Master thesis

The influence of company objectives and plant size on lean tools choice and quality dimensions improvement in SMEs

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Content

Chapter 1. Introduction..4

1.1 Background...4

1.1.1 Lean manufacturing.. 5

1.1.2 Lean tools.. 6

1.1.3 Objectives and LM tools choice.. 7

1.1.4 Plant size and LM tools choice...8

1.1.5 LM tools and quality dimensions improvement..8

1.2 Research model.. 9

1.3 Research aim.. 9

1.4 Demarcation...10

1.4.1 Business type...10

1.4.2 Food industry sector choice...10

1.5 Research questions.. 11

1.6 Research approach...12

Chapter 2 Literature review... 14

2.1 lean bundles introduction.. 14

2.1.1Technological lean tools...14

2.1.2 Managerial lean tools... 18

2.2 Influencing factors of lean bundles selection... 21

2.2.1 Objectives and lean bundles choice...22

2.2.2 LM tools selection in SMEs food industry... 27

2.3 Indicators of performance..29

Chapter 3 Research methodology..35

3.1 Research methodology introduction.. 35

3.1.1 Questions list and questionnaire layout...35

Chapter 4 Results and discussion..43

Chapter 5 Conclusion.. 53

5.1 Overall conclusion.. 53

5.2 Limitation..54

5.3 Recommendation..54

5.4 Reflection..55

Reference.. 57

Appendix...62

Chapter 1. Introduction

1.1 Background

The competition within food industry is becoming more intensive over the last decades due to a growing set of regulations, customer expectation and higher materials and energy cost (Zhou, 2012). Since competitive advantage level is directly related to the financial performance of a company, enabling them to create more economic value to sustain their business. Many resources like capital and expertise are invested by food companies to gain the competitive advantage in the food market. (Dora et al., 2013a; Newbert, 2008; Peteraf and Barney, 2003; Zhou, 2012). Within EU food market, CIAA (2010)points out that EU food sector lacks competitive advantage in comparison with the sector in North America and Australia. The European economy performance has been negatively impacted by the uncompetitive food industry (Commission, 2008). Bititci (2001) believes that different industry, based on its characteristic, has different competitive capabilities. Regarding food industry, cost, product quality, delivery speed and dependability of a company are important competitive capabilities.

These capabilities can all be viewed as different elements in extended quality concept. This concept believes that quality is not only a one-dimensional concept which only focuses on the physical characteristic of the product itself, instead, it views quality from a more broader perspective including six dimensions. These six dimensions can be classified into two groups shown in Figure 1(in the attachment). Therefore, the improvement of these competitive capabilities is actually an improvement of the extended quality of the product.

The benefits of introducing quality management system (QMS) to improve extended quality is well accepted (Dora et al., 2013a). QMS consists of six activities, including quality control, quality design, quality assurance, quality improvement and quality policy and strategy shown in figure 2 (in the attachment). Juran (2003) argues that quality improvement activity is recognized as the cornerstone of the management system. Lean manufacturing (LM), an improvement method in quality improvement activity, already shown obvious benefits in improving extended quality according to Shah & Ward (2007). More specifically, Zokaei and Simons (2006) find encouraging improvements after implementation of LM in food sector. LM is already proven to improve the operational performance of companies regarding cost and quality (Dora et al., 2015). Zhou (2012) found that the application of LM can improve productivity, efficiency, customer satisfaction and cut manufacturing inventory cost in the company. Goncharuk (2009) also claims that the implementation of LM can help a company to become more competitive by improving product quality and reducing cost. Therefore, the trend of LM implementation is increasing(Mahalik and Nambiar, 2010).

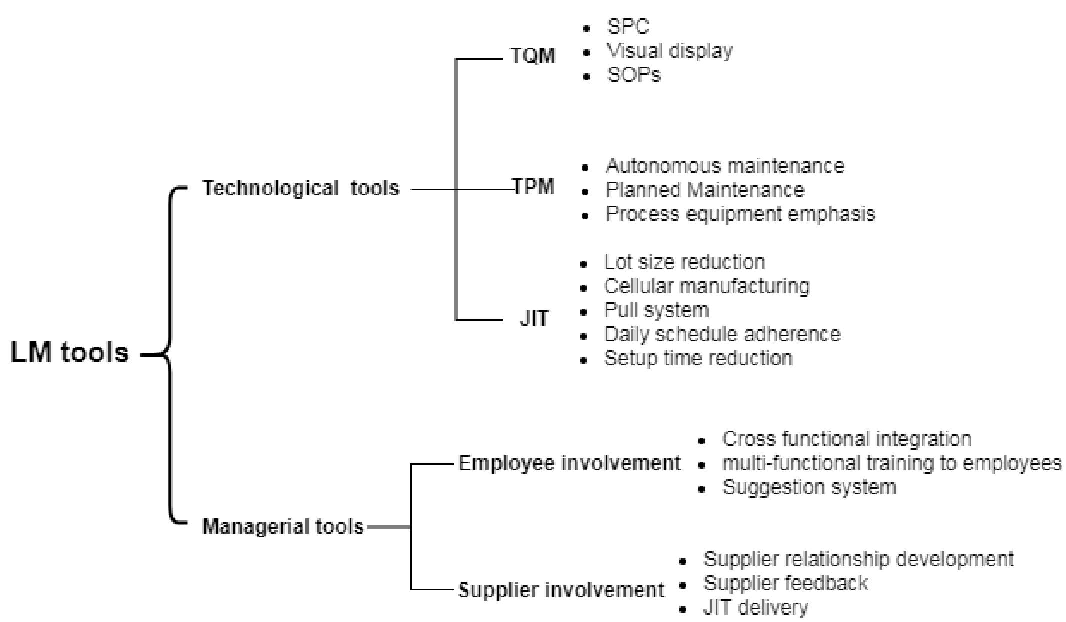
1.1.1 Lean manufacturing

Lean manufacturing (LM) is a quality improvement method that has drawn extensive attention over the last decades (Mahalik and Nambiar, 2010). LM is one of quality improvement methods. Its history can date back to 1960s when Japanese automobile manufacturer Toyota first introduced Toyota Production System(TPS). TPS is recognized as the origin of lean thinking (Diekmann et al., 2004). The definition of lean is defined as "a system that utilized fewer inputs and creates the same outputs while contributing more value to customers" according to Womack (1990). Empirical studies illustrated that several operational performances such as product quality, delivery time and product availability, namely extended quality has been improved by the implementation of LM. The better performance of extended quality is achieved via total elimination of seven wastes (Wilson, 2009). Scott (2009) also argues that LM is used to transform a complex process into a smooth continuous production flow by developing a standardized process and eliminate unnecessary waste. Seven waste are identified and eliminated after implementation: waste of overproduction, waste of inventory, waste of transportation(of material), waste of motion(of people), waste of over-processing, waste of rework and waste of waiting (Heymans, 2015). Quality problems often occur as a result of too much variation in the process. Introducing LM will result in a smooth and standardized production process, namely reducing the variability in the process. Therefore, LM implementation can improve product quality (Wilson, 2009). The elimination of unnecessary motion of people and process can improve productivity to dilute the average cost per product. Production cost can also be reduced by elimination wastes of rework, inventory and etc (Wilson, 2009). Furthermore, throughput time can be reduced by eliminating unnecessary waiting time, thereby improving delivery performance. Theoretically, LM is able to improve the extended quality performance of a company and increase competitive advantages of companies.

LM is a quality improvement system that calls for an integration of human-related and technological related practices to achieve improvement in quality, product availability and cost reduction(Furlan et al., 2011; Paez et al., 2004; Paez et al., 2005). The concept of solving quality problems within food industry from both technological and managerial approach is evolving in recent years. Companies may fail to achieve the desired performance outcome without the help of human-related changes to support the technological change within a company(Lathin and Mitchell, 2001; Luning, 2002). Furlan (2011) argues that in order to ensure the successful outcome of technological lean tools implementation in LM, managers have to design and operate an organization where people are willing to show commitment and involvement. A set of technological and managerial lean tools are indispensable to make the corresponding changes in industry.

1.1.2 Lean tools

Lean tools as instruments are applied to systematically define, evaluate and solve sources of inefficiency in specific ways (Wong et al., 2009). Dora (2015) argues that the principle of LM is to use appropriate lean tools and techniques to identify and eliminate waste. Paez (2004) proposed a framework that classifies lean tools into two categories, human-oriented and technology-oriented tools. Within each category, lean tools are further sorted into several functions based on a combination of a number of studies. (Furlan et al., 2011; Shah and Ward, 2003). Total quality management (TQM), total productive maintenance(TPM), and Just-in-time(JIT) are within the technological lean tools cluster. Statistical process control(SPC) as an important element in TQM is able to investigate and reduce the variability in food production process, thereby preventing product defects at an early stage (Lim et al., 2014). The application of SPC tools such as X bar in confectionery industry resulted in the desired performance in terms of sweet size variation reduction and minimise machine downtime (Knowles et al., 2004). With respect to managerial lean tools, employee and suppliers involvement lean tools are two important elements. More researchers advocate the employees are regarded as assets in LM implementation and its related lean tools are the heart of lean practices, since employees are the one to solve the quality problem and improve the process(Belekoukias et al., 2014; Sharp et al., 1999). Suppliers related lean tools are excluded by Shah and Ward (2003) when making lean tools classification. However, Dora(2013b) argues that supplier related lean tools play a significant role in LM. The reason is that the quality of food product largely depends on the quality of raw materials due to the mild processing procedure applied on these raw material based on Taylor and Fearne (2009). Under each lean function, there are still various techniques available. An overview of the classification of lean tools shown in figure3.



(Adapted from Paez 2004; Furlan et al., 2011; Shah and Ward, 2003)

Figure 3: Lean tools classification

LM is viewed as a technological and managerial approach to improve company performance. The lean tools can be classified into five difference lean bundle. Each lean bundle, based on its focus can be classified into technological and managerial lean bundle. TQM TPM and JIT are technological lean bundle while employee involvement and supplier involvement is viewed as a managerial lean bundle.

A complete LM system is a meta-system that relates to not only production process but also employees and suppliers. It is difficult for companies to implement all mentioned technological and managerial lean tools. Because each lean tool requires expertise, capital investment, especially for SMEs which normally lack these resources(Dora et al., 2015). Sousa and Voss (2008) also point out that a simple application of complete technique is not able to ensure the success of implementation. Lean tools should be selected based on its needs and characteristic.

1.1.3 Objectives and LM tools choice

Decisions need to be made on the choice of lean tools. Dora (2015) has already investigated several factors that could influence the choice and implementation level of lean tools, such as organizational structure, commitment from top management, nature of the industry. However, the influences of objectives of LM on lean tools choice remain untouched in this study. The importance of objectives in the decision-making process is undeniable, since these decisions have to be made to stimulate activities towards the specified objectives, namely, decisions are made to fulfill objectives (Luning, 2002). According to the survey conducted by Kumar and Antony (2008), top three strategic objectives are profit, quality and cost. The objectives of LM implementation proposed by Wilson (2009) are increasing product quality, product availability and reducing product cost. Dora and Kumar (2015) conducted an interview with four SMEs food companies. They found about 14 motivations to implement LM, such as production smoothening, reduce product variation, improve machine efficiency and reduce the cost of production. After deeper analysing, these motivations can be categorised into three dimensions, including cost reduction, quality improvement and product availability improvement. Due to the fact that the influence of implementation objectives on lean tools choice has not been deeply researched, further research is necessary to see if there is an alignment between objectives of companies and function of chosen lean tools. Since lean tools choice may have a direct impact on ultimate extended quality output performance.

1.1.4 Plant size and LM tools choice

Expect for objectives, the possible influence of plant size on LM tools choice and implementation level cannot be neglected(Shah and Ward, 2003). Researchers suggest that SMEs face various problems when implementing LM compared with large companies. The number of adopted LM tools is in general smaller than large companies(White et al., 1999). LM is a meta-system including both technological and managerial tools to achieve performance improvement see section 1.1.2. Each technical change or managerial change require resource investment. For example, in order to improve delivery flexibility, new equipment needs to be purchased to achieve a small lot size(Panwar et al., 2015). Employee training initiatives are also indispensable during LM implementation. SMEs often face challenges in implementing certain lean tools due to the lack of time, expertise, internal technological and financial resource. A study conducted by Shah and Ward (2003) empirically shows that according to different plant size, the mix of different LM practice varies significantly. More specifically, studies shown that lean bundles are more comprehensively implemented by larger plants, however, for certain lean tools such as multi-skilled workforce which does not require intensive finance investment, has the similar implementation level with larger companies. Therefore, it is reasonable to assume that in food industry, LM tools choice is also influenced by plant size. SMEs might have a preference towards less difficult lean tools.

1.1.5 LM tools and quality dimensions improvement

The extended quality improvement is regarded as the result of successful implementation of LM tools (Dora et al., 2015). The significant influence of LM tools on the operational performance like product quality, cost, delivery time, reduced lead time and productivity are the most commonly cited benefits (Lewis, 2000). From the empirical study conducted by Melton (2005), LM can increase companies competitiveness by improving quality, flexibility, and cost reduction, 25% increase in product quality and delivery time. More specifically, from a study conducted by Sriparavastu and Gupta (1997), among responded 154 companies, the result shows that companies who implement JIT or TQM perform better in terms of product quality, productivity levels and reduction in production cost than those companies not implementing such practices. HRM tools such as employees' education and training are recognized as key antecedents of quality improvement according to Dean and Bowen (1994). However, there are only limited researches focusing on the LM performance within food processing industry(Dora and Gellynck, 2015). Companies normally reluctant to implement LM before foreseen the benefits of lean(Rose et al., 2011). In order to give a clear image of the benefits of implementing LM tools in food industry, the actual quality output performance of lean tools implementation in food industry should be investigated. The performance will be evaluated against on product quality, cost and availability. The reason to choose these dimensions is that these three are defined as the most important factors to gain the competitive advantage in food industry(Christiansen et al., 2003; Hallgren and Olhager, 2009). Furthermore that these three dimensions are also considered as key factors to gain consumer loyalty (Zhou, 2012).

1.2 Research model

The influence of company implementation objective on LM choice and the quality performance will be researched. The research model is presented in figure 4.

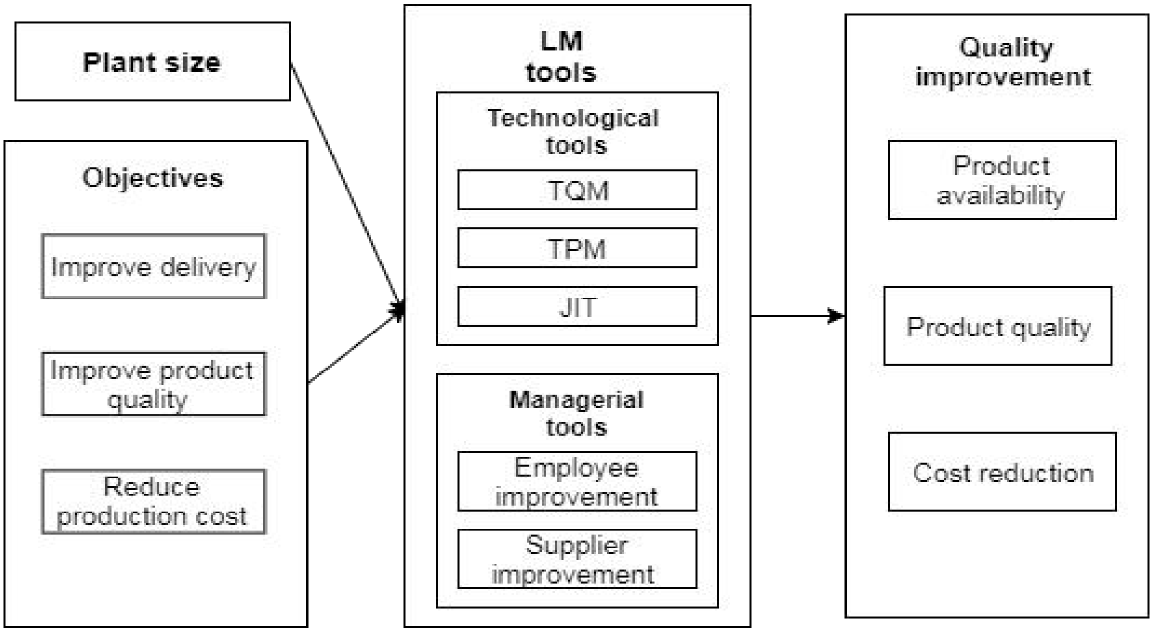


Figure 4: Research model

The possible influence of objectives and plant size on the choice of lean tools and lean bundles will be investigated and what kind of influence of lean bundle and lean tools have on the quality performance of companies will also be researched.

1.3 Research aim

The aim of this research is to investigate if there is an alignment between lean bundle choice and company objective, and to investigate what is the influence of plant size on lean tools choice. Furthermore, how the chosen lean tools influence extended quality performance will also be researched.

1.4 Demarcation

1.4.1 Business type

The research scope is placed on small and medium-sized companies(SMEs). According to European Commission (2003) two factors determining whether a company is SMEs are staff headcount and either turnover or balance sheet total. The more detailed category classification shows in table 1.

The reason of choosing SMEs as study object is that in Europe, more than 90% of the food companies are SMEs which account for 63% of the employment according to Dora and Kumar (2013b). After a detailed literature search, Rajurkar and Jain (2011) concluded that between 1994 and 2009, among 134 papers published on reputed journals about LM, there only a few research focusing on LM in food industry. This is mainly due to the specialty of food processing industry such as the large and inflexible machinery, long setup time and the inherent nature of food perishability (Dora et al., 2015).

Among all these studies, the influence of objectives and plant size of LM on lean tools choice and the quality improvement performance has not been deeply researched. However, the success of quality management initiatives are highly context-dependent (Sousa and Voss, 2001). The implementation of LM in SMEs is more difficult due to the large difference between SMEs and large companies regarding culture, staff patterns and available resources. But there are still some advantages to SMEs when implementing LM. Dora (2013b) argues that the informal structure in SMEs will increase cross-functional exchange, and a relatively smaller team will increase efficiency in the decision-making process. It is necessary to investigate the LM performance within SMEs complex context since the performance output found in large companies does not absolutely apply to SMEs.

