

Mälardalen University Press Licentiate Theses  
No. 120

# **KAIKAKU IN PRODUCTION**

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**2010**



**MÄLARDALEN UNIVERSITY  
SWEDEN**

School of Innovation, Design and Engineering

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ISSN 1651-9256

ISBN 978-91-86135-73-7

Printed by Mälardalen University, Västerås, Sweden

## **Abstract**

In today's fast-changing and dynamic business environment, the pressures on manufacturing companies to compete on the global arena have been intensified. Production is challenged to handle and benefit from ever increasing competitions in terms of cost, delivery capability, and flexibility. In order to gain and sustain the competitive advantage under such circumstances, strong and constant development of production must be ensured not only by continuous improvement but also by radical improvement.

Continuous improvement or called Kaizen has been an established approach for production improvement. The concept of Kaizen is well described and many tools and methods that support Kaizen have been developed and widely applied in industry. However, the need and importance of radical improvement in production or called "Kaikaku" in Japanese are still limitedly recognized at companies. Moreover, knowledge of structured support that facilitates an effective and efficient execution of Kaikaku has been insufficiently developed.

The purpose of the research presented in this thesis is to develop models and methods that address the need and importance of Kaikaku in production and facilitate the realization of it.

The research is comprised of a literature study and three case studies. The literature study was conducted in order to structure the concept of Kaikaku. As a result of the study, a conceptual framework of Kaikaku was developed. The three case studies were conducted to identify influential factors in realizing Kaikaku. Both Swedish and Japanese companies were studied and analyzed. These case studies led to identify a way of realizing a certain type of Kaikaku. Some characteristics of organization setting were also found influential to realization of Kaikaku.



## **Acknowledgements**

The research project “Kaikaku in production” started in the corporation with Nätverket för Produktionsutveckling (NPU), Mälardalen University (MDH), and Deva Mecaneyes AB. I would like to start to thank NPU, especially Mats Ågren - a chairman of NPU who raised the opportunity to initiate the research project.

I would like to send great appreciation to my supervisors, Professor Mats Jackson and Adjunct Professor Monica Bellgran. Their insights, comments, guidance, encouragement, and patience have been invaluable help in doing the research work, including writing the papers and licentiate thesis. I would also like to thank my employer Deva Mecaneyes AB, especially Mattias Lövmärk, Magnus Welén, and Ann-Sofie Eriksson who have supported the research project.

Special thanks must be sent to my personal mentor, Mikami Hiroyuki. With his abundant experience of developing and operating production based on Toyota Production System, he taught me important principles related to managing and improving production. I would not have learned so much without being able to work with him.

I would like to thank all the people in our research group and in the companies involved in this research. It is too many to mention all the names, but they provide valuable inputs to the research and their support has been encouragement to me.

Lastly, I would like to thank my family. Especially Sara, my wife and a part of the reason why I am living in Sweden, thank you very much for all your support and encouragement. Now I wish you good luck for completing your PhD thesis. And Hugo, my son, thank you for giving more joy and meaning to my life.



# Publications

## Appended Papers

**Paper A** Yamamoto, Y. and Bellgran, M. (2009), "Kaizen and Kaikaku for competitive production", Mälardalen University

**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.

## Additional Publications

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.





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# 1 Introduction

This chapter is an introduction, and starts with the background of the research, where the needs, potential, and challenges of “Kaikaku” - radical improvement in production - are described. Then, the research objective and research questions are presented. Finally, the delimitation of the research and the outline of the thesis are described.

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## 1.1 Background

In today’s business environment, the pressures on manufacturing companies to compete on the global arena have been increasingly intensified. Requirements on production capabilities such as quality, cost, delivery capability, and flexibility have become severe to an ever greater extent. Moreover, changes inside and outside of production have become more dynamic and complex. Production is challenged to handle and benefit from, for example, high fluctuations of production volumes and variances, shorter product life cycles, shorter lead time of product realization, rapid technological advancement, corporate mergers and acquisitions, and changes of laws and regulations. Under such circumstances, companies must ensure constant and strong development of the production. Such development is especially necessary for the companies that have the production in high wage countries.

In Sweden, one of the high wage countries, manufacturing industry has been vitally important for the country’s growth and welfare. The industry accounts for more than half of the nation’s exports. Around 700,000 people work in this sector, and an estimated 1.4 million people are indirectly dependent on the industry (IVA, 2005a). For many years, the industry had experienced strong production development. Manufacturing companies were active in developing and transferring new technologies or new work methods to production. Examples included NC machines, CAD/CAM systems, industry robots, time measurement methods, and automation. In the 1980’s, the radically new concept of work organization in production called “the result-oriented team” was invented and applied widely in the industry, which drew the world’s attention.

Despite the efforts mentioned and developments made in the past, it has been said recently that in the last two decades at least, the development of production has been neglected at many Swedish manufacturing companies (Kinnander, 2005; Axelsson and Tangen, 2008). The situation can be described as follows:

- The potential and importance of production have been underestimated by company management and society representatives. They consider that enough investment has already been made in industrial production, and that more focus should now be paid to developing new products and new industry branches such as IT, biotechnology, and nanotechnology. This view has contributed extensively to the trend of outsourcing and the re-localization of production to low wage countries.
- The competence and number of production engineers have been significantly reduced. The devalued view of production mentioned is one of the reasons. The concept of “the result-oriented team” also downgraded the role of production engineers: in this concept, the responsibility for developing production was moved from production engineers to shop floor operators.

During 2009, several workshops were held at Mälardalen University to discuss how to support the development of production in Sweden. The attendants of the workshops, production managers, researchers, and consultants, recognized the similar situation mentioned above:

- Company management is less aware of the potential and importance of production.
- Companies often focus on short term results and provide insufficient opportunities to develop the production with a long term perspective.
- The production engineering function is generally weak. At companies, production engineers work more like support men or repairmen to the production shop floor, rather than developers of production.
- Managers are keen on introducing Lean production, but they consider that no further effort is needed afterwards.

IVA (2005b) warned that the low prioritizing of production may cause significant negative impacts on the competitiveness of manufacturing companies and, eventually, the country’s welfare system. The need for the strong development of production should be especially emphasized in Sweden (e.g. Bellgran and Säfsten, 2005; IVA, 2005b; Kinnander, 2005). For example, Kinnander (2005) states that the country needs to create a greater understanding of the potential and importance of production, in other words, to create a “new production culture”.

The strong development of production can be supported in various ways, but in general two approaches are commonly recognized: incremental and continuous improvement and infrequent and radical improvement.

Incremental and continuous improvement (called Kaizen in Japanese) is a well-known approach for improving production. Kaizen became widely known to the world after the introduction by Imai (1986). The key characteristics of Kaizen are often described as continuous, incremental improvement in nature, participative, and process-oriented. The concept has been extensively described, and a number of supporting methods and tools have been developed and widely applied in industry.

The other approach, radical improvement, has been also conducted by many companies. However, it has been less documented and theorized compared to continuous improvement. Radical improvement is called “Kaikaku” in Japanese. Here, Kaikaku means radical improvements that are conducted infrequently, involve some fundamental changes within the production, cause dramatic performance gain, and are often initiated by top or senior management.

In the recent Japanese manufacturing industry, the importance of Kaikaku in production has been strongly emphasized. The emphasis is evident even at the companies that are highly proficient in Kaizen, such as the Toyota Motor Corporation. The former CEO of the company, Watanabe, says *“Toyota could achieve its goals through kaizen. In today’s world, however, when the rate of change is too slow, we have no choice but to resort to drastic changes or reform: Kaikaku”* (Stewart and Raman, 2007).

Kaikaku in production has become a trend among Japanese manufacturing companies (Ikaida, 2007; Kimura and Takano, 2005). One of the major triggers of the trend is the emerging internal or external competitors in East and South East Asia. In order to sustain competitive advantage from these competitors, many Japanese companies have made intensive efforts to increase the speed of the improvement in production. Many companies have also been trying to make their domestic factories distinctly advanced compared to those competitors. As a result, an increasing number of factories in Japan are becoming more unique and creative (Kimura and Takano, 2005).

The above-mentioned Kaikaku trend in Japan gives meaningful implications to Swedish manufacturing industry. The word Kaikaku has been little known to the industry. However, introducing the concept of Kaikaku to the industry has a potential to raise the awareness about the need for the strong development of production and contribute to creating new production culture.

The potential of Kaikaku is not confined to radical performance improvement in production. It also contributes to increasing a production function’s capability for collective learning and improvement. Such capability is considered especially important for sustaining competitive advantage in the long run. Several authors who

analyze the Toyota Production System (TPS), considered by many scholars and practitioners one of the most competitive production systems today, commonly claim that Toyota's operational excellence resides not only in TPS itself, but also in the company's capability for collective learning (e.g. Shibata and Kaneda, 2001; Fujimoto, 2001; Liker, 2004). Fujimoto (2001) states that the ultimate source of the competitiveness of this company lies in its capability for tenacious learning, in other words, the power of self-evolution. A company that is excellent in Kaizen and capable of effectively handling radical improvement and innovation in production has a higher chance of sustaining the international competitiveness in production.

## **1.2 Problem statement**

The situation of industrial production in Sweden described above gives impulse to research Kaikaku and how to support it. In terms of researching Kaikaku, two problems in particular are addressed in this thesis.

First, the concept of Kaikaku needs to be further analyzed and consistently described. In order to increase the awareness of the need for and potential of Kaikaku, the concept should be communicated effectively to Swedish industry. However, this is difficult to do because Kaikaku has not been well-conceptualized and described in order for non-Japanese companies to understand what Kaikaku really is. There is considerable confusion about how Kaikaku is described in literature and industry. For example, some refer to Kaikaku as introducing new technologies to production. Some refer to it as introducing new production practices, such as Lean production and Six Sigma. Some others say that Kaikaku is an exhaustive execution of Kaizen. The ambiguous concept also makes it difficult to conduct research regarding how to support Kaikaku.

Second, more structured support needs to be developed that helps companies to conduct Kaikaku effectively and efficiently. Most companies have made some sort of radical improvements, but structured guidance for conducting Kaikaku is often insufficiently provided. The companies often rely heavily on a limited number of experienced internal individuals, external consultants, or system suppliers in order to realize radical improvements. The knowledge of how to support Kaikaku is also limited in academia. Even in Japan, where many Kaikaku activities are conducted and reported, authors describe mostly what the companies have achieved by Kaikaku but little of how they have realized it.

### 1.3 Objective of the research

Considering the background and problem statement mentioned above, the research presented in this thesis focuses on Kaikaku in production and specifies the objectives as follows:

*The research has two objectives. The first objective is to analyze and structure the concept of Kaikaku in order to describe the phenomenon comprehensively and consistently. The second objective is to develop methods or guidance that facilitate the realization of Kaikaku. The methods or guidance should contribute to realizing radical improvements in production and to improving the production function's capability for collective learning and improvement.*

### 1.4 Research questions

To meet the research objectives, the following three research questions are formulated. The first research question is related to the first objective, and the other two are related to the second research objective.

In order to meet the first objective, it is necessary to analyze various industrial cases of radical improvement in production and what kind of improvements scholars and practitioners refer to as Kaikaku. It is also important to search for theories that can explain the phenomenon of Kaikaku in a structured way. Therefore, the first research question is:

*RQ 1: How do scholars and practitioners describe the phenomenon of Kaikaku, and what theories are suitable to explain the phenomenon in a comprehensive and structured way?*

In order to develop methods or guidance that facilitate the realization of Kaikaku, it is necessary to identify factors or mechanisms that strongly affect an effective and efficient execution of Kaikaku. It is also important to analyze how these factors and mechanisms are related to improving the capability of collective learning. Therefore, the second research question is as follows:

*RQ 2: What factors or mechanisms significantly contribute to an effective and efficient execution of Kaikaku and to an improvement of the capability for collective learning?*

The workshops mentioned in Section 1.1 implied that “production management and organization setting” (here meaning, for example, mindsets of management,

organization structure, competencies and roles of production engineers) could provide an important foundation for realizing Kaikaku in production. In order to fulfill the second research objective, it was found necessary to investigate management and organization settings that can increase the probability of realizing Kaikaku. Therefore, the third research question is the following:

*RQ 3: What are the characteristics of production management and organization settings that can increase the likelihood of realizing Kaikaku?*

## **1.5 Delimitations**

The research focuses on Kaikaku in production within manufacturing industry. Production functions located in Japan and Sweden are particularly considered as study objects. This is because the accessibility to these objects is high for the author of this thesis, and 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 example, factories at these countries are under strong off-shoring and re-localization pressure due to the high wages.

Borrowing the notion of Dunphy (1996), researchers who study production improvement can be categorized into three types: analysts, actionists, and futurists. Analysts are primarily interested in analyzing the nature of improvements in production. For example, they try to analyze the characteristics of Kaizen and Kaikaku. Actionists are interested in how to intervene production to generate improvements. Finally, futurists try to predict future production, to which one can create trajectories. The research in this thesis mostly takes the perspectives of analyst and actionist. Predicting future production is not the primary interest of the research.

A radical improvement in production usually goes through the following general stages: analyzing the current status quo, identifying the production strategy and the desired future state of production, transition, and a more moderate phase of improvement. All the stages are important, but the research focuses mainly on the transition stage. The research will not deal with how to analyze the current status of production, nor how to formulate a production strategy.

Finally, Kaikaku is often conducted in a project form. However, many of the case studies that report about Kaikaku do not particularly articulate that project management is the decisive factor in the success of Kaikaku. Therefore, the research presented in this thesis does not consider the project management aspect in Kaikaku.



## **1.6 Outline of the thesis**

Chapter 2 introduces the research methodology employed by the research presented in this thesis and motivates why particular methods are applied. Chapter 3 presents the frame of reference that provides a theoretical foundation for the research. Chapter 4 then presents the research results. Finally, in Chapter 5, conclusions are made and future research opportunities are suggested.



## **2. Research methodology**

This chapter discusses the methodology employed by the research presented in this thesis. Motivations are given as to why particular research approaches and data collecting techniques were used in the research. The research process is presented, and, finally, the quality of the conducted research is discussed.

---

### **2.1 Scientific approach**

The choice of scientific approach reflects a researcher's perception of the world as well as his or her view of science. Consensus regarding how to approach the world in terms of research is often referred to as paradigms. Commonly acknowledged scientific paradigms are positivistic and hermeneutic. The positivistic research paradigm is often adopted by a traditional natural science school. Gummesson (2000) describes several characteristics of positivistic research. For example, the vantage point is primarily deductive, statistical and mathematical techniques for quantitative processing of data are central, and researchers are detached from the object of research. On the other hand, hermeneutic research is often adopted in the field of social science and uses a more personal interpretive process to understand reality. The vantage point is primarily inductive, it mainly uses non-quantitative data collection and analysis, and the researcher's personality is also considered a research instrument.

These paradigms can be related to the methodological approaches suggested by Arbnor and Bjerke (1997), called analytic, systems, and actors approaches. The analytic approach is close to the positivistic paradigm, and seeks to explain the reality as objectively as possible. It tries to identify casual relationships of certain phenomena. It strives to find independent causes, considering the classical laws of physics as a model. The systems approach takes a more holistic perspective than the analytical approach. It aims to explain reality from a system theoretical perspective. Finally, the actors approach is close to the hermeneutic paradigm and focuses more on understanding a social construction of reality. The relationships of the paradigms and the methodological approaches is shown in Figure 2.1.

