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Lean Manufacturing in Small and Medium-sized Food Processing Enterprises: Practice, Performance and its Determining Factors

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Lean Manufacturing in kleine en middelgrote voedselverwerkende bedrijven: Praktijk, performantie en determinanten

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Manoj Kumar Dora
17 January 2014, Ghent

CONTENTS

List of figures

List of tables

List of keywords

5S is a 5 steps workplace organization method namely sort, straighten, shine/sweep, standardize, sustain
ACS Approved Contractor Scheme – quality certification system
BRC British Retail Consortium – quality certification system
BSC Balanced Scorecard is a strategy performance management tool, supported by design methods
CTQ Critical to Quality is an attribute of a part, assembly, product, or process that is critical to quality
DFSS Design for Six Sigma is a business-process management methodology related to Six Sigma
DMAIC is a five steps six sigma method, namely Define, Measure, Analyze, Improve, Control
DOE Design of Experiments is the design of information-gathering exercises where variation is present
DPMO Defects per Million Opportunities
EFQM European Foundation for Quality Management – quality certification system
FMEA Failure Mode and Effects is a systematic techniques for failure analysis
FQMS Food Quality Management System
HACCP Hazard Analysis Critical Control Points – quality certification system
IFS International Food Standard – quality certification system
ISO International Organization for Standardization – quality certification system
Jidoka is a feature of machine design also known as automation with a Human Touch
JIT Just In Time - Inventory reduction method
Kaizen – It is a Japanese word/method for continuous process improvement
Kanban is a signaling devices (e.g., to communicate out of stock)
MUDA It is a Japanese word for Waste
OEE Overall Equipment Effectives to evaluate how effectively a manufacturing operation is utilized
PDCA Plan Do Check Act cycle “The Shewart Cycle”
QM Quality management
ROI Return on Investment
SMED Single Minute Exchange of Die: It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product.
SPC Statistical Process Control is a method of quality control which uses statistical methods.
TPM Total Productive Maintenance: is to increase the productivity of plant with proactive maintenance
TPS Toyota Production System
TQM Total Quality Management
VSM Value Steam Mapping used to analyze and design the flow of materials and information required to bring a product or service to a consumer.
WIP Work In Progress are a company's partially finished goods waiting for completion

Preface

This PhD dissertation is prepared within the framework of the project “*Innovative Management System for a sustainable food industry (IMSFood)*” that commenced in January 2010. IMSFood is a collaborative research project funded by IWT under the ERNET-CORNET umbrella. In Belgium, FENAVIAN - a meat association, CHOPRABISCO - the chocolate and confectionary association and the Agri-food Marketing and Chain Management division, Ghent University partnered to carry out this project. The other international partners involved in this project are the German Institute of Food Technologies in Germany and Campden BRI Magyarország Nonprofit Kft. in Hungary. In the frame of the project, ten European food processing SMEs were participated in the case study including four companies from Belgium. Based on the study, lean manufacturing practices implementation framework, tailor-made for food processing SMEs has been developed during the course of the project. This PhD dissertation mainly builds on the results of the research conducted by the division of Agri-food Marketing and Chain Management division in the Department of Agricultural Economics.

We knew all about lean, but could not answer the question ‘How do you get from here to there?’

~ Dan Jones, Co-author “The machine that changed the world”

1. Introduction

1.1. General introduction

The major parts of this thesis contain four research papers that are submitted to peer-reviewed journals (three published/accepted). The thesis can be regarded as a collection of these articles, preceded by this introduction to indicate the relevance and coherence in the issues addressed in these papers.

The food processing industry plays a vital role in European economy, employing over 4.4 million people, and meeting the demands of over 500 million consumers (CIAA, 2010). However, in recent times, the European food sector is lacking its competitiveness compared to North America and Australia (Wijnands et al., 2007). Researchers as well as practitioners called for the application of a quality management (QM) practices, such as lean manufacturing, which can help the food processing industry to be more efficient and competitive (Luning & Marcelis, 2009a; Mann et al., 1999; Trienekens & Zuurbier, 2008). Quality management is defined as the activities and decisions performed in an organization to produce and maintain a product within desired quality level at minimal costs (Ghobadian & Gallear, 1996). And lean manufacturing - an vital QM practice, is meant to transform complex processes to a smooth continuous flow, delivers customer value, improve workflow, standardized processes and eliminate waste (Spear & Bowen, 1999). In simple terms, lean means creating more value for customers with fewer resources.

Lean manufacturing practices significantly improved firms' operational performances with respect to cost, quality and delivery, though predominantly in the automobile sector (Wu, 2003). Scholars claim that the lean manufacturing principles have been applied to numerous industries to yield drastic improvements and there is no reason why food processing industry cannot take advantage of one of the most prominent quality management practice of modern times (Goncharuk, 2009; Mahalik & Nambiar, 2010). Yet, the majority of the literature shows that historically the food processing industry has narrowly focused on food safety issues and neglected the operational excellence aspect (He & Hayya, 2002; Luning & Marcelis, 2009b; Mahalik & Nambiar, 2010). Recent studies including an editorial in the renowned journal "Trends in Food Science and Technology" claim that lean manufacturing practices can help the food processing industry to be more productive (Engelund et al., 2009; Goncharuk, 2009; Mahalik, 2010; Mahalik & Nambiar, 2010). The trend has been changing in recent times as lean manufacturing practices in food processing Small and

Medium sized enterprises (SMEs) have gained attention (Engelund et al., 2009; Jain & Lyons, 2009; Testa, 2010; Zhen et al., 2011). Nevertheless, applicability and effectiveness of lean manufacturing in food processing SMEs is still a debated topic in the academic world (He & Hayya, 2002; Lehtinen & Torkko, 2005; N. P. Mahalik & Nambiar, 2010; Scott, et al., 2009; Simons & Zokaei, 2005; Cox & Chicksand, 2005).

Against this backdrop, scholarly studies have identified two critical elements related to quality management practices in SMEs operating in the food processing industry:

1. The majority of the food processing sector related studies merely focus on food safety methods such as Hazard Analysis and Critical Control Points (HACCP), International Food Standard (IFS), Approved Contractor Scheme (ACS) and discount the importance of QM practices method such as lean manufacturing (Caswell et al., 1998; Georgakopoulos, 2007; Orriss & Whitehead, 2000; Scott et al., 2009; Trienekens & Zuurbier, 2008; Unnevehr & Jensen, 1999).
2. The applicability and effectiveness of lean manufacturing in the food processing industry is still a contentious topic and academia has yet to reach any consensus (Engelund et al., 2009; Goncharuk, 2009; Jain & Lyons, 2009; Mahalik & Nambiar, 2010; Scherrer-Rathje et al., 2009; Scott et al., 2009). There is a need for further studies of the practical issues involved in implementing lean manufacturing practices within the food processing industry (Scott, et al., 2009; Simons & Zokaei, 2005; Cox & Chicksand, 2005).

Two prominent research problems arise from the reviewed quality management literature:

1. Studies indicate a robust correlation between lean manufacturing practices and a firm's operational performance (with the majority in large automobile or other discrete industry sectors)(Cooney, 2002). This leads to the question of why only a few food processing SMEs take advantage of management practices which demonstrate a considerable improvement in efficiency and higher operational performance.

2. Is there anything inherent to food processing SMEs with respect to plant, product and process that influences the applicability and effectiveness of lean manufacturing practices? In other words, what are the factors that contribute to the variations in the lean practice-performance association in the food processing SME context and importantly, how?

These research problems set up the goal of this doctoral study which is to investigate the determinants of lean manufacturing practices implementation in a small and medium sized food processing enterprise environment. Moreover, the association between lean manufacturing and a firm's operational performance is examined. The result of the study will help practitioners and managers confront challenges while undergoing lean implementation for efficient food production in a SME environment. From the societal point of view, the findings of this study can help policy makers and food processing SMEs to devise new strategies to improve their productivity and competitiveness which contributes to European economy and employment. A more detailed explanation of the contribution of the study is presented in section 1.6.

What is of interest here is also the question as to what extent the study can be considered relevant for scientific knowledge creation? The theories on operations management in general and on manufacturing strategies in specific have been explored to produce a deeper understanding of the subject. The research problems (i.e., the choice of a quality management practice, justification of variation in practices-performance association) have been studied through the lenses of the seminal work of Skinner and Voss (Skinner, 1992; Voss, 1995). Skinner proposed three different paradigms of choice and content concerning manufacturing strategy that a firm can opt - the theory extended by Voss (Voss, 1995, 2005). The first paradigm comprises "competing through manufacturing", which means a firm competes through its manufacturing capabilities and aligns its capabilities with the determining factors, its business strategies and the market demand. The second paradigm is a "contingency based approach", where choices made are dependent on the internal and external context and strategy of the firm. The third paradigm is based on the need to adopt the "best practice" to gain the competitive edge in the market. The focus of this approach is the continuous improvement of the "best practice" in all operational areas within an organization. With this theoretical background, this doctoral research intends to contribute to the knowledge by investigating the firm's choice to adopt a particular quality management practice.

Similarly, variations in the practices-performance association have been explained through the contingency theory lens stating that "quality management practices are highly context dependent" (Jayaram et al., 2010; Ketokivi & Schroeder, 2004a; Sousa & Voss, 2008). Literature claims that manufacturing or quality management practices do not always have a significant impact on performance or provide organizations with a competitive advantage (Dow et al., 1999; Kaynak, 2003; Samson & Terziovski, 1999). One common error in the implementation of quality management practice is the failure to recognize that different organizations operate in different, complex and diversified environments, and hence may not realize the same results (Sousa & Voss, 2008). In contrast, the generalized "best practice" theory claims that "some management practices are 'universally' better than the others and bring desirable results to the organizations irrespective of contingency factors" (Agarwal et al., 2012; Boxall & Purcell, 2000; Schoonhoven, 1981). This thesis draws on ideas from the scientific discussion (theories) to understand if contingency factors influence the practice-performance relationship and how. The application of lean manufacturing in a new context (food processing SMEs) will reveal limitations and advantages of the practice-performance association and will also contribute to its theoretical progress. An extended explanation of the contribution to knowledge is presented in section 1.6. The following section outlines the scope and research objectives. In summary, the present study provides a benchmark which makes it possible to transfer scientific and practical experience to the food processing SMEs starting the lean journey. The following section outlines the scope and research objectives.

1.2. Scope and research objectives

Over the last decades, many methods to managing quality have been suggested by prominent quality gurus including Deming (1986), Juran (1986), Crosby (1979, 1984), and Feigenbaum (1983). A variety of technical and organizational approaches including the use of statistical techniques, change in organizational culture, employee education, etc. have been advocated. One of the prominent quality gurus of the modern era - (Crosby, 1979) stated "Quality is free. It's not a gift but it's free". Crosby's seminal work suggests that the cost of machines, materials, and training required to foster high quality can be a minuscule in comparison to the savings from the reduction of the hidden costs of bad quality. Organizations across sectors understand the importance of quality and continuously strive to meet the increasing demands of consumers, governmental regulations and competition in the market. Organizations rely on appropriate quality management systems to help them meet quality standards and fulfill the consumer's requirements. According to (Deming & Edwards, 1982) "by adopting appropriate principles of management, organizations can increase quality and simultaneously reduce costs (by reducing waste, rework, staff attrition and litigation while increasing customer loyalty)". Overtime different quality management systems have been developed and adopted by organizations in order for them to remain competitive in the market. However, the results and applicability of different quality management systems greatly vary across sectors and sizes of the organizations depending on endogenous (internal) and exogenous (external) factors (Flynn et al., 2010; Kaynak, 2003; Lawler et al., 1995; Powell, 1995; Samson & Terziovski, 1999).

One of the noteworthy quality management systems evolved during the 1980s is "lean manufacturing" or "lean production". Lean manufacturing is based on the Toyota Production System developed by Toyota after World War II in 1950s. In simple terms, lean is a system that utilizes fewer inputs and creates the same outputs while contributing more value to customers, all by eliminating waste in the process (Krafcik, 1988). Many companies across different industrial sectors, sizes and geographic regions tried to imitate lean manufacturing practices to improve their own quality, efficiency and productivity. Likewise, in the academic world, the applicability and effectiveness of lean manufacturing in different environments (sector, size of company, product type, and country of origin) sparked a broad debate in the operations management literature. The points of view in the academic debate can be classified into three categories (Cooney, 2002; Oliver et al., 1994): one, lean is universal and can be effectively applied to any situations; two, lean is rare and very difficult to replicate; three, with minor adjustment lean can bring effective results to any organizations. The following three statements provide a good sense of these three different points of view.

First, (Womack et al., 1990) claimed in one of the influential books of modern times "The machine that changed the world":

> "…why should we care if world manufacturers jettison decades of mass production to embrace lean production? Because the adoption of lean production, as it inevitably spreads beyond the auto industry, will change everything in almost every industry - choices for consumers, the nature of work, the fortune of companies, and, ultimately, the fate of nations (Womack et al., 1990)."

Second, Kouchan, et al. claimed "the pace of change and the outcome of quality management initiatives such as lean manufacturing differ significantly across sectors and even across companies" (Kochan et al., 1997). (Taylor, 1997) stated that the lean manufacturing methods are not easy to duplicate, even by those who know them well. (Keys & Miller, 1984) claimed that lean manufacturing has not received great deal of attention outside the auto-industry. (Cooney, 2002) argues that the possibility to become "lean" is highly dependent upon business conditions which are very dynamic in nature; hence universality of lean is very limited. Another extreme argument on lean manufacturing comes from Presidential Professor Jay Barney, a fellow of the Academy of Management:

> "Lean manufacturing is valuable, rare, difficult to imitate (inimitable) and non-substitutable (Barney, 1991)"

A third argument takes a middle ground. Studies claim that with minor adjustments, lean manufacturing can bring considerable quality, productivity and efficiency benefits to organizations across sectors, company sizes and geographic regions (Abdulmalek & Rajgopal, 2007; Melton, 2005). James-Moore & Gibbons stated in a highly cited scholarly article "Is lean manufacture universally relevant? An investigative methodology":

> "…different industries have different requirements and some practices are not transferrable to other industries without modifications. In analyzing these findings it can be concluded that the choice of industry sector will have an impact on lean adaptation (James-Moore & Gibbons, 1997)".

The prime motivation behind this doctoral research derives from the above three viewpoints leading to investigation that "whether lean manufacturing can be regarded as universally relevant?" This doctoral study is an attempt to join the ongoing debate and to find a logical conclusion on the universal applicability of lean manufacturing. The scope of this research is to understand and evaluate the applicability and effectiveness of lean manufacturing in SMEs operating in the food processing industry. According to (Flynn et al., 2010), inconsistency in the outcome of lean manufacturing practices can be explained by the contingency theory, which suggests that the environment, in which an organization operates has a significant impact on the outcome of any such initiative. In simple words, contingency theory suggests "there is no one best way to organize and any way of organizing is not equally effective (Galbraith, 1973)". WG Scott in a reputed scientific article "Organization Theory: A Reassessment", defined contingency theory as follows:

> "Contingency theory is guided by the general orienting hypothesis that organizations whose internal features best match the demands of their environments will achieve the best adaptation (Scott, 1974)".

Hence, it is important to understand the environment or contingency or contextual factors surrounding lean manufacturing. The contextual factors such as the special characteristics of the food processing industry (highly perishable product, seasonality and availability of raw material, diverse recipes, multiple batch sizes, and short self-life) along with the unique features of SMEs (structure, policymaking procedures, resource utilizations, staff patterns, culture and patronage) are ideal for examining the generalizations made by Womack, et al. that “lean manufacturing is universally applicable and effective” (Womack et al., 1990). Furthermore, contemporary articles on this topic have also supported the claim that it is time for the food sector to initiate lean manufacturing practices to increase efficiency and reduce costs of production (Goncharuk, 2009; Mahalik & Nambiar, 2010). This defines the scope of the doctoral research, that is to investigate the adoptability of lean manufacturing in a complex small and medium-sized food-processing enterprise environment.

According to (Sousa & Voss, 2008) a robust operations management research model should include *practices, performance* and *determining factors* in order to gain holistic and in-depth insight into the applicability of a quality management system. Therefore, this study includes practice, performance and determining factors to get a comprehensive evaluation and understanding of the application of lean manufacturing practices in food processing SMEs.

Moreover, studies pointed out a number of control variables that together determine the degree to which these practices are used, such as plant size (Cua et al., 2001a; Fullerton & McWatters, 2001; Inman & Mehra, 1990; Lee & Dale, 1998; Schonberger, 2010; Shah & Ward, 2003; White et al., 1999a) and country of operation (Cua et al., 2001a; De Toni & Tonchia, 2001; Forza & Nuzzo, 1998; Fullerton & McWatters, 2001; Rungtusanatham et al., 1998; White & Prybutok, 2001). This study includes the control variables (size of the company and country of operation) to determine the influence of these factors on lean implementation. In addition, determining factors, organizational and food-sector-specific (i.e., inherent nature of plant, process, and product) are investigated to see its impact on the lean adoption.

The central contribution of this research is that it extends the contingency view in the operations management literature by investigating the determining factors and its relationship between lean manufacturing practices and operational performance. The concluding outcome of this research is an integrated lean implementation framework - “house of lean”, tailor-made for food processing SMEs, which could be achieved by addressing the following objectives:

- to understand the status of lean manufacturing vis-à-vis other quality assurance initiatives (e.g. HACCP) in the food processing SMEs
- to assess the variation in the degree of use of individual lean manufacturing practices in the food processing SMEs
- to evaluate the effect of control factors (size of the firm and country of operation) on the implementation of lean manufacturing practices
- to assess the effect of determining factors on lean adoption in food processing SMEs
- to evaluate the impact of lean manufacturing practices on firm’s operational performance

For a conclusive understanding of the application of lean manufacturing in food processing SMEs and to achieve the aim of the research, a triangulation method of data collection was used. This research was carried out in three stages. In stage one, a through literature review was carried out to find out the current knowledge and gaps in quality management in SMEs focusing food processing sector. In the second stage, an exploratory research (survey) was undertaken to identify the current status of quality management practices existing in food processing SMEs in three European countries (Belgium, Germany and Hungary). The database generated from the second phase of study was used to conduct an explanatory research (case study) in the third phase of the research. In order to get better insights into the lean manufacturing practices, four food processing SMEs in Belgium are selected for the case studies.

Over a period of time, a wide range of theoretical and empirical insights into the development of research on lean manufacturing have been added, such as the lean principles, lean thinking, lean practices, impact of lean, determining factors and lean vis-à-vis other quality management practices. These aspects have further elucidated the lean concept; however, they have also progressively extended the breadth and depth of the concept. The multiplication of ideas and interpretation around lean manufacturing makes it difficult to generalize its impact and applicability. Keeping these points in mind, at the outset a brief evolution and structure of quality management systems focusing on lean manufacturing is presented to avoid complexity and confusion on different concepts used in this study. First, an overview of this evolution of quality management research focusing on food processing SMEs is presented in section 1.2. Section 1.3 describes the conceptual framework and underlying theories. In section 1.4 a list of research propositions is given, while in section 1.5 the scientific contribution and practical relevance of this PhD research are explained. In section 1.6 the research design and the structure of this dissertation are outlined.

1.3. Trends of quality management research

1.3.1. Quality management

It is important to understand the multiple dimension of the concept "quality" before getting into the quality management system in general and lean manufacturing in specific. Literature shows that the definition of quality is neither universal nor unambiguous. There are several schools of thought on defining quality; for instance, one school views quality as a "performance to standards" the other views it as "meeting the customer's needs". Feigenbaum, an American quality expert who devised the concept "Total Quality Management" (TQM) promotes a value based definition of quality. The core meaning of Feigenbaum's definition is "a quality product that provides performance or requirements' conformance at an acceptable price or cost" (Feigenbaum, 1982). Feigenbaum's definition was criticized because of its lack of well-defined limits and subjectivity (Garvin, 1988). Shewhart, a US statistician, used statistical analysis to measure specification and defined quality as "conformance-to-specifications". This definition is likewise criticized because of its narrow focus on the producer's specification of quality and ignoring customer needs. Juran, an evangelist for quality and quality management, emphasized that customers' needs must be the driving force of the product quality specifications. Juran defined quality as the product performance which meets customer needs and is free of deficiencies or errors (Juran, 1986). Juran proposed three managerial processes - quality planning, quality control and quality improvement - that are necessary to manage quality, also known as “Juran Trilogy”.

Similarly, Deming defined quality in terms of developing uniform and dependable work practices that correspond with delivering quality products at low costs in a sustainable market (Deming & Edwards, 1982). Crosby, a legend in the discipline of quality, widely recognized for his concept of "zero defects", wrote a book titled “Quality Is Free” in 1979. He pointed out the massive costs of low quality, which not only include the costs of labor, equipment, rework, and lost sales, but also organizational costs that are difficult to quantify. Crosby emphasized that the effort to correct or rework is very expensive and doing right the first time can prevent unnecessary cost, therefore, quality is free. The one most commonly used definition of quality is “the extent to which a product or service is meeting and/or exceeding the expectations of customers” (Reeves & Bednar, 1994). This commonly accepted, customer-focused definition of quality is used for this study as it suits the context of present-day quality management systems in modern organizations. Similarly, the concept of quality management has changed and evolved over time. The craftsmanship model which started in the medieval age continued in the industrialized world until the early 19th century (Juran, 1995). Then, quality management meant inspecting final products for the purpose of accepting or rejecting them to ensure that they met specifications. The industrial revolution triggered a paradigm shift in manufacturing as well as the history of quality. The way products were manufactured changed from craft production to mass production, pioneered by Ford Motors. Operators were no longer responsible for making the entire product, but only a small part of it. This paradigm shift resulted in a deterioration of the operator’s task ownership as well as the quality of the complete product (Womack et al., 1990). The responsibility for quality specification moved to the foremen. Special rework engineers were appointed to correct defective products. Then Toyota, the Japanese automobile company, pioneered a customer-driven quality management system.

Figure 1-1 shows the evolution of the concept of quality. This customer driven quality approach helped Toyota to grow from a small spin-off of a textile loom maker to the world's biggest automobile company in less than 70 years.

Period	Early 1900s	1940s	1960s	1980s & beyond
Focus	Inspection	Statistical sampling	Organizational quality focus	Customer driven quality
Approach	Inspect for quality after production ←→			Build quality into the process ←→

Figure 1-1 Changing focus of quality

Source: (Dale, 2003)

(Spear & Bowen, 1999) decoded the DNA of the Toyota production system and provided an interesting explanation. Toyota broke down the traditional mindset that had existed in mass production: their philosophy extended beyond the participation of employees within the organizational boundaries and included customers, distribution systems, and suppliers' companies as factors in the decision-making process. Great emphasis was placed on long-term planning and the involvement of all organizational levels in the policy deployment process. Another important element of Toyota's quality philosophy (and probably the most important one) is empowering the work force and installing a "continuous improvement" mentality in order to gradually achieve perfection. This new quality management initiative at Toyota is later popularly known as lean manufacturing/production (contrary to the mass production in the US automotive e.g., Ford). The term "lean production" was first coined by John Krafcik in his 1988 article "Triumph of the Lean Production System" based on his master's thesis at MIT Sloan School of Management.

Developments in quality assurance (QA) and reliability during 1970's (which has a significant role in the agri-food sector) formed another branch of QM practice. QA provides a guarantee that all quality obligations such as food safety and reliability are met by establishing a standard organizational structure, responsibilities, processes and procedures (Van der Spiegel et al., 2003). Several QA systems have been developed to fit the needs of the food sector such as HACCP (Hazard Analysis and Critical Control Points), ISO (International Organization for Standardization), IFS (International Food Standard), and BRC (British Retail Consortium). The objective of the HACCP is to guarantee food safety by following preventive measures through a systematic and cost-effective approach. Similarly, the ISO promotes a standardization of the production process which focuses on quality, health and safety. ISO 9001:2000 series are popular among food companies. BRC was founded in 1998 to evaluate manufacturers of retailers own brand food products for consistent food safety and quality. Likewise, German and French food trade associations developed IFS to enhance transparency along the food chain and reduced the number of customer audits. The structure of IFS matches to ISO 9001, but with a focus on food safety, HACCP, hygiene, and the manufacturing process. In addition, to meet the needs of the retail sector, the Global Food Safety Initiative (GFSI) was initiated to consider supplier issues to assure quality at the chain level (Fulponi, 2006). Table 1-1 highlights the key phases that have contributed to the current understanding of quality management initiatives.

Table 1-1 Time line marking the critical phases of quality evolution

Year	Events and development in research	Reference
1927	Henry Ford outlines the basic principles of Ford Production System	(Ōhno, 1988)
1931	Walter A. Shewhart introduces statistical quality control	(Shewhart, 1939)
1937	Kiichiro & Eiji constitutes Toyota Production System (TPS)	(Womack et al., 1990)
1945	Toyota restarts their car production (3000 cars in year one)	(Womack et al., 1990)
1951	Joseph M. Juran publishes the Quality Control Handbook	(Juran et al., 1999)
1960	HACCP concept was pioneered by the Pillsbury Company, US	(Caswell et al., 1998)
1968	Kaoru Ishikawa outlines the elements of Total Quality Control (TQC)	(Ishikawa, 1990)
1970	Philip Crosby introduces the concept of zero defects	(Crosby, 1992)
1978	Ohno publishes “Toyota Production System” in Japanese	(Womack et al., 1990)
1980	Western industries import the concept of Total Quality Management	(Dale, 2003)
1980	Motorola pioneers the concept of Six Sigma	(Dale, 2003)
1984	Opening of NUMMI, a joint venture - Toyota Motor and General Motors	(Womack et al., 1990)
1988	Ohno publishes “Toyota Production System: Beyond large-scale production”	(Ōhno, 1988)
1988	Krafcik coins the term “lean” to describe the Toyota production system	(Spear & Bowen, 1999)
1990	The machine that changed the world by Womack, Jones and Roos published	(Womack et al., 1990)
1990	HACCP becomes a mandatory quality program	(Caswell et al., 1998)
1996	Lean Thinking by Womack and Jones is published	(Womack & Jones, 1996)
2004	Liker publishes “The Toyota Way”	(Liker & Convis, 2012)
2007	Toyota Motor Company became the number one automobile manufacturer	(Marr, 2009)

Source: Own compilation

1.3.2. Lean manufacturing

The extraordinary performance and growth of Toyota in a very short time period—especially in the aftermath of the devastation of World War II—attracted a great deal of attention among academics and practitioners. As shown in the timeline in Table 1-1, Toyota became the number one automobile manufacturer in 2007, surpassing three American mass producers (Ford, GM and Chrysler) by implementing Toyota Production System (TPS). This also led to a significant surge in academic and non-academic literature in the 1990s to decode the TPS that led to the development of lean manufacturing. Consequently, there is a serious ambiguity in the use of terms, definitions and approaches of lean manufacturing in the literature (Hopp & Spearman, 2004). The degree of difficulty in defining lean can be read in the statement by (Hines et al., 2004) that "lean is constantly evolving, implying that any 'definition' of the concept will only be a 'still image' of a moving target and valid only in a certain point of time". In order to provide an introduction to the concepts of lean manufacturing, some of the widely used definitions in the literature are presented here. One of the earliest definitions comes from Krafcik, who actually introduced the term "lean" in 1988:

> "...compared to mass production it uses less of everything - half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products (Krafcik, 1988)".

(Liker, 1997) in his seminal book "Becoming lean: Inside stories of US manufacturers" defined lean as "a philosophy that when implemented reduces the time from customer order to delivery by eliminating sources of waste in the production flow". This dissertation used the definition proposed by (Shah & Ward, 2007a) which demonstrates clarity, comprehensibility and consistency:

> "Lean production is an integrated socio-technical system whose main objective is to create flow and eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability (Shah & Ward, 2007a)".

The following section explains the essential components of lean manufacturing. To provide a clear overview of lean manufacturing, the research elements are organized in three broad sections: goals, guiding principles and practices (Challis et al., 2005; Fawcett & Myers, 2001; Fullerton & McWatters, 2001; Germain et al., 1994; Sakakibara et al., 1997; Schonberger, 1982; Shah & Ward, 2003) Figure 1-2 breaks down the three segments of lean manufacturing.

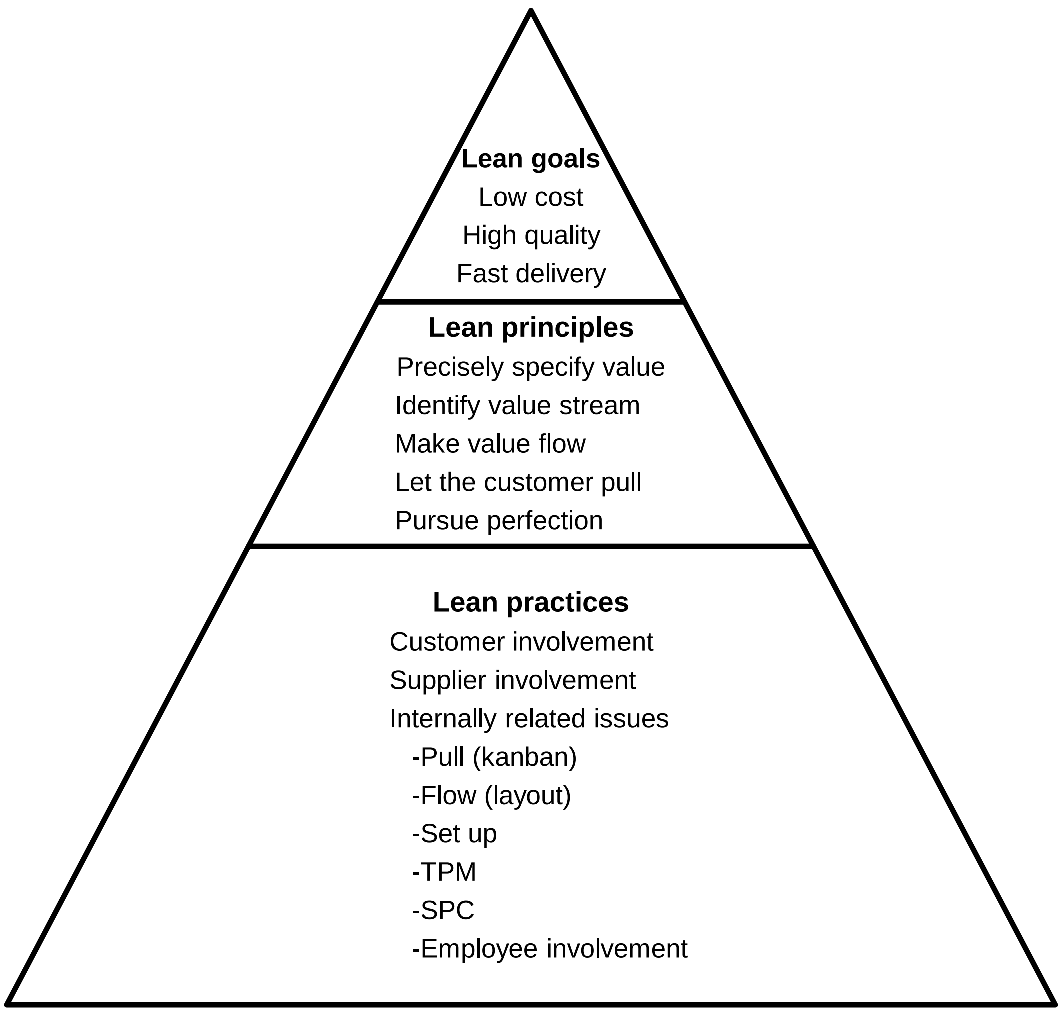

Figure 1-2 Lean goals, principles and practices

Source: Own compilation

The primary goals of lean manufacturing are cost reduction, quality improvement and faster delivery by eliminating non-value-adding activities or waste (Womack et al., 1990). "Waste" in the production processes refers to inadequate processing, unnecessary transportation, excess motion, less-than-perfect quality, waiting, overproduction and inventory (Ōhno, 1988; Shingo, 1989). Lean manufacturing comprises a systematic framework of principles and practices to identify and eliminate these sources of waste (Ohno et al., 1995). (Womack & Jones, 2003) outlined the five guiding principles of lean manufacturing: precisely specify value; identify value stream; make value flow; let the customer pull value; and pursue perfection. The principles of lean are expressed through several key lean manufacturing practices: just-in-time (JIT), employee involvement, supplier involvement, customer focus and internally-related practices (details in section 1.4.2). In a nutshell, lean manufacturing practices reduce the time from customer order to delivery by eliminating waste (i.e. anything other than the amount of equipment, materials, space, and time that are essential to add value) (Liker, 1997; Russell & Taylor, 2003).

Gaps and criticism of lean manufacturing

Despite eye-catching results in the automobile sector and later in other settings, lean manufacturing has been criticized on many accounts: lack of contingency, inability to cope with human aspects, variability and narrow focus on shop-floor. (Hines et al., 2004) summarized the gaps and criticism of lean manufacturing over time in Table 1-2. This summary table shows how lean manufacturing research initially focused on automobile sector.

Table 1-2 Gaps and criticism of lean manufacturing

	1980-1990	1990-mid 1990	Mid 1990-1999	2000+
Key gaps	Outside shop-floor Inter-company aspects Systemic thinking **Auto-assembly only**	Mainly auto Human resources, exploitation of workers Supply chain aspects System dynamics	Coping with variability Integration of processes Inter-company relationships **Still mainly automobile**	Global aspects Understanding customer value Low volume industries Strategic integration
Main critics	Carlisle and Parker (1989) Fucini and Fucini (1990)	Williams et al. (1992) Garrahan and Stewart (1992) Rineheart et al. (1993)	Cusumano (1994) Goldman et al. (1995) Harrison et al. (1999) Suri (1999)	Bateman (2000) Christopher and Towill (2001) van Hoek et al. (2001)

Source: (Hines et al., 2004)

Given this background, this study explores the use of lean manufacturing practices in food processing SMEs, as well as its impact on operational performance and the influence of determining factors in the lean implementation journey. The following section discusses the specific characteristics of the food processing industry and the differences between SMEs and large organizations to specify the context.

1.4. Taxonomy of food processing SMEs and current knowledge gaps

1.4.1. Taxonomy of the small and medium sized food processing industry

The literature underlines that contextual factors hold the key to the success of lean manufacturing practices (Birdi et al., 2008; Salaheldin, 2009; Sila, 2007). Toyota, a *large discrete automobile* company in *Japan* achieved a spectacular result by applying Toyota production system that is similar to lean manufacturing practices. Can lean manufacturing practices have the matching outcome in a distinct environment; *small*, *food processing* company in *Europe*? A literature review was carried out to better understand the contextual factors concerning the specific characteristics of the *food processing industry* and the *differences between SMEs and large organizations*. First of all, what are the differences between the food sector and other manufacturing industries in the manufacturing context? Based on the literature Table 1-3 was constructed to illustrate some important differences (Van Wezel et al., 2006; Wang et al., 2009).

Table 1-3 Differences between Manufacturing Industries and the Food Sector (SME context)

Manufacturing Industry	Food Sector
Generally non-perishable products	Highly perishable products
Standardized raw materials	Variation in quality of raw materials, supply, and price
Relatively limited number of designs	High variation of composition, recipes, products and processing techniques, variable yield and processing duration, variable product structure
Processing equipment is not necessarily sequence-dependent	Processing equipment has sequence-dependent
Mostly, no mandatory microbiological or quality assurance requirement	Mandatory quality assurance certification requirements

Source: own compilation

It is evident that food and its production process have special characteristics such as a short shelf-life, heterogeneous raw materials, seasonality, and varied harvesting conditions. These factors hugely affect storage, conditioning, processing, packaging and quality control which make any QM initiative more complicated. The heterogeneous nature of this industry as a whole, the huge variation in quality of raw materials, their highly unpredictable supply and customer demands make the individual manufacturing sector quite unique. For example, one would expect a meat product (e.g. sausage) with a manufacturing lead time of one day and a shelf life of 3 days to be controlled differently than a dried ham with a manufacturing lead time of 10 months and a shelf life of one month. Yet consumers expect both products to be available in grocery stores at all times and retailers expect the delivery lead time of these products to be identical.

Another example is how rapidly the product deterioration limits the manufacturer's inventory status. Simultaneously, the processing and packaging lead time is often much longer than the customers' expectations for delivery lead time, which means manufacturers must supply products from their inventories. The result is that manufacturers must continuously balance the risk of waste and reduced product quality with the risk of stock-outs and dissatisfied customers. Additionally, a guaranteed minimum shelf life of food products possesses a big challenge for food processors. The product can be perfectly good, but retailers won't accept because of a too short shelf life. Importantly, the retailers put pressure on manufacturers, while the contact with the final consumer is more difficult. Also retailers can demand for some 'quality requirements' that are not always real end consumer requirements.

Similarly, the implications and sustainability of lean manufacturing practices in a SME environment is still a debated topic in the field of operations management research (Thomas & Barton, 2006). Most of the studies focus on either large organizations or SMEs within the non-food sectors (Hulebak & Schlosser, 2002). Literature indicate that the implementation of lean manufacturing depends on organizational factors such as the size of the organization, the type of suppliers and customers, the degree of automation, the type of products and, quality assurance requirements (Trienekens & Zuurbier, 2008). Studies claim that the challenges in establishing an appropriate quality management system are more intense for the SMEs due to a lack of resources, competencies and diseconomies of scale (Antony et al., 2005a). In addition, there are significant differences between SMEs and large manufacturers with respect to structure, policy making procedures, resource utilizations, staff patterns, culture and patronage (Welsh & White, 1981).

Table 1-4 presents an overview of the differences between SMEs and large organizations.

Table 1-4 Difference between SME and large organizations

Determining factors	SMEs	Large organizations	Sources
Leadership & Management	- Entrepreneurial, individualistic - Leaders more involved in Operational activities - Direct supervision - Top management close to the point of delivery - Owners have better understanding of processes & customers	- Professional, administrative - Leaders more involved in strategic planning - Formal delegation of responsibilities to achieve co-ordination - Mostly bureaucratic	(Garengo et al., 2005);(Wessel & Burcher, 2004);(Ghobadian & Gallear, 1997) ;(Deros et al., 2006); (Beaver & Prince, 2004) (Phelps et al., 2007)
Strategic planning	- Short-term planning with focus on niche strategies - Strategic activities are informal, intuitive, invisible - Decisions based on imprecise information	- Both short and long-term planning - Planning based on in-depth analysis - Strategic process is fixed and regulated	(Barnes, 2002);(Sum et al., 2004);(Beaver & Prince, 2004);(Storey, 1994);(Berry, 1998)
Organizational structure	- Flat with few layers of management - Low degree of specialization - Flexible structure and information flow	- Hierarchical with several layers of management - High degree of specialization - Rigid structure and information flow	(Yusof & Aspinwall, 2000a);(Garengo et al., 2005); (Beaver & Prince, 2004) (Phelps et al., 2007)
Human & financial resources	- Individual creativity encouraged - Limited human capital, financial resources - Training and staff development is small-scale - Negligible resistance to change	- Individual creativity stifled - Ample human capital, financial resources - Training & staff development - High degree of resistance to change	(Yusof & Aspinwall, 2000a);(Garengo et al., 2005); (Thomas et al., 2008; Thomas & Webb, 2003b); (Wessel & Burcher, 2004)

Source: Own compilation

The literature on SMEs and QM literature shows that there are several advantages as well as disadvantages of being an SME. Some of the advantages of SMEs are: involvement of top management in day-to-day activities (Mc Cartan-Quinn & Carson, 2003), informal structure and culture which increases cross-functional exchanges and smaller teams that aid in efficient decision making (McAdam, 2000). Some of the major disadvantages of SMEs are: lack of resources (Achanga et al., 2006), lack of training (Koh et al., 2009), lack of long-term planning (Mezgár et al., 2000), shortage of staff and lack of resources for major consulting (Brun, 2011). Moreover, studies also found that the implementation of quality management methods such as lean manufacturing can be relatively costly for SMEs than for large organizations because of the scale and the impact of unsuccessful projects more severe (Mabert et al., 2000; Muscatello et al., 2003). These important contextual differences are taken into account while forming the conceptual framework and analysis of this thesis.

1.4.2. Current knowledge gaps in quality management research

In order to explain the sectoral differences and challenges of lean manufacturing journey (Hines et al., 2004) stated:

> "…when applied to sectors outside the high-volume repetitive manufacturing environment, lean production has reached its limitations, and a range of other approaches to counter variability, volatility and variety have been suggested (Hines et al., 2004)".

Many studies reinforced the claim made by (Hines et al., 2004) regarding the effectiveness of lean manufacturing (Ben Naylor et al., 1999; Christopher & Towill, 2001). This section is dedicated to understand these different views on applicability and effectiveness of lean manufacturing in food SMEs presented in previous studies. The current knowledge on lean in food sector is explained in the context of three broad categories: *processing industry*, *food sector* and *SMEs*, in contrast to Toyota (*discrete industry, automobile sector* and *large organization*).

Processing industry context:

Processing industries are principally defined as those where the primary production processes are either continuous, or occur on a batch of materials that are indistinguishable such as food, beverages, chemicals, or pharmaceuticals. One of the important differences between assembly and process industries are hidden inventories and machines that are difficult to move because of their size and connected pipes (King & King, 2013). Peter King wrote an interesting article "Making Cereal Not Cars" to demonstrate that the application of lean is not straightforward in process industries and needs adjustment (King et al., 2008).

