabilities" answers RQ 2. All the levers are related to both RQ 1 and 2 to different degrees. Which levers should be used in a specific Kaikaku initiative is affected by the context of the company and at the same time it is left to the discretion of the company. Earlier in this chapter, it was mentioned that the identified levers are not comprehensive. However, some of the levers include more detailed information on how to use them in practice (e.g. the event-driven way of realizing Kaikaku). The information is presented in Section 5.2.

The research objective is to propose how to realize Kaikaku so that it contributes to creating unique production systems. The proposal is presented in Section 5.3. The objective is partially fulfilled. The proposal prompts those who are responsible for driving Kaikaku to use the mentioned levers during preparation and execution of Kaikaku so that they contribute to making the production system more unique. However, as mentioned previously, more work is needed to create a comprehensive methodology that supports the kind of effort mentioned.

## 6.4 Contributions of the research

In this section scientific and industrial contributions are discussed.

### 6.4.1 Scientific contributions

Some of the scientific contributions were already mentioned when the generic value of the research was discussed in Section 6.1. As discussed in this section, one of the scientific contributions is that the research has shown a more radical-innovation-oriented and innovation-capability-building-facilitated way of realizing Kaikaku. It was also mentioned that the three levers (i.e. a direction of advancing lean production, the VAPP approach, and the event-driven way of realizing Kaikaku) could be considered as unique contributions of the present research.

As for the direction of advancing lean production presented in Figure 5.1, the development of individual production equipment shown in the figure, for instance lean equipment and reconfigurable automation, has been studied in previous research (e.g. Edwards, 1996; Rösiö, 2012). However, few researchers have linked such development to the broader context of gradual advancement of lean production as a way of making the production system more unique. The present research has shown that the development in the mentioned direction is a trend in Japanese manufacturing companies.

Regarding the VAPP approach, it is mentioned in Chapter 2 that the approach has been rarely known in international research communities. In the present research it is found that the approach often brings a new perspective to its users and it is also supportive to the development in the direction mentioned above. The knowledge obtained as to how to use the approach in practice can be valuable for both academia and industry.

The event-driven way of realizing Kaikaku and building innovation capabilities is a contribution especially to innovation management research. In this research area, the importance of building exploration capabilities has been frequently emphasized (e.g. Tidd et al., 2005). However, few researchers have presented practically how to build those capabilities. The present research has brought practical knowledge about how these capabilities can be built.

Furthermore, the present research has contributed to increasing the understanding of the concept of Kaikaku. In Chapter 2, it is mentioned that Kaikaku involves a wide range of activities from less innovative ones to radically innovative ones, and from technology-focused ones to cultural-change-focused ones. The four types of Kaikaku presented in Section 2.2 help to understand the concept in a more structured way.

Jeffrey Liker, the author of the famous book "The Toyota Way", stated that there is a rich base of Japanese-written articles, books, and documents about Toyota that have not been translated or are difficult to obtain (Hino, 2006). Generally, the same discussion can be applied to innovation efforts in production at Japanese manufacturing companies. One of the scientific contributions of the present research is to introduce those efforts to broader audiences. It has been well known that these companies are active in Kaizen. The present research has shown that Kaikaku is also active at the companies and contributes to maintaining their competitive advantages in production. At the same time, these companies seem not to have forgotten to embed a typical feature of Japanese management in Kaikaku, the emphasis on long-term capability building in organizations (Nonaka, 2007).

### 6.4.2 Industrial contributions

Models, techniques, and practices identified, developed, or studied during the present research have practical value for manufacturing companies. For instance, the proposal presented in this thesis can help managers to realize Kaikaku in the context of making production systems more unique. The practical way of driving lean transformation found in Empirical Study I can be adopted at companies that desire to implement or strengthen lean production with an emphasis on capability building. The VAPP approach can be used at companies to develop simple and compact production lines, cells, and equipment.

Some parts of the empirical evidence collected in the present research included practical information on what and how the companies actually did regarding the topics of the empirical studies. For instance, various forms of organization structures supportive to radical innovation in production are found in Empirical Study II, a variety of actions taken during Kaikaku initiatives are identified in Empirical Study III, and various ways of using the VAPP approach are found in Empirical Study IV. These pieces of practical information are not structured and theorized, but they can be directly transferred from sending contexts to receiving contexts, if they are appropriate.

Therefore, these pieces of information also have practical value for companies.

## 6.5 Future research

The research presented in this thesis has revealed that the knowledge on how to support radical innovation in production is generally underdeveloped. There seems to be a large research potential in this area.