1.4.2 Food industry sector choice

LM is a metasystem, during its implementation, companies will be confronted with various impeding factors such as lack of resources, lack of knowledge, internal resistance or poor employee participation, so the implementation of LM in SMEs food industry is still evolving and at infancy stage (Kumar and Antony, 2008). Form the study conducted by Dora (2013a), confectionery, chocolate and meat sector, compared with other sectors including packaged fruits and vegetable sectors hold more positive attitude in implementing quality management tools and practices.

Among these, the meat industry is the chosen scope out of the following reasons. First, the occurrence of quality issues is more frequent than in the confectionery and chocolate sector. Mathews Jr and Buzby (2001) argues that in recent years, there are several meat-related quality issues that have drawn extensive attention among consumers such as the outbreak of Foot and Mouth disease in 2000 and Mad Cow disease in 1990. Second, in EU, the meat industry is mainly protected by the government and got support via Common Agricultural Policy(CAP) by import tariffs and subsidy payment. However, the budget distribution has been reformulated. Due to the admission of former Eastern Block states, a large amount of cheaper meat suppliers has been introduced to EU market according to Simons and Taylor (2007). The cost competitive is becoming more intense. Therefore, against this background, the performance of LM implementation on quality and cost should be investigated to see whether LM could be a solution to cope with this situation.

Companies will be chosen based on following criteria:

- SMEs meat companies in EU
- Companies with different implementation objectives will be included.
- Prefer companies who have robust data record about quality performance before and after implementation.

The inclusion of companies with different objectives is necessary since the relationship between company objective and its lean bundle choice and the influence on performance output is one of the main objectives of this research. Companies who have robust data can give a clear indication as to what extent they implement these lean tools and how much improvement they have reached after implementation. However, this is not a must, since the implementation of LM in SMEs, based on literature, is still at an infancy level. The detailed data information and registration of the process is not expected to be present in company.

1.5 Research questions

Overall research question

Is there an alignment between lean bundle choice and company objectives, and to what extent quality, cost and delivery performance are influenced by the chosen lean tools? And what is the influence of plant size on the choice of lean tools?

Sub-questions

What are the objectives of LM implementation within chosen SMEs meat companies?

Which lean tools are applied in selected SMEs food companies in different objective context?

Do the implementation level of lean bundles differ in SMEs meat companies?

Do companies have a preference between technological and managerial lean tools?

What is the improvement of output regarding product quality, availability and cost in selected SMEs food companies?

Is there a relationship between objectives, lean tools applied and extended quality improvement output?

1.6 Research approach

First, an in-depth literature review to understand the following desk-top questions

1. What are objectives of LM implementation?
2. What are available lean tools?
3. What is the possible relationship between the lean bundle and company performance from a theoretical point of view?
4. How to measure the level of extended quality improvement?

Then the questionnaire will be formulated and send to SMEs to get insight into the listed questions

5. what are the objectives of LM implementation of selected SMEs
6. which lean tools are chosen by these SMEs?
7. what is the quality output in terms of product quality, cost and availability?

The collected data will be analysed to see if there is an alignment between objective, lean tools choice and quality output.

The outline of research approach is shown below in figure 5

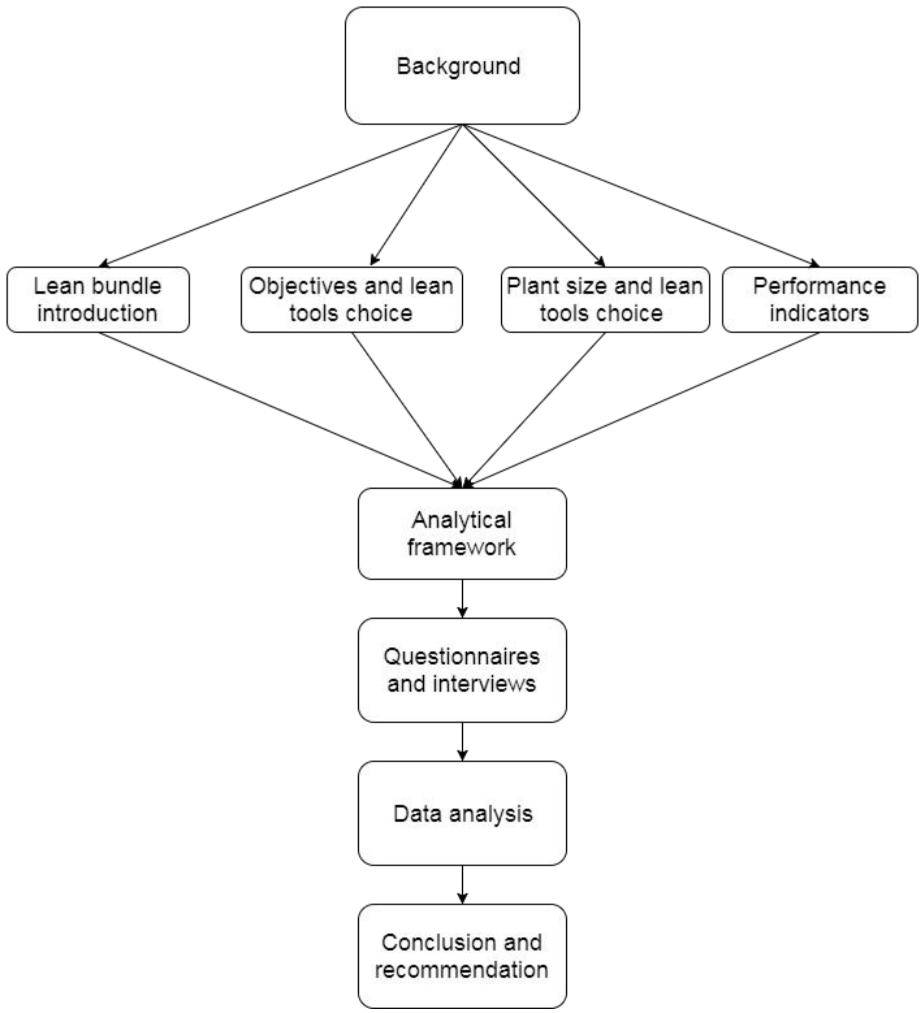


Figure 5: research approach outline

The background information of meat industry and the LM will be introduced first. A literature review is followed to get more in-depth knowledge about lean bundle, the possible influencing factors of company objectives and plant size on lean tools choice. indicators for quality, cost and delivery performance will be formulated to measure the performance of company after LM implementation. An detailed analytical framework will be made based on literature review. Later, questionnaires which are based on literature will be created and sent to target companies. Informal interviews will also be conducted to get more information of LM implementation if necessary. All the collected data will be analysed. Conclusion which are extract from these data will be presented. Possible recommendation, limitation of this research and self reflection is shown in the last part.

Chapter 2 Literature review

In order to answer research questions, several topics need to be researched in the literature review part. The first part is a more detailed introduction about the function and the characteristic of the technological and managerial lean tools. Next, the possible influencing factors in term of lean tools choice, namely objectives and plant size will be further elaborated. Various indicators will also be found to assess the outcome performance of LM implementation. Hypotheses will be formulated based on literature review.

2.1 lean bundles introduction

Lean tools are classified into different lean bundles via a mathematical analysis. These lean bundles are TQM, JIT, TPM, employee and supplier involvement. Lean tools are the heart of LM. Paez (2004) defined LM as a set of technological and managerial lean tools. Areas that need to be improved could be identified, improved by the application of a set of technological oriented lean tools. Studies suggest that more attention has been put on technological lean tools than on managerial lean tools(Paez et al., 2004). However, the same author argues that managerial lean tools, especially employee involvement are necessary to implement. Since these capabilities in this category of employees are demanded to realize a successful outcome of LM implementation. Joint implementation of managerial-oriented and technological-oriented practices should lead to a better performance(Cua et al., 2001). In the following section, the focus of each lean bundle, the possible mechanism of its influence and the proven effect of previous studies will be discussed.

2.1.1Technological lean tools

In this section, the focus of each lean category, the specific lean techniques, the possible reasons why these lean category can be applied to improve quality, delivery, and cost performance respectively will be discussed regarding TQM, JIT and TPM.

TQM

TQM is a lean category designed to improve and sustain the quality of product and process in order to meet customer expectations(Cua et al., 2001). Techniques in TQM cluster are able to reduce manufacturing process variance, thereby reducing defects level and improving quality(Dal Pont et al., 2008). Production process variation affects every aspect of every step of the process and the specification of the final product. It is not possible to eliminate all of them. However, with certain TQM practice, these variances can be identified and minimised to an acceptable level to ensure products meeting specification(Wilson, 2009). It is important in LM that quality is assured at every stage of the process. So that at the end of processing, products are within pre-defined specification can be assured. During the process, when a critical default is identified, the product must be rejected to prevent more value added to it. At the same time, the corrective action should also be taken quickly to adjust the process. The philosophy of TQM is “Right first time-Every time”, which is a built-in quality philosophy. Product with critical defects will be rejected at the early stage to ensure that the final product achieves a zero defect level. This is different from the traditional control that only focuses on the inspection of the final product.

Practices such as SPC, SOPs, visual control and display are frequently mentioned lean tools in TQM cluster. SPC normally set in critical control points(CCPs) in a manufacturing process(Lim et al., 2014). It looks at data at CCPs and compares against the target points to check whether the outcome of this stage is a correct response. In some cutting-edge machines, the corrective action can take automatically(Wilson, 2009). In meat industry, SPC technique is applied to measure and control the moisture, PH and microbial count(Lim et al., 2014). SOPs can be applied to make sure that a standard process is created for the materials to flow through(Wilson, 2009). Only undertaken a fixed procedure and processing sequence, the quality of product are more likely to be ensured. For instance, in meat processing industry, meat products have to go through the water-chilling process for 48mins, and the temperature should be <16°C on entry, otherwise the meat product might be contaminated by Enterobacteriaceae and Pseudomonas bacteria(Lim et al., 2014). So SOPs is an important technique to realise a high quality. The essence of visual display is to use simple tools to give information to operators the process status and quality concerns. A simple example is andon lights. In each work area. There are three color lights. Green light means the line was running. The yellow light signal that a quality problem needs to be consulted on the production line, red light means line should be stopped. This kind of simple signal enables operators to stop production when defects have been identified and called for assistance immediately(Cutcher-Gershenfeld et al., 1994). Visual control is one of visual management tool, which aims to show the production situation to shop floor operators.

Both case study and empirical study have demonstrated the positive influence of TQM have on quality improvement performance. Belekoukias (2014)has empirically proved that TQM initiatives have a significant relationship with quality. This finding is supported by many authors who believe that there is a contingency between the selected practice and corresponding performance output(Christiansen et al., 2003; Shah and Ward, 2003). However, multiple studies also suggest that the benefits of TQM implementing is multi-dimensional. The reduction level of defects directly reduce the number of reworked products and therefore improving cost reduction performance.

JIT

JIT is a lean bundle that has a primary goal to continuously reducing and eliminate different forms of waste(Cua et al., 2001). Especially the waste of work-in-process inventory and unnecessary delays(Brown and Mitchell, 1991). JIT is an important pillar in LM and most people consider it as inventory control techniques. It is necessary to control inventory in manufacturing industry since inventory is costly. The inventory itself is a cost consisting of raw materials and processing expense. Next, extra employees and machines are needed to handle them like forklifts. These inventories will be moved around, usually move more than once before it put on the right location. Space, transportation, human resource are required in the process of handling of inventory, which is costly(Wilson, 2009). The most important thing is that these operations do not have any added value from the perspective of consumers. Therefore inventory should be minimised in manufacturing(Dora et al., 2015). Delays in a process will impede the company to provide the right amount of product at right time. The time that no product is being produced is wasted time or waiting time. Wasted time will cause delays in the production process(Wilson, 2009). JIT lean bundle consist of various lean techniques to eliminate the inventory, delay and other forms of waste in the plant(Brown and Mitchell, 1991; Wilson, 2009).

JIT category consists of practices like pull production (kanban system), lot size reduction, cellular manufacturing, set-up time reduction, daily schedule adherence(Bortolotti et al., 2013; Cua et al., 2001; Shah and Ward, 2003). Pull system means companies produce and ship only what has been consumed by consumers. Kanban cards can be used to control the flow of production. Bortolotti (2013) argues kanban cards can level production process by synchronisation of daily scheduled activities with takt time. Takt time reflects the pace of consumer demand. In this way, inventory level can be maintained at a low level. Lot size reduction is an effective tool to prevent overproduction, thus minimising the inventory cost(Bortolotti et al., 2013; Wilson, 2009). Implementation of quick changeover technique can reduce set-up time effectively. Changeover time is the time needed to converting machine or process to make a different product. This kind of time should remain at the lowest level as possible to prevent delay in production. Cellular manufacturing is a manufacturing equipment layout in which multi-functional machines are put together to produce components or product families. This kind of layout usually is a U or C shape. In this case, the incoming materials and outgoing product are near which aids in materials and information handling(Bortolotti et al., 2013; Wilson, 2009). Unnecessary employees and materials movement is able to reduced, minimising the chance of causing delays in production. Based on customer demand, the required daily quantity is calculated. Compliance with scheduled daily quantity cannot only prevent overproduction but also able to ensure customer demand(Bortolotti et al., 2013).

The influence of JIT on performance outcome mainly reflect on the improvement of delivery and cost reduction performance. This outcome is expected due to the function of JIT regarding delay and inventory reduction. Empirical study also suggests that JIT has the strongest impact on cost and delivery performance improvement(Belekoukias et al., 2014). Furthermore, the study also mathematical show JIT also have an impact on product quality. Flynn (1995)explain this lean bundle may act as mean of exposing problems, which in turn encourage companies to solve problems from root cause thereby improving product quality.

TPM

TPM is a technological lean bundle aimed to maximize the effectiveness of equipment. Most of the production system are human-machine systems. The increasing effectiveness of machine will automatically improve the production efficiency. The improved machine performance is realised by eliminating three types of losses that related to machines. The three types of losses are stoppage losses, speed losses and defects losses(McKone et al., 2001). Stoppage losses result from the failures and adjustment. Failures in machines is that the machine stops working due to the occurrence of a breakdown. Machines have to stop and adjusted when the company needs to change to another production line and this is a source of adjustment stoppage. Speed loss can occur when there are a speed reduction and minor stoppage. Jammed packs and identified rejects will cause minor stoppage since machines have to be stopped for a few seconds to clear these blockages. Speed reduction, as another speed loss reason, is less obvious. This is not realised until the end of production line when it is apparent that the expected quantity outcome has not been achieved(Dudbridge, 2011). The last type of loss associated with machines is defects loss. This kind of loss mainly resulted from process defects, yield declines(Chan et al., 2005; McKone et al., 2001). Process defects and reduced yield are more likely to happen under the circumstance that machines are poorly maintained. TPM is not focusing machines when they are broken, but more prevention and maintenance reduction oriented.

TPM practices are tools to minimise the abovementioned losses associated with machinery. The most common recognized TPM are autonomous maintenance, equipment technology emphasis and planned maintenance strategy(Cua et al., 2001; Konecny and Thun, 2011; Shah and Ward, 2003). Autonomous maintenance is a program for production department. Autonomous maintenance believed that many small maintenance activities such as basic cleaning, lubrication, inspection can be done by operators, therefore skilled maintenance can take their time on more value-added work. The intention of this maintenance is, by the involvement of operators, to keep the plant operating efficiently and stable(Rajput and Jayaswal, 2012). A stable production process means less variability. According to Dudbridge (2011), production process with less variability can reduce defect loss effectively. Therefore, autonomous maintenance is able to reduce defects losses. Planned maintenance is for the maintenance department. Planned maintenances is a disciplined planning approach. Tasks are assigned to specific people and the specific time is also scheduled maintenance activities in this approach. By doing so, unexpected stoppage loss is able to be reduced, thereby improving machine effectiveness performance(Cua et al., 2001). Equipment technology emphasis is a TPM that focus on new technology and equipment capability itself. A vast body of literature have illustrated the importance of advanced equipment on machine performance. All three types of losses can be prevented to some extent by improvement of equipment(Cua et al., 2001; Konecny and Thun, 2011).

TPM has been used as a method which is normally associated with cost reduction. The reason behind this is that well-performed machines are positively related to productivity improvement of machines. The increased yield can dilute the total cost, obtaining a decreased average cost for each product(Roberts, 1997). Wilson(2009)argues that even implementation of TPM require a certain capital investment, but the benefits that cost reduction outweigh its investment.
Besides, the empirical study suggests that this lean bundle have a positive impact on all three performance, including cost, delivery and quality(McKone et al., 2001). The contribution to quality improvement is supported by Nakajima (1988) since defects are reduced by TPM. The reduced machine breakdown also benefits the effectiveness of the process, thereby, ensuring the ability to produce demanded amount. In other words, improving delivery performance(Dudbridge, 2011).

2.1.2 Managerial lean tools

Managerial lean tools include employee involvement, supplier involvement and customer involvement. there is also another classification of these three. Employee involvement and other technological-oriented lean tools are company internal factors that influence the extended quality performance of companies, whereas, others are external factors which contribute to the performance of companies. In the following section, the focus of internal factor i.e supplier involvement managerial lean bundle will be first introduced. The possible mechanism of its influence and the proven effect of previous studies will be discussed.

Employee involvement tools

Employee involvement is a lean bundle focusing on improving the ability and commitment of employees. Companies state that people are the most valuable assets of them(Bhasin and Burcher, 2006). But in actual, only small resources are invested to improve employee involvement. However, from the study conducted by Philips (2002) demonstrating that employee involvement is one of the important success factors in LM implementation. Various authors argue the supporting role of employee involvement during the process of above-mentioned four technological lean tools implementation(Cua et al., 2001; Dal Pont et al., 2008; Furlan et al., 2011). More specifically, this lean bundle is able to create the appropriate environment for workers to contribute the successful implementation of TQM, TPM and JIT.