(Abdulmalek et al., 2006) stated that extensions of lean manufacturing to the process industry have been much slower compared to discrete industries such as the automobile industry. Their study pointed out that the product and/or process characteristics may hinder a straightforward application of lean. They provided a fitting example saying production efficiencies related to large product volumes may impede JIT production, whereas process flexibility determines the relevance of lean practices. Lean manufacturing was designed for a low-mix, high-volume manufacturer of a limited range of assembled products. Consequently, adaptations are required in order to get the desired results in processing industries (Irani, 2011).

Food sector context:

According to (He & Hayya, 2002) quality is measured more subjectively in the food industry compared to other durable goods. Their study claims that durable goods are most likely to be measured objectively based on product-life, reliability, maintainability, and conformance to design, whereas in the food industry quality is largely a matter of taste and preference. Similarly, (Hooker & Caswell, 1996) claimed that, for the food processors and consumers, the term “quality” narrowly refers to food-safety and hygiene. This may be one of the reasons that Hazard Analysis and Critical Control Points (HACCP) is mandated by government in many countries across the world to ensure food safety. This may also be a reason why a large number of studies focus on HAACP and similar food safety focused quality initiatives (Caswell et al., 1998; Fotopoulos et al., 2011; Jacxsens et al., 2011; Ropkins & Beck, 2000; Westgren, 1999). There is limited literature that addresses the issue of suitability of lean manufacturing in the food processing industry (Mahalik & Nambiar, 2010; Scott et al., 2009). Some studies show that adoption of lean manufacturing as it is in the food processing industries will not achieve the desired efficiency gains (Cox & Chicksand, 2005). Other studies purposefully chose to ignore food companies in their study sample (Sanchez & Pérez, 2001). Yet other studies claim that with minor adjustments, lean manufacturing can bring considerable benefits to the food processing industry, such as faster throughputs, reduced inventories and increased profits (Jain & Lyons, 2009). The following section provides a brief overview of lean manufacturing in the food sector.

(Rajurkar & Jain, 2011) presented a detailed review of literature on food supply chains management based on 134 papers published in reputed academic journals between 1994 to 2009 and concluded that there are only a few studies which focus on quality improvement initiatives such as lean manufacturing in the food industry. Further, there is a clear division of opinion among researchers on the applicability and outcomes of lean manufacturing practices in the food processing industry. Similarly, (Marodin & Saurin, 2013) reviewed 102 articles appeared in reputed peer reviewed operations management and engineering journals between 1996 to 2012, and found that there are only three articles included food sector (from US and UK) in their study sample.

Zokaei and Simons, for example, conducted case studies in nine red meat chains in the UK and identified a number of waste areas in the value chain concerning mortality, farm giveaway, cleaning, cutting room, machine effectiveness and storage waste (Zokaei & Simons, 2006). The findings show that by applying two lean concepts-takt time and standard operations-each actor in the chain could save 2 to 3 percent of their costs. However, the limitation of their study is that only two lean manufacturing techniques were considered, which narrowed the scope and outcomes of lean manufacturing. Similarly, Lehtinen and Torkko discussed how the lean technique of value stream mapping could be applied to a Finnish food manufacturing company (Lehtinen & Torkko, 2005). The value stream mapping technique helped the food company to analyze and eliminate unnecessary inventories and other forms of waste along the supply chain. This case study showed that the food company reduced costs and increased customer satisfaction.

In another research project, (He & Hayya, 2002) examined the impact of just-in-time production on food quality through an empirical study by surveying 48 US food companies. The results demonstrated that JIT has a positive impact on food quality. Additionally, employee involvement in problem solving and just-in-time delivery was found to be the most used practice in the food companies. Regression analysis suggested that material management has a definite effect on food quality. Likewise, Upadhye, et al. conducted a case study on a medium-sized biscuit manufacturing company in the framework of lean manufacturing (Upadhye et al., 2010). Their study clearly shows that lean techniques such as 5S, kaizen, quick changeover, and TPM can be effectively used to improve equipment availability, reduce wastage of material and improve quality. The biggest obstacle that was found in the lean journey was the resistance to change from both employees and suppliers. The study also emphasized that the success of the lean implementation rested on commitment from the top management as well as training, awareness and involvement on the employees' parts.

A recent study by Engelund, et al. discussed the application of lean manufacturing to large-scale food production in a Danish hospital (Engelund et al., 2009). It was shown that the lean techniques-value stream mapping, kaizen and 5S-helped improve production efficiency, product quality and working environment. The study also pointed out that the just-in-time and pull production failed to produce the desired results. In addition, the study reported that the successful application of lean in food production depends on the food safety and quality requirement and work organization in the surrounding systems. Similarly, Scott, et al. conducted a quantitative survey of 46 food SMEs to analyze the continuous improvement programs and the motivational factors among the Canadian food companies (Scott et al., 2009). They found that 10 out of 46 companies implemented lean manufacturing. The survey result revealed some interesting findings, e.g. that companies implementing lean or similar programs have fewer product recalls in comparison to the ones who do not have such programs. However, half of the respondents were not sure if these improvement programs had resulted in cost savings. Another finding was that the quality and safety benefits were the biggest motivational factors for the implementation of lean manufacturing and similar programs within Canadian food SMEs.

Providing a counterexample, a case study that was carried out by Cox and Chicksand in the red-meat supply chain in UK revealed that the adoption of lean practices is not easy for all internal and external participants in the food chain (Cox & Chicksand, 2005). Cox and Chicksand pointed out that lean adoption resulted in a high dependency on buyers and a declining profitability for the majority of the stakeholders in the chain. They recommended not extending lean beyond the boundaries of the firm and provided a note of caution, imploring researchers and practitioners to understand the context and the industry before replicating the lean principles. Similarly, the food process innovation unit at Cardiff University concluded that trust and contract complexity between buyer-suppliers is significantly different between the food sector and the automotive industry (Simons & Zokaei, 2005).

In the same note, Kumar and Antony conducted a survey of 64 SMEs in the UK (seven among them are food SMEs) to compare different quality management practices (Kumar & Antony, 2008). Their study found that 17 out of 64 SMEs (26.5 percent) adopted lean manufacturing in their organization and that top management involvement, communication, cultural change and training were the critical success factors for such quality improvement initiatives. However, the findings and analysis in their study was generic in nature and did not specifically mentioned about food SMEs barriers in implementation of lean practices. The study also identified several barriers to quality management practices like lean manufacturing, including availability of resources, lack of knowledge, lack of training, internal resistance and poor employee participation. (Costa et al., 2000) stated that the nature of food products (complex intrinsic and extrinsic values) and the lack of knowledge about these methods in food SMEs are the important barriers of lean implementation in this sector.

SME context:

Studies found the challenge for SMEs are manifold when it comes to establishing an appropriate QM system (Lee, 1997; White et al., 1999; Inman and Mehra, 1990; Schonberger, 1996). According to (Hines et al., 2004) it is not always easy for SMEs to change their usual way of operations. Sánchez and Pérez (2001) excluded small firms with less than 50 employees from the study saying these companies are less likely to adopt lean manufacturing practices. (Trienekens & Zuurbier, 2008) stated that SMEs often struggle to establish a sustainable quality management system because of a lack of resources, training and expertise. One prominent reason cited for the low level of quality management initiative is the deficit of statistical skills among the staff in SMEs due to a lack of provision of resources or training on tools and techniques (Grigg & Walls, 2007; Thomas et al., 2008). For instance, (Scott et al., 2009) revealed that 17 percent and 21 percent of the respondents among the Canadian food SMEs had initiated Six Sigma and Lean respectively. In contrast, (Higgins, 2006) found that 37 percent and 57 percent of the large food companies in the US used Six Sigma and Lean. Similar studies show that SMEs have difficulties in applying quality management tools because of a limited awareness and knowledge of specialized statistical applications (Achanga et al., 2006; Antony et al., 2008).

(Bakås et al., 2011) reviewed the existing literature on lean manufacturing in SMEs between 1992- 2011 and the results are presented in the Table 1-5. It is important to note that none of these studies focuses on food industry, given the fact that 98 percent of the food processing companies have less than 250 employees in Europe according to Confederation of the food and drink industries (CIAA, 2010).

Table 1-5 Studies related to lean manufacturing in SMEs

Studies	Methodology	Focus	Main findings & critical success factors
(Achanga et al., 2006)	Literature review Cases: 10 (UK)	Critical success factors for Lean implementation in SMEs	• Critical success factors: -leadership -management -finance -organizational culture -skills and expertise
(Kumar et al., 2006b)	Case: 1 (India), automobile	Framework combining Lean Six Sigma with Lean Manufacturing	• Implementation of the proposed framework shows dramatic improvement in the key metrics and substantial financial savings in the case SME • Critical success factors not addressed
(Antony et al., 2005b)	Survey – (UK) (literature review)	Strengths and weaknesses of SMEs, Six Sigma projects and lean	• Companies do not have resources to implement Lean Six Sigma projects • Lean and Six Sigma not popular among SMEs • Critical success factors: -Management involvement and participation -Linking Six Sigma to customers -Linking Six Sigma to business strategy
(Kumar et al., 2009)	Survey – UK manufacturing (64 responses)	Quality improvement initiatives, Six sigma and lean	• Factors critical to success of quality initiatives are equal in importance, irrespective of type of initiatives implemented by the firm. • Critical success factors: -Management involvement and commitment -Communication -Link Quality Initiative to employee -Cultural change -Education and training
(Thomas et al., 2008)	Single case – UK SME	An integrated approach to lean and six sigma Model.	• Showcases a successful implementation of the Lean Six Sigma model in the SME case company. The lean approach developed a culture towards continuous improvement throughout • Critical success factors not addressed
(Grewal, 2008)	Single case – India SME	Value Stream Mapping	• Value Stream Mapping proved useful to company • Critical success factors not addressed.
(Shah & Ward, 2007b)	Survey of US plans with 1757 valid Responses	22 management practices from lean and six sigma	• Strong support of the proposition that large plants are more likely to possess the resources to implement lean practices than smaller plants • Critical success factors not addressed.
(Pingyu, 2009)	Survey of 100 SMEs in Wenzhou region in China	Barriers to SMEs implementation of Lean	• Counter measures to barriers to Lean implementations in SMEs: -attention and involvement of senior managers -good communication platform -learning organizations -establishment of performance evaluation
(White et al., 1999a)	Survey, US	Comparing 10 JIT practices in small and large firms	• Larger companies more likely to implement JIT • Performance dependent on manufacturer's size.
(Wilson & Roy, 2009)	Literature Review Theoretical model with case	Lean procurement	• The barriers faced by SMEs trying to implement a lean procurement philosophy are significant. • Low volumes, small lot sizes and high frequency purchases incur additional distribution costs • Critical success factors not addressed

Source: Adopted from (Bakås et al., 2011)

The majority of the literature supports the finding that the success of the quality management system depends on a genuine top management commitment, policy and planning aimed at customer satisfaction, good communication within the organization, and employee involvement and teamwork development (Rahman & Tannock, 2005). (White et al., 1999a) found that the degree of quality initiatives such as quality circles, TPM, set-up time reduction and kanban was higher in large companies. (Shah & Ward, 2007a) described that large plants are more likely to implement lean practices. However, they also stated that practices such as multi-function employees and TQM programmes are better implemented in small companies. However, there are also studies which suggest that there is no correlation between the size of the companies and the degree of lean implementation (Finch & Cox, 1986; Inman & Mehra, 1990).

In summary

The research gaps found in the literature on lean manufacturing in the food processing SMEs can be summarized in the following points which also define the research propositions of this thesis:

- Most of the studies are based on the applicability of individual lean tools and techniques and ignore the holistic, broad lean manufacturing principles. Importantly, there is a very few studies attempted to integrate quality assurance (HAACP) and quality improvement (Lean manufacturing) without providing a concrete framework. The quality assurance literature is dominant compared to quality improvement research.
- The applicability and effectiveness of lean manufacturing in the food processing industry is still a debated topic and academia has yet to reach any consensus.
- There is currently no clear mechanism which can enable companies to assess their eligibility to undertake lean manufacturing implementation.
- There are no studies that investigated which of several available lean manufacturing practices (techniques) are more prevalent in food processing SMEs than the other.
- The impact of control variables such as size of the firm and country of operation on lean implementation have not been investigated in the food processing context.
- There is no study on how determining factors (enabling and/or obstructing) affect the lean adoption in a food processing SME. Likewise, there is no study which explores the impact of sector specific contextual factors related to product type, production process,

organizational culture, and relation with/to the chain actors on lean manufacturing implementation and operational performance.

- The majority of the available studies are case studies and very few studies are based on empirical surveys. The reason being cited in the literature is a low response rate from food SMEs.

The gaps in the literature show that insight is needed into the specific contexts in which food processing SMEs operate, in order to reveal their challenges and possibilities in lean implementation. Only then it will be possible to implement lean manufacturing with the assurance of better outcomes. Considering these background factors, this doctoral dissertation investigates whether any of the contextual characteristics of *food processing SMEs* influence the prospects of success for lean manufacturing implementation. The following section will provide the underlying theory and conceptual framework describing the approach applied to examine the application of lean manufacturing in food processing SMEs.

1.5. Theoretical context

This section will provide an explanation of the main characteristics of the selected underlying theories of operations management and their relationships with lean manufacturing. After presenting the main features of these theories, the main constructs of this PhD dissertation are synthesized into a conceptual framework.

How does a firm choose a specific quality management practice (be it lean, TQM, ISO, BRC) and why do some firms perform better than others applying the same practice? Organizational behavior theorists shed light on the understanding of these two fundamental questions. Organizational behavior theories emphasize identifying, explaining, and predicting the determinants of organizational performance. Past studies have pointed out that to achieve the desired results of manufacturing practices, the firm needs to understand what types of organizational behavior fit with its operational strategy (Christopher & Towill, 2001; Lewis, 2000a; Rich & Bateman, 2003). The theory suggests that individual, organizational, environmental, and other factors attribute to organizational performance (Ketchen & Giunipero, 2004).

Recent studies have investigated lean manufacturing in the context of individual organizational behavior theories such as contingency theory, resource-based view theory, and institutional theory (Kleindorfer et al., 2005; Rothenberg et al., 2001). Table 1-6 provides an overview of previous studies linking organizational behavior theories and lean manufacturing. Some studies combined different theoretical perspectives together in order to get a better understanding of the complex lean manufacturing phenomena (Reeves, 2007). Additionally, lean management is a tool-based manufacturing strategy and organizational behavior could play an important role in understanding the context surrounding its implementation (Punnakitikashem et al., 2009). TQM, a similar quality initiative has also been studied in the context of organizational behavior theory (Sureshchandar et al., 2001). Hence, it is justifiable to examine the lean manufacturing practices through the conceptual lenses provided by organizational behavior. This study therefore uses multiple organizational theories: contingency theory, resource-based view theory, and institutional theory as the basis to formulate research propositions regarding the effects of contextual factors on lean manufacturing practices and practice–performance relationships.

Table 1-6 Studies using organizational behavior theory in lean manufacturing

Theory	Research Stance	Research Finding	Source & sector
Resource-based View Theory	Development of a theoretical construct, development and empirical investigation of propositions, drawn from three case studies, specifying the influence of lean production on the overall competitive positions	Lean production in practice can create strategic resources to underpin sustainable competitive advantage. Being "lean" can curtail the firm's ability to achieve long term flexibility	(Lewis, 2000b) (Automobile)
Contingency Theory	Development and investigation of theory-based contingency propositions	Organizational context, i.e. plant size, unionization and plant age, matters with regard to implementation of lean practices.	(Shah & Ward, 2003) (Mixed)
Contingency Theory	Development of a theoretical framework provided by case study research and investigation the relationship between lean manufacturing initiatives and control components	Accounting practices is an important variable in the relationship	(Kennedy & Widener, 2008) (Services)
Transaction Cost Theory	Development and investigation of the theoretical framework and propositions for studying the relationship between inter-firm linkages, asset specificity and transaction costs	Asset specificity was found to be significantly correlated with transaction costs and with inter-firm linkages. Suppliers who have invested in relationship-specific assets tend to have stronger relationships with their main customer, but also incur higher transaction costs	(Ghani & Khan, 2004) (Automobile)
Transaction Cost Theory & Resource-based View Theory	Examination of theoretical constructs via the examination of two case studies that demonstrate two contrasting approaches	Personal management perceptions of the underlying service can be influenced as much by decidedly subjective criteria as by market realities or the more objective criteria	(Reeves, 2007) (Automobile)
Institutional Theory	Development of conceptual framework and empirical test of the three competing perspectives by testing in a sample of 164 manufacturing plants	Institutional perspective explains the variance in the practices adopted and implemented by the plants than either the structural contingency or the strategic contingency theories	(Ketokivi & Schroeder, 2004b) (Mixed)

Source: Own compilation based on (Punnakitikashem et al., 2009)

The following section further explains the main characteristics of the underlying organizational behavior theories: contingency, resource-based view and institutional theory in order to construct the conceptual framework.

Contingency theory:

The core message of contingency theory is examining how external and internal environments interact with organizational characteristics (Drazin & Van de Ven, 1985). The environmental factors influence the operation of organizations leading to different organizational behaviors (Ketokivi & Schroeder, 2004b). The two key elements of the contingency theory are: first, there is no universal or best way to manage, and second, the design of an organization must "fit" to the environment for the most effective results. In other words, the contingency theory focuses on how a firm could achieve better operational performance by considering the ''fit" of the contextual factors. Previous studies examined control factors such as size, country of operation, unionization, and plant age (Cua et al., 2001a; Gupta & Boyd, 2008; Shah & Ward, 2003). For instance, the size of the firm, which is prominently featured in many studies, was found to be an important determining factor in the manufacturing industry. According to several studies "size does matter" in several ways: first, a higher level of manufacturing performance was found in larger firms compared to smaller firms (Cua et al., 2006) and second, large organizations are more likely to implement lean practices than small ones (Shah & Ward, 2003; White et al., 1999a). Third, though small firms may also implement critical elements of lean manufacturing, the applied practices will, to some extent, be different than the practices in large firms (Welsh & White, 1981; White et al., 1999a). One of the important reasons cited for these differences is the availability of resources in small and large organizations (Inman & Mehra, 1990; Shah & Ward, 2003). The resource availability aspects will be discussed in the subsequent section.

Importantly, proponent of contingency theory claim that the choice of industry can significantly affect the results of the practice (Davies & Kochhar, 2002). This justifies the very purpose of this doctoral research because its prime objective is to understand the contextual factors surrounding lean manufacturing in food processing SMEs. Organizations are not closed systems and are constantly exposed to contingency factors that should be considered at the time of choosing their manufacturing strategies (Schoonhoven, 1981). The contingency model helps organizations to determine how variance in specific structural arrangements and manufacturing practices correlates with operational and economic performance (Snell, 1996). Given these arguments and rationale, the key constructs of this doctoral dissertation are rooted in the structural contingency paradigm of organizational behavior, and consequently, the contingency theory is the key underlying theory of this dissertation.

Resource-based view theory:

The resource-based view theory (RBT) was developed to explain how firms can achieve a sustainable competitive advantage by using their specific resources and capabilities (Conner, 2001). Resources can be tangible (physical capital – like equipment or physical technology) as well as intangible (knowhow, information, and learning) and organizations strive to optimize based on the available resources. The attributes of a resource are that it is scarce, imperfectly mobile, inimitable and non-substitutable in nature. The two fundamental components of the resource based theory are: product differentiation and lower cost provider (Wernerfelt, 1995). Likewise, the prime goal of lean manufacturing is to eliminate all sorts of waste in the process, add value at lower costs. Moreover, the resource based theory highlights product differentiation (Barney, 1991). Lean manufacturing companies differentiate their product by better quality and fastest delivery. RBT suggests an effective and exclusive strategy is a prerequisite for a firm in order to get the best out of all of its available resources (Schroeder et al., 2002). Comparing the remarkable success of Toyota with less favorable results of lean in other manufacturing companies, it is evident that the strategy devised at Toyota is exclusive. It also supports the claim that resources are neither homogeneous nor mobile (Spear & Bowen, 1999).

(Lewis, 2000b) used resource based view theory to investigate the impact of lean manufacturing on the overall competitive positions of firms. The empirical findings drawn from three case studies show that the firms gained competitive advantage because of the resource derived from improved productivity due to lean practices. Moreover, the study claims that the uncertainty of lean manufacturing in practice means that the implementation process can create strategic resources to support sustainable competitive advantage. (Lewis, 2000a) demonstrates the relationships between resource, process (practice) and output (performance) in his model presented in Figure 1-3.

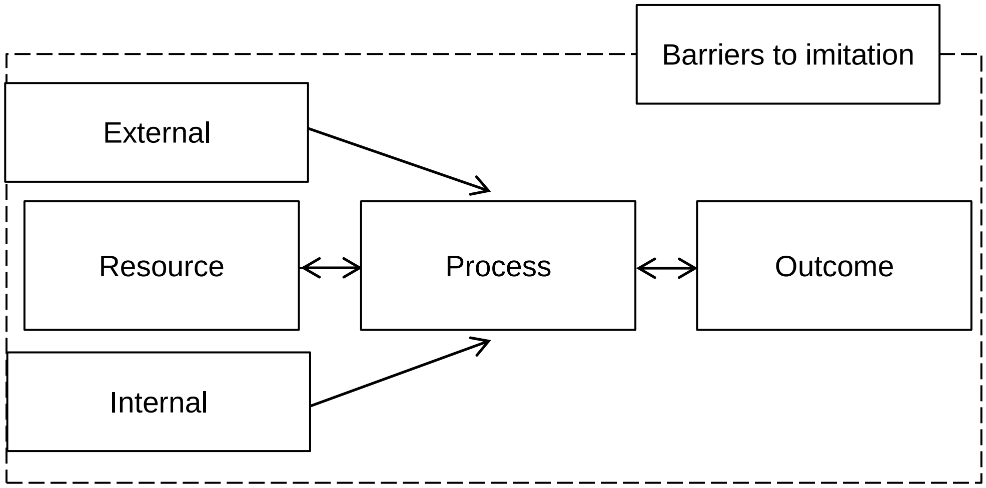

Figure 1-3 Sustainable competitive advantage model

Source: (Lewis, 2000b)

(Lewis, 2000b) in his sustainable competitive advantage model argues that resources (skilled staff, market information, technological data) create value when enacted in the processes (manufacturing practice, product development). In turn, these processes allow the organization to learn and thereby create new resources. However, the sustainability of any competitive advantage (lower cost, product differentiation) depends upon the barriers that exist to prevent rival firms imitating key resources (knowhow). Using this model he proved that the success of lean production in delivering sustainable competitive advantage is contingent upon the external context of the firm (competitor activity, different demand profiles, dominant technology in sector; supply chain structure). Keeping these factors in mind, the key constructs of this PhD dissertation found their roots in the contingency theory of organizational behavior, and the resource based view theory.

Institutional theory:

Institutional theory can be used to study how a company addresses quality management issues due to external pressures, and therefore it has become a major research area in the understanding of quality management practices (Ketokivi & Schroeder, 2004b; Zsidisin et al., 2005). The core idea of institutional theory is organizational isomorphism, which means constraining process forces of one firm to resemble or imitate another firm that faces the same set of environmental conditions (DiMaggio & Powell, 1991). There are three forms of organizational isomorphic drivers: coercive, normative, and mimetic mechanism (DiMaggio

& Powell, 2000). Coercive isomorphic means those in power (be it the customer, supplier or regulator) influence the firm's decisions or actions (Sharpe, 2001). For instance, government agencies coercively influence the actions of an organization, for example, mandatory HACCP compliance. Similarly, mimetic isomorphism happens when firms imitate the actions of successful competitors in the industry (Bae & Rowley, 2002). The classic example is the success story of Toyota which inspired many firms to imitate lean manufacturing. And the third one, normative isomorphism argues that a powerful customer may require the supplier to adopt certain practices or principles.

One widely cited study by (Ketokivi & Schroeder, 2004b) used the neo-institutional arguments to explain the determinants of manufacturing practice adoption. The neo-institutional argument claims that organizations imitate one another in an attempt to enhance economic performance (Haunschild & Miner, 1997). Their study refutes the traditional closed rational systems theory (Scott, 1981) stating that strict profit-maximizing economic rationality does not always respond correctly to the ground reality. (Ketokivi & Schroeder, 2004b) provided examples to substantiate the argument. For instance, lean manufacturing is viewed through an institutional mimicry lens: "mimickers attributed Toyota's success to its manufacturing system and hence tried to mimic the manufacturing system long before the link to economic performance was firmly established." Similarly, organizations imitate each other through a coercive mechanism as seen in the case of Toyota's lean or Motorola's six sigma, which are widely copied across organizations. An example of the coercive mechanism is ISO or HACCP adoption by firms driven by demands from customers, suppliers or regulators. (Snell, 1996) explained this phenomenon in these words, "managers feel considerable pressure to 'do something' about quality and lean, whether this makes sense strategically or not".

Based on the same neo-institutional arguments, (Ketokivi & Schroeder, 2004b) develop a theoretical framework of organizational behavior to understand the relationships among quality management practices, performance and contextual factors. The framework includes strategic goal, environmental contingencies, and institutional effect (Figure 1-4).

First, they argue that it is important to understand the motive or strategic goal of the firm before analyzing the performance effects of a quality management practice. Second, they define environmental contingency as the external business environment as well as the internal task environment, the two basic elements of the structural contingency argument. Third, the institutional effect is included in the framework to provide the three mechanisms (mimetic, normative and coercive) discussed above. The conceptual framework of this doctoral research is based on this theoretical framework proposed by (Ketokivi & Schroeder, 2004b).

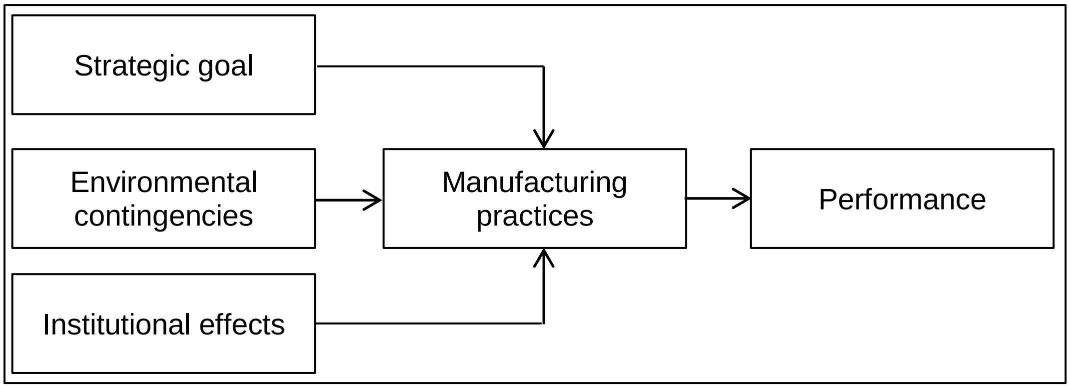

Figure 1-4 Three propositions explaining the implementation of manufacturing practices
Source: (Ketokivi & Schroeder, 2004b)

Hence, the key constructs of this PhD dissertation also found their roots in the institutional theory. This theory can explain how external drivers promote lean manufacturing practices vis-à-vis other quality management practices in the food processing industry. The underlying theory will shed light on how governmental regulations can be key drivers for enterprises to implement quality management practices (Benson et al., 1991). Considering my research problem, it will be interesting to examine how various isomorphic pressures result in firms choosing similar management practices over time. Each of these theories (contingency, resource-based and institutional) has complimentary roles in supporting the operation strategy implementation such as lean manufacturing. The following section explains the conceptual framework derived from the research problems, objective of the study and underlying theories.

1.6. Conceptual framework

There are four distinctive characteristics of a conceptual framework: (1) the type of concept considered, (2) their relationships in terms of causality and directionality, (3) the hierarchy between these elements, and, (4) the representation of these elements (Holweg & van Donk, 2009). This section synthesizes the main constructs of this dissertation into a conceptual framework based on the underlying theories of organizational behavior. The basis of this conceptual framework is derived from the integrated contingency, resource-based and institutional theory as explained in the previous section. The conceptual framework describes the approach that will be applied for investigating the application of lean manufacturing in food processing SMEs. The choice of constructs to be investigated is motivated by the research problem and the previously described theories.

This research follows the guideline of (Sousa & Voss, 2008), (Lewis, 2000b) and (Ketokivi & Schroeder, 2004b) and included *practices, performance* and *determining factors* to get a deeper understanding of the applicability and effectiveness of lean manufacturing practices in food processing SMEs. In the next section, the practice, performance and determining factors are explained with the help of literature for scientific underpinning. Figure 1-5 provides an outline of the conceptual framework that will be applied and analyzed to understand the research problem. The different components of the conceptual framework and the rationale to investigate them will be discussed in the subsequent sections.

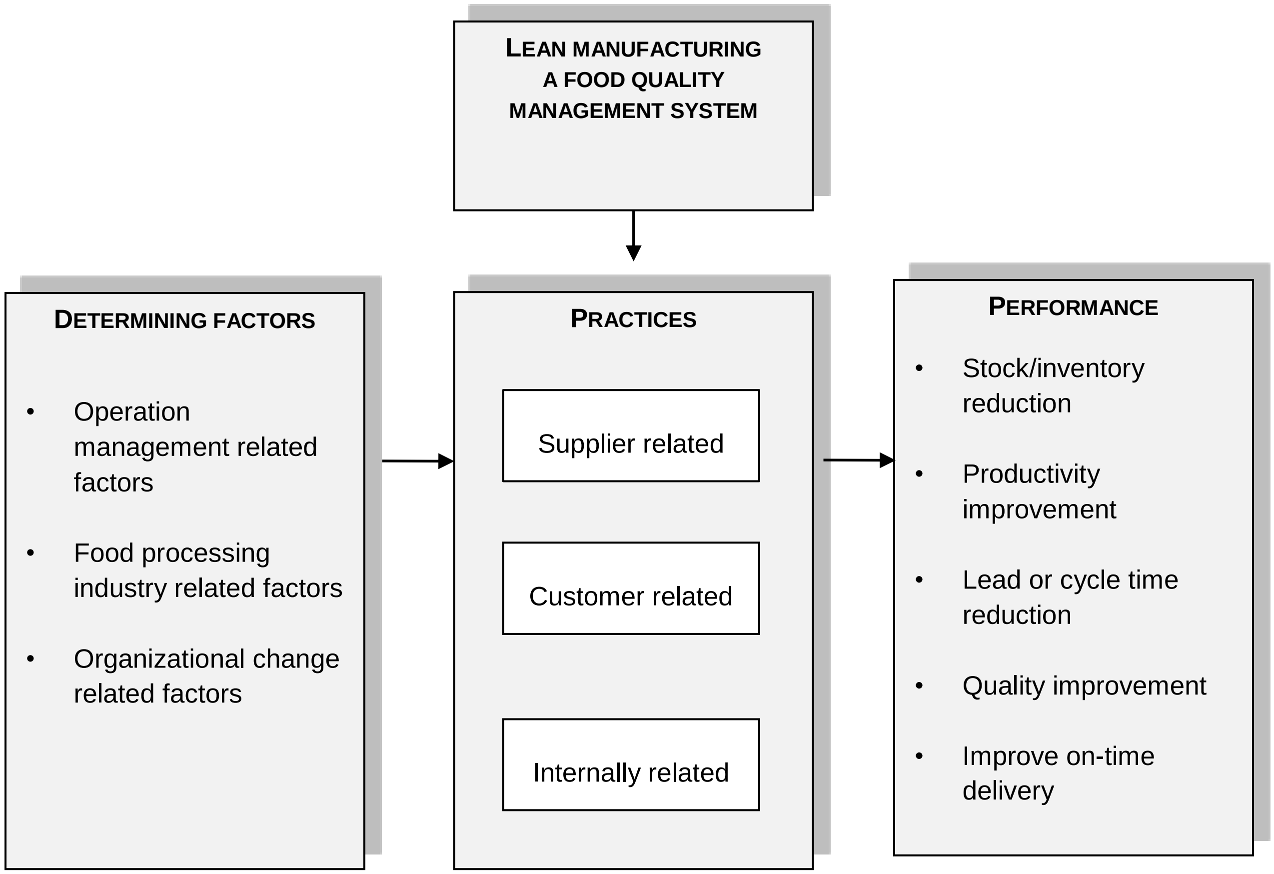

Figure 1-5 Conceptual framework

Source: Own compilation based on (Achanga et al., 2006; Ketokivi & Schroeder, 2004b; Lewis, 2000a; Luning et al., 2002; Shah & Ward, 2007b; Sousa & Voss, 2008).

Practice

Flynn et al. (1995) describes practices as “approaches used by management and workers with the goal of achieving certain types of performance”. The individual practices of lean manufacturing, such as Kanban, preventive maintenance, set-up time reduction, group technology and, JIT supplies are well documented in the literature (Womack and Jones, 1996; Monden, 1998; Feld, 2000; Nahmias, 2001; Shah and Ward, 2003; Liker, 2004; Abdulmalek and Rajgopal, 2007). Voss and Blackmon (1994) relate practices with improved performance stating that new practices tend to improve performance. Many studies combined individual practices into bundles to present the multi-dimensional nature of lean manufacturing (Cua et al., 2001; Katayama and Bennett, 1996; Sakakibara et al. Flynn and Sakakibara, 1995; Forza, 1996; Lowe et al., 1997; MacDuffie, 1995; Shah and Ward, 2003; Smith et al., 2003; Sakakibara et al. 1997).

It is also found that the benefits of using individual practices is limited compared to implementing bundles (Sakakibara et al., 1997; Fullerton and McWatters, 2001; White and Prybutok, 2001). Table 1-7 is constructed in order to give a better understanding of the lean manufacturing practices.

A major contribution in understanding lean manufacturing practices has been made by (Shah & Ward, 2003, 2007a). Their study used a multi-step construct development method and identified three levels of lean manufacturing practices: supplier related, customer related and the internally related issues of the company. The first “supplier related” pillar, justifies the involvement of suppliers and their impact on the company’s quality, cost and delivery target. Involving suppliers not only helps to reduce time and costs but also improves quality (Wagner, 2010). Also, (Carter & Narasimhan, 1996; Cooper & Ellram, 1993) found that companies continuously reorganize their supplier base in order to achieve operational excellence. Another study by (Benton & Krajewski, 1990) emphasized that the supplier lead time is an important factor contributing to the manufacturer’s performance. Supplier related issues include giving regular feedback to the supplier about their performance (supplier feedback), ensuring delivery on time by the suppliers (JIT delivery), and developing a supplier base so that they can be involved in the production process (supplier development).

Table 1-7 Lean manufacturing practices

	Lean practices	Attributes	Studies focused on lean practices
	Supplier related	Close contact with suppliers	(Jayaram et al., 2008; Wagner, 2010; Wu, 2003)
		Key suppliers deliver to plant on JIT basis	(Carter & Narasimhan, 1996)
		Take active steps to reduce the number of suppliers in each category	(Simpson & Power, 2005)
	Customer related	Close contact with customers	(Forza, 2002; Warnecke & Hüser, 1995)
		Customer feedback on quality and delivery performance	(Bruce et al., 2004; Da Silveira et al., 2001)
		Customer satisfaction surveys	(Meyer & Schwager, 2007; Teehan & Tucker, 2010)
Internally related	Pull	Use the pull production system	(Mackelprang & Nair, 2010)
		Use Kanban, squares, or containers of signals for production control	(Åhlström & Karlsson, 2000; Lee-Mortimer, 2008)
		Production at station is pulled by the current demand of the next station	(Abdulmalek et al., 2006; Tommelein, 1998)
	Flow	Products are classified into groups with similar processing requirements	(Rother & Harris, 2001),(Prince & Kay, 2003)
		Products are classified into groups with similar routing requirements	(Åhlström, 1998; Lysecky et al., 2004)
		Product families determine our factory layout	(Bamber & Dale, 2000; Pattanaik & Sharma, 2009)
	Set up	Lower set up times in our plant	(Cakmakci, 2009),(Karlsson & Ahlström, 1996)
		Monitor production-cycle time to respond quickly to customer requests	(Detty & Yingling, 2000; Sahoo et al., 2008)
		Employees practice setups to reduce required time	(Cakmakci, 2009; Panizzolo, 1998b)
	Statistical process control	Processes on the shop floor under Statistical Process Control	(Ahmad et al., 2012; Antony et al., 2003)
		Extensively use statistical techniques to identify process variation	(Arnheiter & Maleyeff, 2005; Taj & Berro, 2006)
		Use visual charts to show defect rates on the shop-floor	(Dahlgaard & Dahlgaard, 2006)
	Employee involvement	Shop-floor employee undergo cross-functional training	(Demeter & Matyusz, 2010; Losonci et al., 2011).
		Shop-floor employees are crucial to problem-solving teams	(Dyer & Nobeoka, 2002; Forza, 1996)
		Shop-floor employees lead product/process improvement efforts	(Motwani, 2003; Treville & Antonakis, 2006)
	Total productive maintenance	Preventive maintenance plan in our firm	(Ahuja & Khamba, 2008),(Cua et al., 2006)
		Dedicate a time every day to plan equipment maintenance	(Katayama & Bennett, 1996a; Kumar et al., 2006a)
		Regularly post equipment maintenance records on the shop-floor	(Ahuja & Khamba, 2008; Muthiah & Huang, 2006)

Source: Own compilation based on (Shah & Ward, 2003, 2007a)

The second pillar of lean manufacturing is the involvement of customers in the company's decision making process. The company embarking on a lean journey primarily focuses on customers and their needs. The involvement of customers in a company's decision making process results in an increase of customer satisfaction, quality and production (Da Silveira et al., 2001).

The third pillar of lean manufacturing is related to internal issues of the company which includes continuous flow (Rother & Harris, 2001), just in time (pull) (Mackelprang & Nair, 2010), set up time reduction (Cakmakci, 2009), total productive/preventive maintenance (Ahuja & Khamba, 2008), statistical process control (Hoerl & Snee, 2010) and employee involvement (Demeter & Matyusz, 2010; Losonci et al., 2011; Pool et al., 2010). (Shah and Ward, 2003) summarizes the ten elements of lean manufacturing in following terms:

1. Customer involvement: focus on a firm's customers and their needs
2. Supplier feedback: provide regular feedback to suppliers about their performance
3. JIT delivery by suppliers: ensures that suppliers deliver the right quantity at the right time
4. Supplier development: develop suppliers so they can be involved in the process
5. Pull: facilitate JIT production which serves as a signal to start or stop production
6. Flow: establishes mechanisms that enable and ease the continuous flow of products
7. Set up time reduction: reduces process downtime between product changeovers
8. Total productive/preventive maintenance: address equipment downtime through total productive maintenance and thus achieve a high level of equipment availability
9. Statistical process control: ensure each process will supply defect free units
10. Employee involvement: employees' role in problem solving and cross functional character

This holistic conceptual model of lean manufacturing proposed by Shah and Ward which captures both internal (process) and external (supplier, customer) practices (Shah & Ward, 2007a) is used in this dissertation. There are two concrete reasons for using the model by Shah and Ward in this study. First, their model includes both people and process elements of lean manufacturing. Second, both internal and external factors were included in the model. The past research had only a limited focus on both people and process aspects of lean implementation (Boyle et al., 2011; Pettersen, 2009; Scherrer-Rathje et al., 2009; Yang et al., 2011).

Performance

There is a large body of literature published on lean manufacturing practices and its impact on firm's operational performances (Karlsson & Ahlström, 1996; Sánchez & Pérez, 2001); (Fullerton & Wempe, 2009a; Gunasekaran et al., 2000; Lewis, 2000a). In general, lean practices have a positive influence of operational performance. The most common cited benefits of lean manufacturing practices are quality improvement, increased productivity, reduced lead time, improved delivery time, and reduced costs (Fullerton & Wempe, 2009b; Shah & Ward, 2007a; White & Prybutok, 2001). Still there are also empirical studies which claim that the correlation between lean practice and operational performance are not always positive (Callen et al., 2000; Fullerton & McWatters, 2001; Sakakibara et al., 1997). For example, (Sakakibara et al., 1997) found that there was no sufficient evidence to support a correlation between lean practices, such as set-up time reduction, and operational performance.

An important study by (Hofer et al., 2012) showed the mediating role of inventory in demonstrating the financial performance benefits associated with lean manufacturing. Similarly, (Eroglu & Hofer, 2011) found a strong correlation between inventory and a firm's performance. Studies also provide a strong evidence that the implementation of lean manufacturing results in an improved operational performance in terms of inventory management, process control, information flows, human factors and flexibility (Cua et al., 2006; Fullerton & McWatters, 2001; Jayaram et al., 2008). This study selects five operational performance indicators of lean manufacturing practices draw from the literature: 1. Stock/inventory reduction (Fullerton & Wempe, 2009a; Wu, 2003), 2. Quality improvement (Cua et al., 2006), 3. Productivity improvement (Shah & Ward, 2003; Taj & Berro, 2006), 4. Lead or cycle time reduction (Droge et al., 2004; Shah & Ward, 2003), 5. Improvement in on-time delivery (Flynn & Flynn, 2004; Nieminen & Takala, 2006). Table 1-8 demonstrates the operational performances indicators of lean manufacturing practices.