As discussed in the current chapter, the proposal presented in this thesis can be developed further. More research is needed to develop a comprehensive proposal.

The present research started from the study of Kaikaku and then expanded to a study of how Kaikaku can contribute to creating unique production systems. It can be relevant for future research to solely focus on the question of how to create unique production systems regardless of the Kaikaku context.

Further, concerning achieving radical innovative Kaikaku by focusing on production technology and equipment, it is realized that seeds of radical innovation in production tend to be created at an early phase of the technology and equipment development. This phase of development is not necessarily a part of Kaikaku or is rather more likely to take place even before initiating Kaikaku. In their analysis of product development at Toyota, Kennedy et al. (2008) identified what they term a "knowledge value stream" that spans across a multiple of product development projects. In that stream, new ideas are constantly created and experimented with so that they become feasible for implementation. Once they become feasible, they are used in product development projects. In this way, the knowledge value stream serves as a continuous source of innovation for those projects. During the present research, the researcher has seen similar phenomena in production development at those companies that he thought had arrived at a state of continuous innovation. How to create and support the knowledge value stream in the production setting can be an interesting topic of future research.

# References


Akita, H. (2004) "Naiseika to chie de moukaru kaisha heno kakushin", *Factory Management,* Vol. 50, No. 1, pp. 53-59 (in Japanese).

Al-Mashari, M. and Zairi, M. (2000) "Revisiting BPR: a holistic review of practice and development", *Business Process Management Journal,* Vol. 6, No. 1, pp. 10-42.

Almström, P. (2005) *Development of Manufacturing Systems: A Methodology Based on Systems Engineering and Design Theory.* Ph.D. dissertation, Chalmers University of Technology, Göteborg, Sweden.

Alänge, S., Jacobsson, S. and Jarnehammar, A. (1998) "Some aspects of an analytical framework for studying the diffusion of organizational innovations", *Technology Analysis & Strategic Management,* Vol. 10, No. 1, pp. 3-21.

Andreu, R., Ricart, J. E. and Valor, J. (1997) "Process Innovation: Changing Boxes or Revolutionizing Organizations?", *Knowledge and Process Management,* Vol. 4, No. 2, pp. 114-125.

Anonymous (2009) "8 tuno kakushin project wo kaishi, zensha ichigan taisei de taishitsu kyoka he", *Factory Management,* Vol. 55, No. 10, pp. 24-31 (in Japanese).

Argyris, C. and Schön, D. A. (1978) *Organizational Learning: a Theory of Action Perspective,* Addison-Wesley, Reading, MA.

Balogun, J. and Hope Hailey, V. (2008) *Exploring Strategic Change,* Pearson Education, Harlow, England.

Banzai, M. and Watanabe, Y. (2007) "Seisan Kakushin katudo wo sasaeru "mieruka" no teian to keyparts naiseka jidoka no suishin", *IE Review,* Vol. 48, No. 2, pp. 37-41 (in Japanese).

Barney, J. (1991) "Firm Resources and Sustained Competitive Advantage", *Journal of Management,* Vol. 17, No. 1, pp. 99-120.

Benner, M. J. and Tushman, M. L. (2003) "Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited", *Academy of Management Review,* Vol. 28, No. 2, pp. 238-256.

Berger, A. (1997) "Continuous improvement and kaizen: standardization and organizational designs", *Integrated Manufacturing Systems,* Vol. 8, No. 2, pp. 110–117.

Bessant, J. and Caffyn, S. (1997) "High-involvement innovation through continuous improvement", *International Journal of Technology Management,* Vol. 14, No. 1, pp. 7-28.

Bessant, J. R. (2003) *High-Involvement Innovation: Building and Sustaining Competitive Advantage Through Continuous Change,* Wiley, Chichester, England.

Bicheno, J. (2004) *The New Lean Toolbox Towards Fast and Flexible Flow,* PICSIE Books, Buckingham.

Blessing, L. T. M. and Chakrabarti, A. (2009) *DRM, a Design Research Methodology,* Springer, London, England.

Bodek, N. (2004) "Lean into it", *Industrial Engineer,* Vol. 36, No. 7, pp. 58-59.

Boer, H. and Gertsen, F. (2003) "From continuous improvement to continuous innovation: a retro perspective", *International Journal of Technology Management,* Vol. 26, No. 8, pp. 805-827.

Boudreau, M.-C. and Robey, D. (1996) "Coping with contradictions in business process re-engineering", *Information Technology & People,* Vol. 9, No. 4, pp. 40-57.