There are three techniques within employee involvement cluster including cross-function integration, multi-functional training program and suggestion system. (Konecny and Thun, 2011). One of most important technique in TPM is autonomous maintenance. Autonomous maintenance system relies on operators to do small tasks to maintain machine performance. Training is necessary to reduce the chance of wrong decisions being made. A qualified employee is important to the success of autonomous maintenance. Employees with multiple skills are able to substitute absent employees without disrupting the flow, quality and quantity of work(Shah and Ward, 2003). The implementation of employee involvement can give incentive to workers to become more innovative. Possible new ways of reducing setup time can be generated via listening to the suggestion of shop floor workers(Konecny and Thun, 2011). This new setup time reduction method can in return improve the performance of JIT. The group effect of employee involvement on TQM is even more obvious than other two technological bundles. Hart and Schlesinger (1991)Point out all the TQM contents require employee implication. Dean and Bowen (1994)Also support this idea by showing how some practices in employee involvement are essential to achieve higher quality performance. Cross-function integration can positively influence the overall performance by breaking down the barriers between different departments and can also diminish the scepticism about the usefulness of lean thinking in the process industry(Panwar et al., 2015).

Except for the above-mentioned possible mechanism, the influence has also been empirically proven(Cua et al., 2001; Dal Pont et al., 2008; Furlan et al., 2011). These authors believe that employee involvement is the driving force of technological lean tools. their researches conform employee involvement as a prerequisite for lean implementation. This bundle can build a suitable ground where other lean tools can be effectively utilized. Some authors also suggest that some techniques such as multi-skilled training should be introduced before other technological lean tools. Companies claim that one of the possible failure reason is lacking pre-training to employees before implementing complex JIT techniques(Dal Pont et al., 2008; Furlan et al., 2011).

Supplier involvement tools

Supplier involvement is an external lean bundle which focus on integration with suppliers to ensure the lean outcome performance(Panwar et al., 2015). Krizner (2001)believe that it is important to bring together different sections that historically present barriers among them in LM. Even though it is difficult as one is looking outside the organization. Cox and Chicksand (2005) argue that internal lean tools are more effective compared with the external lean bundle. However, literature reveal that, in the manufacturing industry, support from suppliers is a critical factor for the successful application of lean production. Black (2007) argues that adoption of lean manufacturing has a strong association with the integration of external suppliers. This lean bundle is a major step that used by many companies. Supplier integration plays an important role in achieving a sustainable cost reduction goal in LM(Bhasin and Burcher, 2006). Consequently, supplier involvement in LM should be encouraged(Bhasin and Burcher, 2006).

JIT delivery, supplier development and supplier feedback are three supplier involvement lean tools(Dora et al., 2014; Hofer et al., 2012). JIT practices extended to the upstream supply chain encourage suppliers to deliver the right quantity of product to the point of consumption. This delivery should be also in small lot size and follow takt-time of the kanban system. Inventories, therefore, will be reduced. Panwar (2015)Point out that in manufacturing holding time is normally much larger than the actual processing time. Raw materials and packaging materials are stored for weeks but only take several minutes to process. A JIT based delivery can help the company to save cost for carrying these inventories(Roy and Guin, 1999). Supplier development mainly consists two elements. One is to take initiative to reduce the number of suppliers and another one is to build a long-term relationship with suppliers(Panwar et al., 2015). In the food industry, the maximum variation in product quality appeared in suppliers' side. Propose that raw materials quality can be maintained to the required or even higher than standard level by developing a long–term relationship with only a few suppliers. The reason is that, in this case, suppliers are able to develop a commitment to maintain a long-term relationship by providing quality products(Panwar et al., 2015). Supplier feedback aims to have close contact with suppliers and give quality or delivery performance feedback to suppliers(Shah and Ward, 2007). Study shows that regular feedback to suppliers is able to encourage them to improve the corresponding performance. This practice is suggested to have a more positive impact on buyer performance improvement regarding cost reduction and quality improvement in comparison with other two supplier involvement practice. The possible reason might attribute to the tacit knowledge that has to share during feedback process(Krause et al., 2007).

Supplier involvement can have a direct impact on cost reduction and quality improvement performance via controlling inventory level and providing high quality raw materials. This finding is supported by an empirical study which demonstrates that three lean practice have a positive impact on a long-term LM adoption in SMEs(So and Sun, 2010).

The previous context gives a detailed explanation of each lean bundle and lean tools that within each lean bundle. The reason why specific lean tools can be used to improve different dimensions of improvement is also illustrated. The relationship between lean bundle and performance shown in figure 6 from a theoretical point of view. The wider arrow in technological lean indicates the main focus of each lean category.

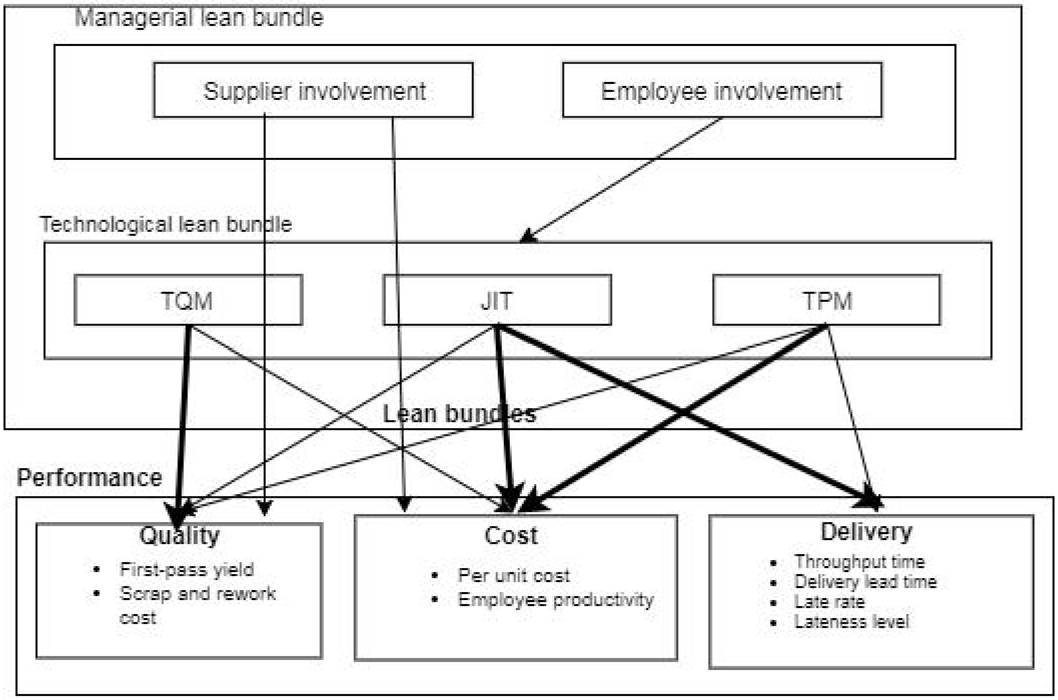


Figure 6: The lean bundles and its related performance

With respect to technological lean bundles, each has a main focus. TQM focus on elimination of variance on the process to reduce defect rate. JIT is designed to reduce waste along whole production line especially for inventory and unnecessary delay thereby reducing cost and improving delivery performance. While TPM aims to improve the availability of machines to ensure and improve the productivity of this plant. The increased productivity directly lower the average cost per product. However, each the relationship between each lean bundle and actual performance outcome is not linear. Due to the characteristic of each lean bundle, they also have an influence on other performance. more specifically, JIT and TPM can also contribute to the quality improvement of products. JIT also show positive influence on quality improvement from a various empirical study. Regarding managerial lean tools, employee involvement as an internal lean bundle, mainly acts as supporting role by providing qualified employees to implement different technological lean bundles. Supplier involvement bundle concentrates its focus on quality improvement and cost reduction via effective integration with suppliers.

2.2 Influencing factors of lean bundles selection

It is not necessary to implement all mentioned lean tools in LM. In 50 SMEs food companies, none of the surveyed companies implement LM in its complete form(Dora et al., 2013a). Researchers also claim that a piecemeal approach is more suitable for

SMEs who lack resources to lunch all LM tools. Since a full implementation of lean tools requires a detailed planning and training(Dora et al., 2015).

Furthermore, a vast body of researches has been conducted to prove the effectiveness of the piecemeal approach. A study conducted by Achanga et al. (2006) demonstrate that nine out of ten SMEs are able to improve its product quality, product availability and cost reduction by following a piecemeal approach. Simultaneously applying several lean tools may realize better performance Ramaswamy, Selladurai, and Gunasekaran (2002). Dora(2015) also demonstrates that lean tools are being adopted partly to solve a specific problem such as improve delivery and reduce machine downtime. Above all, it is necessary and also beneficial to choose certain lean tools in SMEs. But how to choose lean tools? In the following context, companies' objectives and its plant size will be introduced as influencing factors in determining the choice of lean tools.

2.2.1 Objectives and lean bundles choice

The first identified factor that can influence the mix of lean bundles is the objective of the company. The empirical study conducted by Sousa and Voss (2001)strongly suggests that the choice of quality management practices are contingent on plants' manufacturing objective. The manufacturing objective of a company can be seen as a "structural fix" influencing the mix of quality management practices to adopt and the modification of adverse strategic context characteristic. Authors suggest that other manufacturing practice like lean manufacturing should be investigated to check whether there is also a different preference for the practices choices based on different objective context. Limited articles illustrated the influence of objective on lean practice choice. A study conducted by Christiansen (2003) shows that the objective context does influence the mix of practice to adopt. However, this research does not focus on food SMEs industry and the lean bundles he missed an important part of LM practice—managerial lean bundles.

In practice, the objective to adopt LM is diverse. The objectives of LM implementation have been classified into three groups quality, cost and delivery. These three strategic groups are widely accepted by a vast body of literature(Christiansen et al., 2003). They are the most important competitive advantages recognized by companies. Companies pursue multiple strategies simultaneously. But the study conducted by Chatha and Butt (2015) also shows there is preference differentiation among different companies regarding each objective.

The objective to improve quality

The importance of food quality has grown continuously in recent years due to stricter customer expectation, regulation and fierce market competition(Dora et al., 2013a). In response to such trend, food industry start seek solutions from using quality improvement techniques(Dora et al., 2013a; Lim et al., 2014). Around 85.3% SMEs companies agree or strongly agree on that the driver factor to implement LM is to improve quality performance from the study conducted by Zhou(2012) within 200 companies in the USA. Melton (2005)also believed that the potential quality benefits of lean are an important support factor that motivates companies to adopt LM. The definition of quality for capital goods is defined by Garvin (1987), including eight dimensions such as performance, conformance, serviceability, perceived quality etc. shown in figure 7.

Concept of quality dimensions

Capital goods

- Performance: primary operating characteristics
- Conformance: degree to which physical and performance characteristics of a product comply with pre-established standards
- Serviceability: speed, courtesy, and competence of repair
- Features: additional properties, the "bells and whistles"
- Reliability: probability of a product to survive over a specified period of time under stated conditions of use
- Durability: amount of use one gets from a product before it physically deteriorates or needs repair
- Aesthetics: how a product look, deels or sounds
- Perceived quality: subjective assessment of quality resulting from image, advertising, or brand names

Figure 7: Concept of quality dimensions

Conformance quality is the only one for which lean manufacturing has the prime responsibility among all these quality dimensions(Hallgren and Olhager, 2009). The reason is that only conformance quality mainly focuses on the physical characteristic of a product(Garvin, 1987). Whereas, other quality dimensions are more related to product designing phase or consumer perception which is not controlled in the LM system. Conformance quality is improved when the rate of meeting pre-established standards is improved, in other words, the defects level of products is decreased.

Another quality theory modified by Luning(2002) shown in figure 8, specially designed for the food product.

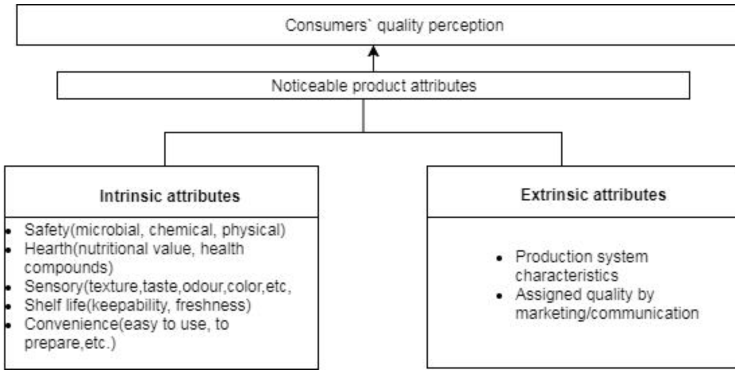


Figure 8: Quality attributes of the food product

Regarding the food industry, the important quality attributes of food are intrinsic attributes and extrinsic attributes. Extrinsic attributes focus on production system characteristic and marketing issues of product. This is in line with the perceived quality dimension develop by Garvin (1987). Therefore, the quality of extrinsic attributes of the food product is not the focus of LM. Intrinsic attributes are results of physiochemical and other properties of a specific product such as PH, composition, microbial contamination (Luning, 2002). These attributes include safety, sensory, health, shelf life and convenience. Among all these attributes, the convenience of a food product is not directly related to certain physical or chemical aspects of products. In contrast, it is mainly due to some preparation, handling and packaging which can create convenience in product preparation(Luning, 2002). Therefore, convenience attribute of a product is not the objective of companies to implement LM. Dudbridge (2011) believed that quality management in LM is to identify the critical quality attributes of a specific food and then to measure early and take corrective action early. Safety(i.e microbial counts) and sensory(size, weight, texture, colour, height) attributes are identified as critical attributes(Lim et al., 2014).

Combing two quality theories from Luning(2002) and Garvin (1987), companies who implement LM with an prioritized objective of quality improvement mainly means to improve conformance quality, namely to reduce the defects level in terms of safety and sensory intrinsic attributes.

The objective to reduce cost

Retailers, in order to get a competitive advantage in the market, compete in terms of the prices of products. This kind of price pressure passed back to the food processing industry, in this case, manufactures only got a small profit margin. Therefore, cost needs to be considered in every decision in the food processing industry (Dudbridge, 2011). One of the main function of LM is to control cost. From the study conducted by Zhou(2012), the reducing cost is the biggest driver for SMEs to adopt LM, accounting for more than 94% of the respondents. After interviews with managers form SMEs food processing industry, Dora (2015)also found that the most cited motivation to implement

LM is to reduce cost in the processing industry. Studies also confirm the benefits of cost reduction by LM implementation(Hallgren and Olhager, 2009; Zhou, 2012).

Different types of cost have to be considered. Variable costs, fixed cost and semi-variable costs are the three types of cost in the processing industry. In the context of the food industry, variable costs are associated with production labour, raw materials and packaging materials. Variable cost will change constantly according to the activity level of business. Fixed cost is the cost that remains stable regardless of changes in the activity level in the food industry. Fixed cost is also called the overhead cost which normally associated with factory services, management. Semi-variable cost is the last type of cost but accounting for the majority percentage. This kind of cost do change based on the changes in the activity level but the changes are not even. Semi-variable cost is made up of a fixed element and a variable element. An overview of different types of cost in the food industry can be seen in Figure 9.

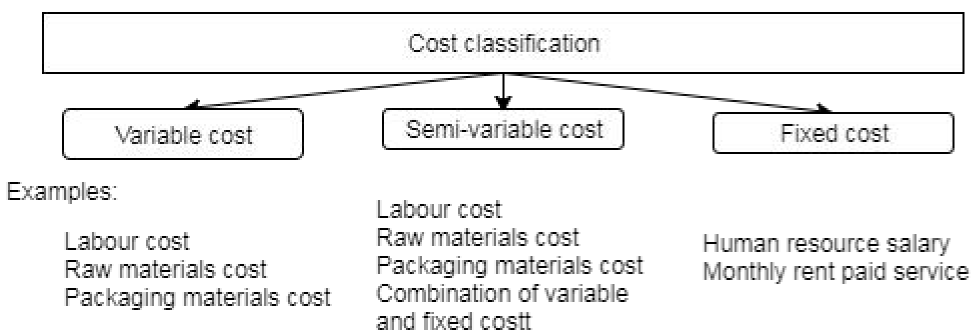


Figure 9: Cost classification

Among these different costs, variable cost is an actionable cost, meaning that compared with semi-variable and fixed cost, this cost is more possible and easier to reduce. The cost of labour can be divided into downtime level, run rate level, rejected level, productivity level and etc(Dudbridge, 2011). It means, by improving the above-mentioned level, the factory can make the best use of labour cost. This is also applied to raw food materials and packaging materials. These two variable costs can be divided into waste, yield, average pack weight, and rejected level(Dudbridge, 2011). Therefore, company aims to reduce variable costs like labour cost, raw materials cost and package cost by implementing LM if it has cost reduction as main objective. The cost can be divided into different activities in the plant. Reducing these cost actually means to reduce the waste caused during this activities. Important wastes are work-in-process inventory and waiting time delay in flow time(Cua et al., 2001). Above all, companies' cost reduction objective is about eliminating waste during production, especially for work-in-process inventory and delays in flow time.

The objective to improve product availability

According to Dudbridge (2011), consumers are very sensitive to the problems in the supply chain. When a product is not available in the market, consumers tend to search elsewhere. This is not just a business loss for the product producer, but also could be a business risk for the retailers. Therefore, ensuring the food product availability, namely, deliveries “ on time ”and ”in full” become major task within the food industry. On time delivery mainly depended on delivery speed while “in full” requirement can be fulfilled by a high delivery dependability performance. Delivery speed and delivery dependability are two important dimensions in delivery performance(Milgate, 2001). Delivery speed is the time that a firm needs to perform an activity or to fill an order. While, reliability is defined as the capacity of a firm to fulfill the delivery as promised(Milgate, 2001). The benefits of implementing LM in terms of delivery performance improvement has been demonstrated in the various literature(Cua et al., 2006; Danese et al., 2012; Rahman et al., 2010). Therefore, Companies with an objective to improve product availability by LM implementation mainly aim to improve its delivery speed and delivery reliability performance. Overview of the different objectives of companies shown in figure 10.

Figure 10: Company objectives

The objective of LM implementation varies according to different companies(Dora et al., 2015). Some of the companies want to improve its conformance quality performance, especially for sensory and safety attributes in conformance quality, while, other companies aim to reduce the variable cost within the company by reducing work-in-process inventory waste and time delay wastes in flow. To improve the delivery performance, i.e delivery speed and delivery dependability can be the objectives of the rest companies.