Table 1-8 Operational performance of lean manufacturing

Performance	**Studies linking lean practice and performance**
Stock/inventory reduction	(Fullerton & Wempe, 2009a; Wu, 2003)
Productivity improvement	(Shah & Ward, 2003; Taj & Berro, 2006)
Lead or cycle time reduction	(Droge et al., 2004; Shah & Ward, 2003)
Quality improvement	(Cua et al., 2006; Fullerton & Wempe, 2009a)
Improve on-time delivery	(Flynn & Flynn, 2004; Nieminen & Takala, 2006)

Source: Own compilation

Determining factors

(Boynton & Zmud, 1984) explains that determining factors are “those few things that must go well to ensure success”. The review of literature shows that there is no consensus among researchers that lean manufacturing practices always show a positive correlation with an improved operational performance of the firm. A considerable number of studies found that the implementation of lean manufacturing practices is a difficult and long journey with many roadblocks (Abdulmalek & Rajgopal, 2007; Denton & Hodgson, 1997; Jha & Iyer, 2006; Safayeni et al., 1991; Shah & Ward, 2003; Sim & Rogers, 2008; Yusuf & Adeleye, 2002). Several studies identified critical success factors or determining factors which make the lean journey either a success or a failure. Determining factors as the essential things that must be achieved by the company to produce the greatest “competitive leverage” (Brotherton & Shaw, 1996). After a comprehensive analysis of different factors provided in the previous studies and their inter-relatedness, following critical determining factors of lean manufacturing were selected:

1.Leadership and management refer to the commitment of the top management, consistent financial support, encouragement, active involvement and supervision of the lean initiative. There are several studies which stress the correlation between effective leadership, clear strategy, vision and operational performance of the organization (Coronado & Antony, 2002; Trkman, 2010);

2. Organizational culture has been formalized by several researchers, which includes internal and external communication, hierarchy, respect and blame game in the company (Fryer et al., 2007; Stock et al., 2007);

3. Skill and training (for instance, soft skills and technical skills) play an important role in the successful adoption of lean manufacturing (Sanchez & Pérez, 2001; Stock et al., 2007);

4. Resources (Financial capabilities) include elements such as finances to cover training costs, external consultants or any other related investments (Bhasin, 2008; Trkman, 2010);

5. Multifunctional team plays a vital role in the success of lean manufacturing practices according to the operations management literature (Dowlatshahi & Taham, 2009; Lee & Allwood, 2003);

6. Organizational structure: Lean manufacturing research also highlights some critical factors for the lean adoption such as a piecemeal approach and organizational structure (Näslund, 2008);

7. Remuneration and rewards: (Karlsson & Ahlström, 1996) found that the role of the remuneration system is vital for the lean implementation process.

8. Change agent: The success of lean initiative appears to be directly associated with the quality of the change agent (Armenakis et al., 1993; Kosonen & Buhanist, 1995; Smeds, 1994);

9. Piecemeal approach means adopting certain parts of lean manufacturing and ignoring its systemic nature (Dowlatshahi & Taham, 2009; James, 2006). It is considered as an obstructing factor in lean implementation.

Both organizational change and lean manufacturing literature points out that the employee skepticism about the management's commitment to the change program has been suggested as a barrier to organizational change (Stanley et al., 2005). Similarly, there are several food processing SME-related factors such as the nature of the plant, product and processes that affect the lean adoption (Van Goubergen et al., 2011a; Van Wezel et al., 2006). Table 1-9 provides an overview of determining factors or critical success factor of lean manufacturing based on the literature.

Table 1-9 Determining factors

Determining factors	Sources
Leadership and commitment of top management	(Coronado & Antony, 2002; Fryer et al., 2007; Trkman, 2010); (Sanchez & Pérez, 2001); (Angelis et al., 2011); (Gurumurthy & Kodali, 2009; Puvanasvaran et al., 2009); (Achanga et al., 2006)
Organizational culture	(Fryer et al., 2007; Stock et al., 2007); (Bhasin & Burcher, 2006); (Achanga et al., 2006); (Dahlgaard & Dahlgaard, 2006); (Hines et al., 2004); (Mann, 2012))
Skill and training	(Worley & Doolen, 2006); (Sanchez & Pérez, 2001); (Karlsson & Ahlström, 1996)
Resources	(Bhasin, 2008; Trkman, 2010) (Achanga et al., 2006; Forrester, 1995) (Hudson et al., 2001; Kumar & Antony, 2008; MacDuffie, 1995)
Multifunctional team	(Motwani, 2003; Paez et al., 2004; Sanchez & Pérez, 2001; Sharp et al., 1999) (Sohal, 1996)
Organizational structure	(Demeter & Matyusz, 2010; Dombrowski & Crespo, 2008; Nahm et al., 2003) (Goss & Jones, 1992)
Remuneration and Rewards	(Bednarek & Fernando, 2009; Hankinson et al., 1997; Watson et al., 1996) (Robson & Bennett, 2000)
Change agent	(Carson & Gilmore, 2000; Koh & Simpson, 2005; Levy & Powell, 2003) (Muchinsky, 2007)
Piecemeal approach	(Crute et al., 2003; Dowlatshahi & Taham, 2009; James, 2006; Shah & Ward, 2007a; Storch, 1999)

Source: Own compilation

1.7. Research propositions

The purpose of this dissertation is to contribute to an integrated analysis of the applicability and effectiveness of lean manufacturing in the food processing SMEs context. In line with the conceptual framework, the key research propositions of this dissertation are specified. Each of the propositions will afterwards be investigated in the respective sections of this dissertation.

Proposition 1: *The food processing SMEs give more priority and acceptance to quality assurance practices (e.g. HACCP) than to quality improvement (lean)*

As discussed in the theoretical context section, there are three forms of organizational isomorphic drivers: coercive, normative, and mimetic (DiMaggio & Powell, 2000) which lead firms to choose and adopt quality management practices. For instance, government agencies coercively influence food processors to adhere to HACCP compliance or a customer (supermarket) asks for any specific quality assurance method such as BRC, IFS or ISO. On the other hand, mimetic isomorphic drives lead firms to imitate or mimic a successful practice already used by a competitor in order to remain competitive in the market (Bae & Rowley, 2002). Quality management research has mainly focused on the implementation of food safety methods (e.g., HACCP, BRC, and IFS) and neglected the importance of improvement practices, like lean manufacturing (Caswell et al., 1998; Georgakopoulos, 2007; Orriss & Whitehead, 2000; Scott et al., 2009; Trienekens & Zuurbier, 2008; Unnevehr & Jensen, 1999). Why do only a few foods processing SMEs take advantage of management practices which clearly demonstrate a considerable positive impact on efficiency and operational performance? Is the institutional coercive isomorphism more dominant than the normative or mimetic isomorphism? (Sturdy, 2004) proposes that a firm selects quality management initiatives based on rational (systematic evaluation) as well as less rational influences including the current trends, impulse, persuasion, power (regulation) or culture. This proposition regarding the choice of quality management practices in food processing SMEs will be dealt with in chapter 2.

Proposition 2: *There is a variation in the degree of knowledge and usage of individual lean manufacturing practice in the food processing SMEs*

As discussed in section 1.3.2 and section 1.4.2 lean manufacturing is a set of practices (customer related, supplier related and internally related) and not all practices are used to the same degree. There are two important research gaps identified during the course of the literature review (section 1.4.2): First, there is no identifiable study that sought to evaluate "which lean manufacturing practices are more prevalent or used in food processing SMEs". Second, most of the food-sector-specific studies focus on the applicability of one or two practices and ignore the holistic, broad lean manufacturing principles. Researchers (Inman & Mehra, 1990; Lee, 1997; White et al., 1999a) claim that employee involvement, statistical process control in the processing industry (Abdulmalek et al., 2006) and customer involvement in SMEs (Lee & Allwood, 2003; White et al., 1999a) are more common than other practices. (Cox & Chicksand, 2008) claims that certain restrictions in the food production process make it unlikely that all lean manufacturing practices could be implemented to the same degree. This proposition regarding the degree of different lean manufacturing practices in food processing SMEs will be dealt with in chapter 3.

Proposition 3: *The degree of lean manufacturing practices is highly dependent on control factors*

Literature pointed out the number of control variables that determine the degree to which lean manufacturing practices are used, such as plant size (Cua et al., 2001a; Fullerton & McWatters, 2001); (Inman & Mehra, 1990; Lee & Allwood, 2003; Schonberger, 2010; Shah & Ward, 2003; White et al., 1999a), and country of operation (Cagliano et al., 2001; Forza, 2002; Hanson & Voss, 1995). This study includes the control variables for size of the company and country of operation to determine whether these factors have any influence. In addition, factors specific to the food sector (i.e. inherent nature of plant, process, and product) are investigated to see if there are any potential barriers to lean implementation. This proposition regarding the relationship between the degree of different lean manufacturing practices and control variables (size, country) will be dealt with in chapter 3.

Proposition 4: *The lean adoption of a firm is contingent on identification and understanding of determining factors (enabling and/or obstructing)*

One important aspect of this study is to evaluate and understand the relationship between determining factors and the lean adoption in a food processing SME. Lean adoption is defined as a process of implementing lean practices in an organization (Aitken et al., 2002; Ben Naylor et al., 1999; Mason-Jones et al., 2000; Papadopoulou & Özbayrak, 2005). The contingency theory of operations management stresses the importance of internal and external factors which greatly influence manufacturing practices (Ketokivi & Schroeder, 2004b; Luthans & Stewart, 1977; Morton & Hu, 2008; Raymond, 2005; Sousa & Voss, 2008). This chapter investigates the determining factors (enabling and/or obstructing) which affect lean adoption in food processing SMEs using the case study approach. The main objective of this chapter is to understand "how determining factors (enabling and/or obstructing) affect the change in a food processing SME. In other words, is there anything inherent in the product and/or process that specifically hinders or helps lean manufacturing implementation? This proposition regarding the relationship between determining factors and the lean adoption will be covered in chapter 4.

Proposition 5: *Food processing SMEs that implement lean manufacturing practices, experience better operational performance*

The impact of lean manufacturing practices on the operational performance of a firm has been studied before and empirical research has proven that lean manufacturing can play a significant role in improving a firm's operational performance. However, there is no common agreement among researchers about the success of lean manufacturing in the food processing industry (Engelund et al., 2009; Goncharuk, 2009; Jain & Lyons, 2009; Mahalik & Nambiar, 2010; Scherrer-Rathje et al., 2009; Scott et al., 2009). The empirical studies show several weaknesses in existing quality-management research as explained in current knowledge gaps section (1.4.2). Consequently, in this dissertation, chapter 2 investigates this debate through the prism of the organizational behavior theories.

1.8. Intended research contribution

The literature justifies that there are clearly advantages of sector-specific research for an in-depth understanding of the practice-performance link alongside contextual factors (MacDuffie, 1995), especially when the interaction among operations-management related factors, organizational-change related factors and food-sector-specific factors have scarcely been explored (Luning et al., 2002). This conveys the particular need for this doctoral study to contribute to the empirical and conceptual understanding of lean manufacturing practices in food processing industries. It is also important to note that this doctoral research uses an integrated approach by blending different organizational behavior theories (contingency theory, resource-based view theory, and institutional theory). Previous studies claim that combining different theoretical perspectives together gives a better understanding of complex phenomena like lean manufacturing (Punnakitikashem et al., 2009; Reeves, 2007). This integrated approach will provide opportunities for future inquiries of theory-based research in operations management. Besides the integrated theoretical perspective, the novelty of the contributions of this doctoral research can be categorized in three main themes: empirical, methodological, and knowledge transferability. Figure 1-6 represents these three areas and their levels of contribution.

Area of contribution	Areas	Extension	Innovation
	Empirical	√	√
	Methodological		√
	Knowledge transferability	√	√

Figure 1-6 Research contribution

Source: Adopted from (Molnar, 2010)

1.8.1. Empirical contribution

One of the significant findings of the reviewed literature is that the majority of the limited available studies on lean manufacturing in the food sector are case studies and only very few studies are based on empirical survey (Engelund et al., 2009; Goncharuk, 2009;

Mahalik & Nambiar, 2010; Van Goubergen et al., 2011b). The reason being cited is the limited response rate from food SMEs (Cox & Chicksand, 2005; Kumar & Antony, 2008). Hence, this research has provided an understanding of how to generate information relevant for assessing applicability of lean manufacturing in food processing SMEs. The intended empirical contributions are established by investigating five theoretically grounded research propositions (Section 1.6) and developing a better understanding and know-how of a less explored research area of "lean manufacturing in food processing SMEs".

1. "Is the institutional coercive isomorphism more dominant than the normative or mimetic isomorphism in the context of choosing an appropriate quality management practice?" The analysis of this important research question will contribute to the knowledge (innovation).
2. Empirically evaluating the debate on effectiveness of lean manufacturing in any environment through the prism of the contingency theory and universalist 'best practice' theory (Voss, 1995) will contribute to the science. The analysis will shed light on the question of whether food processing SMEs that adopt lean manufacturing practices to a greater extent obtain better results in terms of operational performance (extension).
3. This study intends to fill a large research gap with empirical validation by answering the question "which lean manufacturing practices are more prevalent or better suited for the food processing SMEs". Many studies claim that it is unlikely that all lean manufacturing practices could be implemented to the same degree in a small and medium sized food processing environment (Abdulmalek et al., 2006), (Lee & Allwood, 2003; White et al., 1999a), (Cox & Chicksand, 2008) (Extension).
4. One important intended contribution understands the relationship between determining factors and the lean adoption in a food processing SME context. This will be an (extension) to the contingency theory which stresses the importance of internal and external factors that influence manufacturing practices (Ketokivi & Schroeder, 2004b; Luthans & Stewart, 1977; Morton & Hu, 2008; Raymond, 2005; Sousa & Voss, 2008).
5. Another source of value added to the empirical research is the selection and information from different countries and subsectors. This study covers Germany, Hungary, and Belgium to incorporate a wide geographical diversity across Europe (Belgium: Western Europe, Germany: Central Europe, Hungary: Eastern Europe). The selected sectors in this study are chocolate, confectionary, bread and meat processing sectors. The selection of the products was based on their socio-economic importance (number and

size of enterprises, employment rates, value added, turnover, investments, import/export, and consumption rates) in the given countries (Gilg & Battershill, 1998). No other study was found during the literature survey which investigates lean manufacturing practices in food processing SMEs in these three countries (Germany, Hungary, and Belgium). There are a few studies on this topic that were carried out in the US, UK, Canada and Asia (He & Hayya, 2002; Lehtinen & Torkko, 2005; Scott et al., 2009; Simons & Zokaei, 2005).

1.8.2. Methodological contribution

Quality management, specifically, lean manufacturing is a complex, multidimensional concept. In order to get an in-depth understanding and a thorough analysis, this research adopted a mixed method approach to contribute to the advancement of the methodology. This research was carried out in three stages. In stage one; a comprehensive literature review was carried out to find the current knowledge gaps in quality management practices focusing on lean manufacturing in food processing SMEs. In the second stage, exploratory research was undertaken to identify the current status of lean manufacturing practices in food processing SMEs in three European countries (Belgium, Germany, and Hungary).

The database generated from the second phase of the study was used to conduct an explanatory study in the third phase of the research to get a better insight into the lean manufacturing practices in four companies by using the case study method. Thus, a triangulation approach was used to explore the applicability of lean manufacturing implementation within food processing SMEs. The triangulation method provides a deeper understanding of processes that allows a chance to test hypotheses and a good picture of locally grounded causality (Miles & Huberman, 1994). The use of different research approaches, methods and techniques in the same study is known as triangulation and can overcome the potential bias and sterility of a single method approach (Collis & Hussey, 2009). (Denzin & Lincoln, 2000) who support the triangulation approach state that the use of multiple methods to study the same phenomena by a number of researchers, if the conclusions are the same, will lead to greater validity and reliability than a single methodological approach.

Moreover, by applying an appropriate research design including a clear sampling strategy the study is able to control for a number of factors that are not the main focus of the study. There is no other study which used this triangulation method to investigate the applicability of lean manufacturing in food processing SMEs (innovation).

1.8.3. Knowledge transferability

The foremost intended contribution is to propose a lean manufacturing implementation framework tailored to the needs of food processing SMEs. An integrated framework in the form of "house of lean for food processing SMEs" may help managers to develop better understanding of the role of several contextual factors in the success or failure of lean implementation in an organization.. Importantly, the new framework will broaden the scope beyond food safety and include process improvement aspects (Innovation).

Moreover, the identification of individual lean practices that are better suited to food processing SMEs is an important applied contribution. The identification of easy and difficult lean practices will provide a good starting point to lean implementation in the food processing sector.

Additionally, the practitioners get an understanding of the important variables such as size of the company, and its advantages and disadvantages for lean implementation. Similarly, the relationship between lean implementation and firm's country of operation and its cultural and regulatory background will help managers while planning lean journey (Extension).

Furthermore, the managers in food processing SMEs will get a better understanding of the determining factors, especially the food-sector-specific (product, process, plant) during lean adoption. This will immensely help practitioners to confront challenges while undergoing lean implementation for efficient food production in a SME environment (Extension).

Finally, the proposal made in this study to integrate quality issues (e.g., food safety and production efficiency) will open new avenues for the practitioners.

1.9. Research design and structure

1.9.1. Research design

(Rowlands, 2005) emphasized that the starting point in any research project is to understand the nature of the research problem that leads to the choice of an appropriate methodology. The purpose of the research may be to describe (discover), explain (develop), explore (understand) or take action as part of the intention of the proposed study. According to (Yin, 2003), descriptive research focuses on “what, who, and where” questions, explanatory focuses on “how and why” questions, and exploratory focuses on ‘what’ questions. Descriptive research is undertaken for the purpose of producing accurate representations of persons, events or situations (Saunders et al., 2011). It concentrates on reporting and recording elements of situations and events (Meredith, 1998). Explanatory research focuses on studying a situation in order to explain the causal relationship among variables existing within the object of study. Exploratory research aims to seek a new insight into phenomena, ask for more detailed levels of description with respect to the object of study, and assesses the phenomena in a new light. The results from the preliminary descriptive research also can be used to conduct a detailed study of the object leading to further insight and understanding (Meredith, 1998).

This doctoral research took inspiration from this research approach framework and used both explanatory as well as exploratory methods. Accordingly, a prudent research strategy was developed. The research strategy is classified at two levels. Level one takes into consideration the quantitative and qualitative research (Bell & Bryman, 2007) and level two forms the distinctive strategies such as experiments, survey, case study, ethnography, and action research (Saunders et al., 2011). Studies also claim that mixed-method research can help in combining the advantages of both qualitative and quantitative methods within a single research project (Bryman & Bell, 2007; Creswell & Clark, 2007; Teddlie, 2009). The combined approach may also enhance the generalizability of the research findings (Creswell & Clark, 2007; Teddlie, 2009). Each research strategy has limitations in addressing all aspects of validity (construct, content, and external validity) and so triangulation using the mixed-method approach may help to maximize the research validity (Scandura & Williams, 2000). In this research, quantitative research strategy (survey) will be applied to triangulate with and facilitate the qualitative research using the case-study. The survey instruments were used to collect data in the first phase followed up with interviews in the second phase to conduct an in-depth investigation into the research problem. Figure 1-7 depicts a visual diagram to explain the different phases, methods and instruments of this doctoral research.

Survey

There are a number of researchers who have used surveys as the primary strategy to understand, assess, and resolve issues in the area of lean manufacturing (Achanga et al., 2006; Badri et al., 1995; Black & Porter, 1996; Flynn et al., 1994; Yusuf & Adeleye, 2002). Survey research has been used in the past to generate theory, test theory or extend an already existing theory (Forza, 2002; Malhotra & Grover, 1998). The objective of the "exploratory survey" is to become more familiar by gaining preliminary insight into the research topic and provide the basis for a more in-depth survey. Hence, an exploratory survey was used in the first phase of the research to assess the lean practices in food SMEs and to identify the adopters of lean and other quality management initiatives. As mentioned earlier, this research adopted a mixed-method approach with survey (quantitative) being the first part of the research strategy followed by conducting multiple case-studies (qualitative) to answer the research questions.

The representativeness of any sample in a population depends on the sample frame, sample size, and the specific design of selection procedure (Forza, 2002). Hence, three major food associations were contacted to obtain the addresses of the food companies. Only SMEs according to the definition of the European Commission, who have less than 250 employees, a maximum of 50 million euro annual turnover and a maximum of 43 million euro annual balance-sheet total (Commission, 2003) were considered for the study. The selected sub-sectors in this study are chocolate, confectionary, bread and meat processing sectors. The selection of the products was based on their socio-economic importance (number and size of enterprises, employment rates, value added, turnover, investments, import/export, and consumption rates) in the given countries (Gilg & Battershill, 1998).

The survey instrument was developed based on questionnaires used in the published literature of leading lean practitioners and academics (Forza, 2002; Samson & Terziovski, 1999). A questionnaire was prepared based on the literature (Achanga et al., 2006; Bonavia & Marin, 2006; Shah & Ward, 2003; Shah & Ward, 2007b) and by means of a brainstorming session with a number of lean professionals within Europe, who were familiar with lean and other quality management practices in the food sector. We further validated the questions by asking two operations managers, and two consultants to complete the questionnaire. Based on their reactions and feedback, the questionnaire was revised and used for the survey. A total of 35 SME representatives, CEOs and operation managers responded with a participation rate of 15.2%. This sample size is comparable to those of previous surveys carried out in the quality management field, i.e., (Little & McKinna, 2005) – 12%, (Kumar & Antony, 2008) – 12.8% (64 observations), (Scott et al., 2009) – 11 % (48 observations), (Fotopoulos et al., 2011) – 31 observations. Both descriptive and inferential statistical analyses were used to analyze the data. The results of the survey has been analyzed in chapter two and three.

Moreover, non-respondents can limit the generalizability of results. Ten firms from the non-respondent list were randomly selected and contacted to identify the reasons for their non-participation. Some key questions were asked to observe any discernible pattern in their responses. Two firms had a company policy of not participating in surveys and the rest of the SMEs did not participate due to work pressure and limited time to respond to a survey. However, none of the SMEs had any objections about the content of the questionnaire. Finally, no differences were observed in the characteristics of participating and non-participating SMEs in the survey, which limited the biasness creeping in the analysis and results (though it is very difficult to completely eliminate the biasness from the survey). The study was carried out with the cooperation of food associations (e.g., Fenavian, Choprabisco) to include the appropriate respondents who are aware of lean practices. Moreover, we organized workshops at our department on lean manufacturing for food processing companies.

Case study

The motivation to choose research strategies depends on three conditions: 1. type of research questions, 2. extent of control an investigator has over actual behavioral events and 3. the degree of focus on contemporary situation as opposed to historical events (Yin, 2003). Further, (Yin, 2003) has suggested that when the boundaries between phenomenon and context are not clear, an empirical enquiry that investigates a contemporary phenomenon within its real-life context is more appropriate. (McCutcheon & Meredith, 1993) claimed that the case study is an appropriate approach to study unfamiliar situations, where there exists little theoretical background. Similarly, the review of literature shows very little evidence of a successful implementation of lean manufacturing in food processing SMEs. In order to get in-depth insight and analysis of the real situation at the work floor this study adopted multiple-case-study research. This method allows studying the problem and context during a longer period of time to deduce both cause and effect (Leonard-Barton, 1990; Molleman et al., 2002). Hence, through the use of a case study based approach, this study explored information on the key issues, such as impact of determining factors on lean implementation. The first phase of the research facilitated the identification of dichotomous and similar cases from the sample, which were selected in the second phase of the research for an in-depth investigation on lean manufacturing practices within food processing SMEs. There is no prescriptive rule for the number of cases necessary or sufficient while conducting case study research. However, (Eisenhardt, 1989; Yin, 2003) provided a rough guideline on the number of cases and suggested a minimum of two to six or more cases are ideal. Before the sample selection for multiple case studies, the selection criteria were established based on the key research questions established at the start of the research.

In this research, the case study samples were selected from responses collected in the first phase of the research, i.e. survey. At the end of the survey, respondents were asked if they would be willing to participate in the second phase of study, i.e. case study. The data collection methods used in case study research is: historical archive analysis, direct observations, participant observations, interviews, questionnaires, and documentation (Flynn et al., 1990; Yin, 2003). At least two employees were interviewed in each case study company with a maximum of four interviews in two case study firms. Forty-five semi-structured interviews were conducted in the four case study firms. Each interview last for approximately 30 minutes. The position of the interviewees ranged from the top management level to the middle level management, including operations managers, quality managers and shop-floor employees. Semi-structured interviews were the preferred method over the structured interviews to enable the generation of new ideas and leading questions through open discussion with the interviewees. Interviewing multiple respondents in an organization helped data triangulation through comparison of reports and interpretation of various respondents. The results of the case study has been analyzed in chapter four.

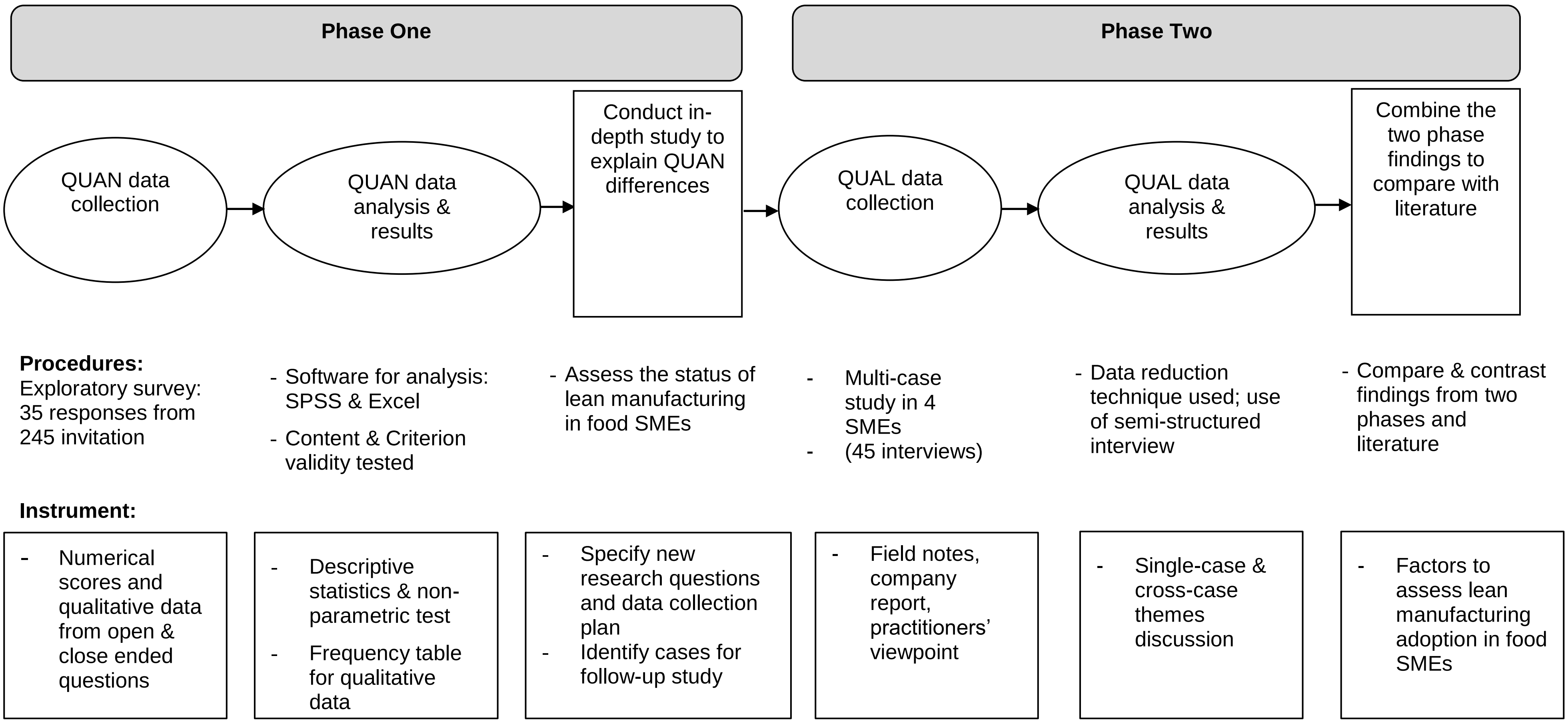

Figure 1-7 Research steps and methods

Source: Own compilation

(QUAN; Quantitative, QUAL: Qualitative)

1.9.2. Structure of dissertation

This dissertation distinguishes six chapters as outlined in Figure 1-8. Chapter 1 describe the trends of quality management research, taxonomy of small and medium-sized food processing SMEs, theory and conceptual framework, contribution to science and the society, research proposition, research design. Chapter 1 is based on the deliverables of "IMSFood" project and a published paper in Food Control journal. Chapters 2 through 5 provide a response to the aforementioned research propositions and represent one or more research papers. The introductory chapter presents the rationale of the conceptual framework, the research questions, research contribution and the research design. The overall aim of this chapter is to provide the reader a broader understanding of the rationale of this PhD dissertation and a foundation for subsequent chapters. As a consequence, the research objectives, the methodologies, the discussion and the conclusions of the respective studies in the forthcoming chapters refer to this underlying overview. Chapter 2 is adapted from a published article in *Trend in Food Science and Technology* regarding lean manufacturing vis-à-vis other quality initiatives in the food sector. The research proposition 1 and 5 is addressed in this chapter. Chapter 3 is dedicated to the application of lean manufacturing in food processing SMEs and investigates research proposition 2 and 3. This study builds upon an accepted paper in *British Food Journal*. Research proposition 4 is addressed in chapter 4, an article currently under revision in *Journal of Operational Research Society*. In chapter 5, a framework for lean implementation in food processing industries is presented. Chapter 5 is based on the final deliverables of "IMSFood" project to the European Commission. Finally, chapter 6 summarizes the main results. In addition, the limitations, implications and directions for future research are highlighted. The last section addresses several important issues to generate recommendations for a successful implementation of lean manufacturing in food processing SMEs. Some of the sections in the following chapters may be an overlap, but it was intended because of smooth readability of each chapters.

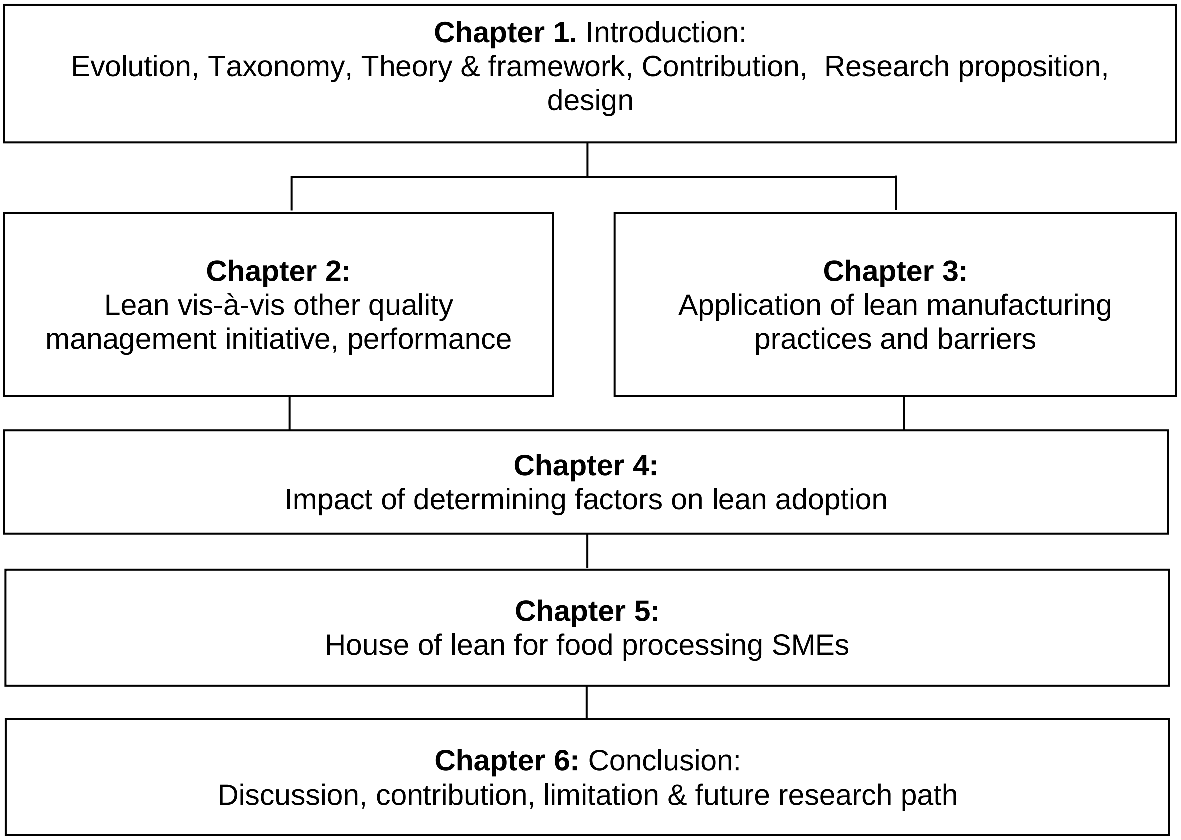

Figure 1-8 Structure of the dissertation

Why not make the work easier and more interesting so that people do not have to sweat? The Toyota style is not to create results by working hard. It is a system that says there is no limit to people's creativity. People don't go to Toyota to 'work' they go there to 'think'.

~ Taiichi Ohno, The father of the "Toyota Production System"

2. Lean manufacturing vis-à-vis other quality management initiative

Adapted from:

Dora, M.; Kumar, M.; Van Goubergen, D.; Molnar, A. & Gellynck, X. (2013). "Operational performance and critical success factors of lean manufacturing in European food processing SMEs", *Trends in Food Science and Technology,* 31(2), 156-164. *(Impact factor: 4.135)*

2.1 Introduction

Two arguments motivate the choice of analyzing issues related to lean manufacturing vis-à-vis other quality management practices in SMEs operating in the food processing industry. Firstly, the food processing industry is the largest manufacturing sector in Europe with a turnover of €965 billion, 4.4 million people directly employed, and constantly serving over 500 million consumers (CIAA, 2010). More than 90% of the food companies in Europe are SMEs, accounting for 63% of the employment. Other industries such as agriculture, chemical and packaging are closely linked to the food processing industry. Secondly, according to the European Commission, the European food sector lacks competitiveness in comparison to the North American and Australian food processing sector (CIAA, 2010). The uncompetitive and inefficient food sector has negatively impacted the European Union’s economy in recent years (Commission, 2008). As such, it is imperative for the European Union’s food SMEs and policy makers to examine the existing practices and take necessary action to improve competitiveness. The competitiveness of a company depends on the cost, quality, delivery, and dependability of the company (Bititci et al., 2001). These parameters can be improved by applying quality improvement methods such as lean manufacturing (Shah & Ward, 2007a). Recent studies have strengthened the claim that lean manufacturing practices may help the food processing industry to be more competitive (Engelund et al., 2009; Goncharuk, 2009; Mahalik & Nambiar, 2010; Van Goubergen et al., 2011b). The majority of the research in quality management, such as in the lean manufacturing is very generic. For instance, there is very limited empirical research conducted on specific industries within the manufacturing sector such as paper & printing industry, food & drink, chemical, etc. There is a need to undertake more industry specific studies to understand whether lean manufacturing principles and theories apply to all industries within manufacturing or service sectors or whether there is an anomaly in the findings between different industries. Such information would contribute to both sciences as well as quality management practices.

The concept of lean manufacturing became popular in the west after the publication of “The machine that changed the world” by (Womack et al., 1990). Empirical studies, including a wide range of organizations, demonstrated that lean manufacturing has generated several tangible and intangible benefits for example improvement in productivity, quality, delivery, and employee and customer satisfaction (Abdulmalek & Rajgopal, 2007; Fullerton &

Wempe, 2009a). Scholarly studies show mixed results of lean manufacturing implementation in different sectors and organizations (Abdulmalek & Rajgopal, 2007; Melton, 2005). In recent years, there has been a rising trend with regard to the application of lean manufacturing in the food processing sector due to increasing pressure from consumers and competition from big players (Mahalik & Nambiar, 2010; Scott et al., 2009; Thomas & Barton, 2006). However, there is a debate in the academic literature regarding the result of lean manufacturing in the food SMEs. On the one hand, past researchers (He & Hayya, 2002; Lehtinen & Torkko, 2005; Mahalik & Nambiar, 2010; Scott et al., 2009; Simons & Zokaei, 2005) found encouraging results of lean manufacturing in the food sector; on the other hand, studies such as (Cox & Chicksand, 2005; Kumar & Antony, 2008) found less than desired results of lean manufacturing. Some studies attributed low impact of lean manufacturing to the unique characteristics of the food sector including short shelf-life, heterogeneous raw materials, seasonality, and varied harvesting conditions (Luning et al., 2002). Moreover, complex production chain and complicated network of many suppliers and buyers hugely affect storage, conditioning, processing, packaging and quality control (Gellynck & Molnar, 2009; van der Vorst et al., 2001). All these factors might be attributing to the difficulty level of lean initiative in the food processing SMEs (Cuevas, 2004; Hartmann & Wandel, 1999).

With this background, this chapter aims to understand two vital issues: One, managers perception on lean manufacturing vis-à-vis other quality management initiatives; two, the impact of lean manufacturing on operational performance of firms. We followed a robust approach to fulfill the objective of the study. Firstly, we reviewed the literature on quality management initiatives, focusing on lean manufacturing in food as well as non-food sectors. Secondly, we have complimented the literature review with a survey of food processing companies in three European countries in order to gain a deeper understanding of lean manufacturing practice. Lastly, we summarize the findings from the questionnaires and discuss the differences with the reviewed literature. The chapter closes with limitations, conclusions and future research agenda.

2.2 Review of literature

Researchers pointed out that failing to develop and implement a holistic quality management system may cause more problems for the food SMEs with respect to food safety, customer satisfaction and product availability (Caswell et al., 1998; Luning et al., 2002; Reardon & Farina, 2002). For example, an improper temperature control of food products containing e.g. cream or meat might lead to a growth of micro-organisms, which can result in food safety problems and product failures. An inadequate production and distribution planning causes overproduction, loss of materials, products unavailability, which results in customer dissatisfaction. The review of QM literature found a conceptual model proposed by (Luning et al., 2002) which attempted to integrate all concepts of quality considering the specific characteristics of the food production. Their model consists of five managerial functions derived from the management literature. The first three functions, design, control and improvement, are adapted from Juran's trilogy (Juran, 2005). The fourth function, quality assurance, is included because of the special characteristics of the food sector. The fifth function, quality policy and strategy is integrated into the framework as it facilitates organizations in setting long-term quality goals and objectives (Hellsten & Klefsjö, 2000). The framework comprises five managerial functions derived from the management literature (Figure 2-1).

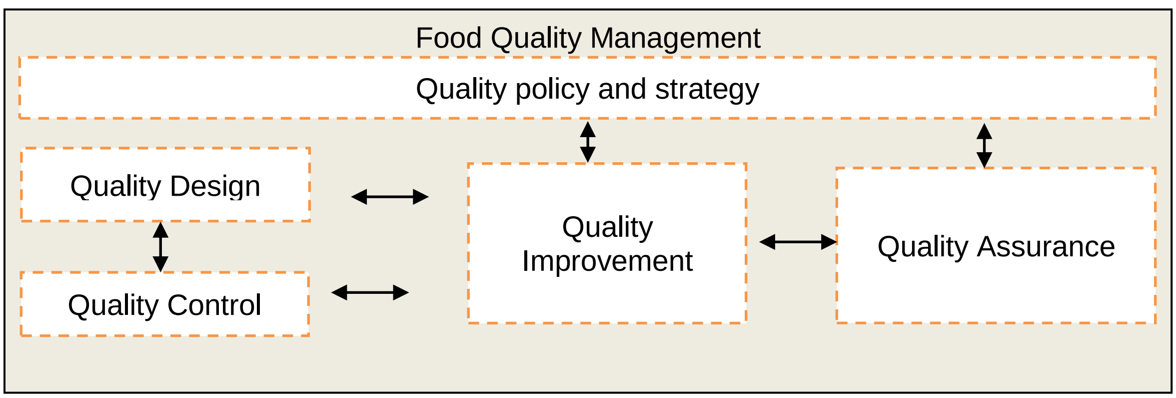

Figure 2-1 Food Quality Management Function

Source: (Luning et al., 2002)

Each quality function incorporates a wide range of tools, techniques and methods which have been developed and deployed over the last several decades to manage quality in organizations across sectors. Table 2-1 illustrates the widely used methods of quality management constructed from the literature (Barendsz, 1998; Higgins, 2006; Karipidis et al., 2009; Van der Spiegel et al., 2003).

Table 2-1 Quality Management components

Quality Assurance	Quality Improvement	Quality Design	Quality Control	Quality Policy and Strategy
• HACCP • ISO • BRC • IFS	• Lean manufacturing • Six sigma • Lean sigma • Dashboard metrics	• Quality function deployment • Failure mode & effect analysis • Design of experiment	• Statistical process control • Acceptance sampling • Visually inspect	• Total quality management • Quality cost analysis • Strategy analysis

Quality Assurance (QA) has a significant role in the food sector (Holleran et al. 1999). It provides a guarantee that all quality obligations such as food safety and reliability are met through establishing a standard organizational structure, responsibilities, processes and procedures (Van der Spiegel et al., 2003). Several QA systems have been developed to fit the needs of the food sector such as HACCP (Hazard Analysis Critical & Control Points), ISO (International Organization for Standardization), IFS (International Food System), BRC (British Retail Consortium). It is important to note that though Table 2-1 shows a different category of QM methods, they are not mutually exclusive but interconnected ISO9001, for example, requires elements of quality improvement (QI) and the adoption of a quality policy and strategy (QP). Quality Improvement (QI) is a systematic approach which involves mapping, documenting, analyzing and redesigning (Luning et al., 2002). There are numerous QI methods such as dashboard matrices, Lean and Six Sigma. Quality Design (QD) is a method to translate the voice of the customer into the technical requirements of the products and processes with the help of specific techniques so that the final quality meets or exceeds customers' expectations (Higgins, 2006). The QD methods such as Quality Function Deployment (QFD) and Design of Experiment (DOE) for the product and process design are widely used across sectors (Scipioni et al., 2002). Quality control (QC) has a significant role in the food sector because there is a huge variation in food products and biological raw materials (MacCarthy & Wasusri, 2002). Quality Policy and Strategy (QP&S) ensure that QMS is included within a company's long-term business strategy and helps a company to take appropriate actions and allocate resources to achieve those goals (Porter, 1998). Total Quality Management (TQM), quality cost analysis and strategy analysis are commonly used methods by companies across sectors. (Hellsten & Klefsjö, 2000) described TQM as a management system which includes core values of the organization, tools and techniques.