Brunet, A. P. and New, S. (2003) "Kaizen in Japan: an empirical study", *International Journal of Operations & Production Management,* Vol. 23, No. 12, pp. 1426-1446.

Bryman, A. and Bell, E. (2007) *Business Research Methods,* Oxford University Press, Oxford, England.

Buckler, B. (1996) "A learning process model to achieve continuous improvement and innovation", *The Learning Organization: An International Journal,* Vol. 3, No. 3, pp. 31-39.

CIRP (2004) *Dictionary of Production Engineering/Wörterbuch der Fertigungstechnik/Dictionnaire des Techniques de Production Mechanique Vol III*, Springer-Verlag, Berlin, Heidelberg, Germany.

Cooper, H. M. (1998) *Synthesizing Research: A Guide For Literature Reviews,* SAGE, Thousand Oaks, CA.

Couger, J. D. (1995) *Creative Problem Solving and Opportunity Finding,* Boyd & Fraser, Danvers, MA.

Couger, J. D., Flynn, P. and Hellyer, D. (1994) "Enhancing the Creativity of Reengineering: Techniques for Making IS More Creative", *Information Systems Management,* Vol. 11, No. 2, pp. 24-29.

Coughlan, P. and Coghlan, D. (2002) "Action research for operations management", *International Journal of Operations & Production Management,* Vol. 22, No. 2, pp. 220-240.

Coulson-Thomas, C. (1994) *Business Process Re-engineering: myth & reality,* Kogan Page, London, England.

Davenport, T. H. (1993) *Process Innovation: Reengineering Work Through Information Technology,* Harvard Business School Press, Boston, MA.

Davenport, T. H. and Short, J. E. (1990) "The New Industrial Engineering: Information Technology and Business Process Redesign", *Sloan Management Review,* Vol. 31, No. 4, pp. 11-38.

Dewar, R. D. and Dutton, J. E. (1986) "The Adoption of Radical and Incremental Innovations: An Empirical Analysis", *Management Science,* Vol. 32, No. 11, pp. 1422-1433.

Dobni, C. B. (2006) "The innovation blueprint", *Business Horizons,* Vol. 49, No. 4, pp. 329-339.

Dougherty, D. and Hardy, C. (1996) "Sustained Product Innovation in Large, Mature Organizations: Overcoming Innovation-to-Organization Problems", *Academy of Management Journal,* Vol. 39, No. 5, pp. 1120-1153.

Drew, J., McCallum, B. and Roggenhofer, S. (2004) *Journey to Lean: Making Operational Change Stick,* Palgrave Macmillan, New York, NY.

Edmondson, A. C. (2008) "The Competitive Imperative of Learning", *Harvard Business Review,* Vol. 86, No. 7-8, pp. 60-67.

Edwards, D. K. (1996) "Practical Guidelines for Lean Manufacturing Equipment", *Production & Inventory Management Journal,* Vol. 37, No. 2, pp. 51-55.

Eisenhardt, K. M. (1989) "Building Theories from Case Study Research", *Academy of Management Review,* Vol. 14, No. 4, pp. 532-550.

Ekvall, G. (1993) "Creativity in Project Work: a longitudinal study of a product development project", *Creativity and Innovation Management,* Vol. 2, No. 1, pp. 17-26.

Enomoto, M. (2007) "Seisan Kakushin to Monozukuri kyoka", *IE Review,* Vol. 48, No. 5, pp. 20-24 (in Japanese).

Fiol, C. M. and Lyles, M. A. (1985) "Organizational learning", *Academy of Management Review,* Vol. 10, No. 4, pp. 803-813.

Fujimoto, A. (2009) "TPM katsudou ni yoru seisansei 2 bai no model line", *IE Review,* Vol. 50, No. 3, pp. 73-78 (in Japanese).

Fujimoto, T. (2007) *Competing to be Really, Really Good: The Behind-the-Scenes Drama of Capability-Building Competition in the Automobile Industry, (English translation from the Japanese original by B. Miller),* International House of Japan, Tokyo, Japan.

Fujita, Y. (2005) "Saikyo no monozukuri shudan" wo mezashite Sanyo tokyo manufacturing no seisan kakushin", *Factory Management,* Vol. 51, No. 3, pp. 52-73 (in Japanese).

Gagnon, S. (1999) "Resource-based competition and the new operations strategy", *International Journal of Operations & Production Management,* Vol. 19, No. 2, pp. 125-125.

Geyer, A. (2003) *The Future of Manufacturing in Europe 2015-2020: The Challenge for Sustainability; Scenario Report (summary), European Commisssion Joint Research Centre,* Institute for Prospective Technological Studies, Seville, Spain.