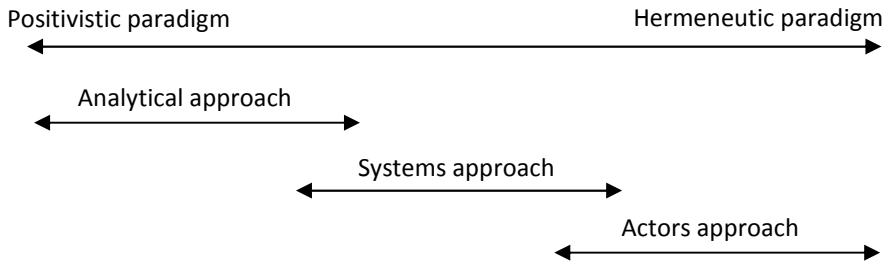


Figure 2.1. The methodological approaches related to the paradigms (Arbnor and Bjerke, 1997)

The research in this thesis is aimed at investigating radical improvements in production. Production is a complex organization of material transformation processes, human beings, equipment, information, and management and control (Hubka and Eder, 1988). When improving production, interactions of all the mentioned elements need to be considered. Therefore, in the research presented in this thesis, the systems approach was the most suitable approach to analyzing and describing the phenomena of production improvement. On the other hand, some aspect of the actors approach was also appropriate to consider. Production and operation management, which often involves people and groups in organizations, bears some of the characteristics of a social science (Westbrook, 1994). Since an improvement in production is conducted by humans, organizational culture and an individual's mindset and behavior considerably affect the process and the result of the improvement. The actors approach allows a researcher to obtain deep access to such "soft" issues of the phenomena.

Since an improvement in production is a complex, human-involved, and context-dependent activity, it is hardly understood and explained sufficiently by numerical data and mathematical formulas. The research that deals mainly with numbers in data collection and analysis is called quantitative research. On the other hand, qualitative research deals mainly with qualitative data and aims to understand the meaning, context, and process of certain phenomena that cannot be explained properly by quantitative research (Maxwell, 2005). In qualitative research, researchers can gain holistic perspectives, personal contacts and insights, access to qualitative data, unique case orientations, and insights into dynamic systems (Patton, 1990). Therefore, qualitative research was adopted as the suitable approach for the research presented in this thesis.

## 2.2 Research design

There are several research design guidelines available in literature (e.g. Maxwell, 2005; Blessing and Chakrabarti, 2002; Flynn et al., 1990; Blaxter et al., 2006). These guidelines commonly explain and discuss the specification of research objectives, the

establishment of theoretical foundations, the choice of research methods, the choice of data collection and analysis techniques, and the analysis of quality of the research. The qualitative research design model suggested by Maxwell (2005) has five components: *Goals*, *Conceptual Framework*, *Research Questions*, *Methods*, and *Validity*. The *Goals* concern the research objective that considers the question of why the research needs to be conducted. The *Conceptual Framework* is about understanding the state of the art within the area of the research. The *Research Questions* are the specific questions that guide the research toward its objective. The *Methods* are the techniques of data collection and analysis. Finally, the *Validity* is related to the quality of the research considering how the result and the conclusions might be wrong. These components form an integrated and interacting whole, with each component closely tied to several others rather than being linked in a liner sequence. This relationship is illustrated in Figure 2.2.

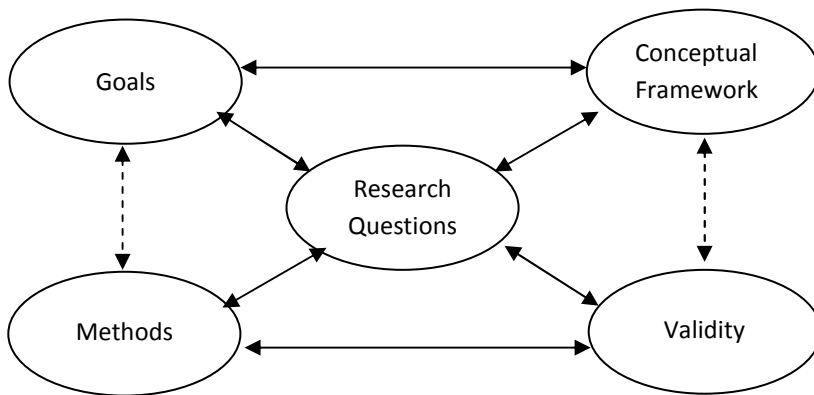


Figure 2.2. An Interactive Model of Research Design (Maxwell, 2005)

The research presented in this thesis mainly relied on Maxwell's (2005) research design method, since it provides detailed guidance regarding how to conduct qualitative research. However, other research design methods were also referred to. One of them is Design Research Methodology (DRM), suggested by Blessing and Chakrabarti (2002). DRM divides a research process into four stages: *Research clarification*, *Descriptive study I*, *Prescriptive study*, and *Descriptive study II*. At the first stage, a research goal is created. Then, deeper understanding of the phenomena under study is obtained through the second stage. In the third stage, supporting models and theories are developed. These models and theories are tested in the last stage. Although a research process in reality is highly iterative both within and between the stages (Blessing and Chakrabarti, 2002), the conceptual division of a research process helps to plan the research and understand its progress.

## 2.3 Empirical data collection – case study

An empirical study uses data gathered from naturally occurring situations or experiments, rather than via laboratory or simulations (Flynn et al., 1990). When not enough evidence is found in literature, better understanding of the phenomena can be obtained by an empirical study (Blessing and Chakrabarti, 2002). There are several empirical data collection methods described in literature. According to Yin (1994), there are five methods: *experiments*, *surveys*, *archival analysis*, *histories*, and *case studies*. In Yin's (1994) definition, a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. The case study is a preferred method when a "how" or "why" question is asked about a contemporary set of events over which the investigator has little or no control (Yin, 1994; Meredith, 1998). An important advantage of the case study is the opportunity to obtain a holistic view of a specific phenomenon or series of events, when one studies them from many different aspects (Gummesson, 2000). An empirical study can be used to either build or verify theory (Flynn et al., 1990), but the case study is most appropriate for generating or extending theory (Meredith, 1998). In the research presented in this thesis, it is important to explore the questions of how to realize radical improvements in production. Little theoretical development has been made in the research area. Thus, the research should be more related to theory building than testing or verifying existing theories. Therefore, the case study was employed as the main empirical data collection method.

In the case study, researchers can rely on various sources of evidence. Yin (1994) states that evidence may come from six sources: *documents*, *archival records*, *interviews*, *direct observation*, *participant observation*, and *physical artifacts*. Each source has its advantages and disadvantages. For example, interviews are the most common technique used for case studies. They allow direct focus on the topics of the studies. However, interviews can be subject to misinterpretations, poor recalls, and selections of inadequate respondents. Direct observation allows the researcher to follow events and their context in real time, but it can be time consuming. Gummesson (2000) and Westbrook (1994) describe the advantages of participant observation, or *action research*. These authors state that deep access to the study object is a prominent advantage of the participant observation, although there is a risk of subjectivity and reliability. No single source has a complete advantage over all the other. Therefore, *triangulation* - the use of multiple sources of evidence - is optimal (Yin, 1994). In the research of radical improvements in production, gaining a high level of access to the events of radical improvements is critically important in order to obtain a deeper insight into the phenomena. Therefore, the case studies presented in this thesis relied on not only interviews but also direct and participant observations.

The selection of cases is an important aspect of case studies. Eisenhardt (1989) states that the selection of cases 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, cases may be chosen randomly, but random selection is neither necessary nor even preferable (Eisenhardt, 1989). Instead, cases are chosen to help generate, replicate or extend theories (Meredith, 1998). As mentioned earlier, the research presented in this thesis is mainly related to theory building. Therefore, the theoretical sampling was considered in the selection of the cases. However, it should be mentioned that pragmatic issues such as the author's personal contacts and the contacts of the research institution with companies significantly influenced the choice of the cases.

The analysis of collected empirical data involves examining, categorizing, tabulating, or otherwise recombining the evidence to address the propositions of the study. Planning how to analyze the collected data before and during a case study is important. Otherwise, a researcher may fall into one of the realities of case studies: a staggering volume of data (Yin, 1994; Maxwell, 2005; Eisenhardt, 1989). The data analysis techniques used in the research were within-case analysis (Eisenhardt, 1989), tabulation, pattern matching, and comparison of the data obtained from the different cases.

## **2.4 Research process**

As mentioned earlier, research methodologists state that conducting research is an iterative process. This was true also for the research presented in this thesis. The research objective, the research questions, and the theoretical framework were frequently reviewed and updated. The research process presented below is more like a result of a journey, instead of a prescribed plan made at the beginning of the research.

In the initial phase of the research, the focus was on finding an answer to the first research question. Then, the research worked on the second research question. In the late phase of the research, the third research question was in focus. The research methods, sources of evidence, and data analysis techniques relied on or employed in order to answer the research questions are shown in Table 2.1.

Table 2.1. Relationship of the research questions and the research methods.

	RQ1	RQ2	RQ3	
<b>Main research method</b>	Literature study	Empirical study (Case study A )	Empirical study (Case study B )	Empirical study (Case study C )
<b>Unit of analysis</b>	Phenomena of Kaikaku	Process of Kaikaku, Lean transformation in particular	Kaizen practice	Management and organization setting
<b>Main source of evidence</b>	Literature	Direct and participant observations	Direct observations	Semi-structured interviews
<b>Data analysis technique</b>	Comparison, categorization	Within-case analysis, pattern matching	Comparison, pattern matching	Tabulation, comparison
<b>Developed theory</b>	Definition of Kaikaku Four types of Kaikaku	A model of driving Lean transformation	Eight guidelines that enhance Kaizen	Characteristics of innovative production organization
<b>Relevant stage of DRM</b>	Research clarification, Descriptive study I	Descriptive study I, Prescriptive study	Descriptive study I, Prescriptive study	Descriptive study I
<b>Appended paper</b>	Paper A	Paper B	Paper A	Paper C

In order to answer the first research question, or in short “what Kaikaku is”, a **literature study** was conducted. The literature study had two goals: to understand the phenomena of Kaikaku better and to identify theories that can explain the phenomena in a structured way. In literature, there were several terms similar to Kaikaku. Examples include innovation, breakthrough improvement, Kakushin, second-order change, and evolutionary or revolutionary improvement. The research paid specific attention to the words Kaikaku and Kakushin that are frequently used among Japanese manufacturing companies. In Japanese, Kaikaku means reform or radical change, and Kakushin means innovation. However, since no distinct difference was identified in the way of using those two words in the context of radical improvements in production, the research considered that Kaikaku and Kakushin meant the same, and they were named as Kaikaku. The word Kaikaku was in focus in the study because analyzing the practices of radical improvements in production in Japan was one of the main research



interests. Kaikaku may connote more specific activities or meanings than the literal meaning of radical improvement, as Kaizen does for incremental improvement. For the first goal of the literature study, dozens of case study reports that feature Kaikaku in production at Japanese companies were reviewed and analyzed. For the second goal, literature in various theoretical areas were reviewed. Production improvement, organization development, manufacturing strategy, production system design, and product innovation are examples. The literature study was complemented by conversations and discussions about Kaikaku with a number of industrial people. As a result of the study, a conceptual framework of Kaikaku was developed. The framework provides a holistic view of Kaikaku. It also classifies various kinds of Kaikaku into four types. Further explanations of the framework will be made in Chapter 4.

The literature study mentioned above identified that Kaikaku is a wide ranged activity. There are various ways to realize Kaikaku. Finding an answer to the second research question, in short “how to realize Kaikaku”, can be too broad to manage. Therefore, the research presented in this thesis focused on a more specific area of radical improvements in production, that is, the implementation of Lean production. The implementation of Lean production, or Lean transformation, at a factory often involves fundamental changes in, for instance, production flow, production planning system, production management structure, and organization culture. Lean transformation was focused on because it has been a popular activity among Swedish manufacturing companies and some interesting cases were available. In order to investigate the Lean transformation process, **case study A** was conducted.

In case study A, one-and-half-year direct and participant observations were made on two Lean transformation cases at two medium-sized Swedish manufacturing companies. One of the two companies (here called company A) is a medium sized company having approximately 150 employees. They produce precision casting goods for automotive, industrial equipment, and infrastructural industries. Product variation is about 600 products. The other company, named as company B, is also a medium sized manufacturing company with about 130 employees. They produce electrical products mainly for infrastructural industry. These two companies had made few improvements in the operations before the transformations were initiated. The managements of the companies wanted to apply Lean production to their factories to increase operational competitiveness.

These transformations were particularly interesting cases, because they were consulted and facilitated by an experienced Japanese consultant. The consultant had worked for one of Toyota’s supplier companies in Japan, where he developed TPS-inspired production for more than 20 years. He retired from the company in 2005 and continues to consult TPS at a number of companies. In total, he has instructed TPS at

more than 150 companies and to 2,800 people globally. His consultation style is the one commonly practiced within Toyota and its related companies: going to the shop floor, seeing and analyzing the operation there carefully, and suggesting improvement. The main focus of his consultation is on shop floor operation. However, the range of change is often extended to the whole company, for example, to the management structure and the management's mindset.

The author to this thesis directly observed the Lean transformations at company A and B. The author participated in the transformations as a translator and also as an assistant to the Japanese consultant. The participation began when the transformations started in September 2007 and September 2008, respectively, at company A and B. The period of the participation was one and half years at company A, and a half year at company B. Observation data were collected in various ways, including through the author's participations of actual improvement activities, through the discussions with presidents, production managers, group leaders, engineers, and operators, and through frequent conversations with the consultant that especially helped to understand the thinking behind of his behaviors, decisions, and actions during his consultation. An important feature of case studies is the frequent overlap of data collection and data analysis (Eisenhardt, 1989). Van Maanen (1988) suggests that field notes should be an ongoing commentary about what is happening in the case study, involving both observations and analysis of them, preferably separated from one another. Collected data were documented and analyzed based on Van Maanen's suggestion. Participant observation has a distinct benefit: the ability to perceive reality from the viewpoint of someone "inside" rather external to it. However, it also has the risk of potential bias produced (Yin, 1994). The author's position as a translator and assistant consultant made it easier to observe the improvement events from a third person perspective. As a result of case study A, a mechanism of how to drive a Lean transformation was identified. Further descriptions of the result of the case study A will be made in Chapter 4.

**Case study B** was performed when the above-mentioned Japanese consultant held TPS-workshops at six Swedish companies in April 2007. The workshops included seminars of TPS at meeting rooms, where the consultant explained basic concepts of TPS and its practice, and on-site shop floor consultations, where the consultant went to the shop floors of the companies and instructed improvements. The attendants of the workshops were mainly middle and senior managers related to production. The six companies are located around the Mälardalen region in Sweden, manufacturing products such as vehicle components, electrical products, and industrial equipments. The author of the thesis was involved in the workshops as a translator for the consultant and, at the same time, as a researcher observing the workshops. The comments and behavior of the consultant and the conversations between the

consultants and the attendants of the workshops were documented, especially those related to improvements in production. Analysis of collected data showed that one of the major differences between the six Swedish companies and the companies proficient in TPS was thoroughness in conducting Kaizen. The analysis also led to developing eight guidelines for enhancing Kaizen at shop floor. The guidelines are presented in Chapter 4. The result was relevant to the second research question, because, as later explained, the literature study and case study A showed that Kaizen is an integral part of Kaikaku in some cases.