The first phase of the literature review reveals an interesting pattern. A comprehensive table is constructed in order to demonstrate the contemporary research trend on quality management in food processing industry. Table 2-2 shows the research method, focused practice, and related sector.

Table 2-2 Studies on quality management practices

(Author, Year)	**Methodology (Sample size)**	**Sector**	**Focus/QM practice**
(Betta et al., 2011)	Survey	Food	HACCP
(Raspor, 2008)	Literature	Food	Food safety, HACCP
(Manning & Baines, 2004)	Literature	Food	HACCP
(Ropkins & Beck, 2000)	Survey	Food	HACCP
(Caswell et al., 1998)	Meta-analysis	Food	HACCP, ISO
(Westgren, 1999)	Case study	Food	HACCP
(Jacxsens et al., 2011)	Review	Food	HACCP, ISO, BRC
(Trienekens & Zuurbier, 2008)	Literature	Food	ISO, BRC, HACCP
(Tajkarimi et al., 2012)	Review	Food	HACCP
(Scott et al., 2009)	Survey, (46)	Food	Lean, TQM, HACCP
(Cox & Chicksand, 2005)	Case study, (7)	Food	Lean
(Van Asselt et al., 2012)	Review	Food	FSMS, RBS
(Mann et al., 1999)	Survey (50)	Food	EFQM
(Fotopoulos et al., 2011)	Survey (31)	Food	HACCP
(Toldrá, 2010)	Book	Food	QA, Microbiology
(Gotzamani & Tsiotras, 2001)	Survey, (84)	Non-food	ISO, TQM
(Pinho, 2008)	Survey, (80)	Non-food	TQM
(MacKerron et al., 2003)	Case study	Non-food	EFQM, SA, TQM
(Wilkes & Dale, 1998)	case study, (7)	Non-food	EFQM
(Hansson & Klefsjö, 2003)	case study, (9)	Non-food	TQM
(Mackau, 2003)	Case study, (1)	Non-food	ISO
(Thomas & Webb, 2003a)	Survey, (500)	Non-food	ISO9000,EFQM
(McAdam, 2000)	Case study, (20)	Non food	BS, BEM
(Gunasekaran et al., 2000)	Case study, (1)	Non food	JIT/Kanban
(Khan et al., 2007)	Survey(150)	Non-food	BPI, Lean Sigma
(Chileshe, 2004)	Survey, (63)	Non-food	TQM
(Ahmed et al., 2004)	Survey, (63)	Non-food	TPM/TQM
(Kumar & Antony, 2008)	Survey, (64)	Non-food, food	Lean, Six Sigma

Source: Own compilation

Table 2-2 demonstrates the perception and differences between food and non-food sectors with respect to quality management. In summary:

1. Most of the studies in the non-food SMEs category are mainly focusing on TQM, Lean manufacturing, and Six Sigma.

2. The majority of the studies in the food SMEs category are focusing on quality assurance methods (HACCP, BRC, and ISO) and microbiological issues. The primary objective of these studies is food safety which is just one part of the broader quality management system (Luning & Marcelis, 2007). There is a limited body of literature on integrated quality improvement practices (e.g. lean manufacturing, Six Sigma). The focus is biased towards the product, while process is grossly ignored.
3. There are limited empirical studies on lean manufacturing practices in food processing SMEs. Moreover, the sample size of these studies is relatively small due to a low response rate.

We did not find any studies which investigated the impact of lean manufacturing on operational performance in the context of SMEs operating in the food processing industry. We learned that the success and failure of QM initiatives are highly context-dependent (Sousa & Voss, 2001). Furthermore, Kouchan, et al. claimed that the pace of change and the outcome of such initiatives differ significantly across sectors and even across companies (Kochan et al., 1997). Given the special characteristics of the food sector there is a clear need to understand the problems and consequences of such initiatives. Failing to develop and implement a suitable management system may cause more problems for food SMEs with respect to food safety, customer satisfaction and product availability. The literature also indicated that distinctive features of the organization, the product process, the complexity of the product and human resource management practices are responsible for the failure of lean manufacturing initiatives (Cox & Chicksand, 2005; Noci & Toletti, 2000). The following section provides a review and conceptualization of lean manufacturing, and operational performance for further analysis in the food SMEs context.

The quality management literature, especially lean manufacturing is characterized by highly diverse definitions, research methodologies, implications and limitations. A major contribution in understanding lean manufacturing has been made by (Shah & Ward, 2007a). Their study used a multi-step construct development method and identified three pillars of lean manufacturing practices; supplier related, customer related and the internally related issues of the company. The first "supplier related" pillar, justifies the involvement of suppliers and their impact on the company's quality, cost and delivery target. Involved suppliers not only help to reduce time and cost but also improve quality (Wagner, 2010). Similarly (Carter & Narasimhan, 1996; Cooper & Ellram, 1993) found that companies continuously reorganize their supplier base in order to achieve operational excellence.

Another study by (Benton & Krajewski, 1990) emphasized that the supplier lead time is an important factor contributing to manufacturer's performance. Supplier related issues include giving regular feedback to the supplier about their performance (supplier feedback), ensuring delivery on time by the suppliers (JIT delivery), and developing a supplier base so they can be involved in the production process (supplier development). The second pillar of lean manufacturing signifies the involvement of customers in the company's decision making process. The core of lean manufacturing is the customer and company embarking on a lean journey which primarily focuses on customers and their needs. Customer involvement in a company's decision making results in an increase in customer satisfaction, quality and production (Warnecke & Hüser, 1995). Similarly (Da Silveira et al., 2001) stressed that customer driven manufacturing substantially improves customer satisfaction, quality and productivity. The third pillar of lean manufacturing is related to internal issues of the company which includes continuous flow (Rother & Harris, 2001), just in time (pull) (Mackelprang & Nair, 2010), set up time reduction (Cakmakci, 2009), total productive/preventive maintenance (Ahuja & Khamba, 2008), statistical process control (Hoerl & Snee, 2010) and employee involvement (Demeter & Matyusz, 2010; Losonci et al., 2011; Pool et al., 2010). In a nutshell, lean manufacturing practices can have a significant impact on the operational performance of companies.

"Operational performance" is defined as the changes happening in the operational metrics after the implementation of lean manufacturing practices in an organization (Karlsson & Ahlström, 1996; Sánchez & Pérez, 2001). Several studies have investigated the correlation between lean manufacturing and operational performance with respect to cost, quality and delivery (Fullerton & Wempe, 2009a; Gunasekaran et al., 2000; Lewis, 2000a). An important study by (Hofer et al., 2012) showed the mediating role of inventory leanness in deriving the financial performance benefits associated with lean manufacturing. Similarly, (Eroglu & Hofer, 2011) found a significant correlation between inventory leanness and firm performance. Studies also provide evidence that the implementation of lean manufacturing results in improved operational performance in terms of inventory management, process control, information flows, human factors and flexibility (Cua et al., 2006; Fullerton & McWatters, 2001; Jayaram et al., 2008).

The review of the literature indicated a dominant correlation between lean manufacturing and a firm's operational performance. Still, very few food processing SMEs take advantage of improving operational efficiency and performance through lean implementation. This raise two questions that is grounded in literature: Firstly, how food processing SMEs perceive lean manufacturing compared to other quality management practices such as HACCP, ISO and BRC? Secondly, how operational performance of food processing SMEs are impacted by lean implementation (if they are implementing lean)?

We further interrogate the literature on operational performance in order to answer the above mentioned questions. This study selected the five operational performance indicators of lean manufacturing practices from the work of (Bonavia & Marin, 2006) supported by other research findings: 1. Stock/inventory reduction (Fullerton & Wempe, 2009a; Wu, 2003); 2. Quality improvement (Cua et al., 2006; Fullerton & Wempe, 2009a); 3. Productivity improvement (Shah & Ward, 2003; Taj & Berro, 2006); 4. Lead or cycle time reduction (Droge et al., 2004; Shah & Ward, 2003); 5. Improvement in on-time delivery (Flynn & Flynn, 2004; Nieminen & Takala, 2006). The following sections explain how the survey was conducted among the food processing SMEs in order to answer the research questions.

2.3 Research Design and Methodology

As outlined earlier in the research design section (1.9.1), the literature review was complemented with a survey of food processing companies in three European countries in order to gain a deeper understanding of lean manufacturing in the backdrop of other similar quality management initiatives. As mentioned, this study was carried out within the scope of a European Union funded project “Innovative Management System for the Food SMEs” (IMSFood) involving Belgium, Germany and Hungary. Only SMEs meeting the definition of the European Commission were considered for the study. The Commission defines SMEs as those organizations with less than 250 employees, a maximum of 50 million euro annual turnover and, a maximum of 43 million Euro annual balance-sheet total (Commission, 2003). The selection of the survey based research strategy seemed logical for conducting an exploratory study that uses well-defined concepts and models (Handfield & Melnyk, 1998). In the quality management research, most scholars used the survey as the most important method of data collection to statistically validate their research questions (Forza, 2002; Samson & Terziovski, 1999). A questionnaire was prepared based on the literature (Achanga et al., 2006; Bonavia & Marin, 2006; Shah & Ward, 2003; Shah & Ward, 2007b) and pilot tested with practitioners and academic experts in the field of quality management.

The questionnaire was revised by incorporating the comments from the pilot stage. The participants were asked to indicate their response on a seven point Likert scale (1= strongly disagree to 7= strongly agree). The selected sectors in this study are meat, chocolate, confectionery, bakery and others. Table 2-3 provides the demographic information of the respondents. The study was carried out with the cooperation of food associations (e.g., Fenavian, Choprabisco) to include the appropriate respondents who are aware of lean practices. Moreover, we organized workshops at our department on lean manufacturing for food processing companies.

Table 2-3 Demographic information of the respondents

Respondents	n	Country	n	Size	n	Product	n
CEO/ Director/ General manager	16	Belgium	17	Micro	4	Meat product	18
Departmental Head	5	Germany	8	Small	22	Chocolate	3
Quality manager	3	Hungary	10	Medium	9	Confectionery	5
Other	11					Bakery	5
						Other	4

2.4 Result and discussion

First of all, customers being the core of any business, the respondents were asked to cite the most important criteria that helped their companies to win customer loyalty. The rationale of this question was to measure the pulse of the companies and their commitment towards customers. The study found that the surveyed companies believe that quality, a wide product range and product reliability are the three most important criteria to win customer loyalty with the large majority (82%) reporting that “Quality” is the most important criterion.

The participants were then asked to choose the most important factors out of cost, innovation, flexibility and quality, which define the company’s strategic objective. Factors like quality, price, and reliability are not mutually exclusive but presented as a separate factor in literature (Achanga et al., 2006; Antony & Banuelas, 2002; Kumar & Antony, 2008). The relationship between quality and cost is not understood well among researchers and practitioners in the industry, otherwise the ‘Quality is Free’ concept should be a well-accepted statement in the industry - which is not always the case. Adhering to past literature and our own viewpoints, we kept these factors separate. This study found that “quality” is the most important factor and it is interesting to observe that “cost” is the least significant factor when it comes to business strategy.

The next question that was identified through the literature review was: How is lean manufacturing perceived in comparison to other quality management practices, especially, when most food companies focused on quality assurance methods such as HACCP, ISO and BRC. Table 2-4 shows that the majority of food SMEs focuses on quality assurance methods (especially HACCP) in comparison to quality improvement method such as lean manufacturing.

Table 2-4 Lean manufacturing and other quality assurance practices

Description	N	Mean	SD	Rank avg*
Currently implementing lean manufacturing practices	35	5.57	1.15	3.79
Implementing lean manufacturing practices even though we do not call it lean	35	5.55	1.17	3.77
Currently implementing HACCP	35	6.05	1.03	4.70
Currently implementing IFS	35	5.07	1.12	2.89
Currently implementing BRC	35	5.03	1.45	3.00
Currently implementing ISO 9000	35	4.97	1.20	2.86

Notes: *Friedman for related samples. Significant rank difference (α < 1 per cent)

Additionally, Friedman's non-parametric rank test was applied to compare the related sample and to show if there are significant differences in the level of the use of the different quality management practices. Results of the analysis indicated that there was a differential rank ordered preference for the quality management practices. The empirical results demonstrate that food processing SMEs give more priority to and have a greater acceptance for quality assurance practices (e.g. HACCP=4.70) than quality improvement method (lean=3.79). One prime reason for this is that government agencies enforce food processors to adhere to HACCP compliance so that contamination and microbiological issues are prevented and food safety ensured (Loader & Hobbs, 1999). The other quality assurance methods such as BRC, ACP or ISO are relatively less prevalent in the participating food processing companies compared to HACCP, a similar result from a study carried out by (Mayes, 1993). The reason for this is that the quality certification requirements are often demanded by their customers (in most cases supermarkets) and that food processors still have a choice to comply the requirement (Trienekens & Zuurbier, 2008). The decision to choose the latter (e.g. BRC, IFS, ISO) is more economic than regulatory as firms may not want to lose an important customer (Busch & Bain, 2004; Henson, 2008; Kinsey & Senauer, 1996). Furthermore, firms simultaneously deploy more than one QA practice. The reason for the multiple QA certificates might be the companies' commitment to their customers' requirements for specific certifications. Further, governmental safety standard requirements are based on product characteristics. HACCP, for instance, is absolute obligatory for meat and poultry processing firms (He & Hayya, 2002). It is also important to note that the majority of the respondents in this study belong to the meat processing industry, hence the score of HACCP is relatively higher than the other QM practices.

However, many respondents of this study stated that they are implementing lean manufacturing practices even though they do not call it “lean”. This is an interesting result because other studies found that many companies follow a piecemeal approach or adopt lean manufacturing practice in a certain section of the company and ignore its systemic nature, which limits the true potential of lean (Dowlatshahi & Taham, 2009; James, 2006). The downside of a piecemeal approach is that it hinders the lean journey (Allen, 2000; Bhasin & Burcher, 2006; Henderson & Larco, 1999). The choice of this approach may be attributed to practice-based studies by consultants, which recommend SMEs to look for the low hanging fruits (Ballé, 2005; Smith, 2003).

It is empirically evident that government agencies coercively influence or enforce food processors to adhere to HACCP compliance or that a customer (supermarket) asks for a specific quality assurance certificate such as BRC, IFS or ISO. As mentioned in the research proposition section, out of the three forms of organizational isomorphic drivers - coercive, normative, and mimetic described by (DiMaggio & Powell, 2000) - the coercive isomorphism predominantly works in the food processing industry, which leads firms to choose and adopt a particular quality management practice. However, there is an increasing trend that food processing industries started implementing (mimetic isomorphism) industry best practices such as lean manufacturing in order to be able to remain competitive in the market by improving operational performance (Bae & Rowley, 2002).

Likewise, the Kruskall-Wallis test was carried out to further understand the differences in the implementation of different quality management practices in three European countries. Table 2-5 shows the country wise variation in quality certification requirements. The analysis shows that the HACCP system is widely implemented in companies in all three European countries. However, Belgian and German firms scored better than the Hungarian firms with respect to HACCP implementation and the difference in mean is significant at 10 percent confidence level. In the EU, since 1998, HACCP is obligatory for all companies in the food chain, except for the primary producer. However, literature suggests that the implementation of HACCP varies strongly across countries, food industry sectors and types of firms (Bernauer & Caduff, 2004). Previous literature on the implementation of HACCP in European SMEs, such as (Van Der Spiegel et al., 2005) found that out of 48 food SMEs 17 are implementing HACCP while the others use ISO, BRC, hygiene code. The FSA survey (2000) suggests that only 48% of red meat slaughterhouses and 59% of poultry meat slaughterhouses in England, Wales and Scotland claimed to have full or partial HACCP systems in place. Similar results can be found in Portugal and Greece, where there is still only a minority of companies that are HACCP certified (Trienekens & Zuurbier, 2008). We further inquired some Belgian food SMEs about the results in the frame of the EU funded IMSFood project and found out that most of the companies follow IFS which is based on the HACCP principle. QA is the distinctive feature, which makes the food sector different from others. Companies in the food processing sector are legally bound to perform one or more QA systems which might not be the case for other manufacturing sectors. However, the analysis shows that the difference by country is not significant with respect to lean implementation (0.80*).

Table 2-5 Kruskall-Wallis average of quality management practices by country

	Belgium		Hungary		Germany		Asymp.
	Mean	SD	Mean	SD	Mean	SD	Sig.*
Currently implementing lean manufacturing practices	5.53	1.07	5.4	1.51	5.57	1.14	0.80
Implementing lean manufacturing practices even though we do not call it lean	5.53	1.07	5.5	1.27	5.54	1.17	0.95
Currently implementing HACCP	6.35	0.61	5.5	1.43	6.06	1.03	0.13
Currently implementing IFS	5.06	0.66	5.4	1.65	5.03	1.12	0.19
Currently implementing BRC	5.06	1.25	5.4	1.51	5.03	1.44	0.49
Currently implementing ISO 9000	4.88	1.17	4.9	1.20	4.97	1.12	0.68

Notes: Sig., significance level on Kruskall-Wallis test (*$\alpha < 5$ per cent)

The Kruskall-Wallis test shows the differences in the implementation of various quality management practices with respect to the firm size. Table 2-6 demonstrates that the differences in firm size is significant with respect to the implementation of the listed quality management practices. The small and medium-sized respondent firms scored better than the micro-sized firms.

Table 2-6 Kruskall-Wallis average of lean manufacturing and quality practices by firm size

	Micro		Small		Medium		Asymp
	Mean	SD	Mean	SD	Mean	SD	Sig.*
Currently implementing lean manufacturing practices	4.00	1.41	5.64	1.00	6.11	0.78	0.02
Implementing lean manufacturing practices even though we do not call it lean	3.75	0.96	5.59	1.01	6.22	0.83	0.01
Currently implementing HACCP	4.00	0.82	6.14	0.71	6.78	0.44	0.00
Currently implementing IFS	3.25	0.96	5.09	0.97	5.67	0.71	0.00
Currently implementing BRC	3.25	1.26	5.18	1.22	5.44	1.59	0.04
Currently implementing ISO 9000	4.00	0.00	4.82	1.18	5.78	0.67	0.01

Notes: Sig., significance level on Kruskall-Wallis test (*α , 5 < per cent)

It is also important to understand the differences between the two major groups: small firms (≤ 50 employees) and medium-sized firms (≤ 250 employees) with respect to quality management practices keeping micro-sized companies aside (≤ 10 employees). In order to find out which variables are differentiated from the rest, we supplemented the previous analysis with the non-parametric Mann-Whitney test to compare two independent samples. Table 2-7 shows the statistically significant difference between the two groups with respect to HACCP (0.01*), ISO (0.03*) and IFS (0.09*).

Table 2-7 Mann-Whitney test small and medium-sized firms

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig.*
Currently implementing lean manufacturing practices	73	326	-1.20	0.23
Implementing lean manufacturing practices even though we do not call it lean	64.5	317.5	-1.57	0.12
Currently implementing HACCP	47	300	-2.55	0.01
Currently implementing IFS	63	316	-1.68	0.09
Currently implementing BRC	84	337	-0.67	0.50
Currently implementing ISO 9000	49.5	302.5	-2.23	0.03

Notes: Sig., significance level on Mann-Whitney Test (*α , 5 < per cent)

Further, the Multiple Correspondence Analysis (MCA) was used to get a better visualization of the link between quality management initiatives and the characteristics of firms, especially country of origin and firm size. MCA describes the relation between firm characteristics and aims to group similar cases. The result is a two-dimensional figure that visualizes the relation between the categories of the variables and the cases. The multiple correspondence analysis with SPSS allows the use of more than two variables. Figure 2-2 displays the relationship between quality management practices and firm characteristics such as country and size. Three blue circles represent country (1=Belgium, 2=Hungary, 3=Germany), three green circles represent firm size (1=Micro, 2=Small, 3=Medium) and the orange circles (objects) represent firms implementing quality management practices. Figure 2-2 shows that there is no clear difference in the quality management practice implementation with respect to country of origin especially Germany and Belgium as they are all clubbed together. However, the Hungarian companies are placed slightly above the x-axis. The analysis also shows that the firm size does matter, especially in the case of micro-sized firms. We can clearly see that quality management practices are mostly centered around small and medium-sized companies in the left. The green circle denoting (1) in the right represents micro-sized companies. It is far up from other groups (small and medium sized firms). We also can see four outliers in this figure (21, 22, 27, and 33). A deeper look into these firms reveals that the first three firms (21, 22, 27) are micro-sized Hungarian firms, which are placed further than the rest of the group. The MCA demonstrates that the micro-sized Hungarian companies are relatively less likely to adhere quality management practices. This result is consistent with Table 2-5 showing Kruskall-Wallis average of quality management practices where we can see that Belgian and German firms scored better than Hungarian firms.

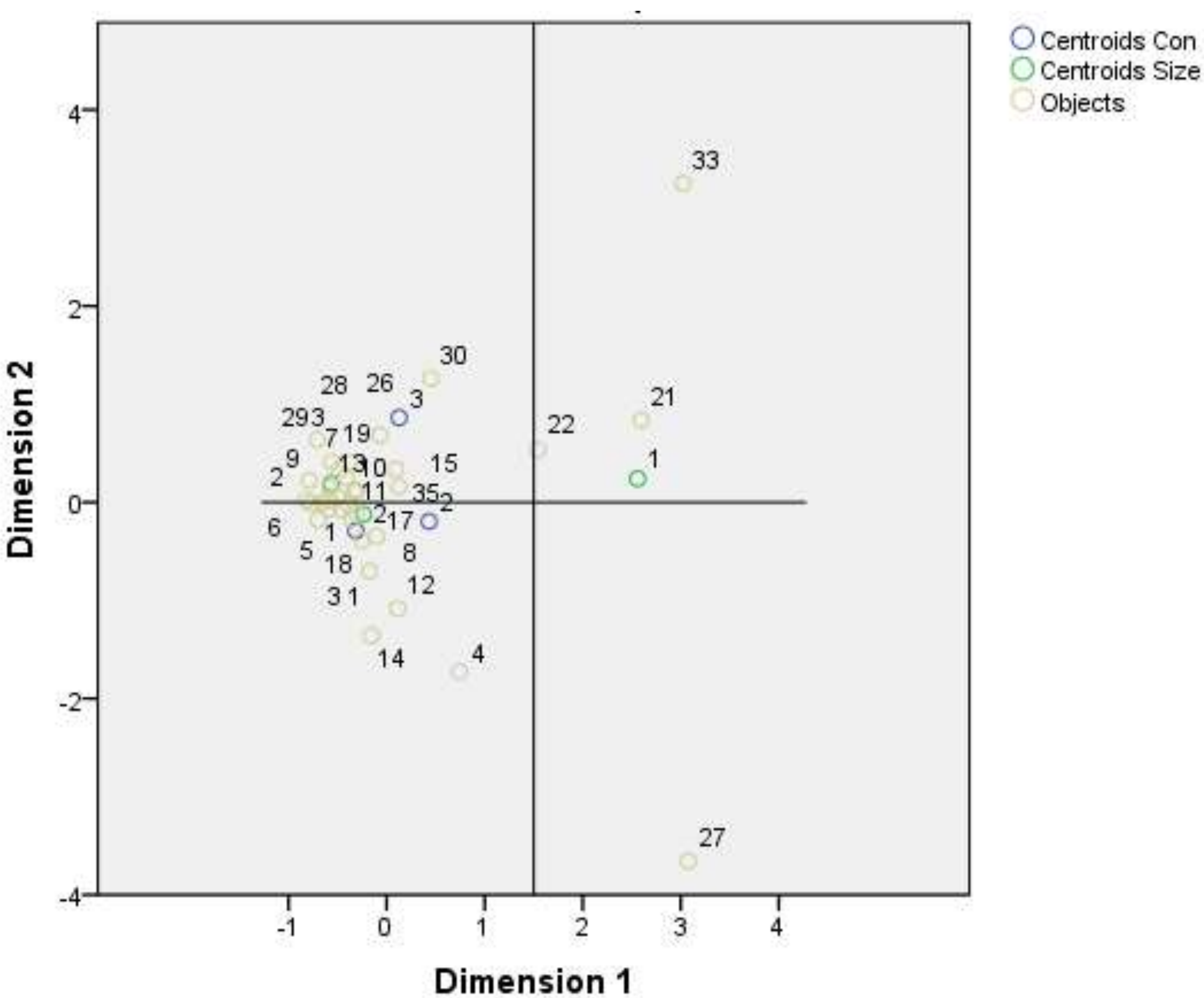

Figure 2-2 Multiple correspondence analysis (QM, country and firm size)

The results from the survey among food processing SMEs return the focus to the analysis of the reviewed literature stated in the beginning. The study found that many food processing SMEs in the sample implement lean manufacturing practices - either implicitly or explicitly. However, the focus of the food processing SMEs is on food safety and food quality issues rather than on process or quality improvement. The application of lean manufacturing in the food sector is evolving and is still at an early stage.

The literature is interrogated further to identify if there is anything inherent to the food processing industry with respect to the product, process and/or plant that may make lean implementation difficult. The nature of the process, such as manual, semi-manual or automatic, has important consequences on the lean implementation. (Jina et al., 1997a) claims that the application of lean manufacturing is not straightforward in a High Product Variety and Low Volumes (HVLV) environment. Further, a highly perishable product can cause more difficulty in lean implementation than the products having a relatively longer self-life. (White & Prybutok, 2001) found that lean practices are less likely to be implemented in non-repetitive systems. The cause of the lower implementation rates in non-repetitive systems is that the lean practices were designed in–and have their roots in–a repetitive production system. Similarly, (Katayama & Bennett, 1996b) showed that lean manufacturing practices are unable to respond to large fluctuations in aggregate demand volumes. Moreover, (White et al., 1999b) suggests that large manufacturers are more likely to implement lean practices than small ones.

The second objective of the study was to analyze what happens to the firms' operational performances when they implement lean manufacturing practices. A large body of literature in both the food and non-food sector (Achanga et al., 2006; Bhasin & Burcher, 2006; Detty & Yingling, 2000; Engelund et al., 2009; Fullerton & Wempe, 2009a; Lehtinen & Torkko, 2005; Shah & Ward, 2003; Sohal, 1996; Zokaei & Simons, 2006) provides empirical evidence suggesting multiple benefits from lean manufacturing, such as cost reduction, increase in profitability and improved customer satisfaction with respect to quality and delivery. First, Friedman's non-parametric test was carried out to see if there are differences in the level of operational performances due to lean manufacturing practice implementation. This study has measured the perception of respondents about the impact of lean manufacturing on operational performances in their firms on a likert scale of one to seven. Table 2-8 presents the descriptive statistics of operational performance in food processing SMEs that have implemented lean manufacturing practices. This study has measured the perception of respondents about the impact of lean manufacturing on operational performances in their firms on a likert scale of one to seven.

Table 2-8 Operational performance due to lean implementation

Variable	N	Mean	SD	Rank avg*
Productivity improvement	35	4.97	1.85	3.60
Quality improvement	35	4.58	1.91	2.90
Lead or cycle time reduction	35	4.56	1.67	2.96
Reduced delivery lead time	35	4.40	1.46	2.73
Stock/inventory reduction	35	4.25	1.62	2.81

Notes: *Friedman for related samples. Significant rank difference (α < 1 per cent)

This study did not attempt to compare firms that apply lean practices with the ones that do not. Based on the analysis, the majority of the companies in this study performed well in improving productivity and quality in comparison to other performance indicators after lean implementation. The impact on quality due to lean implementation is noteworthy. These results suggest that it is easier to attain a quality specification with lean practices because of its association with stable manufacturing practices such as statistical process control. The analysis confirms the earlier studies which found out that operational performance improves due to the implementation of lean manufacturing in food processing SMEs (Engelund et al., 2009; Lehtinen & Torkko, 2005; Simons & Zokaei, 2005; Upadhye et al., 2010).

Moreover, the Kruskall-Wallis test was conducted to understand the differences in the operational performances due to lean implementation in three European countries. Table 2-9 displays that the differences in operational performances among countries are insignificant.

Table 2-9 Kruskall-Wallis average of operational performance by country

	Belgium		Hungary		Germany		Asymp.
	Mean	SD	Mean	SD	Mean	SD	Sig.*
Stock/inventory reduction	4.53	1.66	3.70	1.70	4.38	1.41	0.42
Productivity improvement	4.88	1.83	4.80	2.15	5.38	1.69	0.86
Lead or cycle time reduction	4.76	1.64	4.10	1.60	4.75	1.91	0.58
Improved product quality	4.76	1.99	4.50	1.96	4.25	1.91	0.72
Reduced delivery lead time	4.65	1.37	4.00	1.33	4.50	1.85	0.52

Notes: Sig., significance level on Kruskall-Wallis test (*α , 5 < per cent)

A similar test was also conducted to comprehend the differences in operational performances in the case of micro, small and medium-sized companies. The results of the Kruskall-Wallis test are presented in Table 2-10. Results show that there is a significant difference in the case of three operational performances variables, namely quality improvement, lead or cycle time reduction and improvement in on-time delivery. There was no significant difference found for the two variables productivity improvement and stock/inventory reduction at 5 percent confidence level. One potential explanation of this result could be the homogenous sector (similar product category e.g. meat). The manufacturing practices implemented in one firm can be rapidly spread to another firm and make it difficult to assess differences in the firms' operational performances. This finding is contrary to the research done by other researchers in the past (Lowe & Oliver, 1997; Oliver et al., 1994; Singh & Singh, 2012). Furthermore, the difference show that the small companies more than medium companies benefits from lean manufacturing on productivity improvement while medium companies profit more in quality improvement. The reason may be attribute to the fact that in the case of small companies there is still room for productivity improvement than in medium companies.

Table 2-10 Kruskall-Wallis average of operational performance by firm size

	Micro		Small		Medium		Asymp.
	Mean	SD	Mean	SD	Mean	SD	Sig.*
Stock/inventory reduction	3.00	0.82	4.45	1.65	4.33	1.66	0.29
Productivity improvement	3.25	1.50	5.45	1.74	4.56	1.88	0.05
Lead or cycle time reduction	3.00	0.00	4.86	1.70	4.56	1.67	0.15
Improved product quality	2.50	1.00	4.77	1.90	5.00	1.80	0.08
Reduced delivery lead time	3.25	0.96	4.64	1.33	4.44	1.81	0.21

Notes: Sig., significance level on Kruskall-Wallis test (*α , 5 < per cent)

It was also found that the full benefits of lean manufacturing are not realized by food SMEs because of their early stage of adoption (Bhasin, 2008). The reason may be attributed to the fact that processing industries possess some barriers because of the sector's large and inflexible machinery, long setup time, small batch sizes and resource complexity (Abdulmalek et al., 2006; Van Donk & Van Dam, 1996; Van Goubergen et al., 2011a). In addition, the implementation of lean manufacturing also depends on organizational factors such as the size of the organization, the type of suppliers and customers, the degree of automation and the type of products and quality assurance requirements (Pool et al., 2010; Shah & Ward, 2003; Sim & Rogers, 2008). Similarly, the differences between SMEs and large manufacturers with respect to structure, policy making procedures, resource utilizations, staff patterns, culture, and patronage also affect the result of lean implementation (Antony et al., 2005a; Thomas & Barton, 2006; Welsh & White, 1981). All these organizational and sector specific factors are investigated and analyzed in the case study in chapter 4.

Furthermore, the Multiple Correspondence Analysis is used in order to show the relationship between the operational performance due to lean practice implementation and the characteristics of firms i.e., country of origin and firm size. This provides an alternative method of displaying the discrimination of variables that can identify category relationships. Three blue circles represent country (1=Belgium, 2=Hungary, 3=Germany), three green circles represent firm size (1=Micro, 2=Small, 3=Medium) and the orange circles represent the firm's operational performances. A closer look at Figure 2-3 shows an interesting pattern about the relationship between operational performances and firm characteristics. In this plot, the coordinates of each category (country and size) on each dimension are displayed. This helps us to determine which categories are similar for each variable. The segment 1 in the figure comprises all five operational performance variables and is plotted against country of origin and firm size. The spread of the operational performances variables across all categories reflect little variance. These patterns cannot be illustrated clearly in a plot of discrimination measures. The result is aligned with previous studies, which found that the performance indicators are correlated and difficult to study with a mutually exclusive condition (White & Prybutok, 2001). Hence, we further declassified different operational performances in five more segments.

Figure 2-3 shows that out of all six segments listed below the two operational performances parameters i.e. product quality improvement and reduced delivery lead time have been clubbed together. However, the proximity of groups is not as closely linked as the one in Figure 2-2 for quality management practices. This visual demonstration justifies our earlier Friedman's non-parametric test results stating that most firms improve their performances on these two parameters (product quality improvement and reduced delivery lead time) due to lean practices implementation irrespective of country and firm size. We can see a similar pattern in Figure 2-2, which displays that three Micro-sized Hungarian firms are far up from other groups (segment 4). Seemingly, the lean maturity level at Hungarian micro-sized firms is low compared to their Belgian and German counterparts.

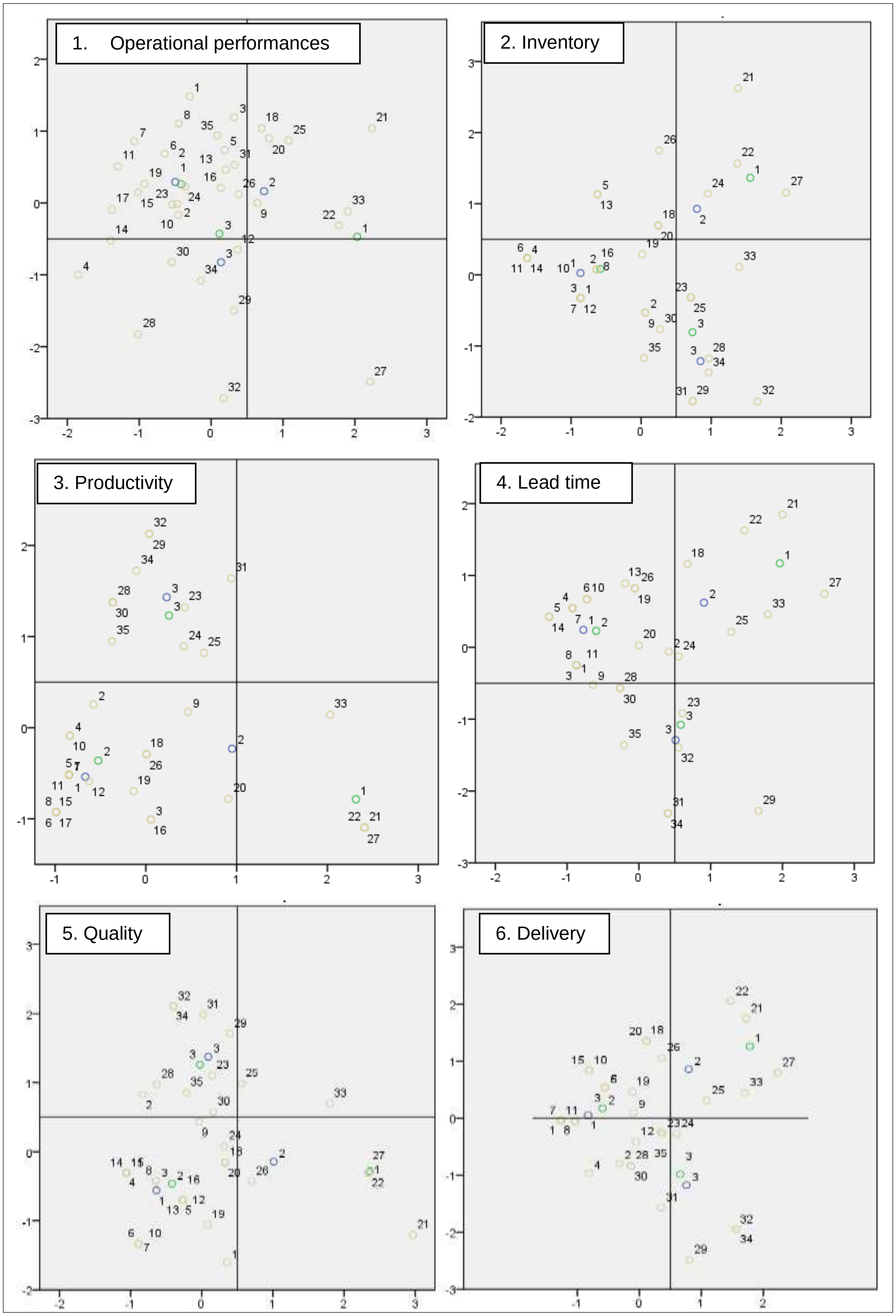

Figure 2-3 Multiple correspondence analysis (operational performance, country and firm size)

In order to provide a better visual deduction we have presented Figure 2-4 and Figure 2-5 to show the differences in operational performance with respect to country of origin and firm size. The differences in these two figures demonstrate that German firms receiving the benefits of lean manufacturing more than their Belgian and Hungarian counterparts. Similarly, small and medium sized companies are more benefited from lean practices compared to micro-sized company. However, country differences are less than the firm size differences.

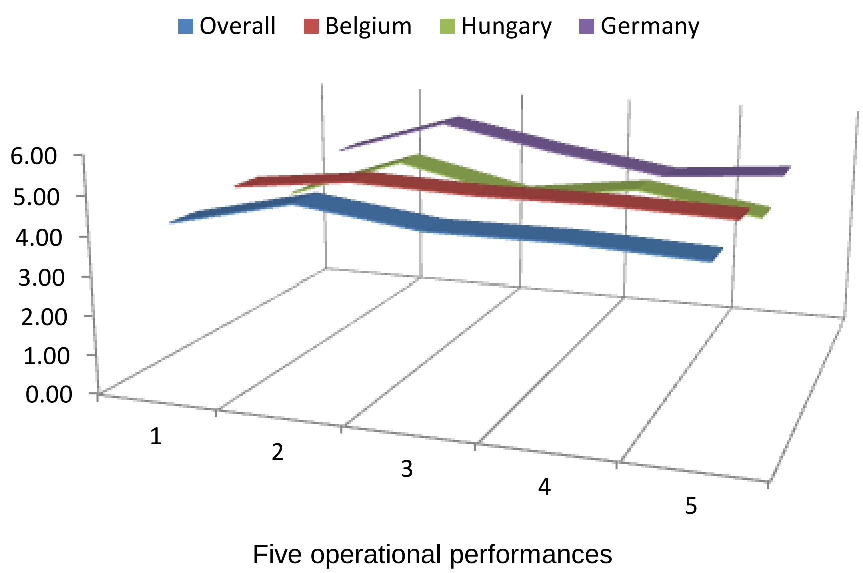

Figure 2-4 Operational performances by country

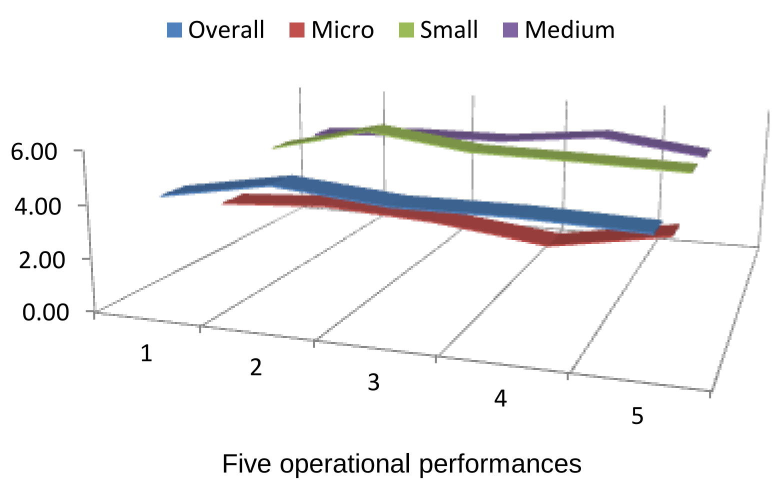

Figure 2-5 Operational performance by firm size

2.5 Conclusion

This section concludes by briefly highlighting the lessons learnt from this chapter. First, this study provides an overall picture of lean manufacturing vis-à-vis other QM practices among food processing SMEs from the secondary literature as well as primary data from three European countries. It is empirically evident that the application of lean manufacturing in the food sector is evolving but it is still at an early stage of development. The focus of the firms is primarily on food safety and quality assurance methods and less on process improvement methods. The reason may be attributed to the stern governmental quality assurance requirements and the customers' (retailers and supermarkets) demands for quality certifications. From a theoretical perspective, institutional coercive isomorphism is more dominant than the normative or mimetic isomorphism in the context of quality initiatives in food processing SMEs.

This study further investigated the link between quality management initiatives and the characteristics of firms, especially country of origin and firm size, with the help of non-parametric explorative statistical techniques. Following are the few important findings of the analysis.

One, though HACCP is the most widely used quality management practice in European food industries, the Belgian and German firms scored better than the Hungarian ones with respect to HACCP implementation. However, the analysis shows that the difference by country is not significant with respect to lean implementation. Furthermore, the MCA demonstrates that the micro-sized Hungarian companies are relatively less likely to adhere the quality management practices.