The focus of each lean tools category also differs. TQM consists a set of lean tools that could improve the quality of products and process by reducing manufacturing variance. The focus of TQM is to improve end-product quality. JIT is a lean bundle that has a primary goal to continuously reduce and eliminates different forms of waste. Especially the waste of work-in-process inventory and unnecessary delays(Brown and Mitchell, 1991). The elimination of inventory and unnecessary time can contribute to cost reduction and delivery performance improvement. JIT has been empirically proved that this technique is directly related to cost reduction performance(Belekoukias et al., 2014). Cua (2006) also points out that the influence of JIT on cost reduction is larger than other lean bundles like TQM and TPM. But it was found by Belekoukias (2014)that JIT in LM is the one that has the strongest impact on delivery reliability. TPM is designed to maximize the overall availability of machines within the production process. A better (Cua et al., 2001). Employee involvement is a fundamental element in LM since, in LM implementation process, qualified staffed are responsible to implement different technological lean bundles. Suppliers can have a direct impact on the cost and quality performance of focal companies via the price they offered and the quality of provided raw materials. But excepts for these mentioned important relationships, as demonstrated before, the relationship is much more complex than this. However, the complex relationship is difficult to illustrated without a large sample size and delicate statistical analysis. Due to the time constraints of this research, this research, therefore, mainly focuses on the important relationship. The simplified lean bundle relationship is shown below figure 11.

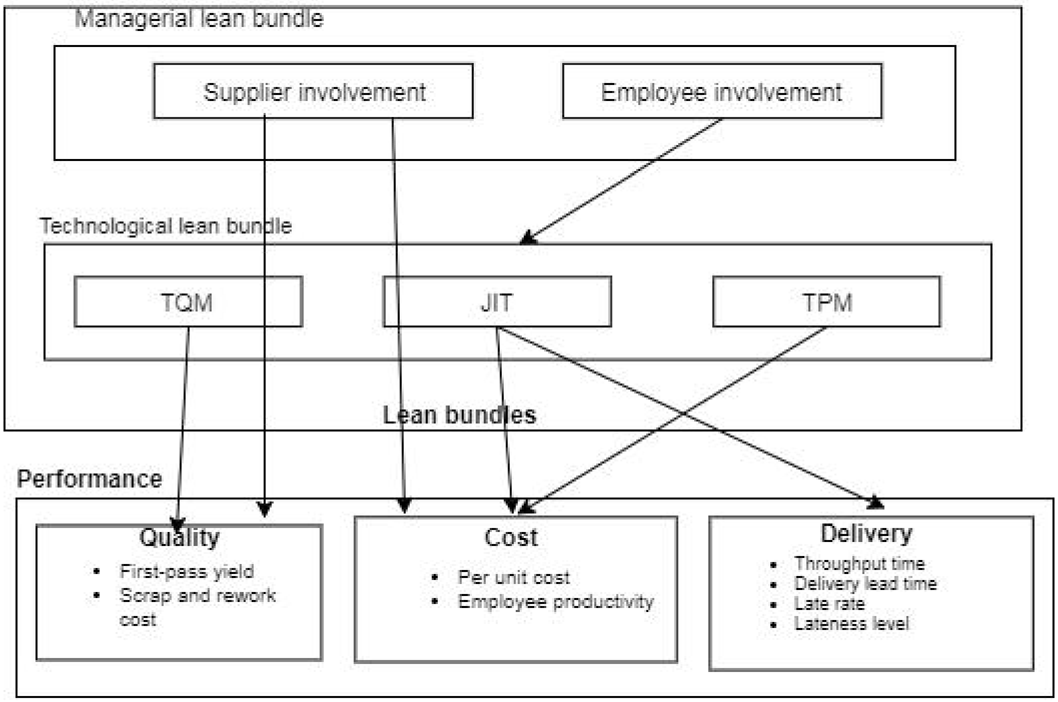


Figure 11: Lean bundle and its mainly related performance

We expect that companies with a different prioritized objective will have a different preference in the types lean bundle. The first hypothesis is derived:

H1: Manufacturing plants with a different prioritized objective will have a different preference in the choice of the lean bundle.

2.2.2 LM tools selection in SMEs food industry

The context that manufacturing plant situated also play an important role in the choice of lean tools. Form the interview conducted by (Cua et al., 2001), several companies claim that some lean tools are not applicable to their plant. Therefore, these lean tools are not selected. Plant size is recognized as an important context factor(Cua et al., 2001; Dora et al., 2014; Shah and Ward, 2003; Zhou, 2012). Plant size can be measured by the number of employees. The number of employees smaller than 250 is defined as SMEs. Plant size as one of the best predictor of managerial behaviour has been examined across different industries such as education, hospital and manufacturing industries(Drazin, 1995). The wildly accepted concept is that, in comparison with large companies, SMEs are less likely to implement certain lean practices(Cua et al., 2001). This is mainly due to the characteristic of SMEs shown in figure 12. It is important to note that SMEs constantly struggle with resource investment(Achanga et al., 2006).

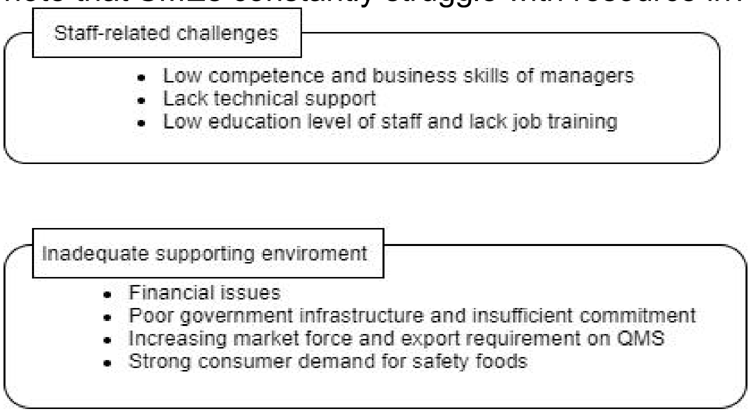


Figure 12: SMEs characteristics

The availability of resources is an important factor for LM. Various resources, such as financial resource, technical know-how, in SMEs food processing are researched and explored by Dora (2014). The research concluded that it is only partially true to state that SMEs lack of resource. SMEs lack of resources to make a big investment for LM implementation, but small investments like training to employees and visual displays are affordable.

This finding is supported by different studies(Shah and Ward, 2003). Dora found that in the SMEs context, lean bundles like supplier involvement, TPM enjoys larger popularization in LM. Pull tool within JIT and SPC within TQM are less adopted in SMEs. Work standardization and visual management, techniques in TQM have a relatively high adoption rate compared with JIT and TPM(Zhou, 2012). Authors argue that SMEs are incapable of implementing all practice due to lack of insufficient technical support and resource investment. The alternative they choose is to focus on the cheapest and easiest lean practice(Rose et al., 2011). Rose (2011) propose a lean tools list recommendation to SMEs based on three selection criteria. These are the least investment, feasible to apply in SMEs and recommended by researchers from the literature review. In another paper of the same author, he categorised the internal lean tools into three different levels based on the mentioned criteria(Rose et al., 2010). Employee involvement, visual display, standardization of operation and SPC are defined as basic lean tools. Cellular layout, TPM and setup time reduction are intermediate lean tools. The author does not take supplier involvement lean bundle into consideration when classifying them into different clusters(Rose et al., 2010). However, the same author in another paper proposes that supplier feedback also meets the requirements to recommend to SMEs(Rose et al., 2011). Therefore, supplier feedback is also included in the basic lean tools list. Rest lean bundles belong to advanced lean tools, which means that these lean tools require intense resource investment, shown in figure 13.

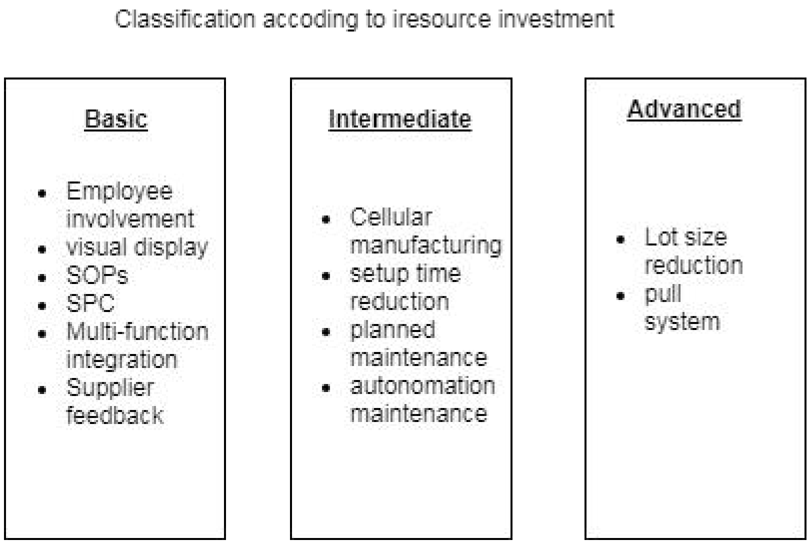


Figure 13: Lean tools classification

Combining the fact that there is a resource investment differentiation among different lean tools and SMEs always struggle in big investment due to limited resources available. The second hypothesis is derived:

H2: The lean tools in the basic cluster, namely employee involvement, visual display, standardization of operation, SPC, supplier feedback and multi-function integration are more frequently adopted by SMEs in food industry than other advanced lean tools.

2.3 Indicators of performance

The possible relationship between a specific lean bundle and quality dimensions improvement have been demonstrated from a theoretical point of view. In reality, the actual relationship between LM tools and performance improvement in the automotive industry has been explored by a vase body of researches. However, the findings from other industries cannot be directly extrapolated to the food industry and the performance of LM in the food processing industry cannot be easily predicted either. Two reasons account for this situation.

Firstly, the adaptability of certain lean tools in the food industry is still a debate topic (Dora et al., 2013b). Lot size reduction is an important lean tool because it is an effective way to reduce lead time and improve productivity. But in the process industry, the quantity of batch size is determined by fixed equipment capacity. Changing to a small batch size sometimes can result in poor mixing or waste excess (Ezingeard and Race, 1995). To achieve a small batch size reduction, extra facilities need to be purchased to have different mixing vessels of various size. However, the large size production in the food processing industry is necessary due to the long set-ups and changeover time of these large machines (Powell et al., 2009).

Secondly, The unpredictable performance is the result of interdependency characteristic of different lean tools function. For example, from a result of an empirical study, that the application of JIT can both improve delivery and quality and cost reduction outcome performance (Furlan et al., 2011). Panwar (2015) argues that it is quite difficult to assess exactly which lean tools have resulted in what improvement. Because the effects of lean tools are interdependent. In other words, Which and how much quality dimensions are influenced by LM implementation in the food processing industry is difficult to predict. Therefore it is necessary to investigate the actual LM tools performance in the context of SMEs food processing industry.

In order to measure the actual performance regarding quality, cost and delivery, the indicators to measure the performance is indispensable. The aim of designing performance indicators is to gain insight as to what extent the objectives of companies are fulfilled. Therefore, the indicators should typically be designed to assess the performance after LM implementation regarding quality improvement, cost reduction and delivery performance improvement in companies. Those indicators should have some common properties according to Behrouzi and Wong (2011).

- Measurable and in line with the objectives of the company and customer value
- Enable to control and evaluation of performance
- Help to understanding the current situation and aid in exploring improvement opportunities
- Up-to-date and realistic

Quality performance indicators

First-pass yield and scrape and rework costs are two indicators to assess the quality improvement level within the food industry. From an empirical analysis, the reliability of these indicators is proven, meaning they can explain a satisfied level of variance of quality factor(Banker et al., 2006; Shah and Ward, 2003).

Finished product first-pass yield is a measure of quality performance. The underlying concept of this indicator is to measure the percentage of product that is produced rightly at first time, before any rework taking place(Corbett, 1998). This is in line with the philosophy of LM, "right first time, every time". This is an indicator that frequently adopted by many researchers when evaluating the operational performance with respect to quality performance(Christiansen et al., 2003; Corbett, 1998; Ghalayini et al., 1997; Shah and Ward, 2003). The implementation of LM is able to reduce the variance of a production process. Therefore, the reliability of the production process is improved. With a reliable production process, the first pass yield can be improved. Products fail to lie in the pre-defined specifications, namely, failing to the standards of conformance quality is not counted.

Products that are rejected during the process or final inspection needs to be re-processed. During the rework process, products that can meet the pre-defined specification can be sold again. Others are scraps which have to be thrown away. Scraps and rework process requires the human resource, machines and capital investment. These costs are wasted due to poor product quality performance. The lower costs which are spending on rework and scraps, the higher level of quality performance.

Banker (2006)empirically shown that this indicator can explain more than 60% variance of the quality performance level. As an indicator for quality performance level, this measure has been adopted by the vast body of literature(Banker et al., 2006; Christiansen et al., 2003; Fynes et al., 2005; Samson and Terziovski, 1999; Shah and Ward, 2003).

Cost performance indicators

Two indicators are formulated to evaluate the improvement of cost reduction level. They are per unit manufacturing cost and productivity of employee(Shah and Ward, 2003). Per unit manufacturing cost is a indicator to directly assess its performance. Unit manufacturing cost can be calculated from the variable costs and fixed cost incurred by a production process, divided by the number of units produced(Banker et al., 2006). Fixed cost cannot be reduced but can be diluted(Dudbridge, 2011). Variable cost like labour cost, materials cost can also be diluted. An increasing yield can dilute the average cost for per unit, thereby decreasing the cost to produce a same amount of product(Dudbridge, 2011). The lower per unit manufacturing cost indicate a better cost reduction performance. The reliability of this indicator has been mathematically demonstrated(Banker et al., 2006; Shah and Ward, 2003). Furthermore, this is the most cited indicator with respect to measuring the cost performance of an organization(Banker et al., 2006; Cua et al., 2001; Shah and Ward, 2003).
Another indicator is the productivity of employees. The productivity is measured by dollar volume of shipments per employee. Variable cost reduction is the main focus when companies implement cost reduction initiatives because this type of cost is more controllable and actionable(Dudbridge, 2011). Labour cost is an important element of variable cost. The absolute value of labour cost is not possible to reduce since wage is significantly important in appealing and recruiting employees(Dearden et al., 2006). However, the relative value of labour cost can be reduced by improving employee productivity. Employee productivity is measured by dollar volume of shipment per employee(Shah and Ward, 2003). If employees can create more value under a fixed wage, the labour cost is diluted. This relative cost reduction can contribute significantly to the overall cost reduction performance(Dudbridge, 2011). Various studies choose this indicator to measure the performance of cost reduction (Banker et al., 2006; Belekoukias et al., 2014; Shah and Ward, 2003). The reliability level is proven by Banker (2006)

Delivery performance indicators

Studies mainly focus on the measurement of the speed performance of delivery, However, from the introduction of objective section(2.2.1), the objective of companies both focus on speed and reliability of delivery. The criteria to formulate indicators claim that the indicators should reflect on the whole objectives of companies. Therefore, indicators of delivery reliability proposed by Milgate (2001) is also included. Delivery speed is the time that elapses from an order placement to an order fulfillment. Delivery reliability is the capacity of the company to comply its promise regarding delivery time(Belekoukias et al., 2014).

Milgate (2001) believes that there are in total four indicators which are suitable to measure the level of these two elements within the delivery performance. Delivery lead time and throughput time are indicators that can measure delivery speed performance. Delivery lead time is a time period from the placement of an order to its shipment to consumers. Transportation time is not included, since reducing the transportation is not the focus of LM. Manufacturing time is the time needed to produce food product, namely the time from its production to its completion. The shorter the lead time and throughput time, the better performance in speed delivery.
The percentage of late deliveries(late rate) is wildly used in industry as a measure of reliability. This measures the percentages of orders that have been delivered late. The average lateness level was also asked. Since from the study conducted by Milgate (2001). Less than 3 percent of interviewed company claim that they had no late deliveries. A more appropriate way to differentiate better and normal delivery performance should also include the measurement of lateness level of different companies.
Overall, different indicators are formulated to measure the improvement level of different performance dimensions. The overview figure 14 shown below.

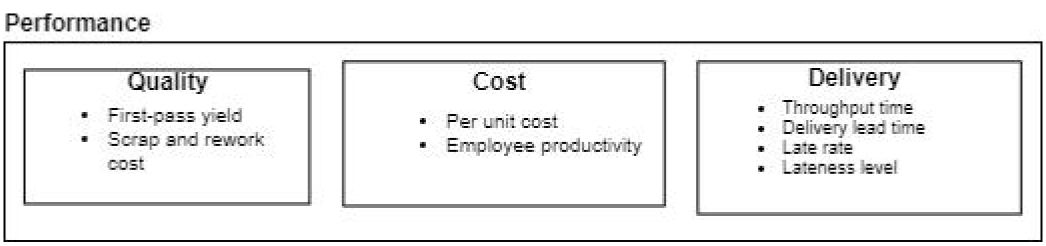


Figure 14: Indicators of performance
In the lean bundles introduction section, it is clearly demonstrated, even though, the impact of each lean bundle is multi-dimensional, technological lean tools theoretically do have one main targeted performance dimension. It is reasonable to hypothesize that the improvement performance of each dimension is different with different lean tools implementation. The performance improvement level can be measured by those mentioned indicators. The third hypothesis is then formulated:

H3: A relative higher implementation level of a certain lean tool will lead to a higher increase in its corresponding quality indicators than others.

In chapter 2, the technological and managerial lean bundles are first introduced, the literature shows that each lean bundle has its own main focus. Then, the possible influencing factors are investigated. These factors from literature research could be companies` objectives and company size. In the third part of chapter 2, indicators of each performance are formulated, in order to evaluate the actual performance of LM implementation within SMEs. The more specific relation of company objectives, size, lean bundle choice and performance can be seen in the following research framework figure 15.