The third research question is about production management and organization settings that can facilitate Kaikaku. The third research question was raised through the workshops mentioned in Chapter 1. In retrospect, it was found that workshops attended by experts from both academy and industry were an effective way to collect data related to a research study. In order to answer the third research question, **case study C** was conducted. The case study, however, focused on a more specific type of Kaikaku, defined as *radically innovative Kaikaku*. This type is described in Chapter 4. In the case study, five Japanese companies and four Swedish companies were studied. These five Japanese companies were selected as extreme cases because various articles, magazines, and newspapers in Japan mentioned that the domestic factories of those companies are highly efficient and use various advanced technologies and work processes. In addition, a practical issue, the accessibility to those companies, also influenced the choice of the companies. The four Swedish companies were selected as reference cases in order to understand the status of production management and organization setting at Swedish companies. All of the studied companies were large manufacturing companies. Six of them were in the automobile industry. The brief profiles of the nine companies are presented in Appended Paper C. Data was collected through semi-structured interviews with production managers or corporate executives of the companies. They can regard production management from a holistic perspective. The interview items were prepared based on a literature study. The questions asked during the interviews were related to four general categories:

- Manufacturing strategy of the company
- Organization of the production engineering function
- Education systems within the production function
- Culture of the production organization

More detailed interview items are found in Appended Paper C. The author of the thesis conducted all of the interviews during May and April of 2009. Collected evidence at each company was tabulated for each interview item, and then compared between the companies. As a result, several characteristics of production organization and

management setting that can facilitate radically innovative Kaikaku were identified. The result of case study C will be more described in Chapter 4.

## **2.5 Estimation of the quality of the research**

Literature often discusses validity and reliability as means of evaluating the quality of the conducted research. Conducting research without considering its validity and reliability is pointless because the researcher will not be able to generalize from the results (Flynn et al., 1990).

The validity is about the degree to which a theory, model, concept, or category describes reality with a good fit (Gummesson, 2000). Maxwell (2005) mentions two specific validity threats: bias and reactivity. Bias is the researcher's selectivity in collecting and analyzing data. Reactivity is the influence of the researcher on the setting or individuals studied. During the research presented in this thesis, the mentioned validity threats were kept in mind. However, the reactivity was difficult to be avoided especially when the participant observation was conducted in case study A. Little could be done other than being aware of the researcher's influence on the study objects. On the other hand, the validity of the result obtained from case study A can be reasonably high. This is because the case study was conducted for a long period of time and a deep access to the study objects was obtained. Westbrook (1994) states that any misunderstandings or wrong assumptions in theory building have multiple opportunities to get exposed and corrected because of the variety of modes of communication between a researcher and the collaborating organization.

In terms of validity, there is another concept called external validity. This is about whether the study's findings are generalizable beyond the immediate case study. According to Yin (1994), there are two types of generalization, statistical and analytical. 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. If a researcher has a good descriptive or analytic language and can grasp the interactions and characteristics of the phenomena studied, the possibilities to generalize from a few cases, or even a single case, may be reasonably good (Norman, 1970). Case studies A, B, and C were in-depth studies of the phenomena of improvements in production, and were not based on statistical data collection and analysis. It can be reasonably assumed that an analytical generalization is possible to a certain degree from the results of those case studies.

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).

Developing a consistent method to study various sites is appropriate, and the method should be documented enough to be used by other researchers (Westbrook, 1994). Gummesson (2000) states that higher reliability can be achieved by, for example, a well-documented and richly-described case, a comprehensive account of the research process, and a clear presentation of the results and the conclusions. In the research presented in this thesis, various efforts were made to increase reliability. During the direct and the participant observations in case study A and B, the collected evidence was frequently written down in documents. In case study C, an interview protocol was designed based on a literature study and two pilot interviews. The interview conversations were written down as memos or recorded when allowed. Even with those efforts, the author of this thesis perceived that achieving high reliability was a challenging issue. During the case studies, many other informal information sources outside of the cases (for example, daily conversations with colleagues, friends, and family members, newspapers, and articles) implicitly influence what conclusions to draw from the cases. Among other things, a researcher's previous experience, cultural background and values, personal openness, and skill at providing deep insight to the observed events can also affect the understanding and interpretation of a case (Westbrook, 1994; Gummesson, 2000). Therefore, it can be assumed that limited reliability is inevitable, especially when one conducts direct and participant observations.



## 3 Frame of reference

This chapter presents the frame of reference that provides a theoretical foundation for the research presented in this thesis. The first section presents some theories related to production systems. Then, the terms Kaizen and Kaikaku are introduced and defined, followed by relevant theories with respect to the realization of Kaikaku. Finally, a summary of this chapter is made.

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### 3.1 Production system

Before discussing theories related to production systems, the term production needs to be defined. In literature, production is defined in various ways. This thesis adopts one of the most accepted definitions suggested by CIRP (1990):

*Production is the act of processes (or the connected series of acts or processes) of actually physically making a product from its material constituents.*

The term “manufacturing” is also frequently used in literature. In this thesis, manufacturing is defined as the activities needed in order to put a product to the market, including product development, production, marketing, and so on.

#### 3.1.1 A systems view on production

Production is generally viewed as a complex activity involving different elements such as machines, materials, information, and humans. These elements are organized to realize the desired functions of the production. Due to this complexity, production is often described from a system perspective. In the system theory, a system has its function of transforming certain inputs into desired outputs. It also consists of a set of elements interlinked by relationships, and has a hierarchical structure where a part of the system is a subsystem and the system itself is the part of a more comprehensive system called a supersystem (Seliger et al., 1987). How to describe a production system depends on which perspective the observer has. For example, when the observer is interested in analyzing the transformation process of the production, he or she may use a process flow chart to describe the production. The production can be also described as a shop floor layout or a value stream map. Some observers may add a production organization in order to describe the production.

In improving production, changes can be made in any elements of the production, for example, production processes, production equipment, employees, information processes, management structures, organization structures, and organization culture.

The influence of the changes can be transmitted to any of the elements as well. In the research of improvements in production, it is necessary to understand production from a holistic perspective, having all elements of the production in consideration. Close attention needs to be paid to the interactions between those elements. In this sense, the model of the transformation system suggested by Hubka and Eder (1984) is most suitable to adopt as the definition of a production system in this thesis. Hubka and Eder (1984) describe a production system as a transformation system, as shown in Figure 3.1. In their description, an operand is transformed through a transformation process to a desired state. Human, technical, information, and management systems participate and drive the transformation process. These subsystems also interact with each other, although such interactions are not explicitly displayed in Figure 3.1.

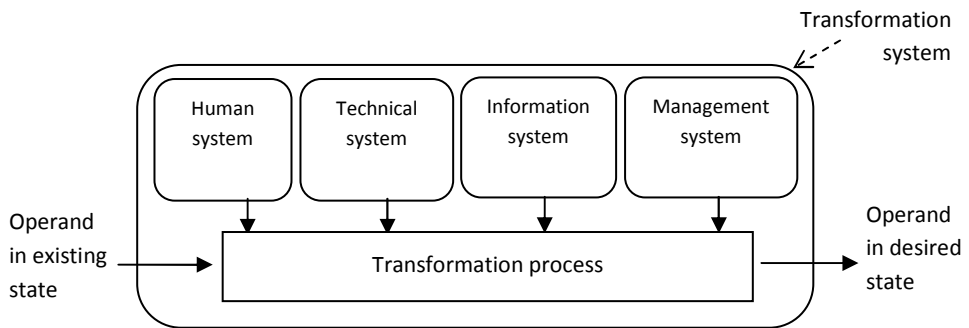


Figure 3.1. Model of the transformation system (Hubka and Eder, 1984)

### 3.1.2 Competitiveness of a production system

Various performance parameters are often used to measure and evaluate the competitiveness of a production system. One of the most common ways is to use so-called “competitive factors” or “manufacturing capabilities”, often described as quality, cost, delivery capability, and flexibility (for example, see Wheelwright and Hayes, 1985). Manufacturing companies constantly make efforts to manage and improve competitive factors in order to gain and sustain their competitive advantage.

Various factors within a production system influence the mentioned competitive factors. According to Fujimoto (2001), the competitiveness of a production system can be analyzed from two aspects, namely static and dynamic aspects. The static aspect of the competitiveness can be evaluated at a certain point of time. It can be, for example, the skills and knowledge of the production operators and the support staff, the state of the production equipment, or the information and management system used in the



production. It can also be how these mentioned components of the production are organized or synthesized in order to function as an effective whole.

On the other hand, the dynamic aspect of the competitiveness is evaluated along with time. How effectively a production system can evolve and constantly increase its performance over time is a dynamic aspect of the competitiveness. Many authors who analyze Toyota Production System (TPS) commonly claim that that Toyota's operational excellence resides not only in TPS itself, but also in the company's capability of collective learning. Fujimoto (2001) asserts that the ultimate source of competitiveness of Toyota lies in the company's capability for tenacious learning or "power of self-evolution". Shibata and Kaneda (2001) mention that the TPS currently known to the public is merely an outcome of Toyota's constant activities of self-evolution. Liker (2004) also mentions that the power behind TPS is the company's management commitment to continuously investing in its people and promoting a culture of constant improvement. These authors imply that the dynamic aspect is becoming increasingly important in order to compete in the present manufacturing competitive environment. Therefore, the research presented in this thesis focuses not only on how to radically improve the competitive factors of production, but also on how radical improvements increase the production function's capability for collective learning and improvement.

### **3.2 Improvement of a production system**

It is widely recognized that there are two general approaches for improving a production system: incremental and continuous improvement, and infrequent but radical improvement. In Japanese, they are called Kaizen and Kaikaku, respectively. Their basic characteristics can be described as Figure 3.2. As mentioned in Chapter 1, doing both Kaizen and Kaikaku effectively and efficiently is essential to gaining and sustaining an international competitiveness of production. In the following subsections, these two approaches are introduced and defined.

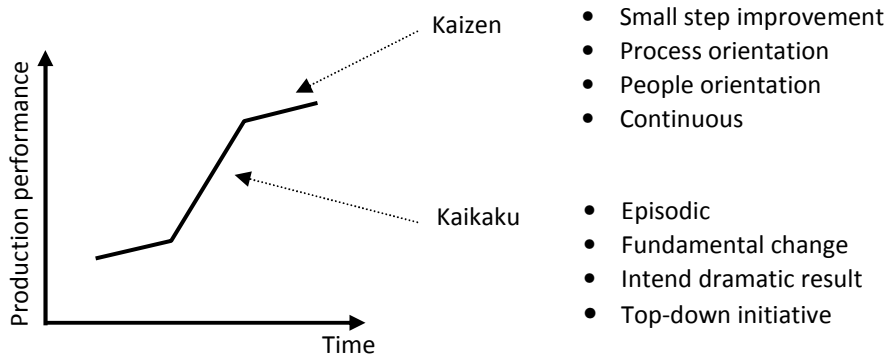


Figure 3.2. Basic characteristics of Kaizen and Kaikaku.

### 3.2.1 Kaizen

Kaizen means improvement in Japanese. However, in terms of industry, Kaizen carries the connotation of more specific activities that take place in a workplace to enhance the operations. The concept of Kaizen and its features are extensively described in literature. One of the most comprehensive descriptions is provided by Imai (1986). According to Berger (1997), the features of Kaizen described by Imai (1986) and other authors can be summarized into three key notions: process orientation, small step improvement, and people orientation. Process orientation means that attention is directed at creating sound processes, assuming that good results will follow automatically. Kaizen is distinctive in its focus on small improvements of work standards as a result of an ongoing effort. People orientation means that Kaizen involves everyone in the organization from the top management to the workers at the shop floor believing that their effort is going to “pay off” in the long run. The similar work is also done by Brunet and New (2003). They identify three core principles of Kaizen: it is continuous, usually incremental in nature, and participative.

The learning aspect of Kaizen is also mentioned in literature. For example, Weick and Quinn (1999) state that an improvement can be seen as an expansion of the range of skills and knowledge, not only as a set of specific actions. They also state that it is not just a substitution of existing systems and practices, but also includes strengthening existing skills and knowledge.

Several authors mention the importance of Kaizen in relation to Kaikaku. Kaizen is necessary in order to maintain and improve the outcome obtained by Kaikaku (Imai, 1986, Harrington, 1995). Brunet and New (2003) state that Kaizen helps to create a mindset in which radical changes and new technologies become more easily accepted in the workplace. Watanabe, the former CEO of Toyota, says that while trying to come

up with incremental improvements, many people come up with revolutionary ideas (Stewart and Raman, 2007). Harrington (1995) claims that organizations just starting their improvement activities should first direct their efforts to continuous improvements, establishing a working base. Then they should expand their improvement effort to include breakthrough improvements.

Kaizen seems to be a well-established concept in literature. Along with the concept, a number of Kaizen methods and tools have been developed and widely applied in industry. Typical examples include the following: a problem-solving process called PDCA (Plan, Do, Check, Action), problem-solving tools called “seven quality tools”, small group improvement activities called “quality control circle”, individual suggestion system, and a performance management method called “policy development” that connects overall system targets and local Kaizen activities.

In terms of the definition of Kaizen, various definitions can be found in literature. In this thesis, Kaizen is defined based on the characteristics mentioned above. The definition of Kaizen is also made in relation to the definition of Kaikaku described later:

*Kaizen is the continuous and incremental improvement of an activity with the purpose of increasing the performance of a production system. Typical activities are updating working standards and gradually reducing wastes in an operation. The performance increase as a result of Kaizen is usually less than 20 or 30 % in a given period of time.*

As mentioned earlier, the performance of a production system can be described using various factors related to quality, cost, delivery, and flexibility. Examples include defect rate, labor productivity, production cost per product, production lead time, delivery accuracy, and level of inventory.

### **3.2.2 Kaikaku**

A literal translation of the Japanese word Kaikaku is reformation, drastic change, or radical change. Japanese manufacturing companies have been using the term to name an improvement in production that is more radical than Kaizen. In literature, Kaikaku is often mentioned in contrast to Kaizen. Imai (1986) states that a Kaizen strategy maintains and improves the 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) says 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.

When we see how Kaikaku is described in literature, some distinctive characteristics that differ from those of Kaizen can be identified. This thesis summarizes them as episodic, fundamental, dramatic result, and top-down initiative. Each of these characteristics is described below.

Kaikaku occurs episodically, while Kaizen takes place continuously. In a reactive manner, Kaikaku can be seen as a consequence of the inability to change as quickly as the environment (Pfeffer, 1998). As adaptation lags, effectiveness decreases, pressures for change increases, and a revolutionary period is entered (Weick and Quinn, 1999). According to Sawa (2007), the Kaikaku activity at Canon Inc. was initiated when the effect of their Kaizen activity became stagnated due to the increasing volume and variation of the products, shorter product life cycles, and increasing number of contract workers. Enomoto (2007) mentions that NEC Corporation initiated Kaikaku at the Japanese plants due to the competitive threats of fast-growing plants in East and Southeast Asia. An organization can also conduct a radical change proactively to establish a solid competitive position against competitors.

In Kaikaku, people intend to bring about fundamental changes. Kaizen can bring about fundamental changes when accumulated over time (Orlikowski, 1996), but it is not always intended to do so. In Kaikaku, a change occurs in the deep structure or shared schemata (Bartunek and Moch, 1994). Replacement with new practice, knowledge, and methodologies occurs (Kondou, 2003). A fundamental change is brought about when the conventional way is discarded (Uno, 2004).