Two, tests were carried out to see if there are differences in the level of operational performances due to lean manufacturing practice implementation. Based on the analysis, the majority of the companies in this study performed well in improving productivity and quality in comparison to other performance indicators. The impact on quality due to lean implementation is noteworthy. Seemingly, the lean maturity level at Hungarian micro-sized firms is low compared to their Belgian and German counterparts. The analysis demonstrates that German firms get the benefits of lean manufacturing more than their Belgian and

Hungarian counterparts. Similarly, small and medium sized companies are more benefited from lean practices compared to micro-sized company.

Three, it is also important to understand the differences between the two major groups: small firms (≤ 50 employees) and medium-sized firms (≤ 250 employees) with respect to quality management practices. The medium sized companies scored more than the small sized companies and the Mann-Whitney test shows the statistically significant difference between the two groups with respect to HACCP, ISO and IFS.

Four, the respondents also highlighted that the application of lean manufacturing improves operational performances, especially productivity and quality. However, it is not straight forward to explain the variations in operational performances in a homogeneous sector with similar products because of the rapid transfer of knowledge. However, the Kruskall-Wallis test result shows that there is a difference in the case of three operational performance parameters, namely quality improvement, lead or cycle time reduction and improvement in on-time delivery with respect to the firm size.

Five, the policy makers in Europe should take note of these findings regarding what makes food processors implement a particular QM practice and what implications are involved in this implementation. This will help taking proper policy measures such as improving training facilities, awareness, subsidies and support for small food processors in order to improve the efficiency and competitiveness of the European food sector. The following chapter investigates the use of individual lean practices in food SMEs and the potential barriers during its implementation.

Implementing lean concepts and principles is not a technological issue, it is primarily a management and human resource issue.
~ Kenneth E. Kirby

3. Application of lean manufacturing practices and its barriers

Adapted from:

Dora, M.; Kumar, M.; Van Goubergen, D.; Molnar, A. & Gellynck, X. (2013). "Application of lean practices in small and medium sized food enterprises", *British Food Journal (2012) (Impact factor: 0.614)*

3.1 Introduction

Womack defined lean manufacturing as “a system that utilizes fewer inputs and creates the same outputs while contributing more value to customers” (Womack et al., 1990). The definition emphasizes the identification and elimination of waste (i.e. anything that does not add value from the customers’ perspective in organizations using lean tools and techniques) (Shah & Ward, 2003). The empirical studies illustrate that lean manufacturing has several favorable impacts on operational variables, such as productivity, quality, delivery, and customer and employee satisfaction (Mann & Kehoe, 1994). However, it is important to understand the context surrounding lean manufacturing. For example, Toyota achieved substantial success with respect to cost, quality and delivery when initiated lean manufacturing in the late 1940s (Spear & Bowen, 1999). Later, many companies across sectors, sizes and geographic regions tried to imitate Toyota’s lean manufacturing system in the pursuit of efficiency and productivity. In academia, the majority of the operations management literature focuses on the application of lean manufacturing in large discrete organizations (Moreno-Luzon, 1993); some scholarly articles even started to raise concerns over the straightforward application of lean manufacturing in processing industries (Abdulmalek & Rajgopal, 2007; Melton, 2005).

The unique characteristics of products and/or processes in processing industries (e.g. large and inflexible machinery, long setup time, small batch sizes and resource complexity) presents a great challenge to the application of lean manufacturing (Abdulmalek et al., 2006; Van Donk & Van Dam, 1996). On top of that, a few studies address the issue of whether lean manufacturing is suitable for the food processing industry (Mahalik & Nambiar, 2010; Scott et al., 2009). Some studies claim lean manufacturing in the food processing industries might not bring the desired efficiency gains (Cox & Chicksand, 2005). The seemingly ineffectual results of lean manufacturing in the food processing industry have been codified by other studies which purposefully have chosen to ignore food companies in their study sample (Sanchez & Pérez, 2001).

Alternatively, Jain and Lyons claim that with minor adjustments, lean manufacturing can bring considerable benefits to the food processing industry, such as faster throughputs, reduced inventories and increased profits (Jain & Lyons, 2009). Moreover, the challenges of lean manufacturing implementations multiply when it comes to resource-constraint SMEs

(Achanga et al., 2006; Sanchez & Pérez, 2001) because of the differences between SMEs and large manufacturers with respect to structure, policymaking procedures, resource utilizations, staff patterns, culture and patronage (Welsh & White, 1981). The adoptability of lean manufacturing in an SME environment is still a debated topic in the field of operations management research (Anand & Kodali, 2008; Cocca & Alberti, 2010; Gurumurthy & Kodali, 2009; Kumar et al., 2006a; Thomas & Barton, 2006; White et al., 1999b). In a nutshell, lean manufacturing implementation can be studied in the context of processing industry characteristics, unique features of the food sector and complicated SME characteristics.

Within this context, this study aims to understand the degree of the use of lean manufacturing practices in European food SMEs. In addition, potential barriers of lean manufacturing are evaluated in European food SMEs. Further, this study also explores the effects of control variables like plant size (Bonavia & Marin, 2006; Brush & Karnani, 1996; Shah & Ward, 2003) and country of origin (Ahmad & Schroeder, 2003; Salk & Brannen, 2000). This chapter begins by reviewing previous studies on lean manufacturing practices focusing on the food processing industry, especially SMEs, in order to identify gaps and justify the need of this study.

3.2 Review of literature

The available literature debates the applicability and outcomes of lean manufacturing practices in food processing SMEs. Table 1-1 demonstrates literature related to lean manufacturing in the food sector and their methodology, key finding and limitation.

A study by Taylor provided an analysis of responses by 682 executives across sectors regarding sectoral differences in total quality management (TQM) implementation (Taylor, 1996). The study showed a significant difference in the level of TQM activity among sectors, especially with respect to organizational performance. Further, the result revealed that in comparison to other sectors the food and drink sector undertook fewer initiatives to improve organizational performance.

Table 3-1 Studies concerning lean manufacturing in food sector

Author, country	Methodology, sample	Key findings	Limitation
(Zokaei & Simons, 2006) UK	case study, (9 red meat chain)	- Identified waste in the value chain, - Focus on two lean concepts - takt time & standard operations	- Narrowed the scope and outcomes of only two lean concepts
(Lehtinen & Torkko, 2005) Finland	Case study	- value stream mapping - inventories and other waste in the chain - reduced costs & increased customer satisfaction	- Only one practice is emphasized - Neglect production process - Determining factors missing
(He & Hayya, 2002) US	Survey, (48 US food companies)	- JIT has a positive impact on food quality - employee involvement & JIT delivery - material management	- Neglect operational performance - Ignore determining factors
(Upadhye et al., 2010) India	case study, medium-sized biscuit manufacturing	- 5S, kaizen, quick changeover, and TPM can be effectively used, - commitment from top management, and training, awareness and employees' involvement important	- Neglect operational performance - Ignore sector specific determining factors
(Engelund et al., 2009) Denmark	Large-scale food production	- value stream mapping, kaizen and 5S - improving production efficiency, product quality and working environment. - JIT and pull failed	- Neglect operational performance - Ignore determining factors
(Scott et al., 2009) Canada	Survey, 46 food SMEs	- 10 out of 46 companies implemented lean - companies implementing lean have fewer product recalls - not sure if resulted in cost savings, - quality and safety benefits were the biggest motivational factors	- Not focused to lean only - More emphasis on QA practices - No reference to implementation aspects
(Cox & Chicksand, 2005), UK	Case study, red-meat supply chain	- lean practices are not easy for all internal and external participants in the food chain - recommended not extending lean beyond the boundaries of the firm	- Narrowed the scope and outcomes of only two lean concepts
(Kumar & Antony, 2008) UK	Survey, 64 SMEs (7 Food and 57 non-food)	- 26.5 percent adopted lean manufacturing - top management involvement, communication, cultural change and training were the critical factors	- Did not mention out of 26.5 % how many are food SMEs - Ignore operational performance

Source: own compilation

The previous literature on lean manufacturing in the food processing industry can be summarized as follows: Research on the applicability of lean manufacturing in the food processing industry in general and SMEs in particular is still evolving. There is a limited body of literature due to recent developments in the implementation or testing of lean manufacturing practices in food companies.

1. The applicability and results of lean manufacturing in the food processing industry is still a debatable topic.
2. The majority of available studies are case studies and very few studies are based on empirical survey. The reason being cited is the limited response rate from food SMEs.
3. Most of the studies are based on the applicability of lean tools and techniques in food SMEs and ignored the holistic, broad lean manufacturing principles.

Lean is much more than mere tools and techniques, it is a philosophy—a way of life for companies to continuously strive for perfection (Hines et al., 2004). This study is an attempt to address this myopic view of lean in the context of European food SMEs. Our study adopted a holistic conceptual model of lean manufacturing proposed by Shah and Ward which captures both internal (process) and external (supplier, customer) practices (Shah & Ward, 2007a). Shah and Ward identified 10 elements of lean manufacturing with respect to supplier involvement, customer involvement and the internally related issues of the company: (1) involved customer, (2) supplier feedback, (3) just in time delivery, (4) developing suppliers, (5) pull, (6) flow, (7) low set up, (8) controlled processes, (9) productive maintenance and (10) involved employees (Shah & Ward, 2007a). There are two concrete reasons for using the model by Shah and Ward in this study. First, this holistic model includes both people and process elements of lean manufacturing. Second, both internal and external factors were included in the model. The past research had limited focus on both the people and process aspects of lean implementation.

3.3 Research Design and Methodology

As explained in the research design section (1.9.1), this study was carried out within the scope of the European Union funded project “Innovative Management System for the Food SMEs” (IMSFood) which started in 2010 involving Belgium, Germany and Hungary. The food SMEs involved in this study are in meat, chocolate, confectionary, bakery, and packaged vegetables sector. A survey was conducted using a structured questionnaire to assess lean manufacturing practices in use and potential barriers. The selection of a survey-based research strategy seemed logical for conducting a confirmatory or explanatory study that uses well-defined concepts and models (Handfield & Melnyk, 1998). A questionnaire was prepared based on the literature (Achanga et al., 2006; Bonavia & Marin, 2006; Shah & Ward, 2003; Shah & Ward, 2007b). The study classified SMEs based on the number of employees - micro (10 or fewer employees), small (11 to 50 employees) and medium (51 to 250 employees). Table 3-2 presents the demographic information of the respondents:

Table 3-2 Demographic information of the respondents

Respondents	n	Country	n	Size	n	Product	n
CEO/ Director/ General manager	16	Belgium	17	Micro	4	Meat product	18
Departmental Head	5	Germany	8	Small	22	Chocolate	3
Quality manager	3	Hungary	10	Medium	9	Confectionery	5
Other	11					Bakery	5
						Other	4

The companies were asked to indicate their agreement or disagreement with statements regarding the implementation of lean practices in their plant on a seven point likert scale (1 = strongly disagree to 7 = strongly agree). The empirical validation of the data was carried out by using Cronbach Alpha for both individual sections as well as the overall data (Billinton et al., 2002). The Cronbach Alpha for each of the factors ranged between 0.72 and 0.89, indicating internal consistency of the responses. Three research questions regarding the degree of the use of lean manufacturing practices and potential barriers of lean manufacturing have been formulated based on the literature and a framework demonstrated in Figure 3-1. The framework is based on previous studies in the field of quality management (Bonavia & Marin, 2006; Brush & Karnani, 1996; Shah & Ward, 2003) and (Ahmad & Schroeder, 2003; Salk & Brannen, 2000).

RQ 1: What is the degree of usage of individual lean manufacturing practices among food processing SMEs?

RQ 2: Are there significant differences in the degree of implementation of lean manufacturing practices with respect to size of the company and country of origin?

RQ 3: What are the potential barriers of the implementation of lean manufacturing practices?

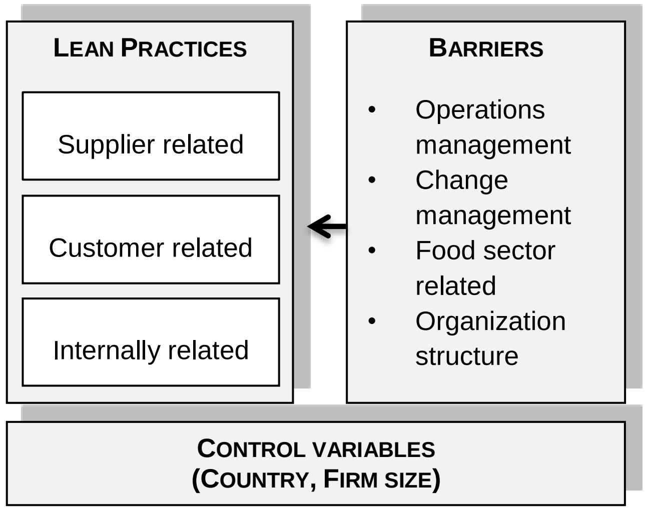

Figure 3-1 Framework for lean practice assessment

Both descriptive and inferential statistical analyses were conducted to check the association between control variables (firm size, country of origin) and the aforementioned research questions. This study used descriptive statistics, non-parametric tests and multiple correspondence analysis for analyzing the data, considering that the assumption of normal distribution of the variables could not be guaranteed. The following section explains the analysis and implication of the results.

3.4 Results and discussion

Degree of use of lean manufacturing practices

In the exploratory survey, the respondents were asked to state whether they were familiar with these lean manufacturing practices and if so, whether they used them in their firms. Table 3-3 gives the results of this exploratory survey. The advantage gained from this step was that it provided us an understanding of the status of lean practice implementation, which further helped us to comprehend the differences in the level of use of various lean manufacturing practices in food processing SMEs. It has been found that some lean practices related to customers engagement, involved employees and productive maintenance are more prevalent among the respondent food processing SMEs. The study shows a low degree of use of some lean practices related to flow, pull, set up, and employee involvement. The result also indicates a low level of statistical process control (SPC) in food SMEs. The low level of use of SPC practice in the food processing industry is an interesting finding because past studies have demonstrated that SPC is relevant for the food industry

(Hubbard, 2003; Srikaeo et al., 2005). The reason of low SPC among the respondents may be attributed to the lack of statistical know-how of staff members in a SME environment (Kumar et al., 2009).

The relatively less use of pull related practices such as kanban in the food processing industry is also shown in previous studies, especially in the processing industry related study (Abdulmalek et al., 2006). Studies related to food processing explained that highly variable combinations of lead times, growing cycle time, production lead times and manufacture to a weather dependent forecast make it complicated for the food industry to respond to pull (Cox & Chicksand, 2005). It is notable that the use of set up reduction practices are relatively less prevalent among the respondents. The sequential cleaning is a necessary step during food production and this may be a potential barrier for managers to speed up the effort in reducing the changeover time (Jain & Lyons, 2009). The findings on the relatively higher use of TPM by SMEs is a diversion to the previous studies, which state that the uptake of TPM is very slow in SMEs (Ahmed et al., 2004).

Some lean practices are found to be universally applicable such as customer involvement and mapping the process (Willaiams et al., 1992). However, it is also important to understand that firms with relatively more human and capital resources are successful in using set-up reduction and process mapping practices. Similarly, practices to assure a smooth flow is also found to be less prevalent among the respondents. It is important to note that the respondents are primarily SMEs and have limited resources to allocate for advanced practices which involve a big investment (Achanga et al., 2006). Hence (Lee, 2004) suggested SMEs to implement feasible practices (mostly internally related) which are in their control and manageable with limited resources. While it is understandable that pull and flow related practices are not widely used in food processing SMEs, the low level of use of SPC and involved employees is unanticipated. It is important to discuss two important elements of lean manufacturing in the context of food processing SMES: pull and flow. As explained in the introduction section, the demand in the food sector is highly unpredictable and production planning is generally based on forecasting (weather factor). Hence, it may be difficult for firms to implement a uniform workload and production. Inconsistent production and workload is a significant barrier to pull or kanban implementation (Alfnes et al., 2000).

Table 3-3 Use of lean manufacturing practices among European food SMEs

Section	Lean practices	n	Mean	SD	Rank avg*
Customer Related	We frequently are in close contact with our customers	35	5.80	1.13	17.63
	Our customers give us feedback on quality and delivery performance	35	5.83	0.95	18.04
	We regularly conduct customer satisfaction surveys	35	4.91	1.12	12.66
Supplier Related	We frequently are in close contact with our suppliers	35	4.20	2.13	10.86
	Our key suppliers deliver to plant on just-in-time basis	35	4.97	1.12	12.71
	We take active steps to reduce the number of suppliers in each category	35	4.71	1.76	12.70
Pull	We use the pull production system	35	4.48	1.15	9.94
	We use Kanban, squares, or containers of signals for production control	35	4.77	1.00	11.59
	Production at station is pulled by the current demand of the next station	35	4.69	0.83	10.87
Flow	Products are classified into groups with similar processing requirements	35	4.86	1.03	11.89
	Products are classified into groups with similar routing requirements	35	4.91	0.85	12.30
	Product families determine our factory layout	35	4.80	1.16	12.27
Set up	We are working to lower set up times in our plant	35	4.89	1.16	12.69
	We monitor our production-cycle time to respond quickly to customer requests	35	4.66	1.00	10.87
	Our employees practice setups to reduce required time	35	4.97	1.15	13.37
SPC	Our processes on the shop floor are currently under Statistical Process Control	35	4.69	1.18	11.99
	We extensively use statistical techniques to identify process variation	35	3.46	2.03	7.99
	We use charts to show defect rates on the shop-floor	35	4.00	1.43	8.13
Employee Involvement	Shop-floor employees undergo cross-functional training	35	4.89	1.62	12.90
	Shop-floor employees are crucial to problem-solving teams	35	4.97	1.38	13.20
	Shop-floor employees lead product/process improvement efforts	35	4.94	1.26	12.91
Total productive maintenance	We have a preventive maintenance plan in our firm	35	5.49	1.22	15.56
	We dedicate a time every day to plan equipment maintenance related activities	35	4.86	1.24	11.91
	We regularly post equipment maintenance records on the shop-floor	35	5.29	1.47	15.03

Notes: *Friedman for related samples. Significant rank difference ($\alpha < 1$ per cent)

Table 3-4 Kruskall-Wallis average of use of lean manufacturing practices by country

Section	Lean practices	Belgium Mean	SD	Hungary Mean	SD	Germany Mean	SD	Asymp. Sig.*
Customer Related	We frequently are in close contact with our customers	5.65	1.11	5.70	1.25	6.25	1.04	0.41
	Our customers give us feedback on quality and delivery performance	5.65	0.70	5.80	1.40	6.25	0.71	0.20
	We regularly conduct customer satisfaction surveys	4.82	0.88	5.50	1.35	4.38	1.06	0.13
Supplier Related	We frequently are in close contact with our suppliers	4.35	2.00	4.80	2.30	3.13	2.03	0.19
	Our key suppliers deliver to plant on just-in-time basis	5.35	1.17	4.50	0.97	4.75	1.04	0.12
	We take active steps to reduce the number of suppliers in each category	5.00	1.94	5.00	1.63	3.75	1.28	0.09
Pull	We use the pull production system	4.47	1.12	4.30	1.42	4.75	0.89	0.77
	We use Kanban, squares, or containers of signals for production control	5.00	0.94	4.40	1.26	4.75	0.71	0.41
	Production at station is pulled by the current demand of the next station	4.76	0.97	4.70	0.82	4.50	0.53	0.70
Flow	Products are classified into groups with similar processing requirements	4.65	1.06	5.10	0.99	5.00	1.07	0.51
	Products are classified into groups with similar routing requirements	4.76	1.03	5.20	0.63	4.88	0.64	0.49
	Product families determine our factory layout	4.41	1.23	5.60	0.97	4.63	0.74	0.01
Set up	We are working to lower set up times in our plant	4.94	1.14	4.90	1.37	4.75	1.04	0.78
	We monitor our production-cycle time to respond quickly to customer requests	4.59	0.71	5.10	1.10	4.25	1.28	0.19
	Our employees practice setups to reduce required time	5.12	1.05	4.90	1.45	4.75	1.04	0.65
SPC	Our processes on the shop floor are currently under Statistical Process Control	4.76	1.30	4.90	1.10	4.25	1.04	0.42
	We extensively use statistical techniques to identify process variation	3.24	1.99	3.00	1.89	4.50	2.20	0.25
	We use charts to show defect rates on the shop-floor	3.53	1.46	4.30	1.25	4.63	1.41	0.17
Employee Involvement	Shop-floor employees undergo cross-functional training	4.82	1.33	5.80	1.32	3.88	2.03	0.05
	Shop-floor employees are crucial to problem-solving teams	5.12	1.62	5.20	1.03	4.38	1.19	0.17
	Shop-floor employees lead product/process improvement efforts	5.65	0.86	3.80	1.32	4.88	0.83	0.00
Total productive maintenance	We have a preventive maintenance plan in our firm	5.18	1.29	5.90	1.10	5.63	1.19	0.35
	We dedicate a time every day to plan equipment maintenance related activities	4.59	0.94	5.00	1.49	5.25	1.49	0.43
	We regularly post equipment maintenance records on the shop-floor	5.59	1.12	5.00	1.49	5.00	2.07	0.58

Notes: Sig., significance level on Kruskall-Wallis test (*$\alpha < 5$ per cent)

Table 3-5 Kruskall-Wallis average of use of lean manufacturing practices by firm size

Section	Lean practices	Micro Mean	SD	Small Mean	SD	Medium Mean	SD	Asymp. Sig.*
Customer Related	We frequently are in close contact with our customers	4.25	0.50	5.73	1.03	6.67	0.71	0.00
	Our customers give us feedback on quality and delivery performance	4.25	0.96	5.86	0.71	6.44	0.73	0.00
	We regularly conduct customer satisfaction surveys	3.75	0.96	4.86	0.94	5.56	1.24	0.03
Supplier Related	We frequently are in close contact with our suppliers	1.75	0.96	4.64	1.87	4.22	2.49	0.05
	Our key suppliers deliver to plant on just-in-time basis	4.00	0.82	5.14	1.25	5.00	0.71	0.15
	We take active steps to reduce the number of suppliers in each category	2.75	0.96	5.05	1.79	4.78	1.48	0.05
Pull	We use the pull production system	2.75	0.96	4.59	1.05	5.00	0.71	0.01
	We use Kanban, squares, or containers of signals for production control	3.25	0.96	5.00	0.87	4.89	0.78	0.02
	Production at station is pulled by the current demand of the next station	4.25	0.50	4.77	0.87	4.67	0.87	0.40
Flow	Products are classified into groups with similar processing requirements	5.25	0.96	4.77	1.02	4.89	1.17	0.70
	Products are classified into groups with similar routing requirements	5.00	0.00	4.82	0.96	5.11	0.78	0.74
	Product families determine our factory layout	4.75	1.50	4.68	1.21	5.11	0.93	0.71
Set up	We are working to lower set up times in our plant	4.00	1.83	4.95	1.13	5.11	0.78	0.50
	We monitor our production-cycle time to respond quickly to customer requests	4.75	1.26	4.64	0.95	4.67	1.12	0.96
	Our employees practice setups to reduce required time	4.50	1.73	5.00	1.15	5.11	0.93	0.80
SPC	Our processes on the shop floor are currently under Statistical Process Control	5.00	1.41	4.64	1.22	4.67	1.12	0.84
	We extensively use statistical techniques to identify process variation	2.75	1.26	3.18	2.06	4.44	2.07	0.22
	We use charts to show defect rates on the shop-floor	4.25	1.50	3.55	1.37	5.00	1.12	0.03
Employee Involvement	Shop-floor employees undergo cross-functional training	4.25	2.06	4.91	1.57	5.11	1.69	0.71
	Shop-floor employees are crucial to problem-solving teams	5.50	0.58	4.91	1.48	4.89	1.45	0.76
	Shop-floor employees lead product/process improvement efforts	4.00	1.41	5.23	1.31	4.67	0.87	0.13
Total productive maintenance	We have a preventive maintenance plan in our firm	6.00	0.82	5.45	1.30	5.33	1.22	0.64
	We dedicate a time every day to plan equipment maintenance related activities	6.25	0.96	4.55	1.10	5.00	1.32	0.05
	We regularly post equipment maintenance records on the shop-floor	4.25	1.71	5.59	1.22	5.00	1.80	0.22

Notes: Sig., significance level on Kruskall-Wallis test (*α < 5 per cent)

First, the non-parametric Kruskall-Wallis average test was carried out to further understand the differences in the implementation of individual lean manufacturing practices in three European countries. Table 3-4 shows the country variation in individual lean practices. The analysis does not provide us a consistent result with respect to the differences by country of origin with all listed individual lean manufacturing practices. For instance, the differences with respect to lean manufacturing practices such as flow, employee involvement and supplier related practices are found significant. However, the differences with respect to lean practices such as pull, set up and total productive maintenance is not significant. It may not be a straight forward conclusion that all lean practices implementations differ across three European countries.

The study further conducted the Kruskall-Wallis test to check the association between the use of lean manufacturing practice and the firm size. Table 3-5 shows the variation in individual lean practices based on the firm size. Unlike the result of the country variation, the firm size does provide us a more conclusive result. Almost all parameters related to customers, suppliers and pull display a statistically significant difference with respect to the firm size. For instance, the mean difference of the use of lean manufacturing practice (customer feedback) among micro, small and medium-sized companies is statistically significant (χ^2 = 4.829, df=2, p=0.009) at a 5 percent significance level. This study is aligned with the literature stating that the size of the company matters with respect to lean manufacturing practice implementation (Hobbs, 2004; Sanchez & Pérez, 2001). In the case of set-up reduction, small companies have statistically significant differences in usage rates compared to medium-sized companies. These findings are consistent with those of other researchers (Abdul-Nour et al., 1999; Singh & Khanduja, 2009). Similarly, the use of pull practices is less evident in micro-sized companies. As for the other lean practices, the differences were not very clear.

Hence, we take a step further and aggregate the lean parameters (sum of scores for lean practices stated in the questions). For instance, the sum of score given by the respondents for three questions related to customers provide us a composite figure for customer related lean practice (represented as *cus* in Table 3-6). Thereafter, the Kruskall-Wallis test was carried out to check the association between the use of composite lean manufacturing practices and the country of origin. The analysis presented in Table 3-6 suggests that there is a significant relation between aggregate lean practices (flow, employee involvement and supplier relation) and the country of origin. To be specific, the lean practice (product families determine our factory layout) under flow section varies across countries (χ^2 = 8.945, df=2, p=0.011). The result is consistent with earlier notions that culture has a bearing on new manufacturing practices and strategies (Kogut & Singh, 1988; Lindberg et al., 1997; Naor et al., 2010). Hence, the country of operation and its cultural background is a factor to consider while planning lean manufacturing practice implementation (Baily et al., 1995; Bloom & Van Reenen, 2006; Cagliano et al., 2001). One prominent example for this comes from the highly acknowledged study by Rungtusanatham, Manus, et al. "A replication study of a theory of quality management underlying the Deming management method: insights from an Italian context." Journal of Operations Management 17.1 (1998): 77-95. Their study debated the universal applicability of quality management practices. They replicated a study in Italy which was earlier conducted by Anderson et al. (1995) on empirical evaluation of a Deming-based theory of quality management in the US. Their findings demonstrate the country and culture effect and its theoretical explanation of the differences in the application of quality management practices.

Table 3-6 Kruskall-Wallis average of lean manufacturing practices (aggregate) by country

	Overall		Belgium		Hungary		Germany		Asymp. Sig*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Cus	5.51	0.90	5.37	0.72	5.67	1.25	5.63	0.81	0.41
Sup	4.63	1.28	4.90	1.20	4.77	1.40	3.88	1.11	0.14
Pull	4.65	0.76	4.75	0.75	4.47	0.97	4.67	0.50	0.66
Flow	4.86	0.67	4.61	0.76	5.30	0.53	4.83	0.31	0.05
Setup	4.84	0.77	4.88	0.76	4.97	0.85	4.58	0.75	0.45
SPC	4.05	1.21	3.84	1.23	4.07	1.18	4.46	1.25	0.61
Emp	4.93	0.79	5.20	0.71	4.93	0.77	4.38	0.78	0.07
TPM	5.21	0.80	5.12	0.78	5.30	0.51	5.29	1.16	0.91

Notes: Sig., significance level on Kruskall-Wallis test (*α < 5 per cent)

Similarly, we conducted the Kruskall-Wallis test to check the association between the use of composite lean manufacturing practices and the size of the company. The analysis presented in Table 3-7 suggests that there is a significant association between aggregate lean practices (customer related, supplier related, pull, and SPC) and the firm size. According to the aggregate score, total productive maintenance is the most used practice among micro-sized firms, whereas small sized firms focused more on customer related lean practices. Similarly, medium-sized firms rely on customer related practices and total productive maintenance. There is a significant difference in the mean value related to customer engagement, supplier involvement, pull and statistical process control among the three categories of firms.

Table 3-7 Kruskall-Wallis average of lean manufacturing practices (aggregate) by firm size

	Overall		Micro		Small		Medium		Asymp. Sig*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Cus	5.51	0.90	4.08	0.57	5.48	0.75	6.22	0.53	0.00
Sup	4.63	1.28	2.83	0.79	4.94	1.14	4.67	1.17	0.02
Pull	4.65	0.76	3.42	0.50	4.79	0.69	4.85	0.53	0.01
Flow	4.86	0.67	5.00	0.27	4.76	0.76	5.04	0.54	0.65
Setup	4.84	0.77	4.42	0.96	4.86	0.75	4.96	0.79	0.52
SPC	4.05	1.21	4.00	1.34	3.79	1.16	4.70	1.16	0.15
Emp	4.93	0.79	4.59	0.83	5.01	0.75	4.89	0.93	0.62
TPM	5.21	0.80	5.50	0.43	5.20	0.73	5.11	1.11	0.75

Notes: Sig., significance level on Kruskall-Wallis test (*α < 5 per cent)

In order to provide a visual conclusion of the above mentioned analysis, two radar graphs have been presented in Figure 3-2 (showing the use of aggregate lean manufacturing practices by country) and Figure 3-3 (showing the use of aggregate lean manufacturing practices by firm size). The principal difference shown in Figure 3-2 and Figure 3-3 is that there is little variation in the use of aggregate lean manufacturing practices with respect to country. However, it cannot be denied that there are differences in individual parameters of lean practices as shown in the earlier section. The main differences in the use of lean practices is among micro, small and medium-sized companies (Figure 3-3) especially related to pull, supplier involvement and customer engagement.

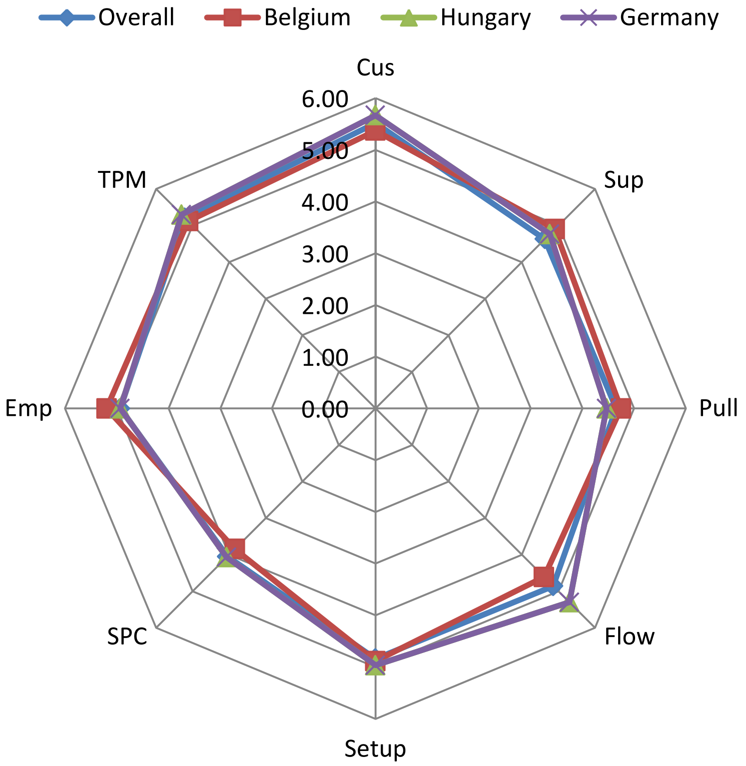

Figure 3-2 Use of lean manufacturing practices by country

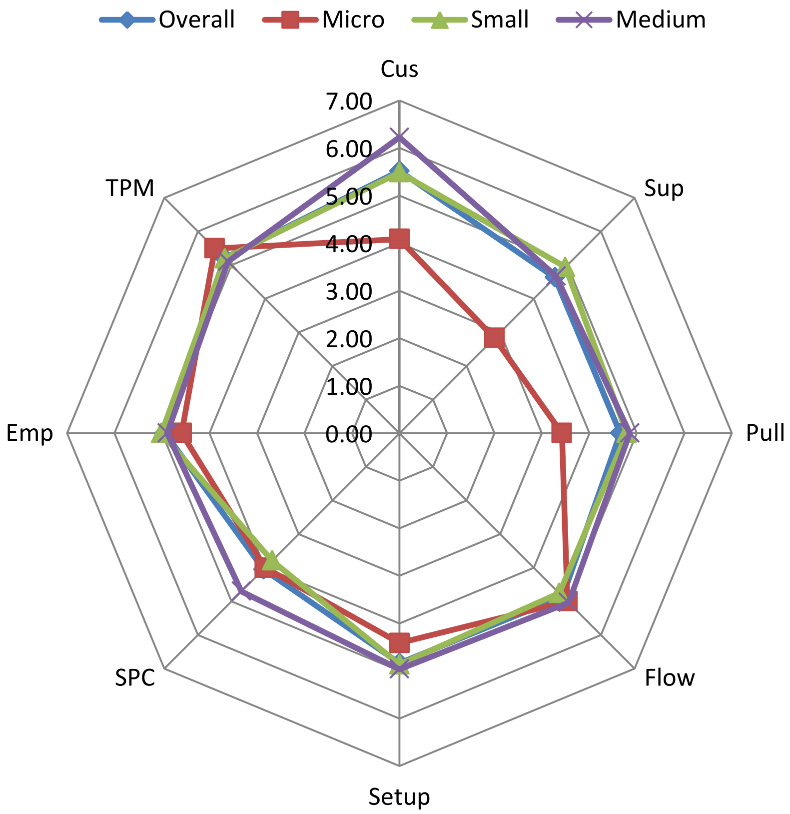

Figure 3-3 Use of lean manufacturing practices by firm size

Potential barriers

One of the important objectives of the study is to identify the key barriers to lean manufacturing practices implementation in food processing SMEs. The barriers to lean manufacturing were enumerated from the general operations management literature, specific characteristics related to the food processing industry and the discussions with two managers in food processing firms (Radnor & Walley, 2008; Van Wezel et al., 2006). Table 3-8 provides Friedman's non-parametric test of the barriers of the lean manufacturing implementation. Most of the potent barriers indicated by the respondents are a lack of knowledge, poor employee participation, availability of resources, lack of training and inadequate process control techniques. The results illustrate that specific aspects of the nature of the food processing industry such as variability in raw materials, sequential cleaning time, long set-up time between product types, and high perishability of the products, are also found to be important barriers to lean manufacturing implementation.

Table 3-8 Barriers of lean manufacturing in food SMEs

Barriers	N	Mean	SD	Rank avg*
Lack of knowledge	35	5.54	1.50	13.37
Poor employee participation	35	5.49	1.20	12.61
Availability of resources	35	5.40	1.14	12.60
Inadequate process control techniques	35	5.20	1.13	12.31
Poor supplier involvement	35	5.09	1.99	11.93
Lack of training	35	5.06	2.29	11.59
Variability in raw materials quality and supply	35	5.06	1.28	11.43
Long set-up times between different product types	35	5.03	0.79	11.00
High variation of composition, recipes, products and processing techniques	35	5.03	0.71	10.61
Highly perishable product	35	5.00	0.73	10.20
Processing equipment has sequence dependent cleaning time	35	4.94	1.03	10.19
Variable product structure	35	4.91	1.01	10.16
Processing and packaging are separated because of food quality assurance	35	4.86	1.26	10.13
Small and single site factories with 30 to 100 employees	35	4.74	1.29	10.07
Variable yield and processing duration	35	4.71	1.18	9.49
Poor project selection	35	4.69	2.55	9.43
Short (i.e. between one to eight hours) throughput time for batches	35	4.60	1.29	9.06
Lack of top management commitment	35	4.57	1.36	8.66
Internal resistance	35	4.26	1.69	8.20
Poor delegation of authority	35	4.11	1.45	6.97

Notes: *Friedman for related samples. Significant rank difference ($\alpha < 1$ per cent)

Especially, lean manufacturing practices related to pull and flow are found difficult to implement by the food companies. The implementation of kanban and production at station is pulled by the current demand of the next station and are less used by the food SMEs. This might be attributed to the highly unpredictable demand in the food sector (Willaiams et al., 1992). For instance, the demand for sausages can vary depending on the weather conditions. On a sunny afternoon there is a greater demand for sausages in comparison to a rainy afternoon.

Similarly, it may be difficult to implement a cellular manufacturing and optimal layout for food processing SMEs, as most of them have a traditional production process. Any major changes in the layout or plant structure requires big investments from the food companies. It is important to note that these companies are small and medium-sized enterprises and constantly struggling for resources for such big investments (Achanga et al., 2006). Likewise, set up reduction is also a considerably little used lean manufacturing practice in food processing SMEs due to complicated production processes and multiple raw materials, recipes and composition. Unexpectedly, one key basic lean practice, supplier involvement, was found to be less prevalent among the food processing SMEs.

Furthermore, the Kruskall-Wallis test helped us to understand the association between barriers of lean manufacturing practices and control variables (country and firm size). Table 3-9 presents the results of barriers of lean implementation by countries. The majority of the Belgian companies indicated that the quality assurance compliance (separation of processing and packaging section) is an important barrier to the lean implementation because it obstructs the production flow and causes extra movement by the operators. The reason might be that the majority of the Belgian companies are meat producers and it is mandatory for meat producers to have a clear separation between processing and packaging. Moreover, some other important barriers of lean implementation among Belgian food processing SMEs that were stated are inadequate process control and poor supplier involvement. Hungarian firms claimed that a poor employee participation and a lack of resources are the major obstacles for the implementation of lean. The food processing SMEs in Germany specified that a lack of training, poor project selection, lack of knowledge and lack of resources are the significant barriers to lean implementation.

Table 3-9 Kruskall-Wallis average of barriers of lean manufacturing practices by country

Barriers	Belgium Mean	SD	Hungary Mean	SD	Germany Mean	SD	Asymp. Sig.*
Lack of knowledge	5.94	0.83	4.00	1.76	6.63	0.52	0.001
Poor employee participation	5.00	1.00	6.70	0.48	5.00	1.20	0.000
Availability of resources	4.53	0.72	6.40	0.52	6.00	1.07	0.000
Inadequate process control techniques	5.82	0.95	4.70	1.25	4.50	0.53	0.003
Poor supplier involvement	6.18	0.88	4.20	1.55	3.88	2.95	0.004
Lack of training	4.76	2.17	4.10	2.69	6.88	0.35	0.001
Variability in raw materials quality and supply	5.59	1.18	5.00	0.94	4.00	1.31	0.015
Long set-up times between different product types	5.18	0.88	4.80	0.63	5.00	0.76	0.344
High variation of composition, recipes, products and processing techniques	4.94	0.75	5.20	0.79	5.00	0.53	0.646
Highly perishable product	5.00	0.71	5.30	0.67	4.63	0.74	0.148
Processing equipment has sequence dependent cleaning time	5.24	1.03	4.70	0.67	4.63	1.30	0.204
Variable product structure	5.06	1.03	4.60	1.17	5.00	0.76	0.365
Processing and packaging are separated because of food quality assurance	5.00	1.37	4.90	1.15	4.38	1.19	0.338
Small and single site factories with 30 to 100 employees	4.59	1.18	5.40	1.35	4.25	1.28	0.185
Variable yield and processing duration	5.12	1.17	4.50	0.97	4.13	1.25	0.118
Poor project selection	3.12	2.45	5.90	2.13	6.50	0.53	0.000
Short (i.e. between one to eight hours) throughput time for batches	5.12	1.11	4.40	1.17	3.75	1.39	0.054
Lack of top management commitment	4.29	1.26	5.60	1.26	3.88	0.99	0.018
Internal resistance	5.06	1.25	3.80	1.75	3.13	1.73	0.092
Poor delegation of authority	3.94	1.14	4.60	1.96	3.88	1.36	0.629

Notes: Sig., significance level on Kruskall-Wallis test (*$\alpha < 5$ per cent)

Similarly, the study conducted the non-parametric Kruskall-Wallis average test to check the association between barriers of lean manufacturing practices and the firm size. Table 3-8 presents the result of barriers of lean implementation by firm size. The analysis shows that the biggest barrier of micro-sized companies are a lack of available resources for lean implementation, poor delegation of authority, poor project selection, and internal resistance. The major obstacles for the small-sized companies are a lack of knowledge, poor supplier involvement and variability of raw materials' quality and quantity. The medium-sized companies stated that poor project selection, resources and a lack of training are the principal constraints.