Goedhuys, M. and Veugelers, R. (2012) "Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil", *Structural Change and Economic Dynamics,* Vol. 23, No. 4, pp. 516-529.

Guha, S., Grover, V., Kettinger, W. J. and Teng, J. T. C. (1997) "Business process change and organizational performance: Exploring an antecedent model", *Journal of Management Information Systems,* Vol. 14, No. 1, pp. 119-154.

Guha, S., Kettinger, W. J. and Teng, J. T. C. (1993) "Business Process Reengineering: Building a Comprehensive Methodology", *Information Systems Management,* Vol. 10, No. 3, pp. 13-22.

Guimaraes, T. and Bond, W. (1996) "Empirically assessing the impact of BPR on manufacturing firms", *International Journal of Operations & Production Management,* Vol. 16, No. 8, pp. 5-28.

Gummesson, E. (2000) *Qualitative Methods in Management Research,* Sage, Thousand Oaks, CA.

Hamada, M. (2003) "Seisan kakushin no nami wo ukete datsubungyo kadokuji no seisan kanri", *Factory Management,* Vol. 49, No. 1, pp. 6-10 (in Japanese).

Hammer, M. and Champy, J. (1993) *Reengineering the Corporation: A Manifesto for Business Revolution,* Harper Business, New York, NY.

Harada, T. and Adachi, M. (2000) "Development of Production Equipment and Metallic Molds for Product Development", *Toshiba Review,* Vol. 55, No. 4, pp. 13-16 (in Japanese).

Harrington, H. J. (1991) *Business Process Improvement: The Breakthrough Strategy for Total Quality, Productivity, and Competitiveness,* McGraw-Hill, New York, NY.

Harrington, H. J. (1995) "Continuous versus breakthrough improvement: Finding the right answer", *Business Process Re-engineering & Management Journal,* Vol. 1, No. 3, pp. 31-49.

Hayes, R. H. and Pisano, G. P. (1994) "Beyond World-Class: The New Manufacturing Strategy", *Harvard Business Review,* Vol. 72, No. 1, pp. 77-84.

Herr, K. and Anderson, G. L. (2005) *The Action Research Dissertation: A Guide for Students and Faculty* Sage, Thousand Oaks, CA.

Herzog, N. V., Polajnar, A. and Tonchia, S. (2007) "Development and validation of business process reengineering (BPR) variables: a survey research in Slovenian companies", *International Journal of Production Research,* Vol. 45, No. 24, pp. 5811-5834.

Herzog, N. V., Tonchia, S. and Polajnar, A. (2009) "Linkages between manufacturing strategy, benchmarking, performance measurement and business process reengineering", *Computers & Industrial Engineering,* Vol. 57, No. 3, pp. 963-975.

Hines, P., Holweg, M. and Rich, N. (2004) "Learning to evolve: A review of contemporary lean thinking", *International Journal of Operations & Production Management,* Vol. 24, No. 10, pp. 994-1011.

Hino, S. (2006) *Inside the Mind of Toyota: Management Principles for Enduring Growth,* Productivity Press, New York, NY.

Hirose, M. (2005) "Jidou souko to computer ni yoru seisan kanri system wo haishi shi kurojika jitsugen", *Factory Management,* Vol. 51, No. 3, pp. 32-41 (in Japanese).

Hora, H. (2003) "K-UP undou gannen keijo rieki 2 bai wo mezashite", *Factory Management,* Vol. 49, No. 1, pp. 11-15 (in Japanese).