Kaikaku tends to bring about a dramatic increase in performance. The increase is usually larger and obtained quicker than that from Kaizen. Womack and Jones (1996) mention that the Kaikaku bonus released by changing a classic batch-and-queue production system to continuous flow with effective pull is a doubling of labor productivity, a cut in production throughput times by 90 percent, and a reduction of inventories by 90 percent. Kaikaku at the Takaoka factory in Toyota re-opened in summer 2007 cut lead times, logistics, and the assembly line in half (Stewart and Raman, 2007). Kaikaku at Aisin, one of the Toyota Group companies, reduced or increased key performance factors (such as lead time, cost, and productivity per area, for example) drastically (Shirai, 2007).

Finally, a top-down approach is often mentioned when Kaikaku is described. In that approach, the direction and initiation of the change come from a strategic level of an organization. It is monitored and driven by top management or their representatives. However, this does not mean that a top-down change is always directive and never

collaborative or participative (Balogun and Hailey, 2008). The initiation is usually triggered by top management. However, in some cases, the actual changes can be planned and driven by a wide group of individuals at a tactical and/or operational level.

When it comes to defining Kaikaku, this can be made in numerous ways. In this thesis, Kaikaku is defined based on the characteristics mentioned above. The definition is also made in contrast to the definition of Kaizen described in the previous subsection:

*Kaikaku is an infrequent but radical improvement where fundamental changes occur in the production system and a dramatic performance increase is obtained. Initiated often by top management, fundamental changes are made through reformations or replacements of the system by introducing new knowledge, work methods, strategies, production technologies, or equipment and so forth. The performance increase as a result of Kaikaku is often 30 to 50 % or more.*

In short, Kaizen is small changes producing small or moderate production performance improvements, whereas Kaikaku is fundamental changes producing radical performance improvements in production. It should be noted that some improvements exist that do not fall into either of the definitions of Kaizen or Kaikaku. One such occurs when fundamental changes of a production system do not generate any radical performance improvement. The other kind occurs when a dramatic performance improvement is realized without any fundamental change. These kinds of improvements can be considered rare instances, and therefore are not discussed in this thesis.

Another point should be mentioned with respect to the definitions of Kaizen and Kaikaku. In order to classify an improvement to Kaizen or Kaikaku, the observers' perspective needs to be specified. For instance, when a two-year improvement program is observed from a "distance" (the macro level of analysis in time and system hierarchy), it may consist of a flow of smaller improvement events resulting in a major change and a drastic performance increase. The improvement program is, therefore, perceived as Kaikaku. On the other hand, when each of the improvement events is observed from a view "closer in" (the micro level of analysis in time and system), they can be seen as Kaizen. An image of this explanation is shown in Figure 3.3.

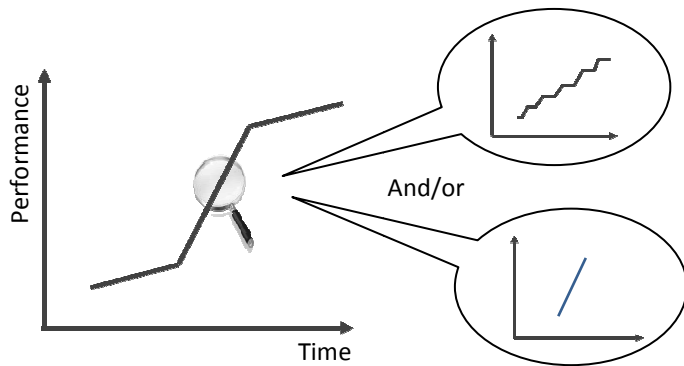


Figure 3.3. Image of the macro and micro levels of analysis.

As shown earlier in this subsection, there is a shared consensus about Kaikaku in literature. However, the consensus only exists at a general level. Kaikaku is understood and described much differently at a more detailed level. Examples are shown in Table 3.1. Imai (1986) describes Kaikaku as technology-oriented, involving large investments in equipment and being conducted by a small group of champions. However, Ikaida (2007) describes Kaikaku as a various and wide-ranged activity involving everyone in an organization. Womack and Jones (1996) often use the word Kaikaku when they mention the changes from batch-production to flow-production. Wakamatsu and Kondou (2003) assert that exhaustive Kaizen will lead to Kaikaku. Norman (2004) mentions that Kaikaku is more commonly referred to as “Kaizen blitz” in USA. Kaizen blitz is an intensive improvement event within a limited period of time, varying from a few days to a few months. It is driven by a small group of people, and it focuses on a limited area of operation (Bicheno, 2004).

Other than those differences shown in Table 3.1, the word of Kaikaku is used for purposes of describing different innovativeness levels. Kaikaku can be achieved by introducing off-the-shelf solutions (examples include off-the-shelf equipment or packaged company-wide improvement initiatives such as TPM, Six Sigma, and Lean). The introduced solutions may be new for the company. However, from the industrial perspective, the solutions are not new. On the other hand, a higher innovativeness level can be achieved by Kaikaku, by creating and using radically new equipment or work methods that do not exist in industry. In Japan, the latter type of innovativeness is increasingly observed as the result of their efforts to create unique plants that have outstanding performances and at the same time are difficult to be copied by foreign competitors (Ikaida, 2007; Kimura and Takano, 2005). An example of this type of Kaikaku is Toyota’s Takaoka plant (Stewart and Raman, 2007).

Table 3.1. Different descriptions or expressions of Kaikaku.

Author	Description or expression of Kaikaku
Imai (1986)	Technology oriented. 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 various and wide-range activity. Needs to be implanted to everyone as DNA.
Womack and Jones (1996)	Radical activity to eliminate waste. Transforming batch production to flow production.
Sawa (2007)	Mass movement.
Uno (2004)	Fundamental change toward the ideal state, discarding the conventional way.
Shibata and Kaneda (2001)	System improvement where a new working method is introduced.
Kondou (2003)	The process of attaining dramatic results by replacing existing practices with new ones. Important to obtain new knowledge as well as to acquire new and externally available methodologies.
Norman (2004), and Bicheno (2004)	More commonly referred as a 'kaizen blitz' in the United States. It delivers a large gain in a short time in a small area.

The different understandings and uses of the term Kaikaku make the concept of Kaikaku unclear and confusing. The unclearness and confusion make it difficult to consistently discuss how to realize Kaikaku. The concept of Kaikaku, therefore, needs to be explored further and developed in order to conduct research within this area.

The lack of consistent terminology implies that Kaikaku is still an immature research area. The number of published articles shown in Table 3.2 illustrates this as well.

Table 3.2. Comparison of number of articles indentified in databases.

Article database	Search word	Search object	Number of relevant articles found (from 2004 to 2009)
CiNii (Database for Japanese articles )	Kaikaku, Seisan* (in Japanese)	Title	82
	Kakushin, Seisan* (in Japanese)	Title	146
	Gemba** Kaizen (in Japanese)	Title	187
Elin@Mälardalen (Database for English-written articles)	Kaikaku	Title, Abstract, Key word	3
	Kakushin	Title, Abstract, Key word	2
	Kaizen	Title, Abstract, Key word	135
	Innovation, production	Title	28
	Breakthrough improvement	Title, Abstract, Key word	4
	Radical improvement	Title, Abstract, Key word	1

\* Seisan means production in Japanese, \*\*Gemba means shop floor in Japanese

In the table above, CiNii is one of the largest article database available in Japan for Japanese-written articles. English-written articles are searched by Elin@Mälardalen, one of the largest database available at Mälardalen University. Several search words were used (for instance, “Kaikaku” and “Kaizen”) and numbers of articles found were counted. Whether the topic of an article is relevant to Kaizen or Kaikaku in production is judged only from the titles of the articles. The statistics show that the number of the Japanese articles featuring Kaikaku is as many as those concerning Kaizen. However, most of the articles featuring Kaikaku are case study reports in which the companies present the outcomes of Kaikaku. Furthermore, they describe very little about how they realized Kaikaku. For English-written articles, the number of articles featuring Kaikaku is significantly fewer than those featuring Kaizen. This indicates that there is much room left to research about Kaikaku.

### 3.4 Realization of Kaikaku

In the previous section, the concept of Kaikaku was introduced and the need for further clarification of the concept was claimed. This section presents and discusses the theories relevant to the questions of when, who, and how to realize Kaikaku. The



first two subsections discuss when to initiate Kaikaku and who conducts it, and the third and fourth subsection discusses how to realize Kaikaku.

#### **3.4.1 When to initiate Kaikaku**

When to initiate a radical improvement and how quickly it needs to be realized should be determined by a strategic analysis (Balogun and Haiey, 2008). Various external and internal factors of the production system need to be investigated in the strategic analysis. The external factors of the production system are, for example, market situation, competitive position of the company, financial situation of the company, product structure and volume, business strategy of the company, and available and upcoming technologies. Internal factors include, for example, performance of the current production system, skill and knowledge of the employees, their capability of handling radical changes, awareness of the need of change, technological level of the equipment, and organization culture. A strategic decision is made in terms of the timing of the Kaikaku initiation, the level of capital investment, the resource allocation, and so on based on the strategic analysis. As stated in Chapter 1, this thesis does not deal with how to conduct strategic analysis and strategic decision making. Therefore, the question of when to initiate Kaikaku is discussed to a limited degree in this thesis.

#### **3.4.2 Who to conduct Kaikaku**

As mentioned in Section 3.2.2, many researchers state that the initiator of Kaikaku is usually top or senior management. However, who actually drives the change can vary. It can be change champions like top management, change agents, or external consultants, for example. The question of who drives Kaikaku can very much depends on the context of the company and also type of changes. For example, key drivers of a change can be different depending on whether the change is technology-oriented or operations-oriented. The “who” question in Kaikaku will not be discussed much further in this thesis, but some discussion is made in the next chapter.

#### **3.4.3 How to realize Kaikaku – the systematic approach**

There are several theories that describe the processes of how to realize a radical improvement in production. Here the processes are divided into two general types: the systematic approach and the contingency and learning approach. This subsection and the next subsection describe these two types respectively.

The systematic approach is about following well-defined systematic and prescriptive processes in order to realize radical improvements in production. A number of researchers have developed and presented such systematic and prescriptive processes. This thesis introduces particularly two research areas; namely, production system design and systemized company-wide improvement initiatives.

### ***Production system design***

With the increasingly dynamic business environment, many manufacturing companies face challenges to redesign or restructure their production systems more frequently than before (Wu, 1994). However, there generally exists a lack of awareness or availability of structured approaches in designing production system. The ad hoc approaches require numerous iterations and correction stages (Wu, 2001). In response to this recognition, research has been done in order to develop a design process of production system. Various design processes are suggested, including those presented by Wu (2001), Bellgran (1998), Bellgran and Säfsten (2005), Axelsson and Tangen (2008), Almström (2005), and Karlsson (2002).

The common characteristics of those design theories can be summarized as follows. They often take a holistic perspective and decompose a whole system design process into several sub-processes. Sub-processes often start by analyzing current internal and external production situations. Then, a manufacturing strategy is formed, and the requirements on the production system are specified. A conceptual design is made and evaluated, and then a more detail design is made. Later, an implementation plan is made and then the plan is executed. At each sub-process, these design theories often specify necessary actions and variables to be considered or decided (e.g. production policy, goal, layout, cycle time, and information flow).

Applying those theories into practice in the context of Kaikaku seems to be meaningful. They provide a comprehensive coverage of production system design activities. They allow for the linking of business and manufacturing strategies to the design of the production system. A systematic process makes it easier to control the design process as well as the outcome. However, some shortages also exist. The suggested design processes are still too simplified and abstract. Though necessary actions and variables are specified at each sub-process, little guidance is made on which actions or variables are more important than others at a specific context. In reality, users of those theories may not need to follow all the suggested actions with the same weight, and the variables are often to a large extent interdependent. Furthermore, these theories often take a general engineering perspective by focusing on designing physical features and information flows of the production system. However, they consider less organization development perspectives (mind and behavior changes of the organization and organizational learning during the change process, for example).

### ***Systemized company-wide improvement initiatives***

Researchers, manufacturing companies, and consulting firms have developed processes of company-wide improvement initiatives. By following the processes, it is believed to be possible to realize a radical improvement in production. Examples of such initiatives include Total Quality Control (TQC), Total Productive Maintenance

(TPM), Lean production, Six Sigma, Theory of Constraints (TOC), Demand Flow Technology (DFT), and Business Process Reengineering (BPR). In this section, only some representative ones are introduced (TPM, Six Sigma, and Lean production). In the following, the concepts and implementation processes of the three improvement initiatives are shown.

TPM is a total activity involving all personnel from top management to every employee, aiming to achieve maximum stability and utilization of production equipment. In TPM, the overall effectiveness of equipment is measured, and various factors that hinder the effectiveness are identified. Based on small group activities, those factors are removed. There are a number of tools, techniques, and practices available that support TPM activities. As for the implementation process of TPM, Osada et al. (2001) suggest following 12 steps. They are: decision of TPM introduction by top management, pre-study, formulation of master schedule, formulation of organization, setting target, kick off, breaking down execution plan, benchmarking, activity promotion, development of instructors, and monitoring and following up the progress. The first seven steps belong to the preparing phase, and the last five belong to the driving phase. Osada et al. (2001) emphasize that the preparation phase is especially important to establish a solid basis for the implementation.

Six Sigma seeks to improve the quality of products by identifying and removing the causes of defects and variation in manufacturing processes. It uses a set of quality improvement methods (statistical methods and quality control tools are two examples). Six Sigma also creates a special infrastructure of people within the organization specialized in using those methods and tools. Six Sigma can be introduced as tool boxes applied to existing local improvement activities in a company, but also as a company-wide strategy. According to Magnusson et al. (2003), if Six Sigma becomes the “DNA” of a company, the company can enjoy breakthrough improvements in the areas of bottom line results, customer satisfaction and performance. The same authors above suggest a 12-step Six Sigma deployment model. The steps can be grouped into four different major stages of deployment, getting started, education, measurement, and improvement. At the getting started stage, top and senior management’s commitment is gained, a facilitator is appointed, and the implementation program is formalized. At the training stage, improvement experts are trained, and first results are obtained and communicated to the organization. At the measurement stage, the performance measurement system is created, and the goal is set. At the last stage, the momentum of improvement is built up throughout the organization.

The term “Lean production” is introduced by Womack et al. (1990) after their investigation of Japanese auto makers, especially of the production system of Toyota Motor Corporation. In the early period of Lean awareness, after the introduction by

Womack et al. (1990), many of the manufacturers' efforts were focused on the emulation of shop floor techniques of Lean, such as 5S, flow production, small batch production, single minute exchange of dies (SMED), standardized work, and Kanban. They found it difficult to sustain them. Later, the necessity of organizational cultural and mindset change in Lean application was noted by several authors. Womack and Jones (1996) identify the importance of "thinking" in Lean production and summarize five principles of "Lean thinking". Liker (2004) further states that the introduction of Lean production involves a far deeper and more pervasive cultural transformation than the application of a set of Lean tools, and he presents fourteen management principles as the foundation of TPS. These mentioned authors and many other advocates of Lean production commonly agree that the goal of Lean transformation is to achieve competitive and adaptive manufacturing with the culture of continuous improvement and organizational learning. Several authors also suggest the implementation process. For example, Womack and Jones (1996) suggested the framework of "Lean leap" which consists of four implementation phases (get started, create a new organization, install business systems, and complete the transformation). At each phase, several specific steps are defined (see Table 3.3). For instance, the first phase of "get started" has the following steps: find a change agent, get Lean knowledge, find a lever, map value streams, and initiate change as soon as possible to win the acceptance.