Table 3-10 Kruskall-Wallis average of barriers of lean manufacturing practices by firm size

Barriers	Micro Mean	SD	Small Mean	SD	Medium Mean	SD	Asymp. Sig.*
Lack of knowledge	4.25	2.06	5.91	1.11	5.22	1.86	0.252
Poor employee participation	6.00	1.41	5.27	1.12	5.78	1.30	0.271
Availability of resources	6.25	0.50	5.00	0.98	6.00	1.32	0.024
Inadequate process control techniques	4.75	0.96	5.50	1.14	4.67	1.00	0.083
Poor supplier involvement	3.25	1.71	5.59	1.79	4.67	2.18	0.026
Lack of training	4.75	3.20	4.86	2.34	5.67	1.87	0.670
Variability in raw materials quality and supply	5.75	0.50	5.32	1.13	4.11	1.45	0.037
Long set-up times between different product types	5.50	0.58	5.00	0.82	4.89	0.78	0.389
High variation of composition, recipes, products and processing techniques	5.50	0.58	5.05	0.72	4.78	0.67	0.231
Highly perishable product	5.25	0.50	5.00	0.76	4.89	0.78	0.711
Processing equipment has sequence dependent cleaning time	4.75	0.50	5.00	0.98	4.89	1.36	0.780
Variable product structure	6.00	0.82	4.86	1.04	4.56	0.73	0.054
Processing and packaging are separated because of food quality assurance	5.50	0.58	4.73	1.45	4.89	0.93	0.591
Small and single site factories with 30 to 100 employees	6.25	0.96	4.50	1.34	4.67	0.87	0.050
Variable yield and processing duration	5.50	0.58	4.73	1.28	4.33	1.00	0.203
Poor project selection	6.50	0.58	3.73	2.73	6.22	1.09	0.004
Short (i.e. between one to eight hours) throughput time for batches	5.50	0.58	4.77	1.34	3.78	0.97	0.042
Lack of top management commitment	5.50	1.29	4.32	1.21	4.78	1.64	0.284
Internal resistance	6.00	0.82	4.32	1.49	3.33	1.87	0.033
Poor delegation of authority	6.75	0.50	3.86	1.17	3.56	1.13	0.006

Notes: Sig., significance level on Kruskall-Wallis test (*$\alpha < 5$ per cent)

One of the key objectives of this study has been to investigate the important sector specific barriers to the implementation of lean manufacturing practices. It is evident from the results that the special characteristics of the food processing industry are perceived to be the major barriers to lean manufacturing implementation in food-processing SMEs. For instance, adequate temperature control is a vital factor for food products which contain cream, fruits or meat. Failure to maintain the required temperature may cause a growth of micro-organisms, which can result in safety problems, product failures and customer complaints. The operators and planners mostly focus on food safety issues while lean practices are ignored.

Further, a highly unstable demand leads to an inadequate planning of production and distribution, which results in overproduction, loss of materials and unavailable products. One of the important barriers of lean manufacturing practices is the quality assurance requirement that the processing and packaging sections have to be separated by an inaccessible wall. This mandatory requirement is against the lean principle, as the flow is obstructed and the operator has to walk a long way to reach the next production station. Similarly, continuous and periodical cleaning is a very important step in the food production process. The cleaning process lengthens the changeover time and makes it difficult for the food processors to implement set up reduction.

3.5 Conclusion

This section concludes by briefly highlighting the lessons learnt from this chapter. First, this study has investigated an important research gap: which lean manufacturing practices are more prevalent in food processing SMEs? The data of this project reveals that several individual lean manufacturing practices are yet to be fully used in food processing SMEs and that variations in the use of lean practices are observable. This study further investigated the link between the individual lean manufacturing practices and the characteristics of firms, especially country of origin and firm size with the help of non-parametric explorative statistical techniques. Following are some important findings of the analysis.

One, the result indicates that lean practices related to customers engagement, involved employees and productive maintenance are more prevalent among the respondent food processing SMEs. The study shows a low degree of use of some lean practices related to flow, pull, set up, and employee involvement. The result also indicates a low level of statistical process control in food SMEs. The reason of the low SPC among the respondents may be attributed to the lack of statistical know-how of staff members in a SME environment. The relatively less use of pull related practices such as kanban in the food processing industry is also shown in previous studies, especially in the processing industries. It is notable that the use of set up reduction practices are relatively less prevalent among the respondents.

Two, the analysis does not provide us a consistent result with respect to the differences in individual lean manufacturing practices by country of origin. For instance, the differences with respect to lean manufacturing practices such as flow, employee involvement and supplier related practices are found significant. However, the differences in lean practices implementations such as pull, set up or/and total productive maintenance with respect to country are not significant.

Third, unlike the result of the country variation, the firm size does provide us a more conclusive result. Almost all parameters related to customers, suppliers and pull display a significant difference with respect to the firm size. For instance, the mean difference of the use of lean manufacturing practice (customer feedback) among micro, small, and medium-sized companies is significant. In the case of set-up reduction, small companies have significant differences in the usage rates compared to medium-sized companies. Similarly, the use of pull practices is less evident in micro-sized companies. As for the other lean practices, the differences were not clear.

Fourth, according to the aggregate score, the total productive maintenance is the most used lean practice among micro-sized firms. Whereas, small sized firms focused more on customer related lean practices. Similarly, medium sized firms are relying on customer related practices and total productive maintenance. There is a significant difference in the mean value related to customer engagement, supplier involvement, pull and statistical process control among the three categories of firms.

Fifth, the most potent barriers indicated by the respondents are a lack of knowledge, poor employee participation, availability of resources, lack of training and inadequate process control techniques. The results illustrate that specific aspects of the nature of the food processing industry, such as variability in raw materials, sequential cleaning time, long set-up time between product types and high perishability of the products, are also found to be important barriers to lean manufacturing implementation.

Sixth, the majority of Belgian meat companies indicated that the quality assurance compliance is an important barrier to the lean implementation because of the mandatory separation between processing and packaging. Moreover, some other important barriers of lean implementation among Belgian food processing SMEs are inadequate process control and poor supplier involvement. Hungarian firms stated that a poor employee participation and a lack of resources are the major obstacles for the implementation of lean. The food processing SMEs in Germany specified that a lack of training, poor project selection, lack of knowledge and lack of resources are the significant barriers to the lean implementation.

Seventh, the principal barrier of micro-sized companies are a lack of available resources for lean implementation, poor delegation of authority, poor project selection and internal resistance. The major obstacles for the small-sized companies are a lack of knowledge, poor supplier involvement and variability of raw materials’ quality and quantity. The medium-sized companies stated that poor project selection, resources and lack of training are the main constraints.

Finally, many scholars in the past question the universal applicability of quality management such as lean manufacturing (Mersha, 1997; Rungtusanatham et al., 1998; Voss & Blackmon, 1996; Voss et al., 1995). We can conclude by agreeing with (Lillrank, 1995) that some lean manufacturing practices (techniques) can relatively easily be adapted to different company and country circumstances but, lack systemic context and might therefore simply be misapplied. The success of lean manufacturing practices critically depends on employee participation, proper training and the commitment from the top management. This chapter has practical implications for managers as it provides an overview of potential barriers to lean manufacturing in food processing SMEs. The next step was to carry out an in-depth investigation of inner working through the case study method to validate the response. The purpose of this second step of our study was to capture the extent of adaptation of lean manufacturing practices and the influence of determining factors (obstructing/enabling) by those companies that actively engage in the lean implementation process in a food processing SME environment.

Improvement usually means doing something that we have never done before.

~ Shigeo Shingo

4. Impact of determining factors on Lean manufacturing adoption

Adapted from:

Dora, M.; Kumar, M.; Van Goubergen, D.; Molnar, A. & Gellynck, X. (2013). “Determinants and Barriers to Lean Implementation in Food Processing SMEs- a Multiple Case Analysis”, *Journal of the Operational Research Society* (submitted for publication).

4.1 Introduction

The primary aim of this is chapter to investigate how and why determining factors that were previously identified in the literature might or might not explain lean manufacturing success in the food SME context. (Boynton & Zmud, 1984) explains that determining factors are "those few things that must go well to ensure success." The review of literature shows that there is no consensus among researchers that lean manufacturing practices always show a positive correlation with an improved operational performance of the firm. A considerable number of studies found that the implementation of lean manufacturing practices is a difficult and long journey with many roadblocks (Abdulmalek & Rajgopal, 2007; Denton & Hodgson, 1997; Jha & Iyer, 2006; Safayeni et al., 1991; Shah & Ward, 2003; Sim & Rogers, 2008; Yusuf & Adeleye, 2002). Several studies identified determining factors which make the lean journey either a success or a failure.

This also relates to one important question in operations management literature - why do some firms perform better than others applying the same practice? Organizational behavior theorists improve our understanding of this fundamental question. Their theories focus on identifying, explaining, and predicting the determinants of organizational performance. Past studies have pointed out that to achieve the desired results of manufacturing practices, the firm needs to understand what types of organizational behavior fit with its operational strategy (Christopher & Towill, 2001; Lewis, 2000a; Rich & Bateman, 2003). The theory suggests that individual, organizational, environmental, and other factors contribute to organizational performance (Ketchen & Giunipero, 2004).

(Sousa & Voss, 2001) claimed that "the successes and failures of lean manufacturing and other similar initiatives are highly context dependent." Similarly, (Kochan et al., 1997) explained that the pace of change and the outcome of such initiatives differ significantly across sectors and even across companies. In this context, food SMEs are ideal for examining the generalization made by Womack, et al. regarding lean manufacturing (Womack et al., 1990). In summary, this is an attempt to investigate the adoptability of lean manufacturing by complex small and medium-sized food-processing enterprises. The knowledge of contextual factors influencing lean manufacturing adoption in food processing SMEs will be a contribution to current research. The study will also help practitioners to anticipate potential obstacles and take proper measures to deal with them during lean implementation. The remainder of the chapter is organized as follows. First, we briefly explain some specific characteristics of the food processing industry and some common features of SMEs to provide the context. The following section explains the research model, methodology, results and discussion. The chapter closes with limitations, conclusions and future research agenda. This chapter contributes to research and practice on lean manufacturing implementation in two ways: 1. It identifies factors that may distinguish between successful and unsuccessful lean implementation in food processing SMEs. 2. It explains how determining factors particular to food processing SMEs influence lean adoption.

4.2 Small and medium sized food processing enterprises

The food sector is based around a very heterogeneous group of products with different degrees of perishability, different manufacturing lead times, and different customers in different amounts at different frequencies. The result is that manufacturers must continuously balance the risk of waste and reduced product quality with the risk of stock-outs and dissatisfied customers. Based on the literature (Van Wezel et al., 2006; Wang et al., 2009) and the authors' own observations, Table 4-1 summarizes the characteristics of the food processing industry with respect to plant, product and production process.

Table 4-1 Characteristics of food processing industry

Component	Food Processing Industry Characteristics
Product	• Perishable product (raw material, semi and finished product) • Variability in raw materials quality, supply, and price due to unstable yield • Industry's use of volume and/or weights (in contrast to discrete industries)
Production process	• Processes have a variable yield and processing time • High variation of composition, recipes, products & processing techniques • Production rate is mainly determined by capacity • Divergent product structure, especially in the packaging stage. • Variable yield and processing duration, variable product structure
Plant	• Processing and packaging are separated because of QA requirements • Long sequence-dependent set-up time between product types • Single purpose expensive machine, product variety and high volume • Usually, the factory shows a flow shop oriented design

Similarly, the literature shows that there are several advantages as well as disadvantages of being an SME with respect to quality management initiatives. Some of the advantages of SMEs are: involvement of top management in day-to-day activities (Mc Cartan-Quinn & Carson, 2003), informal structure and culture which increases cross-functional exchanges and smaller teams that aid in efficient decision making (McAdam, 2000). Some of the major disadvantages of SMEs are: lack of resources (Achanga et al., 2006), lack of training (Koh et al., 2009), lack of long-term planning (Mezgár et al., 2000), shortage of staff and lack of resources for major consulting (Brun, 2011). Moreover, studies also found that the implementation of quality management methods such as lean manufacturing can be more costly for SMEs than for large organizations and the impact of unsuccessful projects more severe (Mabert et al., 2000; Muscatello et al., 2003).

4.3 Lean in Small and medium sized food processing enterprises

Previous studies have recommended research into the implementation and use of lean manufacturing in the food processing industry (Engelund et al., 2009; Mahalik, 2010; Mahalik & Nambiar, 2010; Simons & Taylor, 2007), especially in the SMEs (Nabhani & Shokri, 2009; Shokri et al., 2010). (Cox & Chicksand, 2008) argues that without a proper understanding of specific characteristics of the food sector, the lean manufacturing practices may not bring the expected result or may even be unfruitful. A detailed review of literature presenting the current state of knowledge on lean manufacturing in food processing SMEs as well as knowledge gaps has been provided in section 1.4.2.

Taking into account all of the contextual factors cited in the previous section, this study investigates whether any of the characteristics of food SMEs (process, product, and plant components and organizational factors) affect the prospects of success for lean manufacturing implementation. In other words, for each case, is there anything inherent in the product and/or process that specifically hinders or helps lean manufacturing? The focus of this study is on the determining factors (enabling and/or obstructing) which affect lean adoption in food SMEs. The specific research question investigated in this study is: how do determining factors (enabling and/or obstructing) influence the lean adoption? The next step is to identify the determining factors from the literature and examine their roles in the lean adoption process. The next section outlines the research model, consisting of determining factors, lean manufacturing practices and operational performance.

4.4 Research design and methodology

To meet the research objective, a research model was set up through a comprehensive review of the literature on lean manufacturing and operations management. (Sousa & Voss, 2008) postulates that a robust model in the field of operation management should include practice, performance and determining factors. As a result, the model used in this study includes practice, performance and determining factors (Figure 4-1).

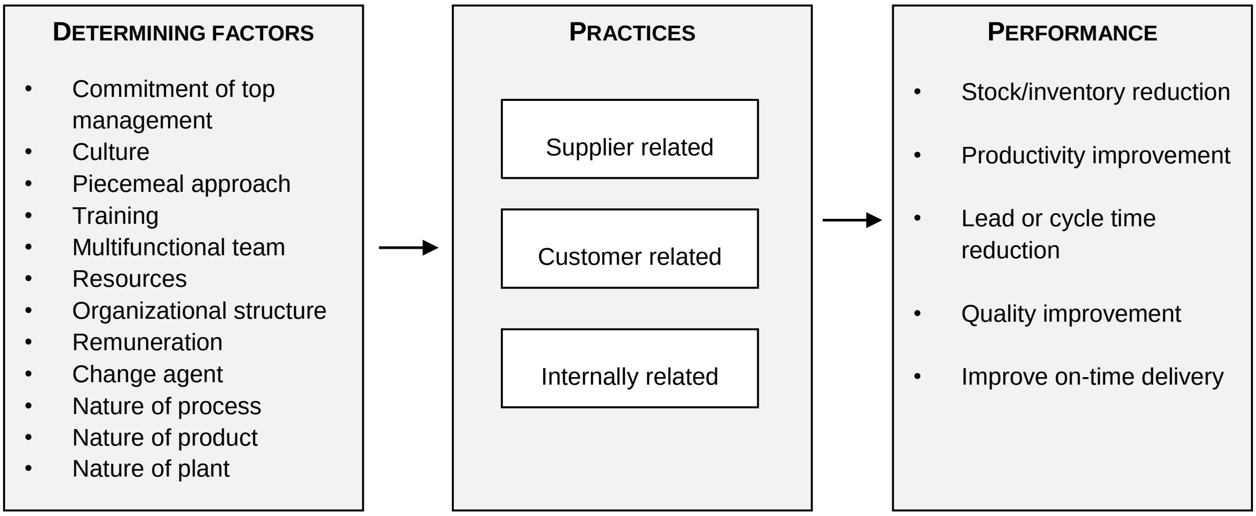

Figure 4-1 Research model

First, this study adopts the Shah and Ward's proposition of lean manufacturing practices (Shah & Ward, 2007a). Shah and Ward identify ten elements of lean manufacturing practices with respect to supplier-related, customer-related and the internally-related issues of the company. The ten elements included in their model are: (1) involved customer, (2) supplier feedback, (3) just-in-time delivery, (4) developing suppliers, (5) pull, (6) flow, (7) low set-up, (8) controlled processes, (9) productive maintenance and (10) involved employees. The reason for using the Shah and Ward proposition in this study is that their model includes both people and process elements of lean manufacturing. Moreover, both internal and external factors were included in the proposition.

Furthermore, a thorough review of literature in the field of operations management was carried out to identify possible enabling and obstructing factors. The review of literature also includes factors related to food processing SMEs. Table 4-2 provides an overview of determining factors related to lean manufacturing and organizational change.

The literature review suggested that some factors (enabling and/or obstructing) are applicable irrespective of sectors such as commitment of top management, culture, and training (Achanga et al., 2006; Karlsson & Ahlström, 1996; Näslund, 2008). Many studies show that the commitment of top management is one of the most important determinants towards a successful lean implementation. Leadership and management refer to the commitment of top management, consistent financial support, encouragement, active involvement and supervision of the lean initiative. There are several studies which stress the correlation between effective leadership, clear strategy, vision and operational performance of the organization (Coronado & Antony, 2002; Fryer et al., 2007; Trkman, 2010). Similarly, the culture of the organization, for instance its incorporation of communication, hierarchy, blame game and respect, is considered to be a vital determinant in lean adoption. Organizational culture has been formalized by several researchers, which includes internal and external communication, hierarchy, respect and blame game in the company (Fryer et al., 2007; Stock et al., 2007).

Table 4-2 Determining factors based on literature

Determining factors	Sources
Leadership and commitment of top management	(Coronado & Antony, 2002; Fryer et al., 2007; Trkman, 2010); (Sanchez & Pérez, 2001); (Angelis et al., 2011);(Achanga et al., 2006)
Organizational culture	(Fryer et al., 2007; Stock et al., 2007); (Bhasin & Burcher, 2006); (Achanga et al., 2006); (Hines et al., 2004); (Mann, 2012))
Skill and training	(Worley & Doolen, 2006); (Sanchez & Pérez, 2001); (Karlsson & Ahlström, 1996)
Resources	(Bhasin, 2008; Trkman, 2010) (Achanga et al., 2006; Forrester, 1995) (Hudson et al., 2001; Kumar & Antony, 2008; MacDuffie, 1995)
Multifunctional team	(Motwani, 2003; Paez et al., 2004; Sanchez & Pérez, 2001; Sharp et al., 1999)
Organizational structure	(Demeter & Matyusz, 2010; Dombrowski & Crespo, 2008; Nahm et al., 2003)
Remuneration and Rewards	(Bednarek & Fernando, 2009; Hankinson et al., 1997; Watson et al., 1996) (Robson & Bennett, 2000)
Change agent	(Carson & Gilmore, 2000; Koh & Simpson, 2005; Levy & Powell, 2003)
Piecemeal approach	(Crute et al., 2003; Dowlatshahi & Taham, 2009; James, 2006; Shah & Ward, 2007a; Storch, 1999)

Similarly, the literature on operations management stresses the need for training in professional skills to make employees more multi-functional (Dowlatshahi & Taham, 2009; Lee & Allwood, 2003). Research also highlights other critical factors for lean adoption such as piecemeal approach and organizational structure (Näslund, 2008). Piecemeal approach means adopting certain parts of lean manufacturing and ignoring its systemic nature (Dowlatshahi & Taham, 2009; James, 2006); is considered to be an obstructing factor in lean implementation. Literature on organizational change as well as lean manufacturing points out that employee skepticism about the management's commitment to the change program has been suggested as an obstacle to organizational change (Stanley et al., 2005). Skill of workforce and in-house expertise, for instance, soft skills and technical skills play an important role in the successful adoption of lean manufacturing (Stock et al., 2007).

Additionally, resources, mainly financial capabilities includes, for example, funds to cover training costs, external consultants or any other related investments play a significant role in lean adoption (Bhasin, 2008; Trkman, 2010). Similarly, there are several food processing SME-related factors such as the nature of the plant, product and processes that affect the lean adoption (Van Wezel et al., 2006), which are presented in Table 4-1. The research model is comprised of lean manufacturing practices, determining factors and operational performance. The following section explains how the study was carried out and present its justification. The determining factors included in this study act as enablers or obstructers, speeding up or slowing down lean adoption process in food processing SMEs.

Methodology

Lean manufacturing is a complex, multidimensional concept and relates to complex systems (e.g. the whole of the operations). To get in-depth insight and a valid analysis of the real situation at the work floor this study adopted multiple-case-study research. The case study method is considered to be the most suitable methodology with regard to the exploratory nature of the study, which combines both qualitative and quantitative data (Panizzolo, 1998b; Voss et al., 2002b). The multiple cases provide a deeper understanding of processes, which give us the chance to test the hypotheses, and “a good picture of locally grounded causality” (Miles & Huberman, 1994). The method allows studying the problem and the context to deduce both cause and effect (Leonard-Barton, 1990). This process aided with studying the phenomenon in its natural setting, and focused on contemporary events (Yin, 2009).

The present study was carried out within the scope of a European Union funded project - “Innovative Management System for the Food SMEs” (IMSFood). The objective of the IMSFood project is to support the implementation of lean manufacturing practices in four food processing SMEs in Belgium over a one-year period. Twelve food SMEs were contacted to participate in the project for lean implementation as well as in the case study. Four food SMEs agreed to join the project and participate in the case study. Ghent University was appointed as an external support provider for the smooth implementation of the lean manufacturing practices. To harmonize the change initiative, Ghent University organized a training program on the lean manufacturing practices for the general manager and operation managers of the involved companies. This provided us with an exceptional opportunity to study four different cases of lean manufacturing adoption in food processing SMEs where both the conceptualization of lean manufacturing as well as the practical approach to its implementation were similar. By comparing these cases, the study explores how both enabling and obstructing factors affect the adoption of lean in food processing SMEs. Table 4-3 provides an overview of the four food SMEs that participated in the study.

Table 4-3 Description of the Food Processing SMEs

Company	Product	Employees	Turnover (€)	Quality Assurance
A	Dried ham	45	12 million	HACCP, ISO 9000
B	Sausages	22	06 million	IFS
C	Gingerbread	70	15 million	IFS
D	Chocolate, cake	21	05 million	HACCP

This study conducted interviews, reviewed documents and made on-site observations before and after lean implementation in order to get an overall picture of how the processes and operations changed as a result of implementation (Eisenhardt, 1989). This combination of data types can be highly synergistic and is therefore referred to as a triangulation of method (Jick, 1979). Moreover, several strategies were used to establish the reliability of the study, as recommended by (Yin, 2009), including detailed documentation of project steps, single interviewer to maintain consistency, and most importantly, establishment of a chain of evidence.

The objective of the interviews was to understand lean adoption in food processing SMEs by asking specific questions to understand the enabling and obstructing factors. During the study, a total of 45 interviews with operators, OMs and general managers were carried out, in addition to walk-throughs of the production processes. These interviews (each lasting approximately 30 min) were semi-structured and sought primarily to establish the general story of lean manufacturing practice implementation in those firms. The overview of the interviews is presented in Table 4-4. During the Gemba walk (Gemba walks a Japanese term denote the action of going to see the actual process, understand the work, ask questions and learn), the researcher asked operators and OMs open questions related to lean initiatives, obstacles encountered during implementation and how those obstacles were overcome. After the Gemba walk, the researcher and the OMs moved to the meeting room for further discussion and to clarify queries related to the identified determining factors, such as cross-functional teams, culture, remuneration etc. In case of non-availability of information at the level of operators and OMs, top management was contacted. Additionally, appropriate measures were taken to reduce the observer bias such as training interviewers to ask questions the same way and only one researcher conducted the interviews throughout the research period (Voss et al., 2002a; Yin, 2003).

Table 4-4 Overview of interviews during the case study

Company	Respondent's position	Number of interview
A	Operator	6
	Operations manager	4
	General manager	2
B	Operator	5
	Operations manager	3
	General manager	1
C	Operator	5
	Operations manager	3
	General manager	3
D	Operator	7
	Operations manager	2
	General manager	4

Furthermore, this study followed the recommendation of (Pettigrew, 1990) in assessing the performance of the case organizations. The successful lean implementation is defined based on the operational performance. As explained in the conceptual framework chapter 1.5.2, the defined operational performance indicators are stock/inventory reduction, productivity improvement, lead or cycle time reduction, quality improvement, improve on-time delivery. Following the recommendation of, cross-case analysis was carried out with food processing SMEs adopting lean manufacturing practices successfully and unsuccessfully. The cross-case analysis method provides a pattern and helps in understanding each determining factor and its positive and negative influence on lean adoption (Voss et al., 2002a). The following section describes each case study company.

4.5 Case analysis

The four food processing SMEs which participated in this study (A: producing ham, B: sausage, C: Gingerbread, and D: confectionery and chocolate products) reported the following motivations for implementing lean manufacturing practices (Table 4-5).

Table 4-5 Motivations for implementing lean manufacturing practices

A	B	C	D
- Reduce cost of production - Concerned about high labor cost especially in packaging section - To improve day-to-day operations - Eliminate variation	- Optimal utilization of space - Minimize the waste especially defects and rework - Production smoothening	- Improve market share - Reduce product weight variation - Improve machine efficiency - Improve customer satisfaction	- Establishing standard procedures - Optimal utilization of space - To improve day-to-day operations

Performance

First, the overall improvement in operational performance is regarded as the result of a successful implementation of lean manufacturing practices. The five operational performance indicators (identified and explained in section 1.5.2) are stock/inventory reduction, productivity improvement, lead or cycle time reduction, quality improvement improve on-time delivery were assessed by multiple participants in each firms. The participants were asked to rate the performance of the firm in each category on a scale (1=negative, 4=neutral, 7= positive). The score given by the participants was further verified to find and adjust discrepancies. A combination of the score provided by the participants, interviews and available documents helped us to consider whether or not a firm was successful in lean implementation. Table 4-6 shows the operational performance realized after the implementation of lean manufacturing practices. The score across each of the performance indicators reflects positive and negative developments in the food processing SMEs after implementing different lean practices.

Table 4-6 Evaluation of operational performance due to lean implementation

Indicator	**A**	**B**	**C**	**D**
Stock/inventory reduction	👎	👎	👎	👎
Productivity improvement	👍	👍	👍	👎
Lead or cycle time reduction	👎	👎	👎	👎
Quality improvement	👍	👍	👍	👎
Improve on-time delivery	👎	👍	👍	👎
Overall assessment	Less successful	Successful	Successful	Unsuccessful

👍 Positive 👎 Negative 👍👎 Neutral

It can be seen from Table 4-6 that companies B and C have realized significant improvements in three operational performance indicators (productivity, quality, delivery). Both company B and C prioritized the reduction of rework and took several other measures which will be explained in further detail in the case analysis section. Within a short period of time both companies could benefit from less rework; the improved quality indicator reflects this. Similarly, the companies have managed to improve on-time delivery by working closely with the customers and through the nature of their personal business. In most cases, the beginning of lean initiative companies can be attributed to the companies' reaction to changing market forces and stiff competition. Specifically, in the case of company C, there was a continued decline in market share because of new entrants from the Netherlands. Unlike the other three companies, company D could not perform well in regard to any of the indicators. In all respects, the company was unsuccessful in lean implementation. There are multiple reasons for the failure of lean implementation in company D, which will be described within the explanation of the determining factors. Company A has achieved considerable results with respect to operational performances with only two accounts - improving quality and productivity. Company A initiated overall equipment effectiveness (OEE), total productivity maintenance (TPM) and workplace organization. It is interesting to observe that none of the food processing SMEs scored with respect to inventory reduction and lead time reduction. This may be attributed to specific characteristics of the food sector; as the demand is very unpredictable the firms could not streamline production and inventory planning. The typical characteristics of the food processing sector, such as compulsory cleaning times, long setup-times and start-up loss, create barriers for production planning. Additionally, the customers (retailers) place their demands on a JIT basis but want the product to have a long shelf life for commercial reasons. Hence, production to order with short lead times and low stocks increases the risk of stock outs. Due to these complex relationships, none of the participating companies could initiate and optimize practices related to pull or flow (the details are explained in the section on determining factors).

Implementation

Case A: Company A is a family-owned company started in 1969 as a small meat producing outlet, and later expanded as a limited liability company in 1980, specializing in naturally dried ham. In 2010, it employed 45 people with an annual turnover of 12 million. The traditional production method is the main selling strategy of the company. In this complicated production process, the pork is first salted with sea salt before resting for three weeks. Thereafter, the dry, salted ham is brushed clean and the meat is left to mature for two months in the cellar. The ham is then sprayed clean with water and after a few weeks of drying the cut end of the leg is rubbed with a mixture of lard, flour, pepper and salt. In the course of many years, the drying rooms have reached a state of bacteriological equilibrium in which natural fermentation can take place. Finally, the meat rests for another nine months to reach its full maturity. The dried and salted Ganda Ham, which ripens according to this natural and traditional process, is then sliced and packaged for store or distribution. The company takes credit for being the first Belgian meat company to obtain ISO 9002 quality certification. The company did not follow an established framework for lean manufacturing implementation. The general manager instructed the operation manager (also the team leader) to start implementing lean manufacturing practices in the packaging section. At the outset, a general training program on lean manufacturing principles was organized for the middle management and the operators.

One year of lean manufacturing implementation resulted in a few changes on the work floor. A few visual management techniques were initiated. There were initiatives taken by the management to collect data from the work floor, such as overall equipment efficiency, total productive maintenance and rework. The example of a visual board from TPM initiative is displayed in Figure 4-2. Some of the important benefits of lean practice implementation at this SME were reduced machine downtime, improved quality and work environment. There was no initiative taken towards pull production. Similarly, the traditional production method and layout possess several bottlenecks for smooth flow, which requires a massive investment and space for any change in layout.

Figure 4-2 Improvement through visual technique

The study produced interesting observations regarding the influence of determining factors on lean manufacturing adaptation. For instance, the general manager, who is also the owner of the company was committed to implementing lean manufacturing practices, but was not very actively involved. The operations manager (OM) was assigned to implementing lean practices in the company. Due to a busy schedule, the OM passed the responsibility on to the junior colleague. It is an interesting observation that the responsibility was shifted when it came to improvements or the implementation of change initiatives like lean manufacturing.

Regarding the company culture, interviews and observations revealed that the communication between functional areas was not well structured in this company. It was also observed that the communication flow from the management to the employees and vice versa was not smooth. This lack of proper communication structure was a major obstacle in the adoption of lean manufacturing. The top management realized these limitations and took initiative to improve the communication flow by organizing regular review meetings to reach out to all stakeholders. It was observed during the study that the company was focusing on a single problem at a time instead of looking at the bigger picture. The packaging area for example was not properly organized and the number of operators in this section was greater than required. Based on this information, company A initiated lean techniques such as visual management and 5S in the packaging section, but ignored the other sections in the production process.

The training on lean manufacturing and leadership for employees as well as management was very helpful for the company. The company even sent a few key employees to a leadership development program. Teamwork or team feeling was a big concern in this company because of the lack of a formal communication system. During the interviews we found that a few employees were not keen on working together in a team. We observed a sense of rivalry among the employees and they complained about unequal treatment by the management. On top of this, dried ham–a traditional food product with very specific characteristics such as right aroma, maturity and quality parameters, combined with a very short shelf-life (six days)–gives little flexibility for the planner with respect to highly volatile customer demand. Additionally, the company has a traditional setup. The design of the layout is not optimal and not planned according to the lean manufacturing principles. The slicing and packaging machines are single-purpose. There are long set-up times (changeover) between different products because of cleaning and other quality assurance requirements. Financial resources were not a constraint for the company, but skilled human resources and time for improvements were. The company has a clearly defined remuneration system. However, there is no provision of bonus for the performance of the employees. Then again, the person assigned to oversee lean implementation was very motivated, which helped to initiate small steps to reach the efficiency objectives.

Case B: This sausage producing company put a lot of improvements into action during the lean manufacturing implementation. They made an assessment of downtime, rework and delivery. After one year, they had been able to reduce downtime by 25 percent and rework by 5 percent, and they improved delivery performance. The example of reducing defects and rework through visual management is displayed in Figure 4-3.

Figure 4-3 Reducing defects and rework through visual management

The commitment of top management was exemplary in company B. The OM was assigned to implementing lean manufacturing and granted power to take quick decisions on the shop-floor. The OM actively participated in the lean manufacturing implementation and successfully guided the team. The motivation of employees and management for lean manufacturing implementation has been high. Even when it was difficult to find the time for improvement work, they still had their weekly meetings led by the team leader (operations manager). There was a drive for improvement and they continuously prioritized the improvement initiatives. The top management emphasized the importance of the training program and encouraged employees to get trained on lean manufacturing tools and techniques. However, company B also took improvement initiatives to fix isolated problems rather than looking into the whole value stream. This "firefighting" behavior dominated their long-term vision.

Company B showed great team work and team feeling. The management put a lot of effort into team building. The employees celebrate birthdays and special days with their colleagues during breaks. The initiatives such as after-work drinks also helped employees to better understand each other. The company has a modern setup. The design of the layout is planned to some extent. Due to quality assurance requirements, the cooking and cooling sections are separated by a wall. This causes extra movement for the operators which results in a waste of time. This is against the lean manufacturing principle because lean principle suggests a clear flow between different activities.

Because the top management is convinced of the benefits of lean manufacturing, resources were not a significant constraint for this company. With a proper lean training, the operations managers acquired knowledge and skills for lean implementation. The company could make substantial continued improvement with very limited investment. The OM had been given all rights to make appropriate decisions with respect to the improvement initiatives in the company. The company provides bonuses to employees based on their performances. One important aspect of case B is the role of the change agent. The OM who was assigned the role of implementing lean manufacturing in the company was very motivated and attended several lean trainings to enhance the knowledge base. He also gained the trust of the employees during lean implementation. He often promoted team building activities such as after-work drinks. These are the factors that helped the company to gain emphatically from lean initiatives.

Case C: In 2010, this gingerbread producing company initiated lean manufacturing with a formal communication from the top management to all the employees. The company made good progress in implementing lean principles over the last year and improved operational performance in many respects. In the initial phase it started slowly because of the company board's extended decision-making process. However, after they approved implementation, it was quickly put into practice. The company was able to improve the product quality, reduce weight variation of the packets and reduce costs by reducing rework. Moreover, total productive maintenance was initiated to reduce machine downtime. Examples of visual boards and problem solving meetings are displayed in

Figure 4-4.

Figure 4-4 Problem solving team meeting with visual board

The top management of company C found motivated to implement lean principles in the production process. The OM was assigned responsibility to implement lean principles in the company. The company also recruited a mentor to guide the OM in leading improvement activities. The drawback found during the visit was that the detailed implementation plan had not been properly communicated to the employees at the shop floor; hence we observed a cold response from the employee side in the beginning phase. From the past documents and interviews we found that there was an undercurrent of dissatisfaction among employees. The reasons mentioned during the interviews were a new work classification system and remuneration system suggested and implemented by a local consultancy company in 2009 (a year before). This initiative backfired in the company and resulted in employee dissatisfaction and poor work culture. Initially, employees did not feel very motivated to support the lean improvement initiatives. The motivation came after a few months when the company started seeing the benefits.

Because the general top management was convinced of the benefits of lean, resources were not a constraint for this company. The top management committed resources to lean training programs for its employees. Regular training programs on lean tools and techniques were organized for the employees and managers. They allocated resources to purchase visual management tools such as display boards. There were regular team meetings where the improvement team discussed issues related to production, quality and maintenance. However, Company C also took improvement initiatives to solve the most pressing problems rather than looking into the whole value stream. As in other companies, firefighting behavior dominated over long-term vision. The company has a traditional setup. The design of the layout is not planned from a lean point of view. This family-owned company takes all major decisions in the board meeting. This was a major constraint for lean because the decision-making took a long time. The OM who was assigned to implement lean manufacturing in the company was enthusiastic. He attended several lean training programs and proved his usefulness in improving processes.

Case D: This luxury chocolate and cake producing company made very little progress in lean implementation in comparison with the other companies in this study. It is interesting to see how the determining factors affect the lean implementation in the case an under-performer compared to the other companies, which started the implementation at the same time and from similar starting points. The general manager/owner is very motivated to implement lean principles. However, the OM was resistant to change. This imbalance in leadership and support for improvement hugely affected the lean implementation. The general feeling in the company was that the production process is optimal and not much can be done. The observations and interviews provided clear evidence of the management's firefighting behavior. The general manager attended a few training programs on lean during the project's span but the operations manager did not attend any training. It was found that the autocratic behavior of the operations manager hindered the teamwork in the company. There was always a feeling of insecurity and suspicion among the employees.

The company produces luxury chocolates and cakes for high-end users, especially in star hotels. The majority of the products are exported to other countries. The process is mostly manual or semi-manual in nature. Production relies on very few machines. It has a very sophisticated packaging process. The company has a disadvantage in terms of available space. The design of the layout is not planned from a lean point of view. Financial resources were not a constraint for the company. However, human resources (skill and knowledge) were big constraints. This is a family-owned company. All decisions are made by the owner of the company although the special designing skill of the key employees also matters in organizational decision making. The company follows the standard remuneration guidelines of the government. The major stumbling block for lean implementation in company D was the lack of a change catalyst or change agent in the lean journey. During the study, several opportunities for improvement presented themselves, for instance unnecessary waiting, overproduction, chaotic order picking and rework (Figure 4-5). However, there was little effort to break the status quo due to the log jam between operations manager and general manager. It was not possible to just fire the OM because he was the top pastry chef in the country and the whole business relies on his exclusive specialized skill. This is unique case and very relevant for the food industry because the business often relies on specialized skill of the key employees (e.g. Chef).

Figure 4-5 Waiting, inventory, rework

The four food processing SMEs initiated lean practices at the same time within the frame of an EU-supported project. However, we can see a significant difference in their approach, difficulties with implementation, and varied operational performances. In each case, the determining factors had different effects. In the following section, each determining factor will be discussed in greater detail: how does it help and/or harm lean adoption in the food processing SME context? A summary of key events during lean implementation in the four food processing SMEs is presented in Table 4-7.

Table 4-7 key events during lean implementation

Company	Key Events
Company A	▪ Formation of cross-functional team ▪ Focus on only packaging area ▪ Major initiatives are OEE calculation, TPM, changeover, rework ▪ Improve communication through visual management ▪ Lack of employee involvement is prominent ▪ Send staff for leadership training ▪ No framework used to start lean implementation ▪ Not much room for changing the layout because of traditional production sequence and lack of funds to make big investment
Company B	▪ Committed general manager and allocated resources for staff training and full decision making support to operations manager ▪ Formation of cross-functional team ▪ Major initiatives are reducing rework, workplace organization, layout in packaging section, employee activity analysis and optimization ▪ Employee empowerment by middle manager to improve individual process ▪ The operations manager attended training and executed lean practice to demonstrate long-term commitment; this also helped in breaking down resistance to change ▪ Employees celebrate birthdays and other occasion in the staff canteen which creates good work environment ▪ Kanban system failed due to poor reliability of forecast and uncertain demand ▪ Developed and established in-house without resorting to external consultant
Company C	▪ Formation of cross-functional team ▪ OEE, takt time calculation, material balance, product costing, brainstorming, Ohno circle, fishbone and quality costing was used to identify and measure ▪ Committed general manager and allocated resources for staff training ▪ Major initiatives are reducing product overweight and variation, rework, workplace organization, TPM ▪ The operations manager attended training and executed lean practice ▪ Top-down and bottom-up communication channel established ▪ Initiated Kanban system but could not sustain ▪ Took the help of an external consultant
Company D	▪ Failed initiatives due to lack of involvement & commitment of a key employee ▪ The general manager was committed and extended all help but could not get the buy-in from his key employee (operations manager) ▪ The exclusive specialized skill (e.g. Pastry chef) creates an attitude in key employee an difficult to fire because of heavy dependency ▪ The employee holds the power because of exclusivity of his unique skill ▪ Struggled to find leader to lead the change ▪ External consultant visited and did the diagnosis but could not sustain

4.6 Result and discussion

In this section, all the determining factors that may enable and/or obstruct firms to successfully implement lean manufacturing practices are assessed. It is important to understand that many distinctive factors stated here have significant influence on any organization embarking on the implementation of lean manufacturing. However, determining how these factors play a role in lean implementation with regard to the unique characteristics of food processing SMEs provides valuable new insights. All four companies started the lean journey at the same time. The assessment results classify companies B and C as successful, company A as less successful and company D as unsuccessful. Describing each determining factor helped us understand the effects of each factor on the lean adoption in a food processing SMEs. Figure 4-6 presents an overview of the cross-case analysis, which reveals the influence of the determining factors (enabling and/or obstructing) on lean manufacturing practice implementation.

Determining factors	**Company A**	**Company B**	**Company C**	**Company D**
Overall assessment	*Less successful*	*Successful*	*Successful*	*Unsuccessful*
Commitment of top management	Neutral	Enabling	Enabling	Enabling
Culture	Obstructing	Enabling	Neutral	Obstructing
Piecemeal approach	Neutral	Neutral	Neutral	Neutral
Training	Enabling	Enabling	Enabling	Obstructing
Multifunctional team	Neutral	Obstructing	Enabling	Obstructing
Resources	Neutral	Enabling	Enabling	Neutral
Organizational structure	Obstructing	Enabling	Obstructing	Obstructing
Remuneration system	Obstructing	Enabling	Obstructing	Neutral
Change agent	Enabling	Enabling	Enabling	Obstructing
Nature of the process	Obstructing	Obstructing	Obstructing	Neutral
Nature of the product	Obstructing	Obstructing	Obstructing	Neutral
Nature of the plant	Obstructing	Neutral	Obstructing	Obstructing

Enabling | Obstructing | Neutral

Figure 4-6 Determining factors (enabling and/or obstructing)

Commitment of top management

Commitment of top management refers to consistent financial support, encouragement, active involvement and supervision of the lean initiative. Especially in the SME context, management commitment is highly relevant due to their close and active involvement in day-to-day operations, in addition to financial support and team motivation functions. Lean implementation requires an initial investment with respect to training, hiring external consultants, providing materials for the visual management and allowing key employees to take the responsibility. These are critical elements for the SMEs and need close attention from the top management. To quote the operations manager in company B:

> "Our general manager has full confidence in our team and provides all support for lean implementation. He is actively involved in several initiatives we have undertaken. He also allowed us to hire new interns, which gives us more time to look for improvement opportunities."