Horio, C. (2008) "21seiki ni ikiru jinzai", *IE Review,* Vol. 49, No. 1, pp. 36-42 (in Japanese).
Hubka, V. and Eder, W. E. (1988) *Theory of Technical Systems: A Total Concept Theory for Engineering Design,* Springer-Verlag, Berlin, Heidelberg, Germany.
Ikaida, S. (2007) "Wagasha no Seisan Kakushin katsudo", *IE Review,* Vol. 48, No. 5, pp. 4-5 (in Japanese).
Imai, M. (1986) *Kaizen: The Key to Japan's Competitive Success,* McGraw-Hill/Irwin, New York, NY.
IVA (2005) *Made in Sweden: Produktion för Konkurrenskraft – syntesrapport,* Kungl. Ingenjörsvetenskapsakademien (IVA), Stockholm, Sweden.
Iwaki, K. (2005) *Jissen Toyota seisan hoshiki,* Nikkei, Tokyo, Japan (in Japanese).
Jarrar, Y. F. and Aspinwall, E. M. (1999) "Business process re-engineering: Learning from organizational experience", *Total Quality Management,* Vol. 10, No. 2, pp. 173-186.
JIPM (1996) *TPM Encyclopaedia,* Japan Institute of Plant Maintenance (JIPM), Tokyo, Japan.
Kamata, Y. (2000) "Okyakusama ga mieru monozukuri", *Factory Management,* Vol. 46, No. 16, pp. 9-43 (in Japanese).
Karlsson, A. (2002) *Developing High Performance Manufacturing Systems: Utilising manufacturing system design, strategy and control possibilities for competitiveness in changing environments.* Ph.D. dissertation, Royal Institute of Technology, Stockholm, Sweden.
Kato, H. (2008) "Work head to ryohin joken (kakouten) wo tsuikyu suru", *IE Review,* Vol. 49, No. 3, pp. 32-37 (in Japanese).
Kawakami, H. and Kobayashi, K. (2005) "Jido hanbaiki seisan ni okeru shijo henka no supi-do ni awaseta monozukuri", *IE Review,* Vol. 46, No. 4, pp. 39-44 (in Japanese).
Kennedy, M., Harmon, K. and Minnock, E. (2008) *Ready, Set, Dominate: Implement Toyota's Set-Based Learning for Developing Products and Nobody Can Catch You,* Oaklea Press, Richmond, VA.
Ketokivi, M. and Schroeder, R. (2004) "Manufacturing practices, strategic fit and performance: A routine-based view", *International Journal of Operations & Production Management,* Vol. 24, No. 2, pp. 171-191.
Kettinger, W., J., Teng, J., T. C. and Guha, S. (1997) "Business Process Change: A Study of Methodologies, Techniques, and Tools", *MIS Quarterly,* Vol. 21, No. 1, pp. 55-80.
Kimura, T. and Takano, A. (2005) 'Dokuso suru nihon no kojo', *Nikkei Monozukuri*, October, Nikkei, pp. 48-55 (in Japanese).
Kishimoto, N. and Fujita, K. (2009) "Cost up ni uchikatsu seisan kakushin", *IE Review,* Vol. 50, No. 1, pp. 27-32 (in Japanese).
Kleinschmidt, E. J. and Cooper, R. G. (1991) "The Impact of Product Innovativeness on Performance", *Journal of Product Innovation Management,* Vol. 8, No. 4, pp. 240-251.

Kolb, D. and Fry, R. (1975) 'Towards a Theory of Applied Experiental Learning', in COOPER, C. L. (Ed.), *Theories of Group Processes*. John Wiley & Sons, Chichester, England.

Kolb, D. A. (1984) *Experiential Learning: Experience as the Source of Learning and Development,* Prentice-Hall, Englewood Cliffs, NJ.

Kondou, S. (2003) "Striving for Kakushin (continuous innovation) for the 21st century", *International Journal of Technology Management,* Vol. 25, No. 6/7, pp. 517-530.

Lee, S. M. and Asllani, A. (1997) "TQM and BPR: Symbiosis and a new approach for integration", *Management Decision,* Vol. 35, No. 6, pp. 409-416.

Liker, J. K. (2004) *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer,* McGraw-Hill, New York, NY.

Magnusson, K., Kroslid, D. and Bergman, B. (2003) *Six Sigma The Pragmatic Approach,* Studentlitteratur, Lund, Sweden.

March, J. G. (1991) "Exploration and Exploitation in Organizational Learning", *Organization Science,* Vol. 2, No. 1, pp. 71-87.

Maruyama, Y. (2008) "Sekisui ryu IE ni yoru monozukuri kakushin", *IE Review,* Vol. 49, No. 1, pp. 31-35 (in Japanese).

Matsuo, H. (2007) "Seizou kakushin katsudou ni okeru 3 nenkan no torikumi", *IE Review,* Vol. 48, No. 3, pp. 79-84 (in Japanese).

Maxwell, J. A. (2005) *Qualitative Research Design: An Interactive Approach,* Sage, Thousand Oaks, CA.

McAdam, R. (2003) "Radical change: a conceptual model for research agendas", *Leadership & Organization Development Journal,* Vol. 24, No. 4, pp. 226-235.

McAdam, R. and McIntyre, S. (1997) "A business process improvement methodology which incorporates learning organization concepts", *Total Quality Management,* Vol. 8, No. 2, pp. 221-225.

McLaughlin, P., Bessant, J. and Smart, P. (2008) "Developing an organisation culture to facilitate radical innovation", *International Journal of Technology Management,* Vol. 44, No. 3/4, pp. 298-323.