Table 3.3. Implementation process of "Lean leap"  
based on Womack and Jones (1996), and Hines et al. (2004).

Phase	Specific steps	Time frame
Get started	Find a change agent Get lean knowledge Find a lever Map value streams Initiate change Expand your scope	First six months
Create a new organization	Reorganize by product family Create a lean function Devise a policy for excess people Devise a growth strategy Remove anchor-draggers Install a "perfection" mind-set	Six months through year two

Install business systems	Introduce lean accounting Relate pay to firm performance Implement transparency Initiate policy deployment Introduce lean learning Find right-sized tools	Years three and four
Complete the transformation	Apply these steps to your suppliers/customers Develop global strategy Transition from top-down to bottom-up improvement	By the end of year five

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These improvement initiatives mentioned can bring about radical improvements in production, especially when a deep cultural change is achieved and everyone within the organization is aligned to the company's strategic direction. However, the risk of adopting these packaged solutions and following the suggested processes are also mentioned by several authors. For instance, relying heavily on the packaged solutions may hinder in-depth organizational learning. Wu (2001) states that companies may adopt them as panaceas without understanding the strategic rationale and concepts behind them. Relying on these packaged solutions and believing that they have learned to solve their problems is not really a "learning organization" (McGill and Slocum, 1993). In a learning organization in their term, people are not only doing things better but also creating completely new things. Another criticism is that the implementation processes such as described above often omit how to actually realize an organizational cultural change, despite its being the key and the most challenging part of the implementation. Following the suggested pre-determined processes does not assure that a deep cultural change will occur. Moreover, some authors state that in reality an implementation process seldom proceeds in a pre-determined and linear fashion. For example, in the context of Lean transformation, Drew et al. (2004) state:

"Although it may be tempting to turn these (Lean transformation) phases into a project plan or a process to be followed, the reality of the journey is not like that. There is no 'right' way to approach a Lean transformation."

Hines et al. (2004) also claim there is no pre-determined way or "one best way" to implement Lean and, thus, a more contingent approach needs to be considered in the implementation.

#### **3.4.4 How to realize Kaikaku - the contingency and learning approach**

As shown in the previous subsection, many production system design theories and implementation theories of company-wide improvement initiatives suggest systematic

and prescriptive processes. However, another kind of approach to realizing a radical improvement in production can be identified in literature. This thesis calls that approach the contingency and learning approach. In the following, the approach is introduced.

### ***The contingency approach***

The contingency approach considers that there is no one best way to organize a process to achieve a certain objective. The approach believes that the process is deeply context-dependent, and therefore proper interventions should be made at proper times based on the organization's changing internal and external context. Several authors claim that the contingency approach needs to be considered when a company conducts an improvement that involves a deep cultural change. Change management is a research area that discusses how to support bringing about a cultural change in an organization. The contingency approach is often adopted in change management theories (for example, the theories presented by Balogun and Hailey (2008) and Hayes (2002)). This thesis introduces them briefly as an example of the contingency approach.

The above-mentioned change management theories suggest analyzing the company's internal and external context factors prior to the change. The theories provide a set of different change options. Top-down change or bottom up change, collaborative change or directive change, which organization level to be changed, and who to be the key person of the change are some of the options. The change options are selected based on the analyzed context factors of the company. The change management theories also describe how to manage personal transition, meaning a change of a person's mindsets and behaviors. For instance, Balogun and Hailey (2008) describe a psychological process of personal transition with three stages: "letting go the past", "adapting to change", and "moving forward". These authors suggest how to support and facilitate the personal transition at each stage. Monitoring a change process is also important in the change management theories. Balogun and Hailey (2008) assert that while managers can drop intervention at the top of the organization, it is impossible to "manage" or "control" the interpretations of the recipient. A change is a more non-linear and on-going process that requires proximity to those on the receiving end and facilitation of creating alignment among the people within the organization.

It can be beneficial to consider the change management theories especially when a radical improvement involves a cultural change. However, the theories are developed from a general organizational management perspective. Thus, they are not particularly concrete in describing and suggesting how to realize a cultural change in the context of radical improvements in production. In fact, radical improvements in production with

the contingent approach is rarely documented or discussed in literature. This indicates that much room is left to research on this type of approach.

***The learning approach***

The learning approach is closely related to the concept of learning organization. Prior to discussing the learning approach, the concept of a learning organization is first described. Senge (1990) describes the basic meaning of a learning organization as “an organization that is continually expanding its capacity to create its future”. McGill and Slocum (1993) mention the characteristics of a learning organization as openness, systemic thinking, creativity, personal efficacy, and empathy. Argyris (1994) states that in a learning organization, individuals or groups can do “double-loop learning”. This is where the individuals and the groups can not only conduct improvements but also question the values, assumptions and policies of the organization that led to the improvements in the first place. Edmondson (2008) says that an embracing atmosphere of learning where trust and respect thrive allows flexibility and innovation flourish. According to McGill and Slocum (1993), there are different degrees in organizational learning. They present four levels of learning organization as shown in Table 3.4.

Table 3.4. Four levels of learning organization (McGill and Slocum, 1993).

Level of learning organization	Description
Level 1: Knowing organization	Bureaucracy, scientific management, separation of thinkers and doers, one best way to do it.
Level 2: Understanding organization	Able to modify routines, but limited within own jobs and divisions.
Level 3: Thinking organization	Company-wide improvement approach, but tend to introduce packaged solutions or off-the-shelf solutions, believing they have learned to solve the problems.
Level 4: Learning organization	Foster continuous experiments, commitment to learning from every aspect of organization’s experiences, more than simply acquiring new knowledge and insights, able to “unlearn” old practice and values.

The learning approach considers a change process itself a learning process. A change is a means of achieving a desired objective. At the same time, it is a means of developing the capability of collective learning and improvement. A change provides an opportunity to bring an organization to a higher state of learning organization. Edmondson (2008) emphasizes the importance of the learning aspect in an execution. She states that the managerial mindset that enables an efficient execution inhibits an employee's ability to learn and innovate. A focus on getting things done, and done right, crowds out the experimentation and reflection vital to sustainable success.

A number of Kaikaku activities at Japanese manufacturing companies seem to favor the learning approach for realizing a radical improvement in production. In these activities, managements often set stretched performance targets, but do not provide processes or solutions to realize these targets. Instead, they let employees find answers through their own experiments and learning. The stretched target is often high enough that the employees need to leave their conventional thinking and performance expectations. Toyota also seems to favor the learning approach to realize radical improvements. As a result of their long term analysis of Toyota, Takeuchi et al. (2008) state that:

“By setting near-unattainable goals, Toyota's senior executives push the company to break free from established routines. ... Toyota has found that a practical way to achieve the impossible is to think deeply but take small steps- and never give up. The company first breaks down a big goal into manageable challenges. Then it experiments to come up with new initiatives and processes for handling the more difficult components of each challenge. This pragmatic approach to innovation yields numerous learning opportunities.”

The learning approach does not appear to be a systematic and efficient way to realize a radical improvement in production. Nonetheless, it helps to develop the capability of collective learning and improvement. Moreover, this approach has a distinct advantage of stimulating creativity to generate an innovation. The systematic approach described in the previous subsection and the learning approach can be compared. The comparison corresponds to Edmondson's comparison of “execution as efficiency” and “execution as learning” respectively (Edmondson, 2008). Her comparison is shown in Table 3.5. In the approach of the execution as efficiency, solutions are provided by leaders and optimal work processes are designed and set up in advance. The processes can be executed efficiently in a top-down and linear fashion, but little room is left for employees to learn. On the other hand, in the learning approach, the leaders set a general direction but let the employees themselves find the answers. Tentative work processes are made at the starting point, but they



continue to be developed through experiments. The execution may be less systematic and less efficient, but the employees have many learning opportunities to improve their actions. In reality, a radical improvement in production contains both approaches, but one of them is usually more emphasized.

Table 3.5: Comparison of two types of execution (Edmondson, 2008).

Execution as Efficiency	Execution as Learning
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 always two-way; the boss gives feedback in the forms of coaching and advice; team members give feedback about what they are learning from the work.
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.

In the discussion of the competitiveness of a production system (see Section 3.1.2), it is mentioned that the production organization's strong capability of collective learning and improvement has become an important factor in competitiveness. From that perspective, the learning approach of realizing a radical improvement in production has a significant potential to contribute to the production's competitiveness. However, the learning approach in the context of radical improvements in production has been little documented or discussed in literature. Similar to the contingency approach, the learning approach of realizing Kaikaku has much room left to be explored and analyzed.

### 3.5 Summary

This chapter aims to present the frame of reference that gives a theoretical foundation for the research presented in this thesis. At each section and subsection, relevant

theories are introduced and discussed. Here, an overall summary of this chapter is made:

- A production system is defined based on the model of the transformation system suggested by Hubka and Eder (1984) as shown in the Figure 3.1. Kaikaku causes some fundamental changes within a production system defined above.
- The competitiveness of a production system can be evaluated from both a static and a dynamic aspect. These aspects are described in Subsection 3.1.2. The recent literature shows that the dynamic aspect becomes more important for the competitiveness of the production.
- The basic ideas of Kaizen and Kaikaku are introduced and defined. The word of Kaikaku has been used in Japanese industry for more than 20 years, but it is not much known to the rest of the world compared to Kaizen. The concept of Kaizen is well-established, but Kaikaku is still understood differently in literature. The concept of Kaikaku, therefore, needs to be more clarified in order to conduct the research on how to realize Kaikaku.
- A wide variety of theories can be associated with the question of how to realize Kaikaku in production. This thesis divides the relevant theories into the systematic approach and the contingency and learning approach. The systematic approach (e.g., production system design theories) favors systematic and prescriptive processes. It considers that an efficient execution of the process contributes to the competitiveness of the production. On the other hand, the contingency approach assumes that a pre-determined process does not always work effectively or efficiently, and that proper interventions should be taken place based on the changing context of an individual or a group. The learning approach can be less systematic, but it allows more experiments in the process that contribute to the dynamic aspect of the production competitiveness. Compared to the systematic approach, the contingency and learning approach of realizing radical improvements in production have been little documented in literature and little theoretical development has been made. This indicates that much room is left to research in this area.

The frame of reference and the problem recognitions mentioned above were not formed at the beginning of the research. Rather, they have been developed and evolved during the course of the research. The problem recognitions influenced the formulation of the research questions presented in Chapter 1, and they also influenced the way case studies were conducted and analyzed. The result of the research work will be presented in the next chapter.

## **4. The research results and analysis**

As mentioned in Chapter 2, the research presented in this thesis was comprised of a literature study and three case studies. The first section presents the findings from these studies. Based on the findings, models or factors related to the research objectives were developed or indentified. The second section presents those models and factors.

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### **4.1 Theoretical and empirical findings**

The following subsections present the findings obtained from the literature study and the three case studies.

#### **4.1.1 The literature study**

The literature study had two goals: to understand the phenomena of Kaikaku better and to identify theories that can explain the phenomena in a structured way. The literature study revealed that Kaikaku is an ambiguous construction and that it involves a wide range of activities. Many of the findings from the study are presented in Chapter 3, which can be summarized as follows:

- At a generic level, there is a shared consensus about Kaikaku in literature. General characteristics of Kaikaku are: it occurs episodically, it causes some fundamental changes within a production system, drastic performance increases are obtained, and Kaikaku is usually initiated by top or senior management. The definition of Kaikaku is made based on these characteristics.
- At a more detailed level, Kaikaku is described much differently in literature. Examples are shown in Table 3.1.
- Many manufacturing companies have initiated Kaikaku in production, but with different focuses. For example, some companies focus on radical changes of production flows, while others focus on radical changes of production equipment.
- Some companies realize Kaikaku by introducing solutions that are already available in industry. Other companies realize Kaikaku by creating radically innovative solutions that are even new to the industry.

The study implied that some sort of a categorization framework was needed in order to understand Kaikaku in a comprehensive and structured way. From the literature study, it was found that two theories were particularly useful for the categorization. One was the typology of product innovation. The other was manufacturing decision categories used in the theoretical area of manufacturing strategy. With modification of

these two theories, a categorization framework of Kaikaku was developed. The categorization framework is presented in Section 4.2.1.

#### **4.1.2 Case study A – practice of Lean transformation**

Case study A was conducted to identify how to drive a Lean transformation. The author of the thesis observed and participated in two Lean transformations at two medium-sized Swedish manufacturing companies. The transformations were consulted and driven by a Japanese consultant with abundant experience developing TPS-inspired production.

During the case study, the studied two companies, named company A and B in Chapter 2, realized radical improvements in production. For example, at company A, the production lead times have been reduced on the average by 35%. This was realized by the drastic changes of production flows, production planning, batch sizes, management structure, organization culture, among other factors. At company B, the lead times of the assembly and test processes were reduced from a few days to a few hours. This was mainly realized by changing from batch production to one-piece flow.

The outcomes of these transformations may not be particularly unique from other Lean transformations found in industry or literature. However, the interesting findings from case study A were related to how the consultant drove these Lean transformations. At the beginning of the transformations, a general direction of improvement (e.g. the lead time shall be reduced by half, or the number of internal defects shall be reduced to half) was set. However, the Japanese consultant was reluctant to make detailed plans. He said, “I can make a rough plan, but I have never seen any Lean transformations that followed any detailed plan.” Moreover, his advice, comments, and behavior appeared spontaneous, with little consistency. Examples of improvement events described below illustrate his behavior and actions during the Lean transformations. More examples can be found in appended paper B.

*Example of improvement event I:* When analyzing one production process at company A, the consultant thought that there were too many buffer stocks. It was because they produced with one-week batches. After a quick investigation showed that it was possible to produce with 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 should 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 prognosis and frequent priority changes of the orders caused chaos at the production. Due to the lack of trust in production, production planning tended to start production orders as much and early as possible in order to offset the risk of delivery delay to the customers. This increased 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 more 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 % 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 of this layout change.”

From the analysis of the improvement events observed during the case study, it was found that there was a consistent thinking behind the consultant’s comments and behaviors. Based on the analysis, a mechanism of how to drive a Lean transformation was identified, and it is presented in Section 4.2.2.

#### **4.1.3 Case study B – Kaizen practice at Swedish and Japanese companies**

Case study B was conducted when the above-mentioned Japanese consultant held TPS-workshops at six Swedish companies in April 2007. From the observation of the workshops, it was found that one of the major differences between the six Swedish companies and Japanese companies proficient in TPS was the way of conducting Kaizen. The difference was especially evident in three areas: finding problems, generating solutions, and taking actions.

*Finding problems:* The workshops included on-site shop floor consultations where the consultant went to the shop floors of the companies and instructed improvements.

There, he pointed out deficiencies in the operations in every detail. Some attendants of the workshops thought he was a fault-finder, but the consultant later explained that examining shop floors with severe eyes was critically important for Kaizen. He called these severe eyes as “Gemba eyes”. Gemba means “actual place” in Japanese, and in the context of production it means shop floor. It was found that Gemba eyes were necessary to identify any tangible and intangible problems at shop floors and also to keep recognizing the need for improvement with a sense of urgency. Moreover, Gemba eyes were also important to capture a holistic view of how the operations were managed at the factories. By questioning how the management systems allowed the deficiencies to occur, the performance of the systems were analyzed. It was observed that most of the attendants at the workshops did not have Gemba eyes.