The study found clear differences between successful and unsuccessful companies regarding these items. Company A's experience showed that lack of active involvement and supervision by the top management results in limited success. Following is the remark of an operator in company A:

> "There is no communication with the top management. The management never asks about the opinion of the employees. We really want to help and make progress but the management is not open for this. The employees do not know anything about the company, the results, the other departments. We are always guessing about such things, for example why the second packaging machine is not being used. The only information we have is what to do today."

Similarly, another employee reports the following regarding the top management's attitude:

> "Nobody knows which method is the best. They (management) just do it like they want to do. There were no meetings organized in the last two years to discuss how to improve things in the shop floor. The only meetings they have are crisis management meetings."

In contrast, company D failed to motivate its key employees to support the implementation though the management showed commitment by providing financial support and active involvement.

Previous studies also emphasized that the commitment of top management plays a significant role in the successful implementation of lean practices (Sanchez & Pérez, 2001) (Angelis et al., 2011) (Gurumurthy & Kodali, 2009; Puvanasvaran et al., 2009) (Achanga et al., 2006; Boyer, 1996). Considering the typical characteristics of SMEs, where top management are personally involved in day-to-day operational activities (Wessel & Burcher, 2004), direct supervision (Ghobadian & Gallear, 1997), top management close to the point of delivery (Deros et al., 2006), better understanding of processes and customers (Beaver & Prince, 2004) the commitment of top management is crucial for lean success (Phelps et al., 2007).

Culture

The concept of organizational culture has been formalized by several researchers (Achanga et al., 2006; Dahlgaard & Dahlgaard, 2006; Hines et al., 2004). The respondents were asked about internal and external communication, hierarchy, respect and blame game in the company. One of the major impediments to proper lean implementation in companies A and D was the absence of appropriate organizational culture with respect to communication, respect for fellow workers and continued blame game (Nahm et al., 2004; Schneider, 2000). It is found that the blame game was very much prevalent in company A. Following is the comment of an operator in company A:

> “There is a very low trust level in the company, it’s very difficult to trust even your fellow colleague. Some of them are close to the top management and get all the benefits and more holidays. There is no equal treatment for all here.”

This is unlike company B, where the company culture has weighted very high with respect to work environment, employees relationship and trust. One employee of company B mentioned:

> “We have a really good work environment. We celebrate birthdays of every employee together at the company canteen. We arrange ourselves who replaces whom when we go on holidays so that the work is not disturbed.”

Similarly another employee reports the following regarding company culture and conflict:

> “We often solve arguments and conflict among ourselves and seldom take it to the top management level. Our immediate team leader helps us in sorting out small issues. Also, the after-work drink helps in conflict resolution and less friction at the workplace.”

The good performance of company B was to a greater extent attributable to the compact organizational culture. Company D serves as an example of how culture can act as a barrier for lean implementation. One operator in D described:

> “We are not comfortable with the autocratic behavior of the chef (the operations manager). He imposes tasks which he considers best and does not take into account others' opinions. Sometimes he is also not nice to fellow colleagues.”

This finding is consistent with the conclusion of (Mann, 2012) and (Bhasin & Burcher, 2006) that organizational culture is a vital factor for a successful lean adoption.

Piecemeal approach

Literature on lean manufacturing has a divided opinion on a piecemeal implementation approach. On the one hand, studies found out that a piecemeal approach, or adopting lean manufacturing practice in a certain section of the company and ignoring its systemic nature, limits the potential of lean (Dowlatshahi & Taham, 2009; James, 2006). Some studies go one step further and say that a piecemeal approach can substantially hinder the lean journey (Allen, 2000; Bhasin & Burcher, 2006; Henderson & Larco, 1999). (Boyle et al., 2011) emphatically claimed that to derive the best out of lean it is critical to not only capture the piecemeal usage of individual lean but also to integrate lean thinking in a company's business strategy. (Scherrer-Rathje et al., 2009) termed the piecemeal approach as Band-Aid approach because it only cures the surface while the problem remains inside. However, literature also claims that a piecemeal approach may be more suitable for those manufactures who lack resources to launch a full-fledged lean implementation project. Such a full-fledged lean implementation needs a great deal of planning, training and financial resources. Moreover, there is an important time lag between its implementation and receiving the rewards of lean. Waiting for the return of an investment is not always easy for a small resource constraint firm. (Achanga et al., 2006) demonstrated that nine out of ten SMEs who participated in their case study have successfully applied lean following a piecemeal approach. (Ramaswamy et al., 2002) found that SMEs trying to implement several lean initiatives simultaneously realized even greater gains. (Hines et al., 2004) demonstrated that the piecemeal lean application could result in the most productive car plants in Europe producing the highest level of finished stocks in Europe. With this background, our observation shows that all the food SMEs that participated in this study have applied lean in a piecemeal manner to fix certain problems, for instance to reduce rework, improve delivery time or reduce machine downtime. The reason may be that consultants recommend SMEs to look for quick wins (Ballé, 2005; Smith, 2003). It also can be claimed that "which piece is being applied" has vital implications. As our study shows the piecemeal approach factor did not appear to explain success variance across four food processing firms. However, this factor provides an important insight into the issues associated with lean manufacturing implementation in the context of food processing SMEs. This factor may be included in the not-so-critical factor category instead of in the one with critical factors for lean implementation, especially in SMEs, irrespective of the sector. However, based on our findings we can conclude that though a piecemeal implementation of lean practices may not gain full benefits, the steps taken could help SMEs to improve their performance gradually.

Training

Several studies have demonstrated that training is vital for the success of lean implementation (Sanchez & Pérez, 2001). Our study also found that training plays an important role in the successful adoption of lean manufacturing. On the surface, "training" as a determining factor does give the impression of a success variance because all four case companies attended the training programs on lean. A deeper look into the training factor reveals two important insights. The first one concerns training on soft skills and on technical skills. Companies B and C, whose lean implementations were successful included both soft as well as technical skills in the lean training modules. This finding is in line with past research (Farris et al., 2009; Losonci et al., 2011). Moreover, both companies (B and C) hired external consultants to deliver the training. The other important finding concerns the target audience who attends the training. In the case of companies A and D, the top management attended the training programs organized outside the company premises. In company D, only the general manager attended the training and the operation manager did not attend, which had an impact on lean implementation in the company. The majority of the studies on determining factors of quality management programs found that "leadership and management" is the key factor of successful lean implementation (Hines et al., 2004; Soriano-Meier & Forrester, 2002). However, it remains that skill of the workforce and in-house expertise are the vital factors for the success of lean manufacturing (Kumar & Antony, 2008). Our findings strengthen the claim that it is imperative to train employees on the basics of lean principles and get them involved at the inception of the quality initiatives in the firm. From the example of the companies B and C, it also becomes apparent that some of the lean initiatives failed due to minimal involvement of shop-floor employees during the early implementation stage or lack of training and knowledge about the initiative. Training and empowerment would make it easier for employees to take decisions in regard to their own processes and make improvements to these processes (Kumar et al., 2011).

Multifunctional team

A large body of literature identified "multifunctional team" as a crucial factor for the successful adoption of lean manufacturing (Karlsson & Ahlström, 1996; Melton, 2005; Sánchez & Pérez, 2001). Our study explored the importance of two important elements (i.e., cross-functional team and size of the team) by asking questions to operators, supervisors and managers in the case companies. It found that a smaller team with 3 to 5 people is more effective compared to larger teams; a smaller team size helps in decision-making and consensus building. As seen in company C, smaller teams were very efficient in taking decisions and putting them into action. Similarly, a cross-functional team is an enabling factor for lean adoption. The operations manager in company C stated:

> "We have two strategies to make our team multifunctional; one, we rotate our operators on a weekly basis in different functional departments (mixing, packaging, cutting, wrapping, etc.) so that everyone can have multiple skills and is aware of the others' work; two, while forming the teams, we take into consideration that each team is comprised of people with diverse skills."

Moreover, the smaller teams also create a sense of ownership and responsibility to get things done among team members. Previous studies have focused on multifunctional teams (de Haan et al., 2011; Tranfield et al., 2000). However, there is limited information on the role of smaller team size in lean manufacturing implementation. (Ramaswamy et al., 2002) suggest that buffer stock removal and lot size reduction are the most important issues for SMEs, and multifunctional workers as well as preventive maintenance the least important ones. However, our analysis does not find evidence that a multifunctional team contributes to the success of lean implementation. Still, this factor provides an important insight into the issues associated with lean manufacturing implementation the context of food processing SMEs. This factor may be included in the not-so-critical factor category instead of critical factors for lean implementation, especially in SMEs.

Resource

For the success of lean practice implementation, it is imperative for the top management to make resources available for the execution. A large body of research found that the availability of resources for successful implementation of lean manufacturing practices is an important factor, especially for SMEs (Achanga et al., 2006). Our study explored various elements to assess the impact of resource availability in food SMEs such as human resources, technical know-how, finances to cover training costs and other investments. Previous studies crudely claim that SMEs lack resources (Gerstenfeld & Roberts, 2000; McAdam & Reid, 2001; Wickramansinghe & Sharma, 2005). Our study found that this claim is only partially true. The case companies have little difficulty with financial support for training, consultancy and other small investment. However, the firms lack financial resources to make big investments, for instance, changing a traditional layout to a modern cellular layout for better flow. Big investment is certainly an obstructing factor for lean implementation, but small investments like training and consultancy fees are not. Another important factor is lack of time among key employees and advanced statistical skills among staff; those were found to be the barriers of lean implementation. Additionally, there is financial support available for SMEs to implement QM practices through government agencies, but it is found limited. One respondent (general manager) report that:

> "There are several subsidies we can receive from the government agencies which are earmarked for SMEs to make them more competitive."

Hence, scarcity of resources can be considered as an excuse from the management to continue working in a fire-fighting mode to tackle day-to-day operations. Company B with 22 people at the production floor managed to implement lean practices and achieve success. Similar observations were made in the rest of the case companies. Broadly speaking, we agree with previous studies that SMEs lack resources (Achanga et al., 2006; Bruce et al., 2004; Hudson et al., 2001). However, this concerns only the big investment. Smaller investments such as training cost, consultancy fees and visual display materials are not a problem for the firms.

Organizational structure

In this study, we examined three organizational structure characteristics: ownership, decision-making process and unionization. These factors are included, bearing in mind the chaotic environment of SMEs (Bierly & Daly, 2007; Fillis, 2007). One of the major causes of limited success of lean in the companies A and D may be unionization. The top management found it difficult to ensure smooth implementation of lean practices because key employees were not convinced of the lean initiatives and their benefits. On top of this, the key employee of company A, who was the leader of the labour union, decided to go against the management's decision to implement lean and the union backed his decision. In company A, it was reported that, in order to reduce set up time (implement SMED), the company initiated video recording of worker's activities. The video recording, however, had to be stopped soon after because the employee union did not allow the activities of the employees to be recorded. In addition to that, the ownership of the company and the decision-making process were found to be important factors of lean implementation. One of the key factors of success in company B is the quick decision-making process. In contrast, it took a long time to get approval for lean initiation from the board of directors in the case of company C. These findings support the claim that organizational structure does matter in the success of lean adoption (Shah & Ward, 2003; Smeds, 1994).

Remuneration

Previous studies demonstrate a significant link between remuneration or reward and lean implementation (Karlsson & Ahlström, 1996; Sim & Rogers, 2008). (Karlsson & Ahlström, 1996) found that the role of the remuneration system is vital for the success of the lean implementation process. Studies emphasize that the remuneration linked quality improvement practices have a better success rate than the ones without remuneration or reward. Our results regarding the claim that the remuneration system plays a big role in a successful lean implementation were mixed. One company, B, benefited from introducing a reward system for good employee performance. The general manager of company B reported that:

> "The reward system is important in motivating employees to the new changes and, most importantly, to make it sustainable."

However, company C, which was also successful in lean implementation has no proper remuneration or bonus system in place. Similarly, company A and D were found to be neutral in the remuneration scale. These findings are a contrast to the claim made by

(Berggren, 1993) who elaborates that remuneration systems can stimulate many small ideas and can help companies to make great changes. Similarly, (De Waal, 2003) showed that the organizations that ignore fundamental change issues, such as appraisal and reward systems, may not succeed in creating the performance-based behaviors by employees. As our study shows, remuneration as a determining factor did not appear to explain success variance across four food processing firms. However, remuneration as a determining factor provides an important insight into the issues associated with lean manufacturing implementation in the context of food processing SMEs. It may be included in the not-so-critical factor category for lean implementation, especially in SMEs. It is rightly argued by (Panizzolo, 1998a) that the aim of reward and encourage behavior should be based on personal initiative and on relationships rather than on hierarchy. (Feld, 2001) proposed that the top management should walk the shop floor, explain what they want from their employees, reward those who follow and instruct those who do not. Similarly, (Antony et al., 2005b) recommended that implementing quality improvement programs requires that organizations invest in training, leadership alignment, reward and recognition of team members, and communication of successes and failures.

Change agent

Apart from training as a critical determining factor, the success of lean initiative seemed to be directly associated with the quality of the change agent. The change agent is the backbone of any initiative taken in the firm; he plays multiple roles. He is the person who co-ordinates improvement activities and acts as a facilitator for the change process (Bateman, 2005). He must possess relevant technical knowledge and soft skills. A crucial task of the change agent is connecting the top management's vision with the operators' ideas at the work floor by means of sensitive communication skill. The change agent could be an internal person or an external consultant. Company A, B, and D have identified internal persons (operations managers) as change agents, and company C appointed an external consultant as a mentor. Some studies consider that an external consultant as a change leader is more effective than the internal ones because external change agents can interact both directly and indirectly with internal change agents to stimulate the change initiatives (Birkinshaw et al., 2008). We do not agree with the claim that external consultant can be more effective than internal ones. An internal change agent with sound knowledge and good soft skills, who stays in the company unlike external consultants, who leave the company after finishing the project, may be more effective and sustainable for the firms. Several respondents clearly stated during interviews that the teams count on the leader (change agent). One operator in company D explained:

> “How can we be motivated when our project leader does not believe in this initiative and its benefits?”

We also observed that, in company B and C, the operations managers (change agents) have clear understanding of the lean principles, soft skills and motivation to lead the team. One operator in company B stated:

> “Our manager has a very charming personality and has the ability to bring everyone together. He sincerely listen to us and takes appropriate decisions for the benefit of the company as well as for the colleagues.”

It is clear from the cross-case analysis that the change agent plays a significant role in the successful implementation of lean manufacturing practices. Previous studies have not given prominence to the change agent factor as a critical success factor in lean implementation (Achanga et al., 2006). However, studies focusing on large firms suggest that the change agent plays a significant role in successful lean implementation (Armenakis et al., 1993; Kosonen & Buhanist, 1995; Smeds, 1994). The cross-case analysis among four food firms suggests that the change agent should be identified as a critical determining factor for lean implementation, given the special characteristics of SMEs.

Nature of the process

The study examined the nature of the production process and its influence on lean implementation. The nature of the food production process has been characterized as: 1. variable yield and processing time, 2. high variation of composition, recipes, products and processing techniques, 3. production rate determined by capacity, 4. divergent product structure, especially in the packaging stage, 5. variable yield and processing duration, variable product structure (Van Donk, 2001). This study explored how these factors influence lean adoption. Firstly, for the food processing companies the delivery times are usually short and customers (supermarket) demand products with quality assurance compliance often on short notice. This phenomena creates a bottleneck in the production planning and makes it difficult to meet the customer's need. The operations manager in Company B stated:

> “It often happens that we get an order for our products (sausages) at 8am in the morning to be deliver to the supermarket at 13.00. It’s more difficult in the summer time. When the weather gets better, the demand for BBQ sausages shoots up, and we have to deliver the product. This makes it difficult to plan and assign workload to people and machines.”

In most cases the supermarkets pass the uncertainty in demand on to the producers. It means that supermarkets place their order based on just in time principle; on top of that, they do not encourage producers to produce in stock because the long product shelf life is crucial from a commercial point of view. In this respect, cooperation and regular communication between supermarket and food processor can help to increase the lead time. Moreover, a minimum shelf life of food products possesses a challenge for food processors. The product can be technically good, but retailers will not accept it because, from a commercial point of view, it has expired based on the best-before-use tag. The operations manager in company A stated:

> “The retailers put pressure on us (manufacturers) to comply to different kinds of requirements on behalf of the end user customers, while for us establishing contact with the final consumer is very difficult; we do not understand the actual needs of the final consumer.”

One of the important issues found during the study is that the quality assurance requirements of the food processors present a barrier for lean implementation. An operation manager who worked for an automobile company before working at the food company stated the following:

> “When you are in a car-making company, it is easier to implement lean practices; there is a lot of flexibility, you can do several things… but in a food processing company, it is not always easy because of many food safety and quality restrictions, for instance, microbiological issues, metal detection, plastic, foreign body etc. need special attention”.

Similarly, the manager from the sausage making company (B) pointed out:

> “We wanted to remove this wall between the cleaning and cooling chamber because it prevents the operator from going directly from one chamber to the other and restricted the smooth flow. But we are not allowed because of quality assurance requirements.”

We also found that the frequent cleaning times and set ups are an integral part of the food processing sector in contrast to other industries, e.g. automobile companies. In most cases, these activities are sequence-dependent and need to be included in the production planning. Especially in both meat processing companies (A and B), there is a very long changeover time due to compulsory cleaning requirements in between product switch in the same machine. It was reported that the set up reduction was not easy and resulted in very little success.

One important observation is that, in all four case companies, the packaging section seems to have major bottlenecks. The reason may be attributed to the pack-to-order approach of the companies and with very unpredictable demand the packaging section is subjected to major pressure. The suggestions made by previous studies - to develop packaging lines with small set ups and standardizing the packaging materials (van Dam et al., 1993) - seems not feasible for the food processing SMEs because of their constraints in respect to financial resources and meeting customer demands in a fiercely competitive market. Some studies also proposed to use advanced computerized planning systems to correctly plan the demand and production for the food industry (Skok & Legge, 2002). However, advanced planning systems need big investment and skill, which seems scarce in SMEs. The cross-case analysis among four food firms proposes that nature of processes should be identified as a critical determining factor for lean implementation, given the special characteristics of the food sector.

Nature of the product

The study examined the nature of the product and its influence on lean implementation. The highly perishable product (raw material, semi and finished product) and the variability in the raw materials' quality, supply and price due to unstable yield have a consequence on lean implementation. For instance, a product sensitive to external variables makes the implementation of certain lean practices difficult. Gingerbread–a traditional product with a unique recipe–presents multiple barriers to lean implementation due to huge variation. To quote the manager of the gingerbread manufacturer:

> "I wish we could pack bricks or metal boxes, which are hardly influenced by moisture, weather, temperature and several other natural factors. All these factors have a significant influence on our product. The weight and height of gingerbread can vary according to parameters which are difficult to control. And the height and weight has an impact on the packing machines, work plan and even on operators."

(White & Prybutok, 2001) found that lean practices are less likely to be implemented in non-repetitive systems. The cause of the lower implementation rates in non-repetitive systems is that lean practices were designed in–and have their roots in–a repetitive production system. Similarly, (Katayama & Bennett, 1996b) demonstrated that lean production is incapable of responding to large fluctuations in aggregate demand volumes. A manager in the sausage-making company provided an interesting perspective:

> "The short self-life of our product also provides an opportunity to respond to the mistakes quickly."

Similarly, one operator in the confectionery (company C) stated regarding the consistency in quality and doing right the first time:

> "Doing right the first time is not always easy with a food product…because a small variation in recipe mix, temperature, baking time, or storing time of one of many ingredients can change the specification of the product. It is very complicated and very difficult to find the root cause of the problem."

Another important issue is the demand fluctuation due to the change of weather. For instance, the manager in the sausage-making company mentioned:

> "We make our production planning based on the weather forecast. There is a huge fluctuation in demand due to unpredictable weather."

One important observation was the anomaly in processing time, product shelf life and storage. The following statement of the operations manager in company A (dried ham) portrays the complexity of food product, processing and selling:

> "We have a long processing time (10 months) and the finished product has a short shelf-life between 2 and 4 weeks, and the customer (supermarket) has a best-before-use criteria of at least two weeks."

Moreover, slow-moving products have a risk of becoming obsolete. These factors make inventory management difficult for the food processors. Our study aligns with the claim that the application of lean manufacturing is not straightforward in a high product variety and low volumes environment such as the food sector (Jina et al., 1997a). The cross-case analysis among four food firms recommends that nature of product should be identified as a critical determining factor for lean implementation, given the special characteristics of the food sector.

Nature of the plant

The study examined the nature of the plant and its influence on lean implementation. The nature of the plant has been characterized as: 1. single-purpose expensive machines, product variety and high volume; 2. long sequence-dependent set-up time between product types; 3. processing and packaging are separated because of QA requirements; 4. usually, the factory shows a flow shop oriented design (Van Donk, 2001). All four food processing SMEs participating in this study have batch processing with between two and seven production lines and packaging lines. The design of the layout in company A, C, D is not planned from a lean point of view. In all case companies, due to quality assurance requirements, the production and packaging sections are separated by a wall. The sections are also known as blue zone and red zone; people in the red zone have to change clothes in order to enter the blue zone and vice versa. This causes extra movement for the operators which results in a waste of time. This is against the lean manufacturing principle because lean suggests a clear flow between different activities. The design of the traditional layout is not optimal and not planned according to the lean manufacturing principle. The slicing and packaging machines are for a single purpose. There are long set-up times (changeover) between different products, because of cleaning and other quality assurance requirements. Additionally, certain characteristics of the plant are so unique that it's hard to change unlike in an automobile production unit. A good example can be found in the following statement of the operations manager in company A:

> "Our drying rooms, after many years, have reached a state of bacteriological equilibrium in which natural fermentation can take place, and it's not feasible to change the layout for most efficient movement."

The cross-case analysis among four food firms indicates that nature of plant should be identified as a critical determining factor for lean implementation, given the special characteristics of the food sector.

The following section summarizes all factors that did and did not appear to explain success of lean implementation among the four food processing SMEs (Table 4-8). These factors provide an important insight into the issues associated with lean manufacturing implementation in the context of food processing SME.

Table 4-8 Critical and not-so-critical determining factors

Critical determining factors	Not-so-critical determining factors
Commitment of top management	Piecemeal approach
Culture	Remuneration system
Training	Multifunctional Team
Resources	
Organizational structure	
Change agent	
Nature of the process	
Nature of the product	
Nature of the plant	

4.7 Conclusion

This study explored determining factors of lean implementation at four food processing SMEs in Belgium. It made three major contributions. One, while many studies have explored lean implementations in large organizations (mostly in discrete industries), fewer have focused on food processing SMEs. Since there is strong evidence that food processing SMEs operate differently from large organizations in other sectors, our study provided specific directions to food producers planning lean implementation. This was done by identifying determining factors that were considered critical to lean implementation success in the participating food processing SMEs. The food processing SMEs that managed these determining factors effectively had a higher probability of implementation success. Further, a set of not-so-critical factors has been identified that the managers of food producers would need to be aware of when implementing lean practices.

Two, the comprehensive interviews with operators, managers and owners provided insightful details to the factors that were influential in lean implementation. This study clearly showed, besides organizational factors, how the sector specific factors such as nature of process, product and plant were critical in lean implementation in the food sector. Through the interviews, we could identify that product perishability, behavior of the supermarket, traditional production process and layout play significant roles in lean implementation. Moreover, it was interesting to observe that the exclusive specialized skill (e.g. pastry chef) creates an attitude in key employee. It was difficult to fire the top pastry chef in the country because the whole business relies on his exclusive specialized skill. This is a unique case and very relevant for the food industry because the food business often relies on specialized skill of the key employees, for instance a specialized chef.

Three, some of the findings are aligned with previous studies. However, some findings are counter-intuitive to existing knowledge. In particular, our findings confirm that factors such as commitment of top management, training, resources, organizational culture and structure were important to lean implementation success. Furthermore, our findings extend the knowledge about training modules on soft skill and technical skill, and most importantly the target audience (shop floor employees). The culture of the company (e.g. communication, respect, discipline) proves to be a very important determinant for successful lean implementation. It was observed that in the less successful companies, employees were complaining and blaming others for slow progress. The nature of the process was found to be a very crucial factor in lean adoption. The example of the naturally dried ham producing company and labor-intensive chocolate and cake making company demonstrated that due to the complex nature of the processes a straightforward lean implementation was not easy. It was difficult for the food companies to adopt lean because of the low shelf life of the food products and the extremely volatile demand and supply. Another finding is that the small size of the plant, the traditional set-up and layout and the quality assurance requirements make it difficult to replicate lean in food processing SMEs. Our research revealed that, out of several organizational factors such as structure, remuneration and change agent, the determinant that most affected the lean implementation was “change agent.” It is very important for the companies to find a motivated “change agent” who can serve as a catalyst for change. Moreover, the lack of a well-structured implementation plan for SMEs may be the reason why lean practices are less likely to be successful in SMEs. Further, sustainability is still a de-prioritized issue for most of the case companies. There is little effort to address environmentally important issues such as a responsible use of water and energy during the production process. In a nutshell, lean manufacturing is a complex process. As the examples show, sheer imitation of lean without understanding the context results in failure (Cox & Chicksand, 2005; Robinson & Schroeder, 2009; Sousa & Voss, 2008).

The limitation of our research with respect to comparability and generalizability cannot be ignored due to the degree of deviation in lean implementation, despite the fact that the companies are of similar size and from the same industry sector. The research was based on four food processing SMEs in Belgium and thus its results may not be generalizable to other countries. Previous studies indicated that country differences might influence aspects of lean implementation and performance (Ahmad & Schroeder, 2003). Moreover, this study focused on SMEs in the food sector, hence it may not be easily transferable to large organizations in other sectors. Finally, our research was based on personal interviews, which means that there is a possibility that the opinions and knowledge of interviewees may have been limited or biased. Given these limitations, this study yielded some important insights and suggested potential areas for further work. This study was an attempt to understand the effects of the determining factors on lean adoption through case studies. The detailed discussion and the quotes from operators, managers and owners may help practitioners confront challenges while undergoing lean implementation for efficient food production in a SME environment.

One important issue observed during the interviews that in general there is a certain level of confusion among manager regarding the lean implementation process. For instance, where to start, what to monitor, what to adjust, etc. to achieve the optimal results of lean manufacturing practices. It has been found that there is a clear need for a systematic implementation framework for lean implementation for food processing SMEs which can answer the above stated questions. Hence, the following chapter proposed a lean implementation framework, tailor-made for the food processing SMEs.

It is the framework which changes with each new technology and not just the picture within the frame.

~ Marshall McLuhan

5. House of lean for food processing SMEs

Adopted from:

Berczeli, A., Sebők, A., Gellynck, X., Molnár, A., Dora, M., Steinkamp, H., & Hollah, K. (2011). “IMS FOOD Best Practice Guide” *EU Cornet ERANET final report*.

5.1 Introduction

The previous chapters provide us with a good understanding of the determining factors and their relationship with lean manufacturing practices and operational performance. Taking cue from our findings, the previous literature and understanding of the limitation of lean manufacturing implementation in food processing SMEs in its current form, this chapter proposes an implementation framework for lean manufacturing – customized for the needs of food processing SMEs. The lean implementation framework has been developed based on reviewing the existing literature on quality management implementation frameworks, and a conclusion has been drawn from the primary data collected through survey and multiple-case studies. The framework will help food processing SMEs build a sustainable and comprehensive quality culture (integrating both safety and efficiency aspects) based on strong leadership, fact based decision making, and customer focus (Berczeli et al., 2011).

It is evident from our analysis that successful lean manufacturing implementation requires proper planning, consistency, flexibility, and a proper understanding of the food sector specific contextual factors. Simply imitating another firm's plan, organizational structure, training, problem solving methods does not guarantee an improved operational performance. Performance depends on the proper execution of practices and execution depends on a well-designed framework for execution. A large body of literature emphasized the development of a cost-effective, sector specific, easy-to-use framework which can help firms successfully implement lean manufacturing practices (Anand & Kodali, 2010; Antony et al., 2007; Hansson & Klefsjö, 2003; Jeston & Nelis, 2008; McAdam, 2000; Power, 2005; Thomas & Webb, 2003b) and it cannot be denied that there are numerous lean implementation frameworks proposed by researchers, consultants and organizations (Anand & Kodali, 2010; Papadopoulou & Özbayrak, 2005). However, the question that then arises is why aren't any of the several existing quality management implementation frameworks suitable for food processing SMEs? What are the critical elements missing in existing quality management frameworks and how can they be filled?

In order to understand these intriguing questions, first, a list of existing quality management frameworks focusing on lean manufacturing, and SMEs has been identified and analyzed. Second, the drawbacks of current frameworks have been discussed. Then, with the help of our research findings, a lean implementation framework for food processing SMEs has been proposed. Furthermore, the proposed framework has been discussed, modified and, validated through a panel discussion. The generated framework was discussed in a panel comprised of two academics, two researchers, one consultant, one operations manager, one quality manager and two general managers. The comments and suggestions from the discussion were incorporated in the revised framework.

5.2 Review of existing frameworks of quality management practices

In simple terms (Yusof & Aspinwall, 2000b) has described a framework as “a prescriptive set of things to do”. A sound framework should first assess the current state of the organization, i.e. what an organization does or tries to do, followed by analyzing the steps taken to do it in a correct sequence (Struebing & Klaus, 1997). (Mathaisel, 2005) has considered a framework as a facilitator in the unification of several disciplines in the change process to allow their combined use in the design process. There is a higher chance of success in implementing a new framework if it is supported by a good foundation, adequately developed and well-articulated (Arya & Callaly, 2005). According to (Anand & Kodali, 2010) a framework is “a guiding torch that helps a manager in providing necessary directions during the change management programmes that are implemented in an organization”. Mostly, frameworks are illustrated through pictorial representations such as diagrams, graphs or flowcharts, while some frameworks are also portrayed descriptively (e.g., Womack & Jones, 1996; five principles of lean).

The studies were carefully identified and included in the review which focuses on QM frameworks primarily designed for SMEs and/or the food sector. Table 5-1 summarizes the important quality management implementation frameworks, their key features, and limitations.

Table 5-1 Review of existing frameworks of quality management

Source	Key aspects covered	Limitations
Lean (Karlsson & Åhlström, 1997)	• Included: product development, procurement, manufacturing, and distribution, lean enterprise	• Very general • Neglect sector specific factors • Lacks technicalities
Lean (Jina et al., 1997b)	• The components necessary for lean • Sector specific factors considered (aerospace)	• Customized for the high variety, low volume discrete industry (aerospace), Low transferability
Lean (Hines et al., 2011)	• Iceberg model • Technical (above waterline) • Organizational & culture (underwater)	• Service sector focus • SME factors (e.g. lack of resource) are ignored
Lean (Gunasekaran et al., 2000)	• 5S, Hoshin exercise, activity based management, and JIT/Kanban. Model focused at operational level; variety of suggestions provided ranging from using basic tools such as Pareto to implementing JIT/Kanban	• Missed to provide suggestions on how to make the model operational, strategically align to business goals, and ensure leadership commitment to introduce such model at operational level
TQM (Asher, 1992)	• Four stage- diagnostic, commitment, implementation, and review.	• Based on the assumption that data collection system to measure cost of quality.
TQM (Ghobadian & Gallear, 1996)	• 10 step TQM implementation framework - recognition of need for TQM; developing management and supervisors understanding; establishing goals and visions; plan implementation; educate and train all employees; create systematic procedure	• Chances of success from full blown implementation of TQM in SMEs is meagre due to resource constraints; • No validation of framework; • Framework constructed based on small sample-size that may limit generalizability
TQM (Yusof & Aspinwall, 2000b)	• System approach; The framework consists of three main elements/ box: quality initiatives, general methodology, and central coordinating body at company level	• Does not explain how to operationalize the framework; • No validation of framework
TQM (Husband & Mandal, 1999)	• 3 phases; Core values include- committed leadership, everybody's commitment, customer orientation, process focus, fact based decisions, and continuous improvements	• Limited discussion by researchers on how to make the framework operational taking into consideration the resources constraints
QM (Thomas & Webb, 2003a)	• Three stages of problem identification, problem solution, and systems development (SMEs factors and dimensions, training and development, project management) integrated with the working mechanisms of the model	• Framework focuses more on the operational issues and application of statistical methods with limited discussion on strategic issues of management commitment, resource availability to apply the framework
QM (Deros et al., 2006)	• Top management vision, soft and hard performance measures, tools & techniques, critical success factors, general methodology (PDCA), and business goals	• Framework still at development stage and needs further validation; some elements of framework connected to each other though not proven statistically

BPI (Khan et al., 2007)	• Business process improvement (BPI) framework supported by management commitment, education, and support, management awareness, training and education on Kaizen, and check the progress	• Attaining world class manufacturing status through application of Kaizen is questionable.
Lean six sigma (Thomas et al., 2008)	• Lean Six Sigma application in SME; Focused on application of tools & techniques from the start of model implementation such as 5S, value stream mapping, DOE, ANOVA	• Lacks strategic focus; Model is applicable at operational level to resolve chronic problems; not an implementation strategy that could be deployed across organization.
Six sigma (Kumar et al., 2011)	• 12 step process in five phases that would help SMEs to get started	• Only three companies tested • No sector specific issues addressed
ISO 9000 (Aggelogiannopoulos et al., 2007)	• Quality assurance; Process map: Inputs Outputs Acceptance criteria Monitoring – process control Performance indicators	• Documentation focus • Quality assurance and control focus
FQM (Luning & Marcelis, 2009a)	• Techno-managerial approach • Integrated quality assurance and improvement	• Theoretical framework • No empirical validation
HACCP (Khandke & Mayes, 1998)	• Assuring product safety • Three distinct elements, transfer of ownership of the HACCP plan, training to implement the plan and maintenance of the plan.	• Quality assurance and control focus • Neglect the operational efficiency aspect
IFS (Schulze et al., 2008)	• Uniform evaluation system used to qualify and select suppliers • Ensure the food safety of their products and monitors the quality level of producers	• Lack the step approach • Quality assurance and control focus • Neglect the operational efficiency aspect • Organizational factors are missing
BRC (Arfini & Mancini, 2003)	• Food hygiene and safety control • Quality of customer relations • Distribution	• More analytical • Step by step frame missing • Safety focus only

Source: Own compilation based on (Anand & Kodali, 2010; Kumar et al., 2011; Schulze et al., 2008)

5.3 Analysis of QM frameworks

Firstly, the analysis of existing frameworks reveals that each QM practice has a very specific focus: (HACCP: food product safety; BRC: hygiene and safety; IFS: uniform supplier selection and safety, ISO 9000: product safety; Six sigma: reduce variation existing in product & process, TQM: process improvement; Lean: waste elimination). It may be very challenging for a small food processor to adhere to all the different QM practices in order to ensure that each aspect of quality is fulfilled (safety, hygiene, and efficiency) (Trienekens &

Zuurbier, 2008). Secondly, there has been an implicit assumption that frameworks developed in large organizations are relevant and directly applicable to SMEs (Kumar et al., 2011). Literature has highlighted the need for a tailor-made implementation framework for SMEs (Gunasekaran et al., 1996; Khan et al., 2007). Thirdly, some frameworks are based on the assumption that firms have no resource constraints, data can be available on demand, customer and supplier feedback system in existence, employees are well skilled, and top leadership is committed to quality initiatives (Thomas & Webb, 2003a). Fourthly, very few researchers questioned the readiness of an organization to implement a QM practice. (Kumar et al., 2011) claims that if the organization is not ready culturally, any change initiatives will fail drastically. Finally, it is interesting to discover that there is no framework which builds on the others and a lack of consensus about the key elements that need to be included in a lean implementation framework. Additionally, there is a limited and not so clearly defined study which explains in which sequence the lean manufacturing practices should be implemented Nordin et al. (2011).

The findings from our survey, case study and critical analysis of the existing frameworks helped to develop a tailor-made lean implementation in food SMEs. The next section discusses the critical findings from the survey and case study which were used to design the implementation framework. Our study reveals that the food processing SMEs are facing multifaceted challenges, while embarking on the lean journey. In a nutshell, our findings can be described in the following words:

1. The perception of “quality” among food processors (especially SMEs) is biased towards assurance, safety, health, and hygiene, neglecting improvement, cost effectiveness, and operational excellence. There is a need for an integration of safety issues and operational efficiency issues in the food quality management system.
2. There is no clear, standardized, easy-to-use framework for a lean manufacturing practice implementation available which also considers sector specific barriers.
3. The costs of applying a lean manufacturing implementation and the benefits derived from it are ambiguous and uncertain.
4. Besides the organizational and lean manufacturing related factors (top management commitment, culture, structure, change agent, etc.) the challenges of smaller firms with respect to skill, human and capital resources, data, and the lack of time are insurmountable for food processing firms. The culture of the company (e.g. communication, respect, discipline) proves to be a very important determinant for successful lean implementation.
5. The sector specific factors such as nature of process, product and plant were critical in lean implementation in the food sector. Product perishability, behavior of the

supermarket, traditional production process and layout play significant roles in lean implementation.

6. The lean maturity level of micro-sized firms is low compared to small and medium sized companies. Similarly, small and medium sized companies are more benefited from lean practices compared to micro-sized company.
7. Lean practices related to customers engagement, involved employees and productive maintenance are more prevalent among food processing SMEs. The study shows a low degree of use of some lean practices related to SPC, flow, pull, set up, and employee involvement. Small sized firms focused more on customer related lean practices. Similarly, medium sized firms are relying on customer related practices and total productive maintenance. Whereas, the total productive maintenance is the most used lean practice among micro-sized firms.
8. The most potent barriers of lean implementation are lack of knowledge, poor employee participation, availability of resources, lack of training and inadequate process control techniques. The principal barrier of micro-sized companies are a lack of available resources for lean implementation, poor delegation of authority, poor project selection and internal resistance. The major obstacles for the small-sized companies are a lack of knowledge, poor supplier involvement and variability of raw materials' quality and quantity. The medium-sized companies stated that poor project selection, resources and lack of training are the main constraints. The food processing SMEs that managed these determining factors effectively had a higher probability of implementation success.

5.4 Lean manufacturing implementation framework for food processing SMEs

The framework for lean manufacturing implementation in food processing SMEs is based on a combination of the existing literature on frameworks for lean implementation, organizational change factors, and sector specific factors. The literature provided sufficient proof that the lean manufacturing practices implementation must ensure that organizational change factors such as commitment of top management, culture, training, multifunctional team, resources, structure, remuneration system, and change agent are in place. In other words, the firms must be prepared to implement lean practices with necessary prerequisites. The factors included in the lean implementation framework for food SMEs are presented in Table 5-2.

Table 5-2 Factors included in the lean implementation framework in food SMEs

Lean practices	Organizational factors	Food-sector-specific factors
Customer related - Involved customer Supplier related - Supplier feedback - just-in-time delivery - Developing suppliers Internally related - Pull - Flow - Low setup - Controlled processes - Productive maintenance	Critical: - Commitment of top management - Culture - Training - Resources - Organizational structure - Change agent Not-so-critical: - Piecemeal approach - Remuneration system - Multifunctional team	Quality assurance requirement - Food safety & hygiene Product - Perishability - Variability (raw material, recipe, product type, & structure) Process - Manual and/or automated - Variability (yield and processing duration) - Throughput time - Set-up times - Sequence-dependent Plant - Traditional or modern layout - QA restriction - Small and single-site factories

Source: Own compilation

As seen in the literature review section (Table 5-1), generally studies focus on the factors included in the left two columns while designing the lean implementation framework and neglect the sector specific factors. Our research findings in the previous chapters clearly state two fundamental aspects that are necessary in order to derive the optimal performance of lean manufacturing practices in food processing SMEs: 1. organizational change factors; and 2. contingency factors (e.g. sector specific) (summarizes in Table 5-2). Previous studies have a similar outlook that the success and/or failure of a QM initiative such as lean manufacturing depends on organizational factors (Shah & Ward, 2007a) and contingency factors (Sousa & Voss, 2001). The inclusion of organizational and sector specific factors will add value to the newly proposed framework for lean implementation and help managers to plan for the contingency factors which significantly influence performance. “The Iceberg” model of lean implementation of (Hines et al., 2008) provides a lead in this direction (Figure 5-1). “The Iceberg” model proposed by (Hines et al., 2008) includes two segments: one below the water which depicts a firm’s strategy, leadership, behavior and engagement and, a segment above the waterline that includes the technical aspects (i.e., lean practices). The framework proposed by (Hines et al., 2008) captures several valuable features. For instance, it captures the concept of the underwater level (behavior, strategy, leadership, etc.) which is considered to be the foundation of lean manufacturing. Once this foundation is strong and supportive of the above waterline features (lean practices) the firm may achieve the expected results.

Figure 5-1 Lean Iceberg Model

Source: (Hines et al., 2011)

However, the model lacks a few key elements: the "contingency factors" or sector specific determining factors and the nature of SMEs. These factors play a vital role in lean implementation, as we have seen in the previous chapter (Ch. 4). For this reason, we propose to fill that gap by providing a middle layer - let us call it "an ice layer", between the above and underwater segments, which integrates the organizational and contingency factors (SME and food-sector-specific). Figure 5-2 presents a graphical design of the adopted lean iceberg model from a contingency view.