Meredith, J. (1998) "Building operations management theory through case and field research", *Journal of Operations Management,* Vol. 16, No. 4, pp. 441-454.

Mintzberg, H. (1987) "Crafting Strategy", *Harvard Business Review,* Vol. 65, No. 4, pp. 66-75.

Mishima, H. (2004) "Yaruzo! konbea toruzo! ikkonagashi!", *Factory Management,* Vol. 50, No. 1, pp. 20-25 (in Japanese).

Motwani, J., Kumar, A., Jiang, J. and Youssef, M. (1998) "Business process reengineering: A theoretical framework and an integrated model", *International Journal of Operations & Production Management,* Vol. 18, No. 9/10, pp. 964-977.

Nadler, G. (1967) *Work Systems Design: The IDEALS Concept,* Richard D. Irwin, Homewood, IL.

Nagai, M., Mizutani, K. and Osakabe, Y. (2001) "Through put saidai wo mezashita seisan kakushin", *Factory Management,* Vol. 46, No. 8, pp. 34-71 (in Japanese).

Nakagi, A. (2004) "Seisan kakushin "Unichikara" katsudou de shueki kaizen wo!", *Factory Management,* Vol. 50, No. 1, pp. 26-31 (in Japanese).

Nakamura, Z. (2003) *Mono koto bunseki de seikou suru simple na shigoto no hassou hou,* Nikkan Kogyo Shimbun, Tokyo, Japan (in Japanese).

Netland, T. (2013) "Exploring the phenomenon of company-specific production systems: one-best-way or own-best-way?", *International Journal of Production Research,* Vol. 51, No. 4, pp. 1084-1097.

Noguchi, H. (2007) "Ikinokori wo kaketa monozukuri ryoku no saikochiku", *IE Review,* Vol. 48, No. 5, pp. 29-34 (in Japanese).

Nonaka, I. (2007) "The Knowledge-Creating Company", *Harvard Business Review,* Vol. 85, No. 7,8, pp. 162-171.

Ohno, T. (1978) *Toyota Seisan Houshiki,* Diamond, Tokyo, Japan (in Japanese).

Olsson, A. (2008) *Innovationsförmåga,* PIEp Product Innovation Engineering program, Stockholm, Sweden.

Omori, K. (2009) "Mieru seisan wo mezashite jigyo bu wo kaeru", *IE Review,* Vol. 50, No. 1, pp. 21- 26 (in Japanese).

Orlikowski, W. (1996) "Improvising Organizational Transformation Over Time: A Situated Change Perspective", *Information Systems Research,* Vol. 7, No. 1, pp. 63-92.

Oxford (2003) *Oxford Dictionary of English,* Oxford University Press, Oxford, England.

Ozawa, H. (2006) "TC-1 shisou ni yoru seisan kakushin", *IE Review,* Vol. 47, No. 5, pp. 63-69 (in Japanese).

Paper, D. and Chang, R.-D. (2005) "The state of business process reengineering: a search for success factors", *Total Quality Management & Business Excellence,* Vol. 16, No. 1, pp. 121-133.

Patton, M. Q. (1990) *Qualitative Evaluation and Research Methods,* Sage, Newbury Park, CA.

Peng, D. X., Schroeder, R. G. and Shah, R. (2008) "Linking routines to operations capabilities: A new perspective", *Journal of Operations Management,* Vol. 26, No. 6, pp. 730-748.

Petersen, A. H., Boer, H. and Gertsen, F. (2004) "Learning in different modes: the interaction between incremental and radical change", *Knowledge and Process Management,* Vol. 11, No. 4, pp. 228-238.

Prajogo, D. I. and Ahmed, P. K. (2006) "Relationships between innovation stimulus, innovation capacity, and innovation performance", *R & D Management,* Vol. 36, No. 5, pp. 499-515.

Raelin, J. A. (2000) *Work-Based Learning: The New Frontier of Management Development,* Prentice-Hall, Upper Saddle River, NJ.

Riis, J. O., Hildebrandt, S., Andreasen, M. M. and Johansen, J. (2001) "Implementing change: lessons from five development projects", *International Journal of Technology Management,* Vol. 22, No. 1-2/3, pp. 13-27.

Rothwell, R. (1992) "Successful industrial innovation - critical factors for the 1990s'", *R & D Management,* Vol. 22, No. 3, pp. 221-240.

Rösiö, C. (2012) *Supporting the design of reconfigurable production systems.* Ph.D. dissertation, Mälardalen University, Västerås, Sweden.