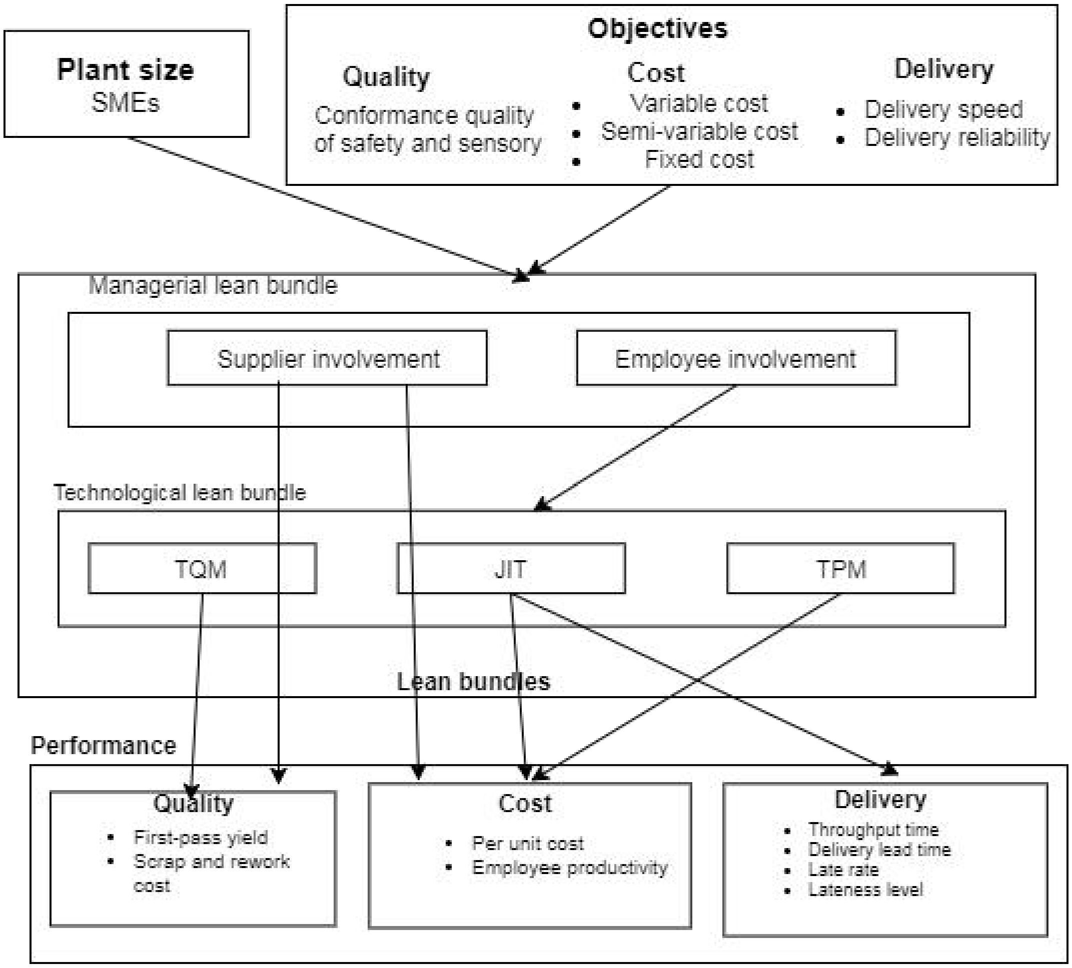


Figure 15: Research framework

In the framework, the arrows between plant size, objective and lean bundles indicate that plant size and companies objectives are possible influencing factors of lean bundle choice. The literature support is in chapter 2.2. SMEs are the chosen focus in plant size. And there are mainly three objectives of companies including quality, cost and delivery. However, each company has its own priority. The priority of objectives and plant size might have an influence on the choice of lean bundles. Lean bundles are further categorized into the managerial lean bundle and technological lean bundle based on its different focus. Each lean bundle both has its own main target in improving a specific performance among quality, cost and delivery as demonstrated in chapter 2.1. The possible relationship of each lean bundle and performance is shown in framework via the arrows between lean bundles and performance. As presented in the picture, supplier involvement bundle targets at both quality and cost performance improvement and employees involvement bundle act as a foundation of the technological lean bundle and then probably could have an influence on all of three performance. Technological lean bundle TQM aims at improving quality, TPM focus on cost reduction and JIT can improve the performance of cost and delivery. Several indicators of each performance are formulated and introduced in chapter 2.3, in order to measure and evaluate the actual performance after LM bundles implementation. The main objective of this research is to test whether these relationship indicating by the arrows in the framework really exist within SMEs meat companies or not. This can be reflected on the three hypotheses that are formulated. They areH1: Manufacturing plants with a different prioritized objective will have different preference in the choice of lean bundle. H2: The lean tools in basic cluster, namely employee involvement, visual display, standardization of operation, SPC, supplier feedback and multi-function training to employee are more frequently adopted by SMEs in food industry than other advanced lean tools. H3: A relative higher implementation level of certain lean tool will lead to a higher increase in its corresponding indicators than others. The detailed research methodology to collect data and test these hypotheses is in introduced in the following chapter.

Chapter 3 Research methodology

3.1 Research methodology introduction

This chapter addresses involved research methodology in this thesis. There are mainly two research methods applied, literature study and questionnaires. An informal interview was also arranged with one of the companies to receive more in-depth information.

The literature study was conducted and the outcome was presented in Chapter 2. Three hypothesis were formulated based on the literature review. In order to test these hypotheses, a questionnaire was formulated based on the literature study. The questionnaire aims to get information about the objectives of different companies and implementation level of different lean bundle to test hypothesis 1. For the test of hypothesis 2, different implementation level of each lean tools should be indicated by respondents. The performance of each indicator for different dimensions was necessary to test hypothesis 3.

3.1.1 Questions list and questionnaire layout

Those questions to test the prioritized company objectives, lean tools implementation level and improvement indicators were obtained from various literature. The information of each question and its reference are shown in table 2 below. Those adopted questions were adapted from various authors(Cua et al., 2001; Dora et al., 2014; Shah and Ward, 2007). They were frequently used questions to estimate the LM implementation level in different industries.

Table 2: Questions list and its reference

	Questions	Reference
Prioritized objective	Please rank the importance of the following objectives or goals for manufacturing at your plant. Rank #1 for the most important objective, #2 for the next important objective and rank 3 for the third important one. If your objective is not within these three, please specify your objective in next question. A: Product quality, especially the safety and sensory performance B: Cost reduction to achieve a low unit cost C: Faster delivery speed and higher delivery reliability	(Cua et al., 2001)
Lean bundle:		
TQM	Our process on the shop floor are currently under statistical process control	(Dal Pont et al., 2008), (Shah and Ward, 2007)
	We extensively use statistical techniques to identify process variation	(Shah and Ward, 2007)
	We use andon lights to indicate production process	(Cutcher-Gershenfeld et al., 1994)
	Operators can call for assistance quickly by andon lights when problems occur	(Cutcher-Gershenfeld et al., 1994)
	Charts showing defect rates are posted on the shop floor	(Cua et al., 2001)
	Our plant emphasizes putting all tools and fixtures in their place	(Dal Pont et al., 2008)
	We use documented standard operating procedures	(Lim et al., 2014)
	We trained employees to use standard operating procedures	(Lim et al., 2014)
JIT	We focus on small lost size to processing products	(Dal Pont et al., 2008)
	We are actively reducing production lot size	(Dal Pont et al., 2008)
	Equipment is grouped based on the product families	(Cua et al., 2001), (Shah and Ward, 2007)
	Families of product determine our plant layout	(Cua et al., 2001), (Shah and Ward, 2007)
	Production at station is pulled by the current demand of the next stations	(Dal Pont et al., 2008), (Shah and Ward, 2007)

	We use kanban squares or containers or signals for production control	(Dal Pont et al., 2008), (Shah and Ward, 2007)
	We usually meet the production schedule each day	(Cua et al., 2001)
	Our daily schedule is reasonable to complete on time	(Cua et al., 2001)
	We are working to lower set-up time in our plant	(Cua et al., 2001),(Shah and Ward, 2007)
	Our workers are trained to achieve a lower set-up time	(Cua et al., 2001),(Shah and Ward, 2007)
TPM	Our maintenance department focus on helping machine operators perform their own preventive maintenance	(Cua et al., 2001)
	The maintenance of the machines is performed by machine operators, instead of a separate maintenance staff	(Cua et al., 2001)
	We dedicate a portion of every day solely to maintenance	(Cua et al., 2001),(Shah and Ward, 2007)
	We have a separate shift, or part of a shift, reserved each day for maintenance activities	(Cua et al., 2001)
	We search for continuing learning and improvement after installation of the equipment	(Cua et al., 2001)
	we are a leader in the effective use of new process technology	(Cua et al., 2001)
Employee Involvemen t tools	The functions in our plant cooperate to solve conflicts between them, when they arise	(Konecny and Thun, 2011)
	Our plant's functions work interactively with each other	(Konecny and Thun, 2011)
	Employees receive training to perform multiple tasks	(Cua et al., 2001)
	Employees are cross-trained as this plant so that they can fill in others if necessary	(Cua et al., 2001)
	Employees are encouraged to make suggestions for improving performance at this plant	(Konecny and Thun, 2011）
	Many useful suggestions given by employees are implemented at this plant	(Konecny and Thun, 2011)
Supplier involvemen	We take active steps to reduce the number of suppliers in each category	(Shah and Ward, 2007)

t tools		
	We have a corporate level communication on important issues with key suppliers	(Shah and Ward, 2007)
	We give our suppliers feedback on quality and delivery performance	(Shah and Ward, 2007)
	We frequently are in close contact with our suppliers	(Shah and Ward, 2007)
	Our suppliers deliver to us on a JIT basis	(Shah and Ward, 2007)
	Our suppliers deliver to us on short notice	(Shah and Ward, 2007)
Performanc e:		
Quality	we increased the finished-product first-pass quality yield	(Shah and Ward, 2003).
	we decreased scrap and rework costs	(Shah and Ward, 2003).
Cost	we decreased per unit manufacturing costs	(Shah and Ward, 2003).
	we increased productivity, defined as dollar volume of shipments per employee	(Shah and Ward, 2003).
Delivery	we decreased delivery lead time: :time period from the placement of an order to its shipment to consumers, excluding transportation time	(Milgate, 2001), (Shah and Ward, 2003).
	we decreased throughput time: the time from its production to its completion	(Milgate, 2001), (Shah and Ward, 2003).
	we increased level of the percentage of on-time delivery	(Milgate, 2001)
	we decreased lateness level: decreased in the extent of delay time	(Milgate, 2001)

The complete questionnaire does not only include the above-mentioned different questions but also general information of responded companies. The following section will give you the detailed introduction about how the questionnaire and answer were designed.

The questionnaire consists of four different parts. The first part is the general background information about the company and respondents, including the number of employees and the position of the respondent in that company

The second part is designed to get insight into the objectives of companies. Respondents were asked to indicate what is the main priority objective among quality, delivery and cost. If their priority is not within these three objectives, they were also required to indicate the objective in the next question. The level of LM tools implementation in the company is measured in the third section and the improved performance is measured in the last section. These questions, unlike testing objectives, were designed to be closed questions where different questions were set up on a seven-point Likert scale for specific lean tools. Respondents were required to indicate to what extent they agree or disagree with the statement about LM tools implementation in the company and the performance improvement. The scale was ranged from 1 to 7 where 1=Entirely disagree, 2=Mostly disagree,3=Somewhat disagree,4=Neither agree nor disagree,5=Somewhat agree,6=Mostly agree,7=Entirely agree. In this case, each lean tool and performance indicator will have a score that could indicate its level. Score smaller than 4 means a lower implementation level. Score larger than 4 reflects a higher implementation level. A higher score indicates a higher implementation level of certain lean tools.

3.2.1 Collection methods and information of respondents

Different methods were used to find respondents including emailing, phone call, and filling in the paper face to face. Questionnaires were first sent to respondents via different ways to different countries within EU including The Netherlands, Germany, Belgium, Italy, Poland and Greeks. An introduction explaining the purpose of this survey was accompanied. The survey is intended to collect information or data from manager directors, quality managers and production managers. Since it is those people who normally in charge of the implementation of LM within a company and have a better understanding of the implementation level of LM. These companies were found via internet searching for SMEs meat companies. In total, around 90 emails were sent to the general email presented on the website of SMEs. Around 10 phone calls were then made out of 25 phone calls to invite companies to join in this research. However, this was not preferred by employees from the feedback and the picked-up rate is low. Therefore, this approach was suspended. And one respondent was collected via filling in the questionnaire face to face. However, the overall response rate was very low. Only two responses, one from Poland and one from The Netherlands were received and both of them were collected via email.

The possible reason for the low response rate could be the infancy stage of LM within the food industry and also lack of contact information of quality manager who is more interested into the topic, instead of only sending a questionnaire to the general email of a company. The third response was collected from a SME meat company where the author did the internship in. Therefore, possible an informal interview can also be made to get a further explanation if necessary.

In total, there are three SMEs meat companies taking participate in this research shown in table 3(Company A: producing cold meat; Company B: producing ready-to-eat meat; Company C: producing sausage).

Table 3: information of responded companies

company	products	Number of employees	position
A	Cold meat	50-250	QA manager
B	Ready-to-eat meat	10-50	QA manager
C	Sausage	50-250	Technical manager

3.3.1 Specific analysis method to address each hypothesis

There are two main analysis methods which were involved, one is the mean score and another one is the ANOVA test. The mean score of each lean tool, lean bundle and performance for each dimension was calculated based on the data collected from the 7-Likert scale. ANOVA test was conducted to see whether there is a significant difference between each lean bundle and each quality dimensions. The following section will be introduced how to use these data to test each hypothesis in details.

Hypothesis 1: Manufacturing plants with a different prioritized objective will have a different preference in the choice of the lean bundle. The objective of different companies and the implementation level of the different lean bundle should all be acquired from the questionnaire. This hypothesis was tested for each company respectively. The prioritized objective of each company was indicated directly by respondents. The implementation level of different lean bundles can be calculated from scores for lean tools. There are in total five lean bundles and each lean tools falls in a different lean bundle. The implementation level of a certain lean bundle can be reflected by its mean value. This mean value can be calculated by adding up the scores of lean tools which are in the same lean bundle and then divided by the numbers of lean tool included. An example could be the calculation of the mean score for JIT bundle. In company A, all score within JIT is added up to 44, and there are in total 10 tools within JIT bundle, so the average of JIT implementation level of company A is 4.4. The higher score indicates a higher implementation level of that specific lean bundle in the company. For further confirmation, an ANOVA analysis for each company is conducted to see if there is an obvious difference between each lean bundle. If a difference exists, the implementation level of lean bundles will be ranked to see if there is an alignment between prioritized objective and lean bundle choice.

Hypothesis 2: the lean tools in a basic cluster, namely employee involvement, visual display, standardization of operation, SPC, supplier feedback and multi-function training to the employee are more frequently adopted by SMEs in food industry than other advanced lean tools. This might because of the lack of finance availability and technical know-how, SMEs tends to have a higher implementation level of basic lean tools.

This analysis is conducted by combining data from all three companies. Since the main goal of this hypothesis is intended to find out what are the lean tools preference on a general level. The mean score of each lean tool from three companies is used to represent the preference level of each lean tools. Scores for the same lean tools will be added up together and divided by the number of questions involved. For example the mean score of multi-function training to the employee. The total added up a score of this lean tools from three companies of 6 questions is 37and then divided by 6, the mean score of lean tools is 6.17.

The higher score indicates a higher implementation level among three companies. Mean score of each lean tool will be calculated in this way. Those with higher scores will be compared with the suggested basic lean tools to check whether they the same, in this way, the hypothesis is tested.

One of the major characteristics is that these lean tools can be classified as technological and managerial lean tools. Therefore, it is also interesting to see if there is a difference in the implementation level of various lean tools from the technological and managerial perspective. This is calculated by adding up all the score of each lean tools within the technological category or managerial category. And divided by the number of questions involved. For example. In order to calculate the mean score of the technological lean bundle in company A, the score of lean tools which belong to technological lean bundle should be added up, in this case, the total score of the technological lean bundle of company A is 97.2, and this is obtained from 24 questions. The mean score of the technological lean bundle is therefore 4.05 for company A. The mean score of the technological and managerial category will be compared to see if there is a different level in this aspect in different companies.

Hypothesis 3: a relative higher implementation level of a certain lean bundle will lead to a higher increase in its corresponding indicators than others. The reason behind this is that literature suggests that each lean bundle has its main focus among quality, cost and delivery, if a higher implementation of a certain lean bundle is achieved, then its corresponding dimensions will have a better performance.

An overall judgment of the implementation of each company is made to see whether the implementation brings positive improvement to the company. And then the test of hypothesis 3 was conducted. The most implemented lean bundle and the performance of each dimension were acquired to test this. This hypothesis is tested for each company respectively. The most implemented lean bundle is chosen based on its mean score. The mean score of each lean bundle was already calculated and presented when testing hypothesis 1. Lean bundle with the highest mean score will be chosen as the most implemented lean bundle. However, this is only valid when the difference does exist among these lean bundle via ANOVA test in hypothesis 1. Otherwise, no most implemented lean bundle exists in that company.

The performance of each dimension is reflected by the mean score of indicators which represent the same dimension. Three dimensions, namely, quality, cost and delivery have 2, 2 and 4 indicators respectively. The performance of each indicator is indicated by respondents from 1-7. An example of calculating a mean score for a dimension could be calculating the mean score of the quality in company A. Two indicators are used to assess quality performance, one has a score of 1 and the other is 2. Then the average score of quality dimension in company A is 1.5. Mean score which is larger than 4 means positive improvement has been achieved. The larger score represents higher performance in that dimension.

However, the same as lean bundle difference comparison, for further confirmation, an ANOVA analysis is conducted to check if there is a significant difference between different dimensions. If a significant difference exists, the performance dimensions will be ranked to see if there is an alignment between the most implemented lean bundle and performance output.

Chapter 4 Results and discussion

First, the influence of company objectives and size on the choice of the lean bundle and lean tools were tested in hypothesis 1 and 2. The relationship between outcome performance and lean tools choice were checked in hypothesis 3.

4.1 Relationship between lean bundles choice and company objectives

This section is intended to address *Hypothesis 1: Manufacturing plants with a different prioritized objective will have a different preference in the choice of the lean bundle.*

Results collected from three companies show they all have different objectives ranking. More detailed rank information of objective regarding each company is shown in table 4 below.