Figure 5-2 Lean iceberg model with contingency view

Source: Adapted from (Hines et al., 2008)

The additional middle layer to Hines's iceberg model (organizational and contingency factors) can also be justified from the theoretical perspective. (Ketokivi & Schroeder, 2004b) claim that environmental factors (internal and external) influence the operation of organizations. This leads to different operational performances. Similarly, (Davies & Kochhar, 2002) asserts the that the type of the industry and its inherent nature has a significant impact on the results of the practice. The consequence of neglecting contingency factors in quality management initiatives lead to failure (Demeter & Matyusz, 2011; Sousa et al., 2005). Hence, the relevant contingency factors (in this case food sector specific ones) are included in the proposed model.

The next question is what is the "optimal sequence" in which the lean manufacturing practices are implemented in food processing SMEs for an effective result?" (Bhasin & Burcher, 2006) has emphasized that the inadequate sequence or structure is a major reason for the failure of lean implementation. In order to provide a step-by-step sequence of lean implementation, tailored for food processing SMEs, we proposed a "house of lean for food processing SMEs" based on the iceberg model (Hines et al., 2008), now with a contingency view. This approach took a leaf out of (Radnor & Walley, 2008) methodology, which followed the similar approach while developing a lean implementation framework for public services. Figure 5-3 demonstrates the proposed four steps lean implementation framework for food processing SMEs:

Step 4: Review operational performance
(Food safety, Cost, Quality, Lead time, Delivery)

Step 3	Choice of practice & Implementation	Customer related - Involved customer	Supplier related - Supplier feedback - just-in-time delivery - Developing suppliers	Internally related - Pull - Flow - Low setup - Controlled processes - Productive maintenance
Step 2	Alignment	Food-sector-specific factors (QA, product, process, plant)		
Step 1	Preparation	Organizational factors (culture, leadership, behavior) and Training		

Figure 5-3 House of lean for food processing SMEs

There are a few steps (1 and 2) of the framework which are generic and applicable to all types of organization irrespective of contingency factors. However, the third step that is included takes into consideration the characteristics of food processing SMEs and their challenges of lean implementation. The following sections illustrate each step in details.

Step 1: The first step is principally a preparation phase. It involves elements pertaining to the organizational factors. It is important to understand and address these elements (top management support, leadership commitment, organizational culture, remuneration system, communication, employee empowerment) before the actual lean implementation begins. Lean manufacturing is considered as a system comprised of different practices (techniques); individual practices cannot be adopted in isolation excluding organizational factors. A long-term clear goal for the company should be laid in the presence of the top leadership and effectively communicated to the employees. An adequate planning for the lean implementation should be developed with clear delegation of tasks. Identification of a proficient change agent (if feasible internal) and an allocation of adequate resource should be earmarked to kick start the lean implementation.

It is also advisable to self-assess the organizational readiness before embarking on the lean implementation. It is evident from our study as well as pervious research that organizational preparedness plays a significant role in the success of QM initiatives such as lean manufacturing (Armenakis et al., 1993; Motwani, 2003). Failure to assess the organizational changes may results in a waste of significant time and limited available resources of SMEs. In an in-depth study (Kumar et al., 2011) included the above stated factors and proposed a readiness index to assess SMEs commencing on a similar QM initiative (six sigma) for SMEs. It is recommended for the firms to use the self-assessment test proposed by (Kumar et al., 2011) in the preparation phase.

Further, training on lean principles and practices are a fundamental prerequisite for lean implementation. (Day & Liker, 2004) has suggested that the learning by doing approach of lean training is suitable. Additionally, (Åhlström, 1998) found that a team of multi-skilled workers and the identification of a team leader proved to be important in early stage of QM initiatives.

Step 2: The second step is primarily an alignment phase. The alignment phase encompasses the contingency factors. It is important to understand and align (adjust) with the sector-specific factors. As described in chapter 4, the challenges of lean implementation due to specific characteristics of the food sector with respect to the nature of food product, processing, and plant need better understanding and adjustment (Deep & Dani, 2009; Fearne & Norton, 2009; Funk, 1995; Jayaram et al., 2010; Simons & Taylor, 2007). For instance, the food processing SMEs mostly produce based on forecast, not on a made to order basis. The forecast lead time for production is often long which results in a huge difference between the production and actual demand. This leads to large inventory of finished goods. This is one important obstacle of lean which advocates limited or no inventory. Moreover, there are many variable combinations of lead times and production lead times that add complexity to an already complex business. For example, the shelf life of food products is short. The procurement lead time for raw material is long. And again the lead time for final packaging is short. These are unique characteristics (contingency) of the food sector which cannot be ignored while planning lean implementation. Moreover, the mandatory quality assurance requirements need attention while implementing lean practices. This step also provides an opportunity to integrate food safety and efficiency issues in the framework (Jacxsens et al., 2011; Luning & Marcelis, 2009b; Van Der Spiegel et al., 2005).

Step 3: After preparation at the organizational level and making alignments with the sector-specific factors, the firm chooses the appropriate lean practices for implementation based on the planning and needs for a higher operational performance. It is seen in the case study chapter that not all lean practices are easy for the food processing SMEs to implement from the start. Previous studies also claim that wrong practices, incorrect use of practices, or wrong order of use of practices lead to lean failures and incur loss for the firms (Abdulmalek et al., 2006; Pavnaskar et al., 2003). This step primarily focuses on "problem determined tool" approach (Convis, 2001; Shingo, 1989). For instance, it was observed during our case study that specific food processing SMEs have difficulty implementing JIT because of very uncertain demand fluctuation. These firms found it challenging to implement pull and kanban in their production process (Abdulmalek et al., 2006). It is also observed that the lack of flexible and multiple use equipment in resource-constraint food processing SMEs make it less likely to implement cellular layouts.

According to researchers there is a basic, logical sequence in which these elements should generally be implemented. For instance, (Shingo, 1989) has suggested that SMED and layout improvements should be prior to the kanban and flow. Similarly, (Smalley, 2006) has highlighted the need for stability (manpower, machines, materials and methods) as the first thing to implement when seeking to become lean. Likewise, (Ōhno, 1988) has emphasized that kanban can only work effectively if the flow is optimal. Standardized work and uninterrupted process flows are the key foundation stones of TPS (Ōhno, 1988). It is important to consider that the easy to use practices (e.g., workplace organization, visual management, customer involvement) should be given more prominence in the beginning stage of the implementation than the more advanced ones (e.g., line balancing, one-piece flow, pull and kanban). It is proven especially in SMEs that the low hanging fruits (initial success) help a firm to sustain QM initiatives such as lean manufacturing (Ballé, 2005; Radnor & Walley, 2008; Smith, 2003).

Step 4: The fourth step is the review of performance with respect to safety, quality, cost and delivery. It was observed during the case study that most participating firms were struggling to measure performance in a right way. Generally, managers tend to make their decisions based on intuition. Moreover, the annual financial accounting consider the firm's performance, which often does not give the right picture. The traditional way of functioning in many food processing SMEs is by making decisions based on intuition and experience, rather than on data from the work floor, which is an important reason for barriers to lean implementation. Hence, it is important to integrate performance measurement in the lean implementation framework. An effective performance measurement requires the selection of an adequate set of measures, transparency, procedure, rules, and routines (Kagioglou et al., 2001).

Additionally, continuous improvement is one of the fundamental principles of lean manufacturing. The review of the operational performance also amplifies the existing waste in the process and is challenged to eliminate them. These new findings will further help firms make plans and bring them into action (Doolen & Hacker, 2005; Marlow & Paixão Casaca, 2003).

5.5 Conclusion

Research has shown that lack of understanding of sector-specific contextual factors and organizational factors such as leadership, culture, employees training and resources lead to failure in lean implementation. The implementation of lean manufacturing has not been easy for many food processing SMEs. There is limited research on the implementation aspects of lean manufacturing, such as where to get started or how to address the contextual factors. There is no evidence of a framework which includes contingency factors and caters the need of the food processing SMEs. The key contribution of this chapter is the development of a house of lean that takes into consideration the needs and characteristics of food processing SMEs. The framework provides a structured and step by step approach for implementing lean manufacturing in a food processing SME environment. The proposed framework aims to present a structured approach to understanding contextual factors and aid food processing SMEs to flourish and reach their full improvement potential. It is not only imperative to drive improvement from implementation of lean manufacturing initiatives but also to sustain the gains over the long-term. The practical applicability of the framework will be further tested by conducting case studies in food processing SMEs and by seeking suggestions for improvement from organizations, academics, and practitioners.

It’s only the last turn of a bolt that tightens it – the rest is just movement.

~ Shigeo Shingo

6. Conclusion

6.1 General discussion

This doctoral research was undertaken because practitioners and researchers in the food processing industry expressed the need for a better understanding of lean implementation (Goncharuk, 2009; Mahalik & Nambiar, 2010). Hence, the main research gap in terms of application of lean manufacturing in a food processing SME environment was identified in the context of this exploratory research (He & Hayya, 2002; Luning & Marcelis, 2009b; Mahalik & Nambiar, 2010) - the quality management practice that has resulted in an improved operational performance in many large discreet organizations (Spear & Bowen, 1999). As there were limited articles published on lean manufacturing in food processing SMEs, this research attempted to answer some critical research questions, discussed in the next section, to make a contribution to knowledge and practice. The present chapter summarizes the key findings from the survey and the case study undertaken during the research period. The discussion is grouped in terms of ***practice, performance and determining factors*** and each of them are analyzed in the scope of the control variables. Thereafter, the research proposition has been revisited. This is followed by a description on contribution to knowledge and practical relevance for managers. The research concludes with limitations, directions for future research and a critical reflection.

Practice

The first point of investigation was the firm's decision to choose and undertake a quality management practice. It is evident from our analysis that food processing SMEs focus more on quality assurance initiatives compared to quality improvement practices. The understanding of quality among small food processors is often limited to only food safety and hygiene. This is also the reason why research on food quality management is profoundly biased towards quality assurance and has neglected the vital operational improvement aspect so far (Black & Porter, 1996; Caswell et al., 1998; Hanf & Hanf, 2007; Luning & Marcelis, 2006).

One fundamental difference between quality assurance and quality improvement practices is the government regulation and/or the customers' quality certification requirements. Quality assurance methods such as HACCP, BRC, and IFS etc. are mostly mandated by government authorities or a customer set the specific certification as a requirement. This is not the case with the lean manufacturing practice (Bredahl et al., 2001; Caswell et al., 2002). There is no legal obligation for firms to implement lean manufacturing. It can also not be denied that the demand of the customer or governmental regulation is not the only reason why food processors adopt certain quality initiatives. Scholarly studies outlined several internal and external factors grouped in costs and benefits that may affect the quality adoption in a small food processing company such as: awareness, discipline, productivity, risk, competitiveness, resistance, time constraint, human resource, training, financial resources, attitude, culture, and knowledge (Aggelogiannopoulos et al., 2007; Fotopoulos et al., 2010; Karipidis et al., 2009; Poksinska et al., 2006).

Another important finding is that bigger food processors are most likely to implement more than one QA method compared to the smaller ones. This finding contradicts the claim made by previous studies that smaller companies have more reasons to implement QA as many large companies demand quality certification from their suppliers, which are often the small companies (Alfonso Rodríguez-Escobar et al., 2006; Husband & Mandal, 1999). However, in a broader context, the claim is true as all SMEs that participated in this study implemented one or several QA practices and were typically obliged by their customers and/or government agencies.

Interestingly, respondents also stated that they were implementing quality improvement practices such as lean manufacturing even though they would not call them “lean”. This is a intriguing finding because previous studies found that many companies follow a piecemeal approach or adopt lean manufacturing practices in a certain section of the company or in patches and ignore its systemic nature, which limits the true potential of lean (Dowlatshahi & Taham, 2009; James, 2006). The “piecemeal approach” is also included as a determining factor in the second phase of this research (case study) to get a deeper understanding of its overall impact on the lean adoption of firms. The findings from the case study confirm that the piecemeal approach hinders the lean journey because it prevents the synchronization among different divisions in/of the organization (Allen, 2000; Bhasin & Burcher, 2006; Henderson & Larco, 1999). The attitude to implement lean in patches instead of company-wide may be attributed to practice-based studies by consultants, which recommend SMEs to look for the low hanging fruits or short-term gains (Ballé, 2005; Smith, 2003).

Importantly, researchers claim that the potential benefit of quality management initiatives depends on the quality culture and long-term objective of the firm (Beatty, 2006; Gotzamani & Tsiotras, 2002; Quazi & Padibjo, 1998). (Gotzamani & Tsiotras, 2002) found the true benefit of quality assurance methods (e.g., ISO 9000) could be achieved because of the firm’s primary focus on quality improvement in operation and product. Some recent studies proposed to integrate these two vital elements of quality management (assurance and improvement) (Engelund et al., 2009; Nicholson, 2012; Zhen et al., 2011). However, there is no study that proposed an integrated implementation framework, which combines QA (HACCP) and QI (lean manufacturing). Based on the findings of this study an integrated implementation framework is proposed which combines lean manufacturing and the HACCP methodology. As most food processing companies are well acquainted with HACCP and lean are finally starting to evolve, it may be useful to integrate lean manufacturing principles in HACCP to get the best results with respect to safety, quality, cost and delivery. This study also found some interesting intersections between HACCP and lean initiatives on the factory floor of food processors.

Subsequently, the degree of use of individual lean practices such as TPM, SPC, supplier, and customer and employee involvement was examined. The result has showed that several lean practices are yet to be fully used in food processing SMEs and variation in the use of lean practices are notable and worth analyzing. The result indicates that lean practices related to customers engagement, involved employees and total productive maintenance are more prevalent among the respondent food processing SMEs. The study shows a low degree of use of some lean practices related to flow, pull, set up, and employee involvement. The result also indicates a low level of statistical process control in food SMEs. The reason attributed to the nature of the production process, product and plant which possess difficulty to implement different lean practices at the same level (van der Vorst et al., 2001; Van Donk & Van Dam, 1996). Similarly, (Abdulmalek et al., 2006) studied the lean practices in a processing industry and he commented on the difficulty of introducing pull and kanban. In addition, the demand in the food sector is very unstable because of unpredictable weather conditions and other seasonal factors (Willaiams et al., 1992). Hence, firms usually have difficulties in implementing a uniform workload and consequently pull systems in the food processing environment are less prevalent. Likewise, the set up reduction is also rarely used with lean manufacturing practice in food processing SMEs due to complicated production processes and multiple raw materials, recipes and composition. It is understandable that as a consequence of the inherent characteristics of the sector some lean manufacturing practices are difficult for food processing SMEs to implement. The reason of the low SPC among the respondents may be attributed to the lack of statistical know-how of staff members in a SME environment. Some of the relatively easy to use practices such as workplace organization and customer involvement are more frequently implemented in food SMEs; this might be because these practices are less resource-intensive (Lehtinen & Torkko, 2005; Zhen et al., 2011). Besides, cleanliness and hygiene are the core focus of the food industry in order to avoid any sort of contamination of products.

Furthermore, almost all parameters related to customers, suppliers and pull display a significant difference with respect to the firm size. For instance, the mean difference of the use of lean manufacturing practice (customer feedback) among micro, small, and medium-sized companies is statistically significant. In the case of set-up reduction, small companies have significant differences in the usage rates compared to medium-sized companies. Similarly, the use of pull practices is less evident in micro-sized companies. As for the other lean practices, the differences were not clear. According to the aggregate score, the total productive maintenance is the most used lean practice among micro-sized firms. Whereas, small sized firms focused more on customer related lean practices. Similarly, medium sized firms are relying on customer related practices and total productive maintenance. There is a significant difference in the mean value related to customer engagement, supplier involvement, pull and statistical process control among the three categories of firms. The results are aligned with the previous studies which claims the size of the company has a significant influence on the use of lean manufacturing practices (Åhlström, 1998; Anand & Kodali, 2008; Bonavia & Marin, 2006; Shah & Ward, 2003). For SMEs it may not be easy to make a major investment on restructuring the layout of the company and on new machinery (Inman & Mehra, 1990). The finding is in line with (Lee, 1997) who claims that firms with less than 50 workers possibly suffer from certain restrictions that hinder implementing lean practices in equal terms. Similar studies also pointed out those large firms have more need of lean manufacturing practices because of the complex production processes and are more able to change things/certain structures due to their available resources. These resources in terms of finance, time, human, knowledge and information put large companies into an advantageous position (Bonavia & Marin, 2006; Inman & Mehra, 1990; Lee, 1997; Shah & Ward, 2003).

An analysis of the control variables (country of operation) does not provide us a consistent result with respect to the differences by country of origin in individual lean manufacturing practices. For instance, the differences with respect to lean manufacturing practices such as flow, employee involvement and supplier related practices are found significant. However, the differences in lean practices implementations such as pull, set up or/and total productive maintenance with respect to country are not significant. Likewise, many scholars divided over the argument about the universal applicability of quality management practices (Mersha, 1997; Rungtusanatham et al., 1998; Voss & Blackmon, 1996; Voss et al., 1995). On one hand, studies argue that the countries with different sociopolitical and economic factors may inhibit the transferability of quality management concepts, principles, and techniques. (Garvin, 1986) explained that US firms for example may not be successful in mimicking Japanese quality management practices without adjusting them to the local conditions. On the other hand, (Choi & Liker, 1995) claim that QM practices such as lean manufacturing are not bound by national culture. Further, (Hofstede, 1984) examined cross-cultural differences and identified four cultural dimensions: power distance, uncertainty avoidance, individualism, and masculinity which influence the implementation success. It will be interesting to compare the quality management initiatives from these cultural dimensions in future research. An in-depth study and a general awareness of cultural boundaries of the quality management phenomenon can help firms make conscious decisions to transfer knowledge quality management practices to other countries. This awareness will enable companies to better manage the cultural barriers and deployment of quality management in different environments.

Performance

There are many studies available on the relationships between practices and performance (Dangayach & Deshmukh, 2001a, 2001b; Fullerton & Wempe, 2009a). Accordingly, researchers found that lean manufacturing practices lead to shorter delivery times, lower inventories and cost and improve quality and productivity. There is, however, limited study that provides empirical examination of the impact of lean manufacturing practices on the operational performance of food processing SMEs. The respondents also highlighted that the application of lean manufacturing improves operational performances, especially productivity and quality. The result of the study confirms earlier studies that claim that the operational performance improves due to the implementation of lean manufacturing (Engelund et al., 2009; Lehtinen & Torkko, 2005; Simons & Zokaei, 2005; Upadhye et al., 2010). However, the Kruskall-Wallis test result shows that there is a difference in the case of three operational performance parameters, namely quality improvement, lead or cycle time reduction and improvement in on-time delivery with respect to the firm size. Moreover, we found that the full benefits of lean manufacturing are not realized by food processing SMEs because of their early stage of adoption and the difficulty in overcoming barriers (Bhasin, 2008). In this research, respondent firms performed relatively low in terms of on time delivery and inventory. The low performance in these indicators justifies the earlier explanation that a pull system is a relatively little used practice in food processing SMEs. This result agrees with (Achanga et al., 2006) who found that the size of the organization is a vital consideration in the lean journey.

The important barriers indicated by the respondents are a lack of knowledge, poor employee participation, availability of resources, lack of training and inadequate process control techniques. The results illustrate that specific aspects of the nature of the food processing industry, such as variability in raw materials, sequential cleaning time, long set-up time between product types and high perishability of the products, are also found to be important barriers to lean manufacturing implementation. The majority of Belgian meat companies indicated that the quality assurance compliance is an important barrier to the lean implementation because of the mandatory separation between processing and packaging. Moreover, some other important barriers of lean implementation among Belgian food processing SMEs are inadequate process control and poor supplier involvement. Hungarian firms stated that a poor employee participation and a lack of resources are the major obstacles for the implementation of lean. The food processing SMEs in Germany specified that a lack of training, poor project selection, lack of knowledge and lack of resources are the significant barriers to the lean implementation. The principal barrier of micro-sized companies are a lack of available resources for lean implementation, poor delegation of authority, poor project selection and internal resistance. The major obstacles for the small-sized companies are a lack of knowledge, poor supplier involvement and variability of raw materials' quality and quantity. The medium-sized companies stated that poor project selection, resources and lack of training are the main constraints.

Cua, et.al. analyzed the practice-performance relationship on two levels: the group level (combination of practices) and the single practice level. Their results show that at the group level implementation, for instance, a combination of JIT, TPM and TQM practices was significant in explaining the improvement in performance indicators. However, at the single practice level, not all practices improved the operational performance (Cua et al., 2001b). Our analysis also shows, due to sector specific constraints, that food processing SMEs may not afford to improve every aspect of the production process and have to choose a specific area of improvement aligned with their business strategy. Hence, it is important to consider for future research that the practice–performance relationship studies might gain from including other considerations such as business strategies and sector specific factors.

Determining factors

The type and magnitude of operational performance differ according to the type of production process, the products it produces (e.g., perishable, bulk, seasonal), the country of operation where the products are made and sold, government regulation, and organizational factors (Abdulmalek et al., 2006; Kumar & Antony, 2008; Luning & Marcelis, 2009a; Testa, 2010; Upadhye et al., 2010; Zarei et al., 2011). Importantly, the determining factors have a significant impact on the lean adoption of companies. What follows is a closer look at all the determining factors, which are identified and examined during the case study, and how they agree or disagree with the previous findings.

Commitment of top management

The commitment of the top management consists of financial support, encouragement, active involvement and the supervision of the lean initiative (Achanga et al., 2006; Boyer, 1996). The result from the case study also substantiates this claim by revealing differences among successful and unsuccessful companies. Especially in the SME context, management commitment is highly relevant due to their close and active involvement in day-to-day operations, in addition to financial support and team motivation functions. Lean implementation requires an initial investment with respect to training, hiring external consultants, providing materials for the visual management and allowing key employees to take the responsibility. These are critical elements for the SMEs and need close attention from the top management. Previous studies also emphasized that the commitment of top management plays a significant role in the successful implementation of lean practices (Gurumurthy & Kodali, 2009; Puvanasvaran et al., 2009). Considering the typical characteristics of SMEs, where top management are personally involved in day-to-day operational activities (Wessel & Burcher, 2004), direct supervision (Ghobadian & Gallear, 1997), top management close to the point of delivery (Deros et al., 2006), better understanding of processes and customers (Beaver & Prince, 2004) the commitment of top management is crucial for lean success (Phelps et al., 2007).

Culture

Organizational culture (internal and external communication, hierarchy, respect and blame game) is a significant factor for effective lean adoption (Mann, 2012). Investigation shows that compact organizational culture contributes to the better performing companies. The findings align with previous studies in the field (Nahm et al., 2004; Schneider, 2000). Furthermore, (Lewis, 2002) claims on the one hand, quality management must fit to the existing culture to succeed; on the other hand, quality management implementation may change an organization’s culture as well. Managers should be aware of the cultural values on which their company relies before trying to implement the QM practices (Zu et al., 2006).

Piecemeal approach

This study found that all the food SMEs surveyed applied lean in a piecemeal manner to fix certain problems, for instance rework or machine downtime. The lean project and practice is often selected based on intuition, not data. This is also known as firefighting behavior of firms (Dowlatshahi & Taham, 2009; James, 2006). Moreover, many consultants recommend

SMEs look for the low hanging fruit (Ballé, 2005; Smith, 2003). (Ramaswamy et al., 2002) found that SMEs trying to implement several lean initiatives simultaneously realized even greater gains. As our study shows, the piecemeal approach factor did not appear to explain success variance across four food processing firms. However, this factor provides an important insight into the issues associated with lean manufacturing implementation in the context of food processing SME. This factor may be included in the not-so-critical factor category instead of critical factors for lean implementation, especially in SMEs, irrespective of sector.

Training

The finding is in line with past research that found that training plays an important role in the successful adoption of lean manufacturing (Sanchez & Pérez, 2001). A deeper look into the training factor reveals two important insights. For instance, what is the content of the training program, who gives the training and finally, who attends the training. The first one concerns training on soft skills and on technical skills. This finding is in line with past research that soft skills is a key factor for success in lean implementation (Farris et al., 2009; Losonci et al., 2011). Second, hiring external consultants to deliver the training seems more effective. Finally, the target audience who attends the training should focus on shop floor employees. The majority of the studies on determining factors of quality management programs found that "leadership and management" is the key factor of successful lean implementation (Hines et al., 2004; Soriano-Meier & Forrester, 2002). However, it remains that skill of the workforce and in-house expertise is one of the most vital factors for the success of lean manufacturing (Kumar & Antony, 2008). Our findings strengthen the claim that it is imperative to train employees on the basics of lean principles and get them involved at the inception of the quality initiatives in the firm.

Multifunctional team

Our study explored the importance of two important elements (i.e., cross-functional team and size of the team) (Karlsson & Ahlström, 1996; Melton, 2005; Sánchez & Pérez, 2001) (Slomp & Molleman, 2002). It found that a smaller team with 3 to 5 people is more effective compared to larger teams; a smaller team size helps in decision-making and consensus building. Moreover, the smaller teams also create a sense of ownership and responsibility to get things done among team members. Previous studies have focused on multifunctional teams (de Haan et al., 2011; Tranfield et al., 2000). However, there is limited information on the role of smaller team size in lean manufacturing implementation. (Ramaswamy et al., 2002) suggest that buffer stock removal and lot size reduction are the most important issues for SMEs, and multifunctional workers as well as preventive maintenance the least important ones. However, our analysis does not find evidence that a multifunctional team contributes to the success of lean implementation.

Resource

This study explored various elements to assess the impact of resource availability in food SMEs such as human resources, technical know-how, finances to cover training costs and other investments. Previous studies crudely claim that SMEs lack resources (Gerstenfeld & Roberts, 2000; McAdam & Reid, 2001; Wickramansinghe & Sharma, 2005). Our study found that this claim is only partially true. The case companies have little difficulty with financial support for training, consultancy and other small investment. However, the firms lack financial resources to make big investments, for instance, changing a traditional layout to a modern cellular layout for better flow. Big investment is certainly an obstructing factor for lean implementation, but small investments like training and consultancy fees are not. Another important factor is lack of time among key employees and advanced statistical skills among staff; those were found to be the barriers of lean implementation. Additionally, there is financial support available for SMEs to implement QM practices through government agencies, but it is found limited. Hence, scarcity of resources can be considered as an excuse from the management to continue working in a fire-fighting mode to tackle day-to-day operations. As explained in chapter 4, a small sausage company with 22 people at the production floor managed to implement lean practices and achieve success. Broadly speaking, we agree with previous studies that SMEs lack resources (Achanga et al., 2006; Bruce et al., 2004; Hudson et al., 2001). However, this concerns only the big investment. Smaller investments such as training cost, consultancy fees and visual display materials are not a problem for the firms.

Organizational structure

We examined three organizational structure characteristics: ownership, decision-making process and unionization. One of the major causes of limited success of lean in the case companies may be unionization. The top management found it difficult to ensure smooth implementation of lean practices because key employees were not convinced of the lean initiatives and their benefits. In addition to that, the ownership of the company and the decision-making process were found to be important factors of lean implementation. These findings support the claim that organizational structure does matter in the success of lean adoption (Shah & Ward, 2003; Smeds, 1994).

Remuneration

It is proven that firms with a good and dynamic remuneration system fared better in implementing lean compared to companies with a static system. Our results regarding the claim that the remuneration system plays a big role in successful lean implementation were mixed. These findings are a contrast to the claim made by (Berggren, 1993) that elaborate remuneration systems can stimulate many small ideas and can help companies to make it big. As our study shows, remuneration as a determining factor did not appear to explain success variance across four food processing firms. However, this factor provides an important insight into the issues associated with lean manufacturing implementation in the context of food processing SMEs. It may be included in the not-so-critical factor category for lean implementation, especially in SMEs, irrespective of sector.

Change agent

The success of lean initiative seemed to be directly associated with the quality of the change agent. He must possess relevant technical knowledge and soft skills. A crucial task of the change agent is connecting the top management's vision with the operators' ideas at the work floor by means of sensitive communication skill. The change agent could be an internal person or an external consultant. Some studies consider that an external consultant as a change leader is more effective than the internal ones because external change agents can interact both directly and indirectly with internal change agents to stimulate the change initiatives (Birkinshaw et al., 2008). We do not agree with the claim that external consultant can be more effective than internal ones. An internal change agent with sound knowledge and good soft skills, who stays in the company unlike external consultants, who leave the company after finishing the project, may be more effective and sustainable for the firms. It is clear from the cross-case analysis that the change agent plays a significant role in the successful implementation of lean manufacturing practices. Previous studies have not given prominence to the change agent factor as a critical success factor in lean implementation (Achanga et al., 2006). However, studies focusing on large firms suggest that the change agent plays a significant role in successful lean implementation (Armenakis et al., 1993; Kosonen & Buhanist, 1995; Smeds, 1994), given the special characteristics of SMEs.

Nature of the process

The nature of the food production process has been characterized as: 1. variable yield and processing time, 2. high variation of composition, recipes, products and processing techniques, 3. production rate determined by capacity, 4. divergent product structure, especially in the packaging stage, 5. variable yield and processing duration, variable product structure (Van Donk, 2001). This study explored how these factors influence lean adoption. Firstly, for the food processing companies the delivery times are usually short and customers (supermarket) demand products with quality assurance compliance often on short notice. This phenomenon creates a bottleneck in the production planning and makes it difficult to meet the customer's need. In most cases the supermarkets pass the uncertainty in demand on to the producers. It means that supermarkets place their order based on just in time principle; on top of that, they do not encourage producers to produce in stock because the long product shelf life is crucial from a commercial point of view. In this respect, cooperation and regular communication between supermarket and food processor can help to increase the lead time. Moreover, a minimum shelf life of food products possesses a challenge for food processors. The product can be technically good, but retailers will not accept it because, from a commercial point of view, it has expired based on the best-before-use tag. One of the important issues found during the study is that the quality assurance requirements of the food processors present a barrier for lean implementation. We also found that the frequent cleaning times and set ups are an integral part of the food processing sector in contrast to other industries, e.g. automobile companies. In most cases, these activities are sequence-dependent and need to be included in the production planning. It was reported that the set up reduction was not easy and resulted in very little success. One important observation is that, in all four case companies, the packaging section seems to have major bottlenecks. The reason may be attributed to the pack-to-order approach of the companies and with very unpredictable demand the packaging section is subjected to major pressure. The suggestions made by previous studies - to develop packaging lines with small set ups and standardizing the packaging materials (van Dam et al., 1993) does not seem feasible for the food processing SMEs because of their constraints in respect to financial resources and meeting customer demands in a fiercely competitive market. Some studies also proposed to use advanced computerized planning systems to correctly plan the demand and production for the food industry (Skok & Legge, 2002). However, advanced planning systems need big investment and skill, which seems scarce in SMEs. The cross-case analysis among four food firms proposes that the nature of processes should be identified as a critical determining factor for lean implementation, given the special characteristics of the food sector.

Nature of the product

The study examined the nature of the product and its influence on lean implementation. The highly perishable product (raw material, semi and finished product) and the variability in the raw materials' quality, supply and price due to unstable yield have a consequence on lean implementation. For instance, a product sensitive to external variables (moisture, weather, temperature and several other natural factors) makes the implementation of certain lean practices difficult. (White & Prybutok, 2001) found that lean practices are less likely to be implemented in non-repetitive systems. The cause of the lower implementation rates in non-repetitive systems is that lean practices were designed in – and have their roots in – a repetitive production system. Similarly, (Katayama & Bennett, 1996b) demonstrated that lean production is incapable of responding to large fluctuations in aggregate demand volumes. Similarly, a small variation in recipe mix, temperature, baking time, or storing time of one of many ingredients can change the specification of the product. It became very complicated and very difficult to find the root cause of the problem. Another important issue is the demand fluctuation due to the change of weather. One important observation was the anomaly in processing time, product shelf life and storage. Moreover, slow-moving products have a risk of becoming obsolete. These factors make inventory management difficult for the food processors. Our study aligns with the claim that the application of lean manufacturing is not straightforward in a high product variety and low volumes environment such as the food sector (Jina et al., 1997a).

Nature of the plant

The nature of the plant has been characterized as: 1. single-purpose expensive machines, product variety and high volume; 2. long sequence-dependent set-up time between product types; 3. processing and packaging are separated because of QA requirements; 4. usually, the factory shows a flow shop oriented design (Van Donk, 2001). It is observed that the layout of the most traditional food processing firms is designed according to the quality assurance (e.g., HACCP, BRC) requirements. These restrictions are often not flexible and prevent a smooth flow and movement. This causes extra movement for the operators, which results in a waste of time. The design of the traditional layout is not optimal and not planned according to the lean manufacturing principle. Moreover, there are long set-up times (changeover) between different products, because of cleaning and other quality assurance requirements (White et al., 1999b). The design of the traditional layout is not optimal and not planned according to the lean manufacturing principle. The slicing and packaging machines are for a single purpose. There are long set-up times (changeover) between different products, because of cleaning and other quality assurance requirements. The analysis indicates that nature of plant should be identified as a critical determining factor for lean implementation, given the special characteristics of the food sector.

The **core message** derived from the overall analysis regarding the challenges confronted by food processing SMEs in the quality management journey can be summarized as follows: A first key finding in this study is that food processing industries are currently focusing on food safety and quality assurance methods and less on process improvement methods. This is most likely due to the stern governmental quality assurance requirements and the customers' (retailers) demand for quality certification. In this way, little attention is still given to quality improvement methods such as lean manufacturing.

Secondly, our empirical results highlight that applying lean manufacturing improves the operational performance in food processing SMEs significantly, especially in relation to productivity and quality. Thus, there is a potential for a lot of improvement in the food processing sector due to lean manufacturing practice implementation.

Thirdly, the data reveal that variations in the use of lean practices are substantial and that some lean manufacturing practices are yet to be fully used in food processing SMEs. Respondents found it challenging to implement specific lean practices such as Pull and Kanban in their production process. Furthermore, the lack of flexible and multi-functional equipment as well as the lack of resources in food processing SMEs make it less likely to implement cellular layouts.

Fourthly, this empirical research has examined the relationship between the size of a company and its country of origin in the implementation of lean manufacturing practices. The analysis confirms that the size of the company is positively correlated with the use of lean manufacturing practices. The use of some lean manufacturing practices also varies across countries but the inconsistent across practices.

Fifthly, this study identifies determining factors which are critical to the successful implementation of lean. The food processing SMEs that manage these determining factors effectively have a higher probability of implementation success. The findings confirm that factors such as commitment of top management, training, resources, organizational culture and structure are important to the successful implementation of lean. Additionally, our findings extend the knowledge about the design of training modules and target audience. Training on soft skills is equally important as technical knowhow for successful lean implementation. Moreover, targeting the right audience (i.e., shop floor employees) for the training program is critical. The culture of the company (i.e., communication, respect, discipline) proves to be a very important determinant for successful lean implementation.

This study clearly shows, besides organizational factors, how sector specific factors, such as nature of process, product and plant structure, are critical for the implementation of lean in the food sector. The study identify that product perishability, supermarket behavior, extremely volatile demand and supply, traditional production process and layout all play a significant role in lean application. Further, small companies with a traditional layout and mandatory quality assurance requirements have difficulties in replicating lean practices. Out of a wide range of contextual factors among which organizational structure, remuneration and change agent, the most important determinant is “change agent.” It is crucial for companies to find a highly motivated “change agent” who can serve as a catalyst for

change. Moreover, the lack of a well-structured implementation plan for SMEs may be the reason why lean practices are currently less successful in SMEs.
Moreover, the lack of a well-structured implementation plan for SMEs may be the reason why lean practices are less likely to be successful in SMEs. There is no clear, standardized, easy-to-use guideline for a lean manufacturing practice implementation available, which also takes into account the sector specific barriers. Moreover, the cost of applying lean manufacturing implementation and the benefits derived from it are ambiguous and uncertain. There is a lack of standard operational tools, which can help food processing SMEs choose the best investment alternative for quality improvement at the lowest possible cost. This is an important impediment for a small food processor. Secondly, it is true that the smaller companies have some advantages because of their flexibility and quick decision making abilities but challenges with respect to skill, human and capital resources, data, and most importantly, the lack of time possesses a stumbling block in their lean journey. Finally, unlike cars, most food products are perishable, seasonal, subtle, and sensitive to contaminations. These factors significantly influence the firms' initiatives and their operational performance.

Hence, in order to assist food processing SMES and facilitate the effective implementation of lean manufacturing, this study proposes a framework - house of lean that takes into consideration the needs and characteristics of food processing SMEs. It provides a step-by-step approach for implementing lean manufacturing in a food processing SME environment. The "house of lean" aims to present a structured approach to understand contextual factors and to support food processing SMEs to flourish and reach their full improvement potential.

6.2 The research propositions revisited

Proposition 1: *The food processing SMEs give more priority and acceptance to quality assurance practices (e.g. HACCP) than to quality improvement (lean)*

What makes food processing SMEs choose and undertake a specific quality management practice? It is evident from the analysis that the respondent SMEs focus more on quality assurance initiatives compared to quality improvement practices. This study found that one of the prominent reasons for this is the obligation to fulfill quality certification criteria, typically imposed by government agencies, compliance to customer demands and/or the need to attract new customers. Firms consider implementing lean manufacturing practices based on the return on investment or cost-benefit analysis. This analysis includes different factors ranging from resistance to resources. Unfortunately, small food processors lack the competence as well as an effective method to access the costs and benefits involved in lean implementation, which prevents them from making an informed decision.

From the analysis we can conclude that out of three forms of organizational isomorphic drivers (coercive, normative, and mimetic) as proposed by (DiMaggio & Powell, 2000), the coercive isomorphic drive explains the behavior of food SMEs best. The findings agree with other scholars who previously stated that government agencies coercively influence food processors to adhere to HACCP compliance. Similarly, customers demand for a specific quality assurance method and food SMEs are (mostly) forced to comply with the demands to retain the customers in a highly competitive market. However, in recent years, mimetic isomorphic drives have started to influence firms to implement lean manufacturing practices in order to remain competitive in the market (Bae & Rowley, 2002). But, to answer the question whether the institutional coercive isomorphism is more dominant than the normative or mimetic isomorphism, one has to say ‘yes’ in this context. Food processors are mostly driven by institutional coercive isomorphism rather than the normative or mimetic isomorphism (Sturdy, 2004). The findings agree with (Ketokivi & Schroeder, 2004b) who found that firms select quality management initiatives based on rational (systematic evaluation) as well as irrational factors such as the current trend, impulse, persuasion, power (regulation) or culture.

Proposition 2: *There is a variation in the degree of knowledge and usage of individual lean manufacturing practice in the food processing SMEs*

Lean manufacturing is comprised of a set of practices (customer related, supplier related and internally related). This study has investigated an important research gap: Which lean manufacturing practices are more prevalent in food processing SMEs? Empirical research that mostly focused on the non-food sector (especially in the processing industry) claims that the employee involvement, statistical process control and customer involvement are more common than other practices (Inman & Mehra, 1990; Lee, 1997; White et al., 1999a). Hence, the degree of the use of individual lean practices are examined in this study and it was observed that the lean practices are yet to be fully used in food processing SMEs and that variations in the use of lean practices are notable. The reason attributed to the food sector specific characteristics such as perishability, weather dependency, multiple variation in ingredients, recipes, products, traditional layout, etc. possess a barrier to selected lean practices (van der Vorst et al., 2001; Van Donk & Van Dam, 1996).

Some lean practices are found to be universally applicable such as work place organization, visual management, set-up reduction and mapping the process (Willaiams et al., 1992). However, it is also important to note that firms with relatively more human and capital resource are successful in using set-up reduction and processing mapping practices. As the priority of the food sector is cleanliness and hygiene, the workplace organization can also be combined with quality assurance methods. Moreover, it was observed that specific food processing SMEs producing confectionary and meat products have difficulty implementing JIT because of very uncertain demand fluctuation. Similarly, food processing SMEs found it challenging to implement pull and kanban in their production process (Abdulmalek et al., 2006). It is also observed that the lack of flexible and multiple use equipment in resource-constraint food processing SMEs make it less likely to implement cellular layouts.

It is also important to mention that there could also be some limitations and potential barriers to implementing the different lean practices. For instance, one of the limitations for the SMED is video recording of the activities at the work floor. It is observed that the worker union was against the video recording. Moreover, the employees found it uncomfortable to the recording and their work analysis. Additionally, moving staff from the maintenance department to the other department was also not easily acceptable for employees because they have to do the extra work.

Proposition 3: *The degree of lean manufacturing practices is highly dependent on control factors*

This empirical research examined the impact of the control variables (size of the company and country of operation) on implementation of lean manufacturing practices. The analysis confirms that the size of the company has a role in the use of lean manufacturing practices (Åhlström, 1998; Anand & Kodali, 2008; Bonavia & Marin, 2006; Shah & Ward, 2003). Similar studies also pointed out that large firms have more need of lean manufacturing practices because of the complex production processes and are able to make necessary changes because of their available resources (Inman & Mehra, 1990). The finding is in line with the claim that the firms need resources in terms of finance, time, human capital, knowledge and information (Bonavia & Marin, 2006; Inman & Mehra, 1990; Lee, 1997; Shah & Ward, 2003).

The analysis does not provide us a consistent and conclusive result with respect to the differences by country of origin in individual lean manufacturing practices. For instance, the differences with respect to lean manufacturing practices such as flow, employee involvement and supplier related practices are found significant. However, the differences with respect to lean practice implementations such as pull, set up or/and total productive maintenance with respect to country is not significant. We can conclude by agreeing with (Lillrank, 1995) that some lean manufacturing