Sasaki, M. (2009) "IMM de susumeru seisan management system", *IE Review,* Vol. 50, No. 2, pp. 39-43 (in Japanese).

Sawa, J. (2007) "Seisan Kakushin katsudo to konnichi no kadai", *IE Review,* Vol. 48, No. 5, pp. 15- 19 (in Japanese).

Schroeder, D. M. and Congden, S. W. (1995) "Integrating manufacturing innovation through organizational learning", *Production and Inventory Management Journal,* Vol. 36, No. 3, pp. 55-60.

Schroeder, R. G., Scudder, G. D. and Elm, D. R. (1989) "Innovation in Manufacturing", *Journal of Operations Management,* Vol. 8, No. 1, pp. 1-16.

Seliger, G., Viehweger, B. and Wieneke, B. (1987) "Decision Support in Design and Optimization of Flexible Automated Manufacturing and Assembly", *Robotics and Computer-Integrated Manufacturing,* Vol. 3, No. 2, pp. 221-227.

Shibata, M. and Kaneda, H. (2001) *Toyota shiki saikyo no keiei: naze Toyota wa kawaritsuzukeru no ka,* Nihon Keizai Shinbunsha, Tokyo, Japan (in Japanese).

Shiina, R. (2009) "Kaizen katudou keizoku no point", *IE Review,* Vol. 50, No. 5, pp. 27-30 (in Japanese).

Shimoda, K. (2004) "3 shuno katsudou wo yukiteki ni kumiawasete shueki kaizen wo jitsugen shita seisan kakushin", *Factory Management,* Vol. 50, No. 1, pp. 32-39 (in Japanese).

Shinoda, S. and Kono, H. (1997) "Koyu gijutsu to kanri gijutsu no tougou ni yoru yasui setsubi rain zukuri - mono koto bunseki ", *The Society of Plant Engineering Japan,* Vol. 9, No. 1, pp. 67-69 (in Japanese).

Shinoda, S. and Nakamura, Z. (1996) "A Method for Work System Analysis from the Viewpoint of Transformation of Handled Objects", *Journal of Japan Industrial Management Association,* Vol. 47, No. 5, pp. 317-326 (in Japanese).

Shinoda, S. and Niwa, A. (2000) "A Fundamental Study of Listing Alternative Ideas for Designing a Work Process A Case of Assembly-Type Work", *Journal of Japan Industrial Management Association,* Vol. 51, No. 4, pp. 321-329 (in Japanese).

Shirai, Y. (2007) "1/3 ni kodawatta Simple and Slim setsubi-zukuri heno chosen ", *IE Review,* Vol. 48, No. 2, pp. 21-25 (in Japanese).

Smeds, R. (1994) "Managing Change towards Lean Enterprises", *International Journal of Operations & Production Management,* Vol. 14, No. 3, pp. 66-82.

Smeds, R. (1997) "Radical change through incremental innovations: generic principles and cultural differences in evolution management", *International Journal of Technology Management,* Vol. 14, No. 1, pp. 146-162.

Smeds, R. (2001) "Implementation of business process innovations: an agenda for research and action", *International Journal of Technology Management,* Vol. 22, No. 1-2/3, pp. 1-12.

Speier, C., Harvey, M. and Palmer, J. (1998) "Implementing intra-organizational learning: an infrastructure to support business process reengineering", *Knowledge and Process Management,* Vol. 5, No. 2, pp. 76-86.

Stewart, T. A. and Raman, A. P. (2007) "Lessons from Toyota's long drive", *Harvard Business Review,* Vol. 85, No. 7/8, pp. 74-83.

Stoddard, D. B., Jarvenpaa, S. L. and Littlejohn, M. (1996) "The Reality of Business Reengineering: Pacific Bell's Centrex Provisioning Process", *California Management Review,* Vol. 38, No. 3, pp. 57-76.

Sundström, P. and Zika-Viktorsson, A. (2009) "Organizing for innovation in a product development project. Combining innovative and result oriented ways of working – A case study", *International Journal of Project Management,* Vol. 27, No. 8, pp. 745-753.

Takahashi, S. (2001) "60 nenrai no zyurai taishitsu wo hitei shite", *Factory Management,* Vol. 47, No. 14, pp. 30-47 (in Japanese).

Tanahashi, T. (2009) "Henka shitsuzukeru kojo wo mezasu keizoku teki kaizen katsudou", *IE Review,* Vol. 50, No. 5, pp. 39-44 (in Japanese).