Table 4: objectives ranks in each company

	Rank: 1st	2nd	3rd
Company A	Quality	Delivery	cost
Company B	Delivery	Quality	cost
Company C	Quality	Cost	Delivery

Company A and Company C view quality as their main objective, however, Company B recognized delivery as the most important objective. Three companies have a different view of what are the second important objectives. For the least important objectives, company A and B believed that cost is the one which is least considered while company C view delivery performance is less important compared with quality and cost.

The mean score of each lean bundle within each company is presented in Table 5 and an ANOVA test was conducted to test the difference of each lean bundle.

Table 5: Mean score of the lean bundle in each company

	Company A: a	Company B: b	Company C: a
TQM: mean	3.7	2.7	6.6
JIT: mean	4.4	2.3	6.8
TPM: mean	4.0	1.0	6.6
Employee involvement: mean	3.6	5.1	6.8
Supplier involvement: mean	4.8	2.8	6.3

"1"=low implementation level "4"= neutral implementation level "7"= high implementation level

(a: not significant, b: significant)

In company A, supplier involvement tools have the highest score. There is no obvious difference between lean bundle implementation in company A and Company C. In Company B, the difference exists, and employee involvement tools are the one that has the highest implementation level.

Company A and C have quality as the main objective, which means they should have a higher implementation level of TQM lean bundle. But there is no obvious difference in the types of lean bundle in these two companies. Therefore hypothesis 1 is not valid in case A and C, And for company B, JIT is the corresponding lean bundle of delivery objective but in case B, employee involvement has the highest implementation level. Overall, the first hypothesis is not valid. It is suggested that manufacturing plants with a different prioritized objective do not have a different preference in the choice of lean bundle

This reason can be the lack of knowledge of the change agent in SMEs. However, literature does not specify what these knowledge are (Dora et al., 2013a; Zhou, 2012).

To find out what these knowledge are, a short and informal discussion was conducted with QA officer from Company C where the author did the internship. During the short discussion, questions like "which quality dimension do you think that TQM (a specific lean bundle) targets at?" are raised. From the collected data, company C shows a higher implementation level of LM than other two companies with a higher score in each lean bundle. However, the change agent doesn't have a very accurate understating the function of each lean bundle. For most of the technological lean bundle, she directly related to quality and cannot differentiate the difference of these lean bundle`s objectives. It is even confusing when it comes to the function of the managerial lean bundle. She does not recognize those managerial bundles as part of lean manufacturing.

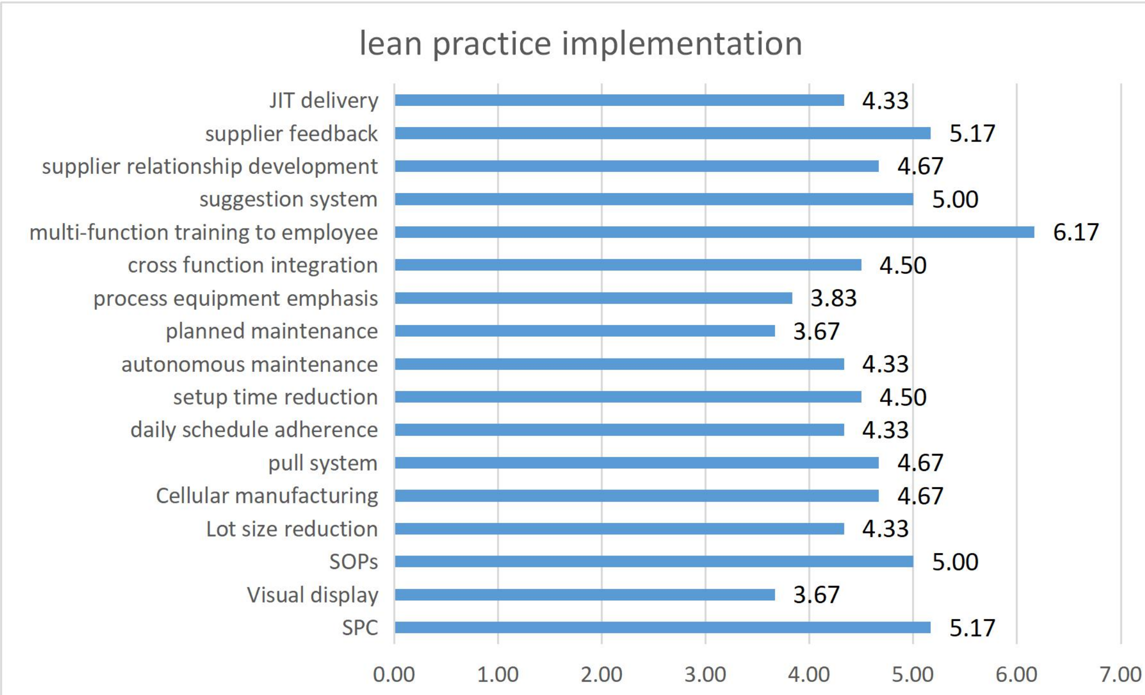
Therefore, the possible reason for this misalignment could be that in SMEs companies, employees or the change agent lack of adequate knowledge about the main focus of each lean bundle. They do not have a clear understanding of what could be the influence and which quality dimension these lean bundles target at.

The influencing factor of the objective in lean bundle choice is not proved, however, from the ANOVA analysis, the big variance within each lean bundle indicates that, compared with focusing on a specific lean bundle, the company tends to focus on certain lean tools. And this leads to the second hypothesis.

4.2 Lean tools choice preference in SMEs

This section focuses on *H2: The lean tools in the basic cluster are more frequently adopted by SMEs in food industry than other advanced lean tools.*

The top five lean bundles were chosen based on the mean score of each lean tools. Figure 16 about the mean score for each lean practice is shown below.



"1"=low implementation level "4"= neutral implementation level "7"= high implementation

Figure 16 Mean scores for each lean tool from three companies

The top five lean practices are multi-function training to employees, SPC, supplier feedback, suggestion system and SOPs. Multi-function training to employee tool is the one that has the highest implementation level with a mean score of 6.17 and followed by SPC and supplier feedback, with the same score of 5.17. Suggestion system and SOPs, with a score of 5, are the last two that within top 5 implemented list.

This is in line with the hypothesis except for visual display. Therefore, this hypothesis is valid in these three companies and this finding provides extra evidence that within SMEs food companies, basic lean tools are more preferred than other lean tools. The staff-challenge and inadequate supporting environment might be the reasons demonstrated in Chapter 2.2.2. However, due to the limited data collected, this result is only suggestive.

Lean tools preference from a technological and managerial perspective

In order to get a more in-depth view of the implementation of the lean tools in SMEs meat companies, analysis from the perspective of technological and managerial is adopted. Since improving company performance through both technological and managerial approach is the main characteristic of LM. And LM is also viewed as technological and managerial manufacturing practice and all the lean tools can be classified as technological or managerial lean bundle.

The detailed information of each company is shown in table 8 below.

Table 8: Tech-managerial lean bundle preference in companies

	Company A: Medium size	Company B: Micro size	Company C: Medium size
LM implementation mean	4.38	3.0	6.65
Technological lean tools mean	4.05	2.01	6.62
Managerial lean tools mean	4.25	4	6.67

"1"=low implementation level "4"= neutral implementation level "7"= high implementation

The average score of technological and managerial lean tools are calculated and shown by each company. The implementation level of LM tools shows a difference between three companies. Company C has the most comprehensive implementation level with an average score of 6.6 and followed by Company A and company C, averagely scoring at 4.3 and 3.0 respectively. Company A and C have a relatively higher implementation level compared with micro size company B with the number of employees smaller than 10. It is interesting to see that the gap between two lean categories also varies. The gap in Company B around 2 points, is larger than the difference of Company A and C with a gap less than 1.

Company B is categorized as a micro size company with less than 10 employees and others two are the medium size companies with employees larger than50. Therefore, the result also suggests that the medium size company show more balance with respect to the technological and managerial lean tools implementation than the micro size company at least for these companies.

This can be possibly explained by financial availability. Those medium size companies make more turnover than the small ones, which means they are able to financially support the company to introduce some technological lean bundle which is considered more money-consuming. Therefore, the difference level of managerial and technological in the medium size company is smaller than the difference in the small size company.

However, in the literature, the small and medium size companies are always viewed as one category. Therefore this finding needs to be further validated by more researches focusing on the difference between the small and medium size companies.

Overall, hypothesis 2 is suggested to be valid in these three cases. Lean bundles within basic cluster indeed enjoy more popularity compared with other relatively advanced lean tools. It is also found that medium size companies show more balance with respect to the implementation of the technological and managerial lean bundle compared with the micro size company. However, due to limited sample size, the finding is only suggestive.

4.3 Relationship of prioritized lean bundle and performance output

This section focuses on *H3: A relative higher implementation level of a certain lean bundle will lead to a higher increase in its corresponding indicators than others*

An judgment on the overall performance of each company was made to check whether implementing LM brings a positive influence on company performance or not.

There are in total eight indicators are formulated to assess the quality, cost and delivery performance. Respondents are required to rate the performance of each indicator on a scale of 1-7(1=negative, 4=neutral, 7=positive). The detailed performance of each indicator for each company is presented in table 9. “-” means negative improvement with a score smaller than 4. “+/-” indicates no obvious improvement with a score of 4. “+” explains the positive improvement in performance. If overall performance improvement has been realized, then the implementation of LM can be recognized as successful.

Table 9: Company performance overview

Dimensions	Indicator	Company A	Company B	Company C
Quality	First-pass quality yield	-	+	+
	Scrap and rework cost reduction	-	+/-	+
Cost	Per unit cost reduction	-	+/-	+
	Productivity of employees	-	+	+
Delivery	Delivery lead time reduction	-	+/-	+
	Throughput time reduction	+/-	+/-	+
	Late rate reduction	-	+	+
	Lateness level reduction	-	+	+
	Overall assessment	Unsuccessful	Successful	Successful

“-” = negative performance “+/-”= neutral performance “+”=positive performance

Company A does not show positive improvement in every aspect of performance. Therefore the implementation of LM in company A is unsuccessful. Company C has the highest level of LM implementation level and also shows positive improvement in every indicator. So the implementation is successful in Company C. Even though, Company B does not show positive improvement in each indicator, in every dimension, there is still some progress has been made in improving first-pass quality yield, the productivity of employees and reduction of lateness level. The implementation is successful in Company B.

The following section will address the hypothesis 3 to see if there is an alignment between the implemented lean tools and performance outcome for each company. Each lean bundle has its own main focus. Therefore the relationship of each lean bundle and performance will only focus on prioritized lean bundle. This is meant to check if there is an alignment between a higher implementation level of a certain lean bundle and a higher performance level of the targeted indicators. Possible other findings can be extracted from the performance of each company. And this is presented by each company.

Company A

The mean score for different dimensions was calculated and presented in table 10. A score which is larger than 4 means that positive improvement is achieved. The higher score reflects better performance. Variance test shows that there is a obvious difference among the three performance dimensions. with a p-value of 0.04. The performance of each quality dimension was ranked and shown in table 10.

Table 10: Performance output of Company A

Performance indicators	Rank	Average score	score
Quality indicators:			
first-pass yield	3	1.5	1
scrap and rework cost			2
Cost indicators:			
per-unit cost	2	2.5	3
employee productivity			2
Delivery indicators:			
Throughput time	1	3.25	3
Delivery lead time			4
Late rate			3
Lateness level			3

"1" = negative performance "4"= neutral performance "7"=positive performance

The delivery performance ranks the first with a score of 3.25, followed by cost and quality. the higher score implies a better performance. Company A has a better performance in delivery.

However, since there is no difference in the lean bundle as shown in table 5, the possible alignment relationship between the prioritized lean bundle and performance improvement is not able to prove. Therefore H3 is not able to prove in company A. But the possible reason for the unsuccessful performance is identified.

The failure can be attributed to the lack of implementation of employee involvement tools. Philips (2002) proposed that employee involvement tools are one of the most important success factors in LM implementation. The common situation in SMEs is that most of them hire people with low skills. And normally operators do not have the mindset of skill enhancement. LM as a quality improvement management system requires the ideology of skill enhancement. The reason is that some implementation of technological lean tools requires employees` skills. One of the functions of LM is to improve plant productivity and reduce cost. And this improvement, in some cases, is able to create a fear of job loss. Therefore, some of them do not feel motivated and reluctant to make some changes according to Achanga et al. (2006).

This is also in line with the situation of Company A. The significant difference of company A compared with the other two companies is the implementation level of employee involvement tools. As demonstrated in Table 5, mean score for each lean bundle, Employees involvement have the highest mean score in both company B and C, whereas, Company C does not put much attention on this lean bundle from the perspective of mean score.

Company B

The same analysis method was adopted as company A. The performance of company B in each dimension is shown in table 11.

Table 11: Performance output of Company B

Performance indicators	Average score	score
Quality indicators:		
first-pass yield	4.5	5
scrap and rework cost		4
Cost indicators:		
per-unit cost	4.5	4
employee productivity		5
Delivery indicators:		
Throughput time	4.5	4
Delivery lead time		4
Late rate		5
Lateness level		5

"1" = negative performance "4"= neutral performance "7"=positive performance

The ANOVA analysis is not conducted since, in three different dimensions, Companies have the same performance, meaning the same score is acquired in each dimension. And this score is larger than 4 implying that positive improvement in each dimension is achieved in Company B with the implementation of LM. The implementation is successful.

In order to discover the possible relationship between chosen lean tools and performance. The lean bundle chosen situation in company B is presented in table12. And in table 7, the ANOVA test indicates that the significant difference in the implementation of a different lean bundle in Company B does exist, the lean bundle implementation level was ranked and presented also in table 12.

Table 12: Lean bundle implementation in company B

Lean bundles	score	Rank
TQM	2.75	3
JIT	2.3	4
TPM	1	5
Supplier involvement tools	2.83	2
Employee involvement tools	5.17	1

“1” = negative performance “4”= neutral performance “7”=positive performance

This mean score for each lean bundle is calculated based on the score of each lean tools that within the same lean bundle category. Within company B, employee involvement tools enjoy the highest level of implementation. And the score of other lean bundle are all smaller than 4, shows a lower level of other lean bundles.

The prioritized lean bundle in company B is employee involvement tool. Employee involvement tools act as a foundation for LM which can create a suitable environment for LM technological and managerial lean tools implementation. Therefore it is suggested that employee involvements tools can have an influence on all quality indicators from literature(Cua et al., 2001; Furlan et al., 2011). This also means that employee involvement tools do not have a specific corresponding indicators, therefore it is also not possible to check hypothesis 3 in company B.

The literature suggested that SMEs are able to improve its performance by following a piecemeal approach (Achanga et al.,2006). This finding can be underpinned with the situation of company B.

The low mean score for other lean bundles expect for employee involvement tools indicates that company B only focus on implementing one lean bundle which is a piecemeal approach. In the judgement of company performance, the implementation in company B is recognized as successful. The single emphasis on employee involvement brings positive improvement of each aspect in company B, meaning the piecemeal approach can also help the company to improve its performance.

Company C

The performance of indicators was presented and the variance between them was also calculated. From the ANOVA analysis, the p-value of the three dimension performance is 0.19 which means that obvious difference does not exist and the performance level will therefore not be ranked. The more detailed information shown in table 13.

Table13: Performance output of Company C

Performance indicators	Average score	score
Quality indicators:		
first-pass yield	5.5	6
scrap and rework cost		5
Cost indicators:		
per-unit cost	6	6
employee productivity		6
Delivery indicators:		
Throughput time	6.5	7
Delivery lead time		6
Late rate		7
Lateness level		6

"1" = negative performance "4"= neutral performance "7"=positive performance

The score which is larger than 4 means positive improvement has been achieved. The score of each indicator is larger than 4. Delivery performance has the highest score of 6.5 and followed by cost and quality performance. The overall performance of the three dimensions is also the best of the three companies from the perspective of the mean score.

However, since there is no difference in the lean bundle as shown in table 5, the possible alignment relationship between the prioritized lean bundle and performance improvement is not able to prove. Therefore H3 is not able to prove in company C. But an extra finding can be made which is explained in the following content.

A high implementation level of all lean bundles can possibly result in a better performance in all three dimensions. This was demonstrated by Dora (2015) that implementation of LM can improve company performance in terms of quality, delivery and cost.

Table 5 shows the situation for each lean bundle implementation in company C, and each score is larger than 6, indicating an advanced implementation level of each lean bundle in company C was achieved. And in Table 13, the average score for all the performance indicators is 6, showing that a higher improvement in overall performance was also achieved. This alignment can be explained by that each lean bundle has its main focus regarding quality, cost and delivery. And can also provide extra evidence that a higher implementation level of all lean bundles can results in a better performance in all three dimensions.

The relationship of prioritized lean bundle and performance, namely H3 is not able to prove in Company A and Company C since there is no difference in the implementation level of each lean bundle. Due to the fact that employee involvement do not have its corresponding indicators, hypothesis 3 is not able to test in Company B case. But different findings can be discovered based on the performance situation in each company and these findings can all be supported by the literature. More specifically, employee involvement might be an important success factor in LM from company A case. Piecemeal approach can also bring positive benefits to performance in SMEs based on the situation of company B. The last finding is that a higher implementation of all lean bundle can have a higher performance in all three different quality dimensions.

Chapter 5 Conclusion

5.1 Overall conclusion

In this research, three hypotheses of LM in SME meat companies have been tested respectively based on the collected data.

Hypothesis 1, it is suggested that manufacturing plants with a different prioritized objective do not have a different preference in the choice of the lean bundle. From asking the priority of each company`s objective, it is clear to see that they do show preference over quality, cost and delivery. However, this is not reflected in the lean bundles that they choose. ANOVA analysis demonstrates that the variance within each lean bundle is actually larger than that between each lean bundle, meaning that companies do not have a preference on a certain lean bundle with different objectives. On the contrast, the corresponding lean bundle surprisingly has a low-level implementation, namely a lower mean score among all lean bundles. More specifically, both Company A and Company C put quality as the main objective. However, TQM which has a direct relationship with quality from literature has a relatively low implementation level. Delivery performance is recognized as the main objective of Company B, JIT, as the corresponding lean bundle also is also relatively low. The possible reason, as suggested by the literature, could be the lack of knowledge of specific lean bundle of SME change agent. A short discussion with QA officer from company C confirms that change agent does have limited knowledge about each specific lean bundle even though they have an overall highest implementation LM in both three companies.