*Generating solutions:* During the workshops, the consultant said that one could identify many small improvements realized by simple but creative devices or equipment at shop floors of companies proficient in Kaizen. At such companies, employees were often trained to use wisdom thoroughly before using money. The consultant stated that Kaizen could be done even with pens and cartons. However, such simple but creative solutions were rarely found at the shop floors of the six companies.

*Taking actions:* One of the general impressions that the consultant felt about Kaizen at the shop floors of the six companies was that there was a large time lag between recognizing problems and taking actions against them. Managers and employees seemed to prefer reaching a full consensus and removing all the uncertainties before initiating improvements. The consultant commented that sometimes it could be better to initiate improvements even when some uncertainties were left, because further or better improvement ideas often became clearer after the initiation. Taking actions immediately was encouraged by saying that small changes could be easily undone if they would not work well.

Based on the findings from case study B, eight guidelines for enhancing Kaizen at shop floor were developed. The guidelines are briefly presented in Section 4.2.2. The results obtained from case study B are relevant to the second research objective. The above mentioned literature study and case study A indicated that in some cases Kaizen was an integral part of Kaikaku. In these cases, Kaizen proficiency can strongly influence an effective and efficient execution of Kaikaku.

#### **4.1.4 Case study C – organization setting that facilitates Kaikaku**

Case study C investigated five Japanese companies and four Swedish companies, in order to identify production management and organization settings that can increase the likelihood of *radically innovative Kaikaku* (defined in Section 4.2.1). As mentioned

in Chapter 2, the five Japanese companies were selected as extreme cases. The domestic factories of these companies are regarded as highly efficient in using various advanced technologies and work processes. The four Swedish companies were selected as reference cases in order to understand the status of production management and organization settings at Swedish companies. The questions asked during the interviews with these nine companies were related to four general categories:

- Manufacturing strategy of the company
- Organization of the production engineering function
- Education systems within the production function
- Culture of the production organization

A brief summary of the result of the interviews is presented in below, but the more detailed description of the results is found in Appended Paper C.

*Manufacturing strategy of the company:* Production function's strategic roles within companies were asked in the interviews. The respondents of all the studied Japanese companies answered that the production functions in Japan were and would be playing significant roles in sustaining the companies' competitive advantage. These companies set their domestic production functions as global production development centers, where new production equipment and new work methods are developed, tested, and refined. Two of the studied Swedish companies assigned their domestic factories as master plants, but the respondents of these companies did not emphasize the role of production as much as those of Japanese companies.

No significant difference was found among the studied nine companies in terms of the general processes of formulating manufacturing strategies. 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.

The five Japanese companies also had strategies for developing production equipment. Most of these companies aimed at developing simple, slim, and low-cost equipment. To realize such equipment, for example, one of the five companies required a significantly short payback-period for certain types of equipment. Another company restricted the height of equipment to lower than 150 centimeters. The importance of developing their own unique equipment that could differentiate the factories from the competitors was emphasized at the five Japanese companies. None of Swedish companies had such a strategy for developing in-house equipment. Instead, they mostly buy equipment from external suppliers.

*Organization of the production engineering function:* Organization structures of production engineering functions were asked about in the interviews. A tendency of all studied companies was that the companies tried to separate engineering support functions for factories and production development functions. Production development functions mean here functions for developing future production technologies, production equipment, production lines and cells, among other things. A respondent of one of the Japanese companies said that such a separation was needed, otherwise, the respondent contended, the production engineers tended to be drawn into daily problem-solving tasks for the shop floors. Generally, the Japanese companies studied had larger production development functions than the Swedish companies studied. The ratio of production engineers to shop floor operators was also inquired about at each company. The ratios of the studied Japanese companies were in general higher than the studied Swedish companies. One of the Japanese companies had a considerably high ratio that was 28%. This company had 2,800 production engineers, and 700 of them were assigned to develop in-house production equipment. The company had developed its own industrial robots, and the number of the robots used at the factories was higher than that of the operators.

The interview respondents were asked about the cooperation between product development and production engineering functions. Most of the nine studied companies used design review as a facilitator of the cooperation. However, the respondents of three Swedish companies said that the cooperation needed to be improved much more. Three studied Japanese companies had specific mechanisms that enhanced the cooperation. For instance, one of the companies organized a so-called “next product generation team”, which consisted of engineers from both product and production development functions. The team simultaneously developed future platforms for products as well as future production systems. Another company organized a special department coordinating production engineers, product development engineers, and factories in order to drive large improvement projects in production.

*Education systems within the production function:* The respondents were asked about the education systems within the production functions. 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 education of the production engineers, most of the studied companies educated production engineers based on learning by working. Two Japanese companies that had a large number of production engineers had developed central education systems.



As for the education of the shop floor workers, most of the studied companies had more systematic education schemes than for the production engineers. Skill-matrixes were commonly used among the studied companies. All of the studied Japanese companies had central education systems for the skill development of operators. They also organized or joined internal or external skill competitions in order to motivate skill development.

*Involvement of shop floor workers and staff:* The studied companies were asked how shop floor operators and staff contribute to creating and using new equipment and work processes in production. The respondents of all of the Japanese companies and two Swedish companies answered that a high level of skill in continuous improvement on the shop floors was an important pre-condition for realizing such innovations in the production. A respondent of one of the companies studied said that without the shop floor's skills in making problems tangible, analyzing them, and giving feedback to production engineers, new equipment and work processes could not be matured and exert their full potential. A respondent at another company studied answered that without the shop floor's expertise in the operation, the development of new equipment and work processes would rarely succeed.

Based on the analysis of the collected evidence from the interviews, six characteristics of production management and organization settings that can increase the likelihood of realizing radical innovations in production were identified. The six characteristics will be presented in Section 4.2.3.

## **4.2 Analysis of the findings**

Based on the theoretical and empirical findings from the literature study and the case studies, models or factors that serve to fulfill the research objectives and answer the research questions were developed or identified. This section presents these models and factors.

### **4.2.1 A conceptual model of Kaikaku**

From the literature study described in Section 4.1.1, a model of four types of Kaikaku was developed. The model describes the phenomena of Kaikaku from a macro level of analysis (from a plant or a production system level). The model is shown in Figure 4.1. In the model, the horizontal and vertical axes represent two different ways of categorizing Kaikaku.

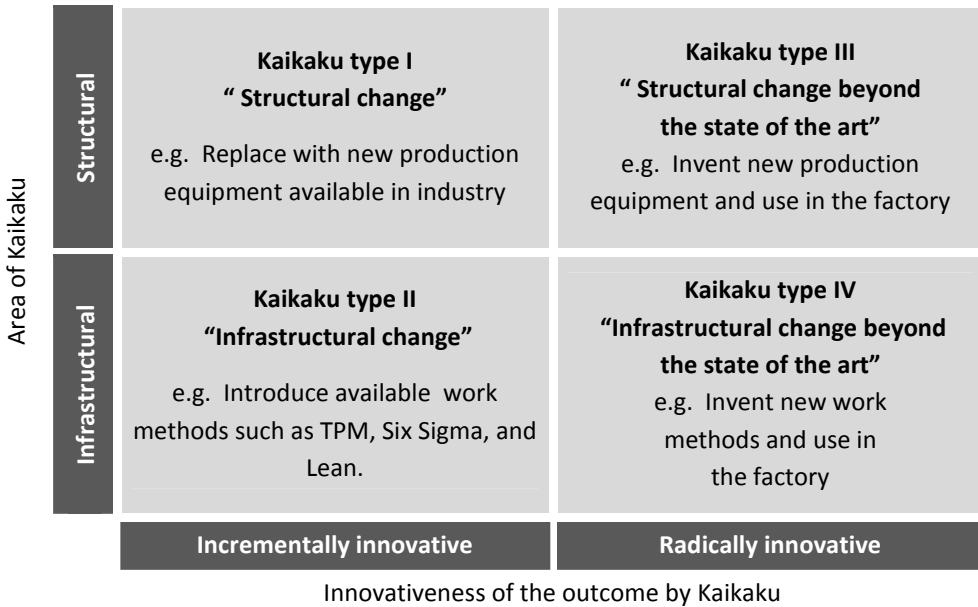


Figure 4.1. Model of four types of Kaikaku.

The horizontal axis of the model represents the categorization in terms of innovativeness of the outcome by Kaikaku. This categorization has its theoretical basis in the typology of product innovation. Extensive research has been done in the area, and it can be applied to Kaikaku as well. By modifying and applying the classification of product innovation suggested by Garcia and Calantone (2002), Kaikaku can be categorized into two types, *incrementally innovative* and *radically innovative Kaikaku*.

**Incrementally innovative:** Incrementally innovative Kaikaku occurs when a newly formed production system as an outcome of Kaikaku is novel to the plant or to the company, but a similar system already exists in the industry. Thus, the system does not appear particularly innovative from the industrial perspective. Here, an industry means a particular field of international manufacturing industries, such as automobiles, home electric appliances, and mobile telephones. This type of Kaikaku often occurs when off-the-shelf equipment or packaged production management solutions are introduced to a plant or a company. Examples include off-the-shelf automation systems or packaged company-wide improvement initiatives, such as Six Sigma, TPM, and Lean.

**Radically innovative:** Radically innovative Kaikaku occurs when a newly formed production system is not only new to the plant or to the company but also new to the industry. In this type of Kaikaku, novel technological solutions, work methods,

production flows, and work organizations, among other things, are invented and used in a plant or a company. Such innovative solutions make the plant appear unique to the industry.

The vertical axis of the model represents the categorization in terms of the area of change in Kaikaku. This categorization is inspired by the framework of manufacturing decision categories proposed by Wheelwright (1984) and Fujimoto (2001). These authors classify the decision categories into two groups, namely structural and infrastructural. The comprehensive coverage of the decision categories and the characteristics associated with the mentioned groups are useful to categorize Kaikaku. By adapting the framework of manufacturing decision categories with some modifications, Kaikaku can be categorized into two types, *structural* and *infrastructural*.

**Structural:** Basic changes mainly take place in the structural area (for example, plant network and production equipment) as shown in Table 4.1. 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 cause long-term impact. It is often carefully planned or developed by limited number of people, such as strategic planners or production engineers.

Table 4.1. Structural area, based on Wheelwright (1984) and Fujimoto (2001).

<b>Structural area</b>
<ul style="list-style-type: none"> <li>• <b>Production capacity</b> - volume per year</li> <li>• <b>Plant network design</b> - size, location, focus</li> <li>• <b>Production technology</b> - equipment, automation level</li> <li>• <b>Vertical integration</b> - direction, extent</li> </ul>

**Infrastructural:** Basic changes mainly take place in the infrastructural area as shown in Table 4.2. Examples are production control system, quality control system, material flow, and organization. This kind of changes tends not to require a large capital investment at a single point of time. Instead, they tend to require continuous and consistent efforts in improving the operation. 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 of the way of working. Every employee’s active

involvement and the consistency in the patterns of their conduct are considered important.

Table 4.2. Infrastructural area, based on Wheelwright (1984) and Fujimoto (2001).

<b>Infrastructural area</b>
<ul style="list-style-type: none"><li>• <b>Human resource</b><ul style="list-style-type: none"><li>- pay system, evaluation system, union relation</li></ul></li><li>• <b>Production planning &amp; control</b><ul style="list-style-type: none"><li>- inventory, order system, batch size</li></ul></li><li>• <b>Quality control</b><ul style="list-style-type: none"><li>- defect prevention, monitoring</li></ul></li><li>• <b>Cost control</b><ul style="list-style-type: none"><li>- cost calculation, accounting</li></ul></li><li>• <b>Material flow<sup>1</sup></b><ul style="list-style-type: none"><li>- connectedness, layout</li></ul></li><li>• <b>Maintenance</b><ul style="list-style-type: none"><li>- routine, monitoring</li></ul></li><li>• <b>Organization</b><ul style="list-style-type: none"><li>- structure, culture</li></ul></li></ul>

The four types of Kaikaku shown in Figure 4.1 are the combination of the two axes presented above. Below, each type of Kaikaku is described. Some industrial examples associated with each Kaikaku type are also presented.

**Kaikaku type I:** Basic changes in the structural area result in an incrementally innovative outcome. This type of Kaikaku tends to be realized by importing existing solutions in the structural area. One example is increasing the level of automation with off-the-shelf equipment.

Many industrial examples are available for this type of Kaikaku. For example, Schroeder and Congden (1995) present cases of radical improvements at several foundries where drastic improvements in production capacities were achieved by purchasing and installing automatic molding machines. Sower and Foster (1990) present a case of a radical improvement in production where the production quality and the labor productivity increased dramatically by installing controller equipment and handling robots.

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<sup>1</sup> A basic change of material flow at a production plant may require a large amount of capital investment. In such a case, the change of material flow can instead be categorized to the structural area.

**Kaikaku type II:** Basic changes in the infrastructural area result in an incrementally innovative outcome. This is typically realized by importing a set of work processes developed by external parties or packaged company-wide improvement initiatives, such as TPM, Lean production, and Six Sigma.

There are many industrial examples that can be categorized to this type of Kaikaku. One example is Six Sigma implementations at ABB and Alfa Laval described by Magnusson et al. (2003). Kaikaku at vending machine production at Kubota Corporation (Kawakami and Kobayashi, 2005) is another example. At this company, the productivity of certain production lines was increased by 300 percent by introducing Lean production. The Lean transformations observed and participated during case study B can be also categorized to Kaikaku type II. In the transformations, radical improvements in production lead times and in-process stocks were achieved by the basic changes of, among other things, the production flow, production control, organization structure, and organization culture.

**Kaikaku type III:** Basic changes in the structural area lead to a radically innovative outcome. In this type of Kaikaku, new technologies, production equipment, or other kinds of solutions related to the structural area are invented and applied to the plant or to the company.

An example of this type of Kaikaku in industry is Kaikaku at the Takaoka factory in Toyota. Toyota introduced numbers of innovative pieces of equipment to the plant. This led to a 50% reduction in production lead times and the length of production lines (Stewart and Raman, 2007). Protean Production System (PPS), developed by Denso (Sugito et al., 2004), is another industrial example of this type of Kaikaku. PPS consists of plug-and-play robot assembly modules that realize highly reconfigurable production lines.

**Kaikaku type IV:** A radically innovative outcome is achieved by basic changes in the infrastructural area. In this type of Kaikaku, innovative work processes, production flows, or other kinds of unique solutions in the infrastructural area are created and used in the plant.

An industrial example of this type of Kaikaku is the trolley-pull production created at Ricoh United (Tanaka, 2005). This copier 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, the lead time and in-process stock were reduced by 80 percent.

More industrial examples categorized to one or few types of Kaikaku are found in Table 4 in Appended Paper A.

The model of four types of Kaikaku presented above has served to fulfill the research objectives in a few ways.

First, the model helps to understand the phenomena of Kaikaku in a more comprehensive and structured way. The ambiguity of Kaikaku accompanied by the different understandings of the phenomena in literature has been to some degree reduced by the model. For example, Imai (1986) says that Kaikaku is a technology-oriented change conducted by a small number of champions, while Wakamatsu and Kondo (2003) say that Kaikaku is an accumulation of exhaustive executions of Kaizen. According to the presented model, it can be understood that Imai refers to the structural type of Kaikaku, while Wakamatsu and Kondo refer to the infrastructural type of Kaikaku. The recent Kaikaku trend in Japan in which an increasing number of plants in Japan have become creative and unique (Ikaida, 2007; Kimura and Takano 2005) can be understood that more and more Japanese companies expand their efforts from incrementally innovative Kaikaku to radically innovative Kaikaku.