Tanaka, T. (2005) "Daisha biki konryu seisan hoshiki no tanjo", *IE Review,* Vol. 46, No. 4, pp. 31-37 (in Japanese).

Taniguchi, Y. (2009) "Seisan kakushin katudou keizoku heno torikumi", *IE Review,* Vol. 50, No. 5, pp. 21-25 (in Japanese).

Teece, D. J., Pisano, G. P. and Shuen, A. (1997) "Dynamic Capabilities and Strategic Management", *Strategic Management Journal,* Vol. 18, No. 7, pp. 509-533.

Teknikföretagen (2008) 'Svensk produktionsforskning 2020: Strategisk forskningsagenda'. Teknikföretagen, Stockholm, Sweden (in Swedish).

Terziovski, M., Fitzpatrick, P. and O'Neill, P. (2003) "Successful predictors of business process reengineering (BPR) in financial services", *International Journal of Production Economics,* Vol. 84, No. 1, pp. 35-50.

Thomas, A. J., Byard, P. and Evans, R. (2012) "Identifying the UK's manufacturing challenges as a benchmark for future growth", *Journal of Manufacturing Technology Management,* Vol. 23, No. 2, pp. 142-156.

Tidd, J., Bessant, J. and Pavitt, K. (2005) *Managing innovation: Integrating technological, market and organizational change,* John Wiley & Sons, Chichester, England.

Tushman, M. L. and O'Reilly III, C. A. (1997) *Winning Through Innovation: A Practical Guide to Leading Organizational Change and Renewal,* Harvard Business School Press, Boston, MA.

Uno, A. (2004) *Koujo Kaikaku 90 no point,* Nikkan Kogyo Shinbun, Tokyo, Japan (in Japanese).

Wakamatsu, Y. and Kondou, T. (2003) *Toyota shiki Kaizen ryoku,* Diamond, Tokyo, Japan (in Japanese).
Valiris, G. and Glykas, M. (1999) "Critical review of existing BPR methodologies", *Business Process Management Journal,* Vol. 5, No. 1, pp. 65-86.
Van Maanen, J. (1988) *Tales of the Field: On Writing Ethnography,* University of Chicago Press, Chicago, IL.
Watabe, N. (2010) "Seisan gizyutsu ga redo suru sekkei kakushin to seisan kakushin no ayumi", *IE Review,* Vol. 51, No. 1, pp. 29-34 (in Japanese).
Watai, T. (2004) "1 rino 100 po yori 100 nin no 1 po - seisan kakushin de shokuba wo mamoru ", *Factory Management,* Vol. 50, No. 1, pp. 46-52 (in Japanese).
WebFinance. *BusinessDictionary.com* [Online]. Available at: http://www.businessdictionary.com/definition/waste.html, Accessed March, 2013.
Weiss, R. S. (1994) *Learning from Strangers : The Art and Method of Qualitative Interview Studies,* Free Press, New York, NY.
Westbrook, R. (1995) "Action research: a new paradigm for research in production and operations management", *International Journal of Operations & Production Management,* Vol. 15, No. 12, pp. 6-20.
Wheelwright, S., C. (1984) "Manufacturing Strategy: Defining the Missing Link", *Strategic Management Journal,* Vol. 5, No. 1, pp. 77-91.
Whittemore, R. and Knafl, K. (2005) "The integrative review: updated methodology", *Journal of Advanced Nursing,* Vol. 52, No. 5, pp. 546-553.
Womack, J. P. and Jones, D. T. (1996) *Lean Thinking: Banish Waste and Create Wealth in Your Corporation,* Free Press, New York, NY.
Wu, B. (1994) *Manufacturing Sytems Design and Analysis: Context and Techniques,* Chapman & Hall, New York, NY.
Yin, R. K. (1994) *Case Study Research: Design and Methods,* Sage, Thousand Oaks, CA.
Yin, R. K. (2011) *Qualitative Research from Start to Finish,* Guilford Press, New York, NY.
Yoneya, M. (2001) "Zeiin de kachitotta genka teigen 100 okuen", *Factory Management,* Vol. 47, No. 14, pp. 3-29 (in Japanese).
Yoshida, M. and Fujiwara, H. (2007) "Inverter no seisan kakushin", *IE Review,* Vol. 48, No. 5, pp. 45-49 (in Japanese).
Yoshida, S. and Saito, A. (2008) "Tannoki to teikosuto de fukakachi wo umidasu", *IE Review,* Vol. 49, No. 3, pp. 27-31 (in Japanese).
Younker, D. L. (2003) *Value Engineering: Analysis and Methodology,* Marcel Dekker, New York, NY.