Hypothesis 2 is that the lean tools in the basic cluster, namely employee involvement, visual display, standardization of operation, SPC, supplier feedback and multi-function training to the employee are more frequently adopted by SMEs in food industry than other advanced lean tools. Among all these lean practices, basic lean practices except for visual display are found to be more popular in SMEs meat companies. Therefore, hypothesis 2 is suggested to be valid in these three cases. Those lean practices are multi-function training to employees, SPC, supplier feedback, suggestion system, and SOP. They are selected as popular ones because they have the higher mean score compared with other lean tools. Lean practices are also compared from technological and managerial perspective. It suggested that company size might play a role in the balance of these two different lean bundle. More specifically, company A and C, as medium size companies, have an equal implementation level of technological and managerial lean bundles whereas, company B, as a micro size company, has a higher preference in implementing managerial lean bundles.

Hypothesis 3 addresses the possible relationship between the chosen lean bundle and performance output. It is hypothesized that the relatively higher implementation level of a certain lean tool will lead to a higher increase in its corresponding indicators than others. However, this hypothesis is not able to prove. Since there is no obvious difference in the implementation level of the lean bundle in Company A and Company C. It is not able to draw conclusion only based on Company B. There are still some other findings based on the performance of each company. In company A, the lack of implementation of employee involvement tools might be the reason for the unsuccessful performance. Company B can provide evidence that the adoption of piecemeal can still bring positive improvement in performance. Since slight improvement has been achieved in every dimension of company B even though, employee involvement bundle is the only focus. A higher implementation level of every lean bundle can lead to a significant improvement of different performance dimensions.

5.2 Limitation

The main limitation of this thesis is the small amount of data collected. In total, only three companies, two of them are medium size companies and one is the micro size company. Therefore, the conclusion is only suggestive.

The second limitation is that the answers to these questions are subjective. Questions are designed to ask the QA manager about their perception of the performance of the company. However, these subjective views probably cannot reflect the whole image of LM implementation level and performance within that company accurately.

5.3 Recommendation

There are some recommendations can be made if further research would be conducted.

- This research can also be extrapolated to another food sector to see the difference between each sector regarding lean tools implementation and performance.
- This research can reflect the general situation of lean implementation in SMEs, however, how SMEs, in practice, implement and view these lean tools still remain unclear. Further research can be conducted on how SMEs implement or modify these lean tools to make it suitable in this context.

- Information from large companies can also be collected and compared in further research to see the difference between large companies and SMEs in terms of objective and lean tools and outcome performance.

5.4 Reflection

This chapter focus on the self reflection of the whole Master thesis process and self-evaluation of the achievement from both an academic and a personal progress perspectives.

This is a rewarding and challenging process from the very beginning until the end. Based on my own understanding of this topic, the first proposal draft was submitted. However, I agreed with the comment from my supervisor Geoffrey that what I wrote at that time was a bit drift away from quality and also difficult to use the tech-managerial approach. A lot of discussions have been made on the direction and objective of this research. Later, I was also feel challenged in the literature review part. It is not only extensive literature review work but building a logical thinking along reading and expressing in a logical and proper way, which also requires a lot of time and energy. The most difficult part is the data collection part. Only seldom response from around 100 emails, makes me feel depressed. However, it is in this period that I learn the importance of being positive and keep trying when difficulties come. I also got the valuable suggestion for the data analysis part from my supervisors both Geoffrey and Catriona. Their suggestion makes me realize how to formulate analysis part in a more clear way.

Those challenges that I face during the thesis motivate and help me to make progress in terms of academic level. Formulating a research framework based on literature research teaches me how to do a decision making in a report. In the relationship between lean bundles and quality performance, different authors have the different view and sometimes similar researches could propose different conclusions. By doing judgment on the usefulness, reliability, validity and relevancy of all reviewed literature. Important relationships have been identified and finally, a research framework could be formulated.

It is also a process that helps me to make some personal progress. The first one is the ability to organize literature. Lots of paper are read and downloaded, during this process, I learned how to be able to organize them and find them efficiently and acutely when needed. Another important skill that I picked is emotion management. I felt a lot of pressure when building a research framework and searching for respondents. Sometimes I can not even focus on work because of this stress feeling. However, thanks for the emotional support from friends and technical advises from supervisors of how to do things, I would say I am more confident now in confronting difficulties and be able to deal with it in a more effective and efficient way.

This is a long and challenging journey. However thanks to all these valuable suggestions given by both Geoffrey and Catriona at every stage of this thesis work, I am able to manage it and get ready to graduate.

Reference

Achanga, P., E. Shehab, R. Roy, and G. Nelder, 2006, Critical success factors for lean implementation within SMEs: Journal of Manufacturing Technology Management, v. 17, p. 460-471.

Banker, R. D., I. R. Bardhan, H. Chang, and S. Lin, 2006, Plant information systems, manufacturing capabilities, and plant performance: MIS quarterly, p. 315-337.

Behrouzi, F., and K. Y. Wong, 2011, Lean performance evaluation of manufacturing systems: A dynamic and innovative approach: Procedia Computer Science, v. 3, p. 388-395.

Belekoukias, I., J. A. Garza-Reyes, and V. Kumar, 2014, The impact of lean methods and tools on the operational performance of manufacturing organisations: International Journal of Production Research, v. 52, p. 5346-5366.

Bhasin, S., and P. Burcher, 2006, Lean viewed as a philosophy: Journal of manufacturing technology management, v. 17, p. 56-72.

Bititci, U. S., P. Suwignjo, and A. Carrie, 2001, Strategy management through quantitative modelling of performance measurement systems: International Journal of production economics, v. 69, p. 15-22.

Black, J., 2007, Design rules for implementing the Toyota Production System: International Journal of Production Research, v. 45, p. 3639-3664.

Bortolotti, T., P. Danese, and P. Romano, 2013, Assessing the impact of just-in-time on operational performance at varying degrees of repetitiveness: International Journal of Production Research, v. 51, p. 1117-1130.

Brown, K. A., and T. R. Mitchell, 1991, A comparison of just-in-time and batch manufacturing: the role of performance obstacles: Academy of Management Journal, v. 34, p. 906-917.

Chan, F. T. S., H. C. W. Lau, R. W. L. Ip, H. K. Chan, and S. Kong, 2005, Implementation of total productive maintenance: A case study: International Journal of Production Economics, v. 95, p. 71-94.

Chatha, K., and I. Butt, 2015, Themes of study in manufacturing strategy literature: International Journal of Operations & Production Management, v. 35, p. 604-698.

Christiansen, T., W. L. Berry, P. Bruun, and P. Ward, 2003, A mapping of competitive priorities, manufacturing practices, and operational performance in groups of Danish manufacturing companies: International Journal of Operations & Production Management, v. 23, p. 1163-1183.

CIAA, 2010, SMEs in the EU food and drink industry: Confederation of the Food and Drink Industries of the EU, Brussels.

Commission, E., 2003, SME user guide, Official Journal of the European Union,L124, 36.

Corbett, L. M., 1998, Benchmarking manufacturing performance in Australia and New Zealand: Benchmarking for Quality Management & Technology, v. 5, p. 271-282.

Cox, A., and D. Chicksand, 2005, The Limits of Lean Management Thinking:: Multiple Retailers and Food and Farming Supply Chains: European Management Journal, v. 23, p. 648-662.

Cua, K. O., K. E. McKone-Sweet, and R. G. Schroeder, 2006, Improving performance through an integrated manufacturing program: The Quality Management Journal, v. 13, p. 45.

Cua, K. O., K. E. McKone, and R. G. Schroeder, 2001, Relationships between implementation of TQM, JIT, and TPM and manufacturing performance: Journal of operations management, v. 19, p. 675-694.

Cutcher-Gershenfeld, J., M. Nitta, B. Barrett, N. Belhedi, J. Bullard, C. Coutchie, T. Inaba, I. Ishino, S. Lee, and W.-J. Lin, 1994, Japanese team-based work systems in North America: explaining the diversity: California Management Review, v. 37, p. 42-64.
Dal Pont, G., A. Furlan, and A. Vinelli, 2008, Interrelationships among lean bundles and their effects on operational performance: Operations Management Research, v. 1, p. 150-158.
Danese, P., P. Romano, and T. Bortolotti, 2012, JIT production, JIT supply and performance: investigating the moderating effects: Industrial Management & Data Systems, v. 112, p. 441-465.
Dean, J. W., and D. E. Bowen, 1994, Management theory and total quality: improving research and practice through theory development: Academy of management review, v. 19, p. 392-418.
Dearden, L., H. Reed, and J. Van Reenen, 2006, The impact of training on productivity and wages: Evidence from British panel data: Oxford bulletin of economics and statistics, v. 68, p. 397-421.
Diekmann, J. E., M. Krewedl, J. Balonick, T. Stewart, and S. Won, 2004, Application of lean manufacturing principles to construction: Boulder, CO, Construction Industry Institute, v. 191.
Dora, M., and X. Gellynck, 2015, House of lean for food processing SMEs: Trends in Food Science & Technology, v. 44, p. 272-281.
Dora, M., M. Kumar, and X. Gellynck, 2015, Determinants and barriers to lean implementation in food-processing SMEs – a multiple case analysis: Production Planning & Control, v. 27, p. 1-23.
Dora, M., M. Kumar, D. Van Goubergen, A. Molnar, and X. Gellynck, 2013a, Food quality management system: Reviewing assessment strategies and a feasibility study for European food small and medium-sized enterprises: Food Control, v. 31, p. 607-616.
Dora, M., M. Kumar, D. Van Goubergen, A. Molnar, and X. Gellynck, 2013b, Operational performance and critical success factors of lean manufacturing in European food processing SMEs: Trends in Food Science & Technology, v. 31, p. 156-164.
Dora, M., D. Van Goubergen, M. Kumar, A. Molnar, and X. Gellynck, 2014, Application of lean practices in small and medium-sized food enterprises: British Food Journal, v. 116, p. 125-141.
Drazin, R., 1995, Organizational size: The Blackwell Encyclopedic Dictionary of Organizational Behavior. Blackwell, Cambridge, MA, p. 399-400.
Dudbridge, M., 2011, Handbook of lean manufacturing in the food industry, John Wiley & Sons.
Ezingeard, J.-N., and P. Race, 1995, Spreadsheet simulation to aid capacity management of batch chemical processing using JIT pull control: International Journal of Operations & Production Management, v. 15, p. 82-88.
Flynn, B. B., S. Sakakibara, and R. G. Schroeder, 1995, Relationship between JIT and TQM: practices and performance: Academy of management Journal, v. 38, p. 1325-1360.
Furlan, A., A. Vinelli, and G. Dal Pont, 2011, Complementarity and lean manufacturing bundles: an empirical analysis: International Journal of Operations & Production Management, v. 31, p. 835-850.
Fynes, B., C. Voss, and S. de Búrca, 2005, The impact of supply chain relationship quality on quality performance: International Journal of Production Economics, v. 96, p. 339-354.
Garvin, D., 1987, Competing on the eight dimensions of quality: Harv. Bus. Rev., p. 101-109.
Ghalayini, A. M., J. S. Noble, and T. J. Crowe, 1997, An integrated dynamic performance measurement system for improving manufacturing competitiveness: International Journal of Production Economics, v. 48, p. 207-225.
Goncharuk, A. G., 2009, How to make meat business more effective: a case of Ukraine: British Food Journal, v. 111, p. 583-597.

Hallgren, M., and J. Olhager, 2009, Lean and agile manufacturing: external and internal drivers and performance outcomes: International Journal of Operations & Production Management, v. 29, p. 976-999.

Hart, C., and L. Schlesinger, 1991, Total quality management and the human resource professional: applying the Baldrige framework to human resources: Human Resource Management, v. 30, p. 433-454.

Heymans, B., 2015, Lean manufacturing and the food industry: Journal of Technology Management & Innovation, v. 10, p. 120-130.

Hofer, C., C. Eroglu, and A. Rossiter Hofer, 2012, The effect of lean production on financial performance: The mediating role of inventory leanness: International Journal of Production Economics, v. 138, p. 242-253.

Juran, J. M., 2003, Juran on leadership for quality, Simon and Schuster.

Knowles, G., M. Johnson, and S. Warwood, 2004, Medicated sweet variability: a six sigma application at a UK food manufacturer: The TQM Magazine, v. 16, p. 284-292.

Konecny, P. A., and J.-H. Thun, 2011, Do it separately or simultaneously—An empirical analysis of a conjoint implementation of TQM and TPM on plant performance: International Journal of Production Economics, v. 133, p. 496-507.

Krause, D. R., R. B. Handfield, and B. B. Tyler, 2007, The relationships between supplier development, commitment, social capital accumulation and performance improvement: Journal of Operations Management, v. 25, p. 528-545.

Krizner, K., 2001, Manufacturers adopt a lean philosophy: Frontline Solutions, v. 2, p. 22-22.

Kumar, M., and J. Antony, 2008, Comparing the quality management practices in UK SMEs: Industrial Management & Data Systems, v. 108, p. 1153-1166.

Lathin, D., and R. Mitchell, 2001, Lean manufacturing: techniques, people and culture: ASQ World Conference on Quality and Improvement Proceedings, p. 321.

Lewis, M. A., 2000, Lean production and sustainable competitive advantage: International Journal of Operations & Production Management, v. 20, p. 959-978.

Lim, S. A. H., J. Antony, and S. Albliwi, 2014, Statistical Process Control (SPC) in the food industry–A systematic review and future research agenda: Trends in food science & technology, v. 37, p. 137-151.

Luning P A, M. W. J., Jongen W M F, 2002, Food quality management: a techno-managerial approach: Wageningen Pers.

Mahalik, N. P., and A. N. Nambiar, 2010, Trends in food packaging and manufacturing systems and technology: Trends in food science & technology, v. 21, p. 117-128.

Mathews Jr, K., and J. Buzby, 2001, Dissecting the challenges of mad cow and foot-and-mouth disease: Agricultural Outlook, p. 4-6.

McKone, K. E., R. G. Schroeder, and K. O. Cua, 2001, The impact of total productive maintenance practices on manufacturing performance: Journal of Operations Management, v. 19, p. 39-58.

Melton, T., 2005, The Benefits of Lean Manufacturing: What Lean Thinking has to Offer the Process Industries: Chemical Engineering Research and Design, v. 83, p. 662-673.

Milgate, M., 2001, Supply chain complexity and delivery performance: an international exploratory study: Supply Chain Management: An International Journal, v. 6, p. 106-118.

Nakajima, S., 1988, Introduction to TPM: Total Productive Maintenance.(Translation): Productivity Press, Inc., 1988, p. 129.

Newbert, S. L., 2008, Value, Rareness, Competitive Advantage, and Performance: A Conceptual-Level Empirical Investigation of the Resource-Based View of the Firm: Strategic Management Journal, v. 29, p. 745-768.

Paez, O., J. Dewees, A. Genaidy, S. Tuncel, W. Karwowski, and J. Zurada, 2004, The lean manufacturing enterprise: An emerging sociotechnological system integration: Human Factors and Ergonomics in Manufacturing & Service Industries, v. 14, p. 285-306.

Paez, O., S. Salem, J. Solomon, and A. Genaidy, 2005, Moving from lean manufacturing to lean construction: Toward a common sociotechnological framework: Human Factors and Ergonomics in Manufacturing & Service Industries, v. 15, p. 233-245.

Panwar, A., B. P. Nepal, R. Jain, and A. P. S. Rathore, 2015, On the adoption of lean manufacturing principles in process industries: Production Planning & Control, v. 26, p. 564-587.

Peteraf, M. A., and J. B. Barney, 2003, Unraveling the resource‐based tangle: Managerial and decision economics, v. 24, p. 309-323.

Philips, E., 2002, Pros and cons of lean manufacturing: Forming and Fabricating, v. 9, p. 1-5.

Powell, D., E. Alfnes, and M. Semini, 2009, The application of lean production control methods within a process-type industry: the case of hydro automotive structures: IFIP International Conference on Advances in Production Management Systems, p. 243-250.

Rahman, S., T. Laosirihongthong, and A. S. Sohal, 2010, Impact of lean strategy on operational performance: a study of Thai manufacturing companies: Journal of manufacturing technology management, v. 21, p. 839-852.

Rajput, H. S., and P. Jayaswal, 2012, A Total Productive maintenance (tpm) approach to improve overall equipment efficiency: International Journal of modern engineering research, v. 2, p. 4383-4386.

Rajurkar, S. W., and R. Jain, 2011, Food supply chain management: review, classification and analysis of literature: International Journal of Integrated Supply Management, v. 6, p. 33-72.

Roberts, J., 1997, Total productive maintenance (TPM): Available from: JackRobert@ TAMU_Commerce. edu (accessed June, 2007).

Rose, A., B. M. Deros, and M. A. Rahman, 2010, Development of framework for lean manufacturing implementation in SMEs: The 11th Asia Pacific industrial engineering and management systems conference, Melaka, Malaysia.

Rose, A., B. M. Deros, M. A. Rahman, and N. Nordin, 2011, Lean manufacturing best practices in SMEs: Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management, p. 872-877.

Roy, R., and K. Guin, 1999, A proposed model of JIT purchasing in an integrated steel plant: International journal of production economics, v. 59, p. 179-187.

Samson, D., and M. Terziovski, 1999, The relationship between total quality management practices and operational performance: Journal of Operations Management, v. 17, p. 393-409.

Scott, B. S., A. E. Wilcock, and V. Kanetkar, 2009, A survey of structured continuous improvement programs in the Canadian food sector: Food Control, v. 20, p. 209-217.

Shah, R., and P. T. Ward, 2003, Lean manufacturing: context, practice bundles, and performance: Journal of operations management, v. 21, p. 129-149.

Shah, R., and P. T. Ward, 2007, Defining and developing measures of lean production: Journal of operations management, v. 25, p. 785-805.

Sharp, J., Z. Irani, and S. Desai, 1999, Working towards agile manufacturing in the UK industry: International Journal of production economics, v. 62, p. 155-169.

Simons, D., and D. Taylor, 2007, Lean thinking in the UK red meat industry: a systems and contingency approach: International Journal of Production Economics, v. 106, p. 70-81.