Second, the model of Kaikaku provides a platform for further investigations as to how to realize Kaikaku. The model shows that characteristics of changes are different among each type of Kaikaku. This implies that necessary actions are also different depending on the types. The model allows focusing on a specific type of Kaikaku when discussing and analyzing how to realize Kaikaku.

Third, and finally, the model can be used in order to consider a basic strategic direction in terms of what type of Kaikaku needs to be conducted at a specific company. Two general rules can be related to this question. First, before initiating the structural type of Kaikaku, improvements in the infrastructural area should be conducted first. Ohno (1978) states that improvements of manual operations and layout changes shall be performed before improvements of equipment or automatization; otherwise, the cost will be increased rather than reduced. Harrington (1995) says that work processes need to be reformed before automation is applied. Womack and Jones (1996) state that an introduction of Lean production may significantly change the prospects for the structural issues. The other rule is that the incrementally innovative Kaikaku should occur before radically innovative Kaikaku. As far as better solutions are available outside of a company, it is reasonable to introduce them. When the plant has reached the state of the art, radically innovative Kaikaku can be considered in order to sustain the competitive advantage.

#### **4.2.2 A practical way of driving Lean transformation**

From the empirical findings from case study A, a practical way of driving Lean transformation was identified. The identified way is related to the second research objective – in short “how to realize Kaikaku”. The identified way is related especially to Kaikaku type II.

As mentioned in the previous section, the way of the Japanese consultant driving Lean transformations seemed planless, spontaneous and inconsistent. However, it was found that there was consistent thinking behind his comments, behavior, and actions. He strongly believed that creating the need for improvements was the central driver of Lean transformation. The identified practical way of driving Lean transformation can be described as follows: *occasionally by force, create a situation where people have no choice (or little choice) but to feel the need of improvement. The situation is such that brings different problems up to surface. Through letting people solving these problems one-by-one, the performance of the operation as well as the capability of individual or organizational learning are improved.*

The image of the way of driving Lean transformation discussed can be explained by “the Japanese sea model” as shown in Figure 4.2. This is usually used to explain why stock levels need to be reduced in Lean production. When the water level is high, the objects are hidden under the water. By reducing the level of it, the objects are brought up to the surface. Likewise, a high stock level hides different problems underneath. Problems such as lack of parts, producing defect parts, and machine break-downs are absorbed by the stock and do not affect the operation directly. Consequently, these problems are not likely to be recognized with a sense of urgency. When the stock level is reduced, however, 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. This reducing-water-level way of working can be generally applied to nearly any kinds of improvements. The examples of improvement events presented in Section 4.1.2 are based on this way of working.

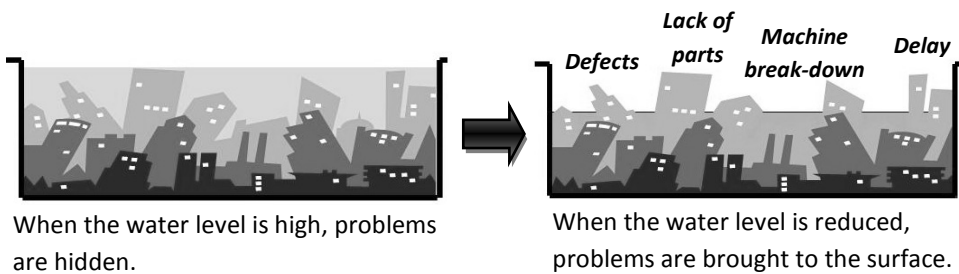


Figure 4.2. The Japanese sea model.

The reducing-water-level way of working can be decomposed into four steps; namely, *reduce*, *see*, *think*, and *act*. At *reduce*, a certain parameter or setting is changed in order to create a situation where people feel the need for improvement. It can be stock level, space for stock, lead time in production planning system, tact time production, no acceptance of receiving defect parts from the previous process, and so forth. Which parameters should be changed depends on the context of a specific company, but there is a general rule. According to the Japanese consultant, it is recommended to change the parameters related to delivery accuracy first, then to proceed to change those related to quality and cost. It is because it is generally easier to raise employees' sense of urgency with the problems related to delivery accuracy. The extent of parameter changes should be enough to provoke people to feel the need for change with the sense of urgency. But if it is too much, people feel discouraged. "Edge of chaos" - the edge between order and chaos where the creativity, growth, and use of self-organization are at the optimal (Burnes, 2005) - can be a good indication for the parameter setting. The *reduce* step must be initiated by the responsible person of the operation, because the initiator must have an authority to change, can take the risk of changing the operation, and can see the operation from a holistic perspective to analyze the influence of the change.

The rest of the three steps are similar to the Kaizen process. The *see* step is to carefully observe the shop floor to identify the problems that are brought up to surface. In the *think* step, solutions to the problems are generated. Then, in the *act* step, the solutions are implemented. These steps can be conducted by Kaizen actors who are often shop floor leaders and operators. By conducting the *reduce* step, the leaders and the operators face the problems with a sense of urgency. Then, Lean techniques or other improvement methods become useful help for solving the problems. In this way, the leaders and operators can learn the meaning of the Lean techniques or other improvement methods more than when they are merely provided them without the people feeling the need to employ them. Along with *see*, *think*, and *act* steps, the eight



guidelines of enhancing Kaizen presented in Paper A can be used. The eight guidelines are developed based on the empirical findings obtained from case study B. The overview of the guidelines is shown in Figure 4.3. The thesis will not go into the further detail regarding the guidelines. The detailed description of each guideline is found in Paper A.

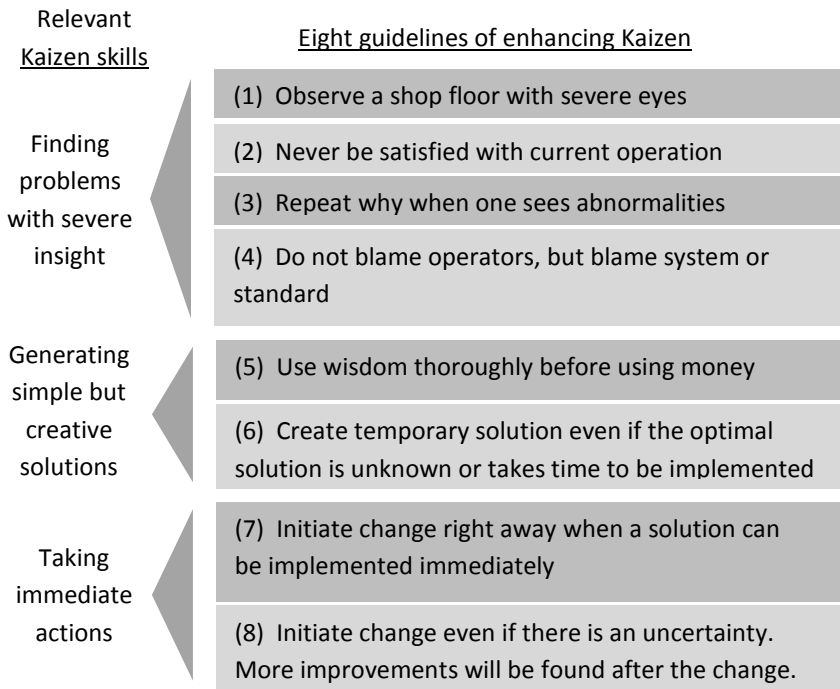


Figure 4.3. Eight guidelines of enhancing Kaizen, based on Yamamoto (2008).

By running the cycle of the mentioned four steps, a Lean transformation is progressed. In this way of Lean transformation, there is little sense to make a pre-determined and detailed transformation plan. This is because necessary interventions in the course of the transformation are deeply dependent on the problems that emerge on the surface. In the presented way, the time plan may not appear structured. But when we look at the pattern of conducts, the cyclical process of the four steps is consistent throughout the Lean transformation. This gives a certain structure to the transformation. The reducing-water-level way also makes the implementation of the Lean techniques and the thinking (e.g. flow, pull, Kanban, standardized work, Andon, Jidoka, visualization, customer focus, and pursuit for perfection, among others) simpler. They are simply

implemented in order to provoke the need for improvement, or to solve the surfaced problems.

In order to understand the advantages and disadvantages of the presented way, it is meaningful to compare it with a “plan-oriented way” of Lean transformation, where solutions and implementation plans are carefully designed by a small number of specialists and they are implemented in a top-down fashion. Table 4.3 shows the comparison of the two ways.

Table 4.3. A comparison of two ways of Lean transformation, modified from Appended Paper B.

<b>The reducing-water-level way</b>	<b>The plan-based way</b>
The transformation process is contingent and less systematic	The transformation process is systematic
Flexible to the unexpected changes during the transformation process	Process is rigid, thus less flexible to unexpected changes
What outcome is obtained when is not exactly predicted	Outcome is designed prior to the execution
Much time is spent in actions	Much time is spent in planning
Managers set direction, and employees find answers	Managers provide answers, employees follow orders
“Execution as learning” (Edmondson, 2008)	“Execution as efficiency” (Edmondson, 2008)
Chance to become a learning organization is higher	Chance to become a learning organization is limited

For the plan-based way, the transformation process is more systematic than the other way. However, the process is more rigid and the plan-based way has, therefore, difficulty dealing with unexpected changes during the transformation. One of the major disadvantages of the plan-based way is that it provides less learning opportunities to shop floor employees, since solutions are often already designed during the planning phase and given to the shop floor to be implemented. The reducing-water-level way has a less systematic process of transformation, 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 reducing-water-level way is that it includes a process of collective learning. Thus, it has a higher probability of achieving a cultural change toward a learning organization. In fact, at one of the studied companies, the managers' and the employees' behavioral change toward collective learning was observed. Their mentality shifted from making excuses for not being able to meet the changed water-level to trying to find how to meet the changed water-level. Considering the mentioned characteristics of the reducing-water-level way, it can be said that it involves both the contingency approach and the Learning approach described in Chapter 3. In Chapter 3, it was mentioned that the contingency and learning approach of realizing radical improvements in production had been little documented in literature. The results obtained from case study A contribute to this scarce research area.

From the empirical findings from case study A, it is also possible to draw some key factors that influenced the effective and efficient executions of the Lean transformations. The identified factors are shown in Table 4.4.

Table 4.4. Key factors that influenced on the effective and efficient executions of the Lean transformations.

Categories	Key factors
Leadership	<ul style="list-style-type: none"> <li>• Managements' strong initiative, involvement, and commitment           <p>The managements' strong initiative, involvement and commitment critically influenced the result and the speed of the improvements during the Lean transformations.</p> </li> <li>• Leading the change by setting an example           <p>When the managers and the shop-floor leaders led the changes by setting an example, many of the employees became motivated for the change. They felt attention and expectations from the managers.</p> </li> </ul>
Mindset	<ul style="list-style-type: none"> <li>• Leaving behind the established mental mode           <p>The studied Lean transformation required the managers and the employees to leave behind the mental mode established in the past. Some people were not able to do it, which hindered the progresses of the transformations significantly.</p> </li> <li>• Feeling the need for improvement           <p>Lean tools seldom took their full effect or were sustainably used, when the shop floor operators and staff did not feel the need of them. The reducing-water-level way was an effective way to bring problems up to surface and provoke employees to feel the need for improvement.</p> </li> </ul>

Organization	<ul style="list-style-type: none"> <li>• Creation of a “tight organization” <p style="margin-left: 20px;">A “tight organization” is an organization where close cooperation, open communications, shared mindsets and behavior, and mutual trust among different functions and organization layers are evident. When the case studied companies were not “tight”, a large amount of time and effort was needed to bring about the major changes.</p> </li> <li>• Establishment of Kaizen culture <p style="margin-left: 20px;">During the Lean transformations, a number of Kaizen activities were initiated at the shop floor (for instance, 5S, operators’ maintenance, measurement and follow up of OEE, and the improvement of set up times). The companies’ capability of Kaizen significantly influenced the process of the transformation.</p> </li> </ul>
Change process	<ul style="list-style-type: none"> <li>• Integration of the learning approach in the change process <p style="margin-left: 20px;">The learning approach stimulated by the reducing-water-level way was an effective way to change the organizations toward a learning organization. The managers and the employees became more problem-solving oriented than making excuse oriented.</p> </li> <li>• Finding leverage through deep analysis <p style="margin-left: 20px;">It was learned that in some cases root causes that hindered radical changes lay in the areas that were not self-obvious. For instance, a root cause of slowing the change process in the Lean transformation could be attributed to the mindset of the production management.</p> </li> </ul>
Knowledge	<ul style="list-style-type: none"> <li>• Basic knowledge of problem-solving tools and production principles <p style="margin-left: 20px;">Sharing basic knowledge of problem-solving tools, Lean techniques, and Lean principles with the managers and the employees helped to maintain a common language among them and to facilitate the alignment of their behavior within the organizations.</p> </li> </ul>

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#### **4.2.3 Production management and organizational setting that can increase the likelihood of realizing radically innovative Kaikaku.**

The empirical findings from case study C have indicated that six characteristics of production management and organizational setting are important in order to increase the likelihood of realizing radically innovative Kaikaku. The identified six characteristics are relevant to the second research objective and the third research question, and they are especially related to Kaikaku type III and IV. The identified characteristics are:

1. Strong management intent
2. Severe target and requirement setting on production engineering functions

3. Strong production engineering functions
4. Close cooperation of production engineering functions with other functions
5. Strong emphasis on knowledge and skill development
6. Shop floor workers and staff highly competent in problem solving

### **1. Strong management intent**

The empirical findings have indicated that management's strong intent is needed in order to realize radical innovations in production. The strategic importance of production function was considerably high at the companies that tried to make their factories radically innovative. For example, the Japanese companies studied considered the production as the important competitive weapon of the companies. These companies assigned the domestic production functions as the global centers of production development, and allocated a large amount of resources to the production development functions. These efforts imply that a radical innovation in production is most likely a consequence of the company's strategic intent, rather than a natural occurrence.

### **2. Severe target and requirement setting on production engineering functions**

The empirical findings have indicated that severe target and requirement settings can provoke radical innovations in production. Many of the Japanese companies studied had such severe target and requirement settings, especially on production engineering functions. Examples include the following:

- Production cost should be reduced by half
- Production lead time should be reduced by half
- Production area should be reduced by half
- Change over time should be zero
- Payback period of investment in a piece of equipment should be reduced by half
- Height of production equipment is no more than 150 centimeters
- Number of actuators used in a piece of equipment should be reduced by half.

It is rational to set such challenging targets in order to realize a radical innovation in production, because targets must be set higher than the level that can be reached by merely copying or combining existing solutions. To reach the challenging targets, the employees may have to leave their conventional thinking and performance expectations, and use their creativity to find innovative solutions. Certain amounts of experiments are also needed, which provide the employees many learning opportunities to develop their knowledge and train their skills in realizing radical innovations.

### ***3. Strong production engineering functions***

It has been found from the empirical findings that allocating a sufficient amount of competent human resources to production engineering functions is important in order to realize radical innovations in production. At the studied companies that tried to make their factories unique and creative, a large amount of human resources was assigned to the production development functions. The strong emphasis on production development functions is relevant to radical innovations in production because the realization of such innovations often requires advanced engineering knowledge and a certain amount of time for development.