So, S., and H. Sun, 2010, Supplier integration strategy for lean manufacturing adoption in electronic-enabled supply chains: Supply Chain Management: An International Journal, v. 15, p. 474-487.
Sousa, R., and C. Voss, 2008, Contingency research in operations management practices: Journal of Operations Management, v. 26, p. 697-713.
Sousa, R., and C. A. Voss, 2001, Quality management: universal or context dependent?: Production and Operations Management, v. 10, p. 383-404.
Sriparavastu, L., and T. Gupta, 1997, An empirical study of just-in-time and total quality management principles implementation in manufacturing firms in the USA: International Journal of Operations & production management, v. 17, p. 1215-1232.
Taylor, D. H., and A. Fearne, 2009, Demand management in fresh food value chains: a framework for analysis and improvement: Supply Chain Management: An International Journal, v. 14, p. 379-392.
White, R. E., J. N. Pearson, and J. R. Wilson, 1999, JIT manufacturing: a survey of implementations in small and large US manufacturers: Management science, v. 45, p. 1-15.
Wilson, L., 2009, How to implement lean manufacturing, McGraw Hill Professional.
Womack, J. P., Jones, D. T., & Roos, D. , 1990, Machine that changed the world: Simon and Schuster.
Wong, Y. C., K. Y. Wong, and A. Ali, 2009, A study on lean manufacturing implementation in the Malaysian electrical and electronics industry: European Journal of Scientific Research, v. 38, p. 521-535.
Zhou, B., 2012, Lean principles, practices, and impacts: a study on small and medium-sized enterprises (SMEs): Annals of Operations Research, v. 241, p. 457-474.
Zokaei, K., and D. Simons, 2006, Performance improvements through implementation of lean practices: a study of the UK red meat industry: International Food and Agribusiness Management Review, v. 9, p. 30-53.

Appendix

Dear participants,

I am Lirong Ma, a second year Master student in Wageningen university and my major is Food Quality Management. I am now doing my master thesis research about "The influence of company objectives to choose lean tools and quality dimensions improvement in SMEs". I appreciate that you are willing to take time to join in this research and answer the following questions, since without your contribution, I am not able to get insight into this research topic and finish my master thesis. Many thanks in advance!

The aim of these research is to investigate if there is an alignment between lean tools choice and company implementation objective and to understand to what extent this alignment influence quality dimensions improvement. This research is specially designed for small and medium sized (SMEs) meat industry in Europe, therefore opinion from your company is highly valued. This result may also help you to get a better understanding of what are the lean tools that frequently adopted by other SMEs and the effectiveness of these lean tools on quality improvement. The insight may also give you some suggestions for further lean manufacturing system improvement in your company.

The questionnaire consist of four different parts: (a) the background information about company and respondents, (b) the main objective of LM implementation (c)lean practice implementation and (d) the improvement performance. It will only take you around 15 minutes to fill out. The results will only analysed by me for educational purpose and all response will be confidential.

If you have any questions or concern, feel free to contact me via email: lirong.ma@wur.nl or via phone: 0031626963207.

Thanks again for your contribution!

Yours sincerely,

Lirong Ma

The screenshots of survey are shown below

* 1. what is the number of employees in your company?

- [ ] larger than 250
- [ ] smaller than 250 but larger than 50
- [ ] smaller than 50 but larger than 10
- [ ] smaller than 10

* 2. Years of history in implementing lean manufacturing in the company

* 3. Role in the firm of the one who fills this questionnaire

4. Please rank the importance of the following objectives for your lean manufacturing implementation. Rank #1 for the most important objective, #2 for the next important objective and rank 3 for the third important one. If your objective is not within these three, please specify your objective in next question.

- To improve product quality, especially the safety and sensory performance
- To reduce cost by eliminating different wastes along processing and improve process productivity
- To improve delivery speed and delivery reliability

5. what is your objective to implement lean manufacturing

* 6. Please indicate your agreement or disagreement with statements regarding the implementation of lean practices about Total Quality Management(TQM) in your plant.

	Entirely disagree	Mostly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Mostly agree	Entirely agree
Our process on the shop floor are currently under statistical process control	○	○	○	○	○	○	○
We extensively use statistical techniques to identify process variation	○	○	○	○	○	○	○
We use andon lights to indicate production process	○	○	○	○	○	○	○
Operators can call for assistance quickly by andon lights when problems occur	○	○	○	○	○	○	○
Charts showing defect rates are posted on the shop floor	○	○	○	○	○	○	○
Our plant emphasizes putting all tools and fixtures in their place	○	○	○	○	○	○	○
We use documented standard operating procedures	○	○	○	○	○	○	○
We trained employees to use standard operating procedures	○	○	○	○	○	○	○

* 7. Please indicate your agreement or disagreement with statements regarding the implementation of lean practices about Just-In-Time(JIT) in your plant.

	Entirely Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Mostly Agree	Entirely Agree
We focus on small lost size to processing products	○	○	○	○	○	○	○
We are actively reducing production lot size	○	○	○	○	○	○	○
Equipment is grouped based on the product families	○	○	○	○	○	○	○
Families of product determine our plant layout	○	○	○	○	○	○	○
Production at station is pulled by the current demand of the next stations	○	○	○	○	○	○	○
We use kanban squares or containers or signals for production control	○	○	○	○	○	○	○
We usually meet the production schedule each day	○	○	○	○	○	○	○
Our daily schedule is reasonable to complete on time	○	○	○	○	○	○	○
We are working to lower set-up time in our plant	○	○	○	○	○	○	○
Our workers are trained to achieve a lower set-up time	○	○	○	○	○	○	○

* 8. Please indicate your agreement or disagreement with statements regarding the implementation of lean practices about Total-Productive-Maintenance(TPM) in your plant.

	Entirely Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Mostly Agree	Entirely Agree
Our maintenance department focus on helping machine operators perform their own preventive maintenance	○	○	○	○	○	○	○
The maintenance of the machines involved in production is performed by machine operators instead of a separate maintenance staff	○	○	○	○	○	○	○
We dedicate a portion of every day solely to maintenance	○	○	○	○	○	○	○
We have a separate shift, or part of a shift, reserved each day for maintenance activities.	○	○	○	○	○	○	○
We search for continuing learning and improvement after installation of the equipment	○	○	○	○	○	○	○
we are a leader in the effective use of new process technology	○	○	○	○	○	○	○

* 9. Please indicate your agreement or disagreement with statements regarding the implementation of lean practices about employee and supplier involvement in your plant.

	Entirely Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Mostly Agree	Entirely Agree
The functions in our plant cooperate to solve conflicts between them, when they arise	○	○	○	○	○	○	○
Our plant's functions work interactively with each other	○	○	○	○	○	○	○
Employees receive training to perform multiple tasks	○	○	○	○	○	○	○
Employees are cross-trained as this plant so that they can fill in others id necessary	○	○	○	○	○	○	○
Employees are encouraged to make suggestions for improving performance at this plant	○	○	○	○	○	○	○
Many useful suggestions given by employees are implemented at this plant	○	○	○	○	○	○	○
We take active steps to reduce the number of suppliers in each category	○	○	○	○	○	○	○
We have a corporate level communication on important issues with key suppliers	○	○	○	○	○	○	○
We give our suppliers feedback on quality and delivery performance	○	○	○	○	○	○	○
We frequently are in close contact with our suppliers	○	○	○	○	○	○	○
Our suppliers deliver to us on a JIT basis	○	○	○	○	○	○	○
Our suppliers deliver to us on short notice	○	○	○	○	○	○	○

* 10. Please estimate the percentage of the changes achieved in the following performance indicators because of the implementation of lean manufacturing

* 9. Please indicate your opinion about how your company performed in following dimensions after the implementation of above manufacturing practices.

	Entirely Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Mostly Agree	Entirely Agree
we increased the finished-product first-pass quality yield	○	○	○	○	○	○	○
we decreased scrap and rework costs	○	○	○	○	○	○	○
we decreased per unit manufacturing costs	○	○	○	○	○	○	○
we increased productivity, defined as dollar volume of shipments per employee	○	○	○	○	○	○	○
we decreased delivery lead time: time period from the placement of an order to its shipment to consumers, excluding transportation time	○	○	○	○	○	○	○
we decreased throughput time: the time from its production to its completion	○	○	○	○	○	○	○
we increased level of the percentage of on-time delivery	○	○	○	○	○	○	○
we decreased lateness level: decreased in the extent of delay time	○	○	○	○	○	○	○

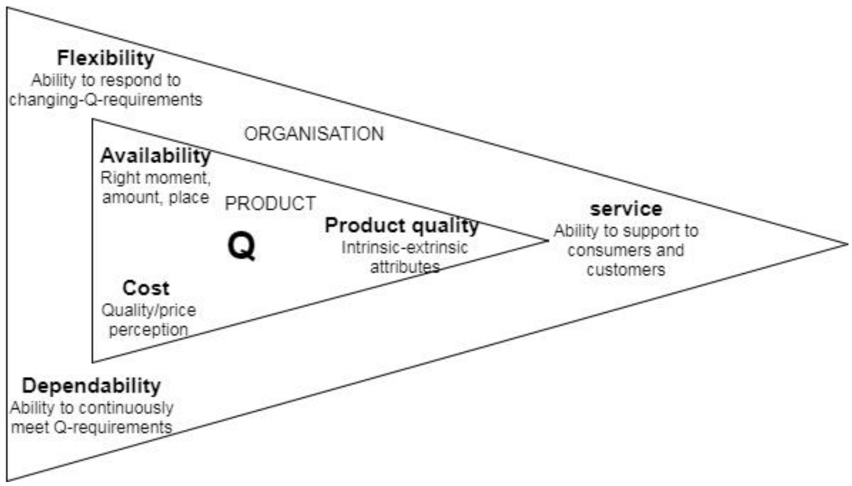


Figure 1: Extended quality concept

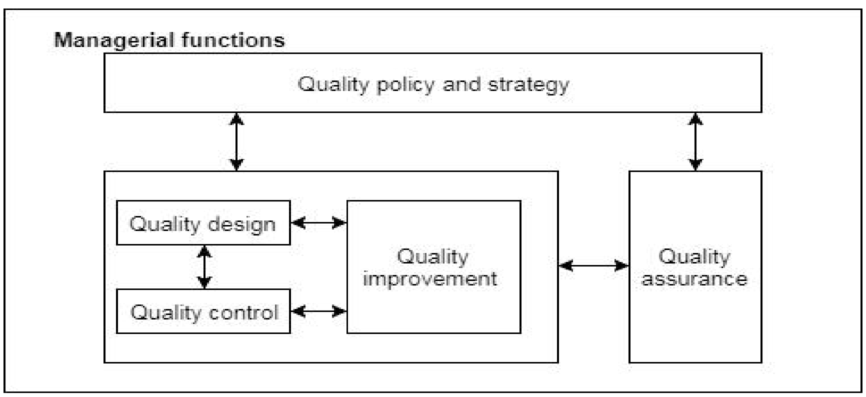


Figure 2: Food quality management system

Table 1 Small and medium sized company classification

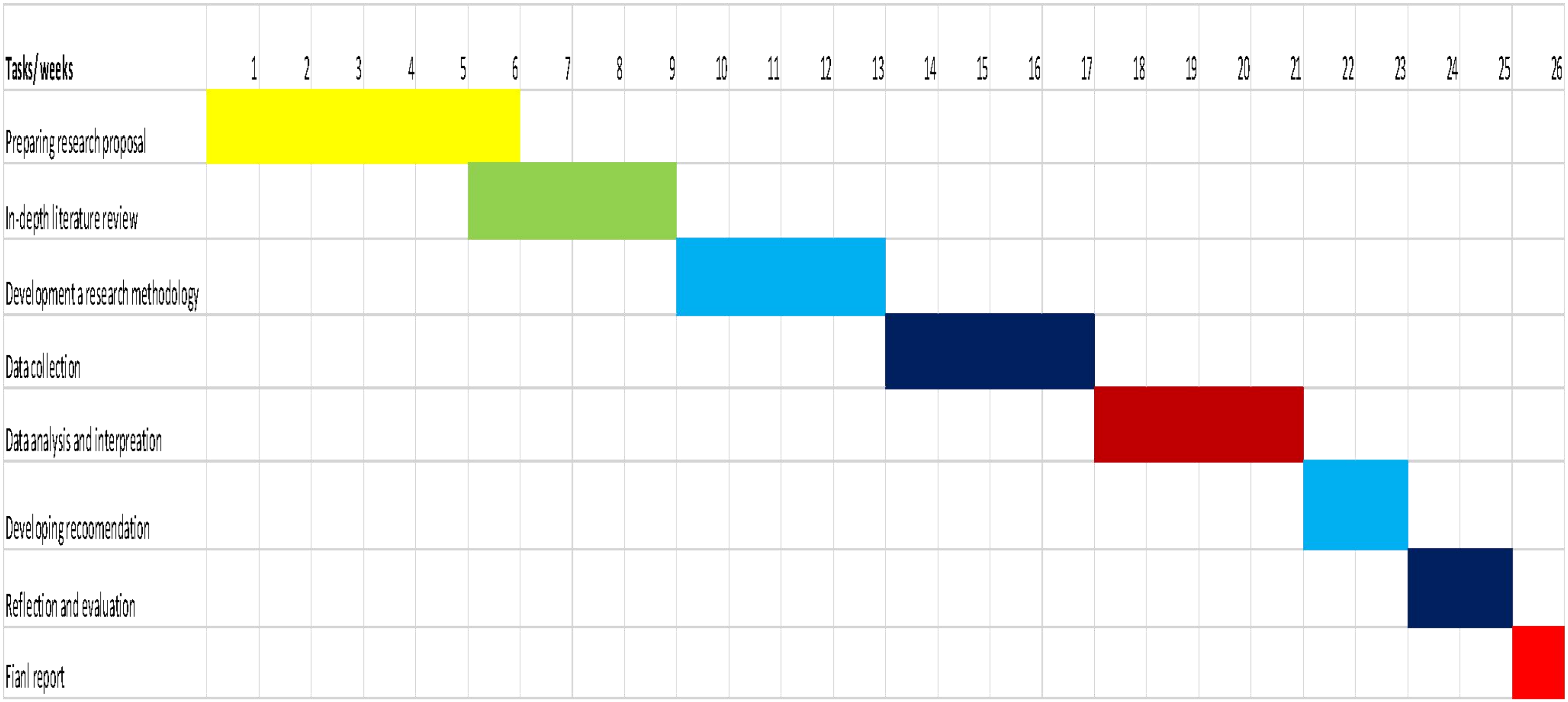
company category	staff headcount	turn over or	balance sheet
medium-sized	<250	≤€50m	≤€43m
small	<50	≤€10m	≤ €10
micro	<10	≤€2m	≤ €2

Table 6: ANOVA analysis of lean bundle within company A

Result Details				
Source	***SS***	***df***	***MS***	
Between-treatments	6.2389	4	1.5597	$F = 0.49305$
Within-treatments	98.0667	31	3.1634	
Total	104.3056	35		

The *f*-ratio value is 0.49305. The *p*-value is .740838. The result is *not* significant at $p < .05$.

Thesis planing



Questionnaire answers from three companies

		company A objective ranking: quality, delivery, cost	company B:delivery, quality, cost dutch company 10-50	company C objective ranking:quality,cost,delivery
TQM				
Our process on the shop floor are currently under statistical process control	SPC	3	4	6
We extensively use statistical techniques to identify process variation		6	5	7
We use andon lights to indicate production process	Visual display	7	1	7
Operators can call for assistance quickly by andon lights when problems occur		1	1	7

Charts showing defect rates are posted on the shop floor		4	1	5
Our plant emphasizes putting all tools and fixtures in their place		2	1	7
We use documented standard operating procedures	SOPs	4	4	7
We trained employees to use standard operating procedures		3	5	7
JIT				
We focus on small lost size to processing products	Lot size reduction	2	4	6
We are actively reducing production lot size		6	2	6
Equipment is grouped based on the product families	Cellular manufacturing	4	4	7

Families of product determine our plant layout		3	3	7
Production at station is pulled by the current demand of the next stations	pull system	5	1	7
We use kanban squares or containers or signals for production control		7	1	7
We usually meet the production schedule each day	daily schedule adherence	1	2	7
Our daily schedule is reasonable to complete on time		6	3	7
We are working to lower set-up time in our plant	setup time reduction	5	1	7
Our workers are trained to achieve a lower set-up time		5	2	7

TPM				
Our maintenance department focus on helping machine operators perform their own preventive maintenance	autonomous maintenance	5	1	7
The maintenance of the machines is performed by machine operators, instead of a separate maintenance staff		5	1	7
We dedicate a portion of every day solely to maintenance	planned maintenance	2	1	7
We have a separate shift, or part of a shift, reserved each day for maintenance activities		4	1	7

We search for continuing learning and improvement after installation of the equipment	process equipment emphasis	5	1	6
we are a leader in the effective use of new process technology		3	1	6
Employee involvement				
The functions in our plant cooperate to solve conflicts between them, when they arise	cross function integration	4	4	7
Our plant' s functions work interactively with each other		1	4	7
Employees receive training to perform multiple tasks	multi-function	6	7	7

Employees are cross-trained as this plant so that they can fill in others if necessary	training to employee	3	7	7
Employees are encouraged to make suggestions for improving performance at this plant	suggestion system	5	5	7
Many useful suggestions given by employees are implemented at this plant		3	4	6
Supplier involvement				
We take active steps to reduce the number of suppliers in each category	supplier relationship development	5	4	6
We have a corporate level communication on important issues with key suppliers		4	3	6

We give our suppliers feedback on quality and delivery performance	supplier feedback	5	3	7
We frequently are in close contact with our suppliers		6	3	7
Our suppliers deliver to us on a JIT basis	JIT delivery	7	2	6
Our suppliers deliver to us on short notice		2	2	6
performance				
we increased the finished-product first-pass quality yield	quality performance	1	5	6
we decreased scrap and rework costs		2	4	6
we decreased per unit manufacturing costs	cost performance	3	4	6

we increased productivity, defined as dollar volume of shipments per employee		2	5	6
we decreased delivery lead time: :time period from the placement of an order to its shipment to consumers, excluding transportation time	delivery performance	3	4	7
we decreased throughput time: the time from its production to its completion		4	4	6
we increased level of the percentage of on-time delivery		3	5	7
we decreased lateness level: decreased in the extent of delay time		3	5	6