### ***4. Close cooperation of production engineering functions with other functions***

It has been indicated that close cooperation of production engineering functions with other functions can enhance radical innovations in production. The cooperation among production engineering functions, product development functions, and factories has been found especially important. At the studied companies that tried to realize radical innovations in production, various organizational mechanisms were developed in order to facilitate cooperation. One possible explanation of why close cooperation is important can be that the knowledge interaction between the different functions may have a positive influence on creating new ideas. The close cooperation can also be an effective way to make new ideas become operationally useful on production shop floors.

### ***5. Strong emphasis on knowledge and skill development***

The empirical findings have indicated that employee knowledge and skill development is important in order to realize radical innovations in production. This is reasonable because highly competent human resources are necessary to realize such innovations. The companies studied that intended to make their factories unique and creative enhanced the knowledge and skill development in various ways. Those ways included setting challenging targets, promoting the development of in-house equipment, and organizing internal skill competitions. Investing in education with a long-term perspective was commonly observed at the Japanese companies studied, but this can be related to the long-term employment system at those companies.

### ***6. Shop floor workers and staff highly competent in problem solving***

The empirical findings have also shown that shop floor workers and staff highly competent in problem solving is an important factor in realizing radical innovations in production. At many of the studied companies, the importance of problem solving skills on shop floors was especially emphasized in the context of making new equipment and work processes operationally effective and sustainable on shop floors. For example, one of the Japanese companies studied had created innovative flexible automation lines consisting of plug and play robot modules. A respondent of the

company said that the automation lines probably could not be operated at other companies because highly trained operators specialized in identifying and correcting problems at the lines were required to operate the lines effectively. Another possible benefit of having highly competent shop floor workers and staff is that these employees can improve the operation by themselves without relying so much on production engineers. This releases the production engineers from spending a large amount of time dealing with daily problem-solving tasks for the operation.

Besides the identified characteristics, it was found that the importance of systematic processes of realizing radical innovations in production was not emphasized at the studied companies. One of the possible explanations can be that similar to a research process, the realization of a radical innovation can be a highly complex and iterative process. Therefore, it may be difficult to create a systematic process to be followed. Instead, the studied companies seem to focus on more manageable factors, such as organization structures, resource allocations, and target settings.

The identified six characteristics are generally consistent with the previous findings in literature. For example, Dobni (2006) states that an innovative organization needs eight areas of focus, such as strategic intent for innovation, employees' skills, knowledge management, culture of learning, and technological and financial support. Schroeder et al. (1989) state that ways to improve the probability of realizing innovations in production can be categorized into four areas: goals, structure/process, culture, and resources. At a more detailed level, however, the results obtained from case study C differ from the previous research in some respects. For example:

- The result of the case study is more related to a specific type of innovations in production – radically innovative Kaikaku.
- The importance of production engineering functions is particularly emphasized in the context of realizing radical innovations in production.
- Practical examples in industry associated with the six characteristics are identified.

When comparing the studied Japanese companies with the studied Swedish companies, all of the companies made various efforts related to the six characteristics mentioned above. The difference, however, is the degrees of the efforts. Generally, the Japanese companies studied strove for the mentioned characteristics more than the Swedish companies studied. One of the reasons can be that these Japanese companies begin to recognize that improvements such as purchasing off-the-shelf production equipment or emulating best practices in industry do not always assure long-term international competitiveness. Such improvements can be done at external and internal competitors in fast-growing countries such as those in East and South East

Asia. All the respondents of the five Japanese companies studied commonly expressed the fear of those competitors' speed of competence development. The Japanese companies probably felt that building the capability of realizing radical innovations was one of few ways to keep domestic factories in Japan. None of the respondents of the Swedish companies expressed the threat of the competitors in low-wage countries as much as the Japanese companies. However, the competitive threat may become larger in Sweden due to the ever-escalating global competition. In the near future, the importance of realizing radical innovations in production can be highlighted more in Swedish industry.

#### **4.4 Summary**

This chapter has presented the literature study and three case studies conducted during the research presented in this thesis. The models and the factors developed or identified from these studies have also been introduced. A short summary of this chapter follows.

The literature study indicated that Kaikaku was an ambiguous construction. The theoretical study led to create a model of four types of Kaikaku. The model helps to understand the phenomena of Kaikaku in a comprehensive and structured way. The model also provides a platform for further investigations as to how to realize Kaikaku. In the end, the model serves to fulfill the first research objective – in short, “what Kaikaku is”.

A practical way of driving Lean transformation was identified from the analysis of case study A – the observation of the Lean transformations at two Swedish companies. The identified way can be supported by the Kaizen guidelines developed from case study B. It differs from the systematic ways of implementing Lean production that have been common in literature. The results obtained from case study A serve to fulfill the second research objective- in short “how to realize Kaikaku”. The results are particularly relevant to Kaikaku type II.

The six characteristics of production management and organization setting that can increase the likelihood of realizing radical innovations in production were identified from the empirical findings of case study C. Practical examples of these characteristics at the studied companies have been also presented. They can serve as examples for companies considering realizing radical innovations in production. The results obtained from case study C are relevant to the second research objective, especially for Kaikaku type III and IV.

Finally, conclusions are drawn in the next chapter based on the results presented in this chapter.



## 5. Discussions and conclusions

This chapter presents the conclusion of the research, answering the formulated research questions and discussing the fulfillment of the research objectives. Then, the research contribution to academia and industry is stated. Later, the quality of the conducted research is examined. Finally, the chapter closes with proposals for future research.

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### 5.1 Fulfillment of the research objective

In Chapter 1, the research objectives were formulated as follows:

*The research has two objectives. The first objective is to analyze and structure the concept of Kaikaku in order to describe the phenomenon comprehensively and consistently. The second objective is to develop methods or guidance that facilitate the realization of Kaikaku. The methods or guidance should contribute to realizing radical improvements in production and to improving the production function's capability for collective learning and improvement.*

To fulfill the research objectives, the research objectives were transformed into three research questions. The frame of reference was developed in order to understand the state of the art in the addressed research field, as presented in Chapter 3. A literature study and three case studies were conducted.

- The literature study was conducted with the purpose of understanding the phenomena of Kaikaku and finding appropriate theories that can explain the phenomena in a structured way.
- Case study A was conducted to analyze and identify how to drive a Lean transformation. The case study was also conducted to identify key factors that strongly affect an effective and efficient execution of radical improvements in production.
- Case study B was conducted in order to compare Swedish and Japanese companies in terms of Kaizen practice (The results obtained from case study B are relevant to the second research objective).
- Case study C was conducted with the purpose of identifying the characteristics of production management and organization settings that can increase the likelihood of realizing radically innovative Kaikaku.

The results obtained from these studies were presented in Chapter 4. The results are relevant to answering the three research questions.

The first research question was formulated to fulfill the first research objective:

*RQ1: How do scholars and practitioners describe the phenomenon of Kaikaku, and what theories are suitable to explain the phenomenon in a comprehensive and structured way?*

This question has been answered through the mentioned literature study. At a generic level, a consensus exists in the way of describing Kaikaku. Kaikaku is often described as radical improvements that occur episodically, involve fundamental changes within a production system, cause drastic performance gains, and are often initiated by top or senior management. The research defined Kaikaku based on the general characteristics of Kaikaku mentioned above in the following way:

*Kaikaku is an infrequent but radical improvement where fundamental changes occur in the production system and a dramatic performance increase is obtained. Initiated often by top management, fundamental changes are made through reformations or replacements of the system by introducing new knowledge, work methods, strategies, production technologies, or equipment and so forth. The performance increase as a result of Kaikaku is often 30 to 50 % or more.*

At a more detailed level, however, Kaikaku is differently understood and described in literature, as shown in Table 3.1. The literature study implied that some sort of categorization framework was needed in order to explain the phenomena of Kaikaku in a structured way. Two theories were found particularly useful for the categorization. One was the typology of product innovation. The other was manufacturing decision categories used in the theoretical area of manufacturing strategy. Based on these two theories, a categorization framework of Kaikaku was developed that was presented in Section 4.2.1.

The second research question was formulated in order to fulfill the second research objective:

*RQ 2: What factors or mechanisms significantly contribute to an effective and efficient execution of Kaikaku and to an improvement of the capability for collective learning?*

The second research question can be answered from the results obtained from case study A. From this case study, it was possible to glean some key factors that strongly

affected the effective and efficient executions of the Lean transformations. These factors also had positive influences on increasing the capability for collective learning within the studied companies. The identified factors were presented in Table 4.4:

- Management's strong initiative, involvement, and commitment
- Leading the change by setting an example
- Leaving behind the established mental mode
- Feeling the need for improvement
- Creation of a "tight organization"
- Establishment of Kaizen culture
- Integration of the learning approach in the change process
- Finding leverage through deep analysis
- Basic knowledge of problem-solving tools and production principles

"The reducing-water-level" way described in Section 4.2.2 was identified as a mechanism for driving Lean transformation practiced by an experienced Japanese TPS practitioner. The identified way supports some of the above mentioned factors. They are: leaving behind the established mental mode, feeling the need for improvement, establishing the Kaizen culture, integrating the learning approach into the change process, and finding leverage through deep analysis.

The nine factors mentioned above and the reducing-water-level way can be the answers to the second research question, but these findings were derived from the case study of Lean transformations. How much can they be generalized? Since these findings were not tested in other situations than Lean transformations, only hypotheses can be made. A plausible assumption is that they can be applied to Kaikaku type II, since the studied Lean transformations belong to this type of Kaikaku. For other types of Kaikaku, further research is most likely needed.

The third research question was formulated as:

*RQ 3: What are the characteristics of production management and organization settings that can increase the likelihood of realizing Kaikaku?*

The third research question has been answered through case study C. However, this case study focused only on radically innovative Kaikaku (Kaikaku type III and IV). From the case study, six characteristics of production management and organization settings were identified as relevant. The detailed explanations of each characteristic were presented in Section 4.2.3:

- Strong management intent
- Severe target and requirement setting on production engineering functions

- Strong production engineering functions
- Close cooperation of production engineering functions with other functions
- Strong emphasis on knowledge and skill development
- Shop floor workers and staff highly competent in problem-solving

The research did not investigate Kaikaku type I and II with respect to the third research question. Further research is needed to answer the question for these types. One assumption is that strong management intent is also necessary for Kaikaku type I and II. However, the other identified characteristics are more like things that can be improved or developed during these types of Kaikaku, rather than pre-conditions for these types.

The answers to the research questions indicate the fulfillment of the research objectives. The first research objective can be considered fulfilled because the model of four types of Kaikaku describes Kaikaku in a comprehensive and structured way and the model actually helped to conduct further research concerning how to realize a specific type of Kaikaku. However, the second objective is only partially fulfilled. The results obtained from case study A, B, and C address only a limited area of Kaikaku. Further research is needed to fulfill the second objective.

## **5.2 Reflection on the scientific and industrial contribution**

In the field of production research, Kaikaku has been researched much less than Kaizen. The concept of Kaikaku is ambiguous, often a sign of an immature research area. In terms of how to realize radical improvements in production, research has been conducted in a piecemeal manner. Many researchers focus on specific topics, for instance, introduction of new production equipment and implementations of company-wide improvement initiatives such as Six Sigma and Lean. There has been little attempt to capture a more holistic view of radical improvements in production that helps to understand the phenomena in a comprehensive and structured way. The model of four types of Kaikaku presented in this thesis can be considered as contributions to this challenge.

In the international research community, Kaizen is often considered as the main contributor to high production competitiveness at Japanese manufacturing companies. The research presented in this thesis has highlighted the fact that Kaikaku has also been actively conducted among Japanese manufacturing companies and contributes to the competitiveness of the production.

The importance of organizational learning during the execution of improvements has been emphasized by several authors in literature. However, few documents and theories have been presented as to how to practically facilitate organizational learning during a radical improvement of production. The reducing-water-level way of driving

Lean transformation presented in Chapter 4 can be considered a contribution to the scarce amount of research.

The scientific contribution mentioned is also applicable to industry. Furthermore, more specific contribution was made through the case studies. In case study A and B, the researcher invited a Japanese consultant with significant TPS experience. His consultations to the case-studied Swedish companies constitute direct contributions to the industry. During the research, the author of this thesis took advantage of access to Japanese manufacturing companies and introduced their recent Kaikaku efforts to Swedish industry. The recent trend of Kaikaku in Japan - shifting toward radically innovative Kaikaku - can be an inspiration for Swedish industry. Finally, the research results will be used to make a handbook called "Kaikaku in production" for industrial use. This is also an exciting contribution to industry.

### **5.3 Quality of the conducted research**

As discussed in Section 2.4, research quality can be evaluated in terms of internal validity, external validity, and reliability.

Internal validity is about the degree to which a theory, model, concept, or category describes reality with a good fit (Gummesson, 2000). As for the model of four types of Kaikaku presented in this thesis, the internal validity was tested by sorting a number of Kaikaku case study reports into the four types. All the reports are categorized into one or a few types, as shown in Table 3 in Appended Paper A. Regarding case study A, B, and C, the validity was improved by studying more than one organization. Triangulation, collecting evidence from difference sources, was employed in case study A and B, which also improved the validity of the research results. However, the main source of the evidence in those case studies was the observations of the Japanese consultant. Even though the similarity of his behavior and conduct to other Japanese TPS practitioners is found in literature or heard as second-hand information, the validity can be better supported if more than one such individual could be observed.

External validity is whether a study's findings are generalizable beyond the immediate case study. The analytical generalization can be considered possible from the results obtained from case study A, B, and C. However, the results from these case studies were not tested at any other companies than the case-studied companies. The external validity could be improved if such a test was conducted.

Reliability means whether two or more researchers studying the same phenomenon with similar purposes would reach approximately the same results. Various efforts were made during the case studies to increase reliability. For instance, memos were frequently taken during the direct and participant observations and the interview

items are carefully made before the interviews. However, as estimated in Section 2.4, reliability was difficult to achieve, especially for the direct and participant observations. The researcher's previous experience within the study field, his cultural background and his personal skill from having deep insight into the observed events all influenced his interpretation of the empirical data obtained during the case studies. Moreover, in the research, a large amount of information was collected from Japanese written documents. This made it difficult for the international research community to evaluate the reliability. It would be optimal if all those documents could be translated into English or Swedish, but this was difficult due to time limitations.

## **5.4 Future research**

The research presented in this thesis analyzed the phenomena of Kaikaku from a holistic perspective. As a consequence, the research results stayed at a rather general and abstract level. Future research can be conducted at a more specific and concrete level. Since the fulfillment of the second research objective has not been completed, future research should be more focused on how to realize Kaikaku.

Little knowledge has been developed in terms of how to realize radically innovative Kaikaku. Provided that this type of Kaikaku may become increasingly important for manufacturing companies in Sweden and many other countries, it is an interesting research area for future work.

If radically innovative Kaikaku gains more attention in the future, the role of production engineering will become more important. The development of a production system with "low cost automation strategy" can be an important step to realizing radical innovations in production. The low cost automation strategy is to develop in-house automation equipment that has just enough functions for the specific operations. This strategy has been adopted by many Japanese companies and is quite compatible with Lean production. Therefore, it can be applied more often to Swedish industry. Developing support that facilitates realizing the low cost automation strategy is also an interesting area of research.

Finally, when to initiate Kaikaku has not been discussed much in this thesis. It should be closely related to the manufacturing strategy of a company. Kaikaku should not be a "one-shot project" concerned solely with meeting an annual performance goal, requirements of payback period or return on investment. Rather, it should be aligned with a long-term scenario of how a production system should be developed. Investigating how to relate Kaikaku to such a long-term development scenario is also an interesting area for future research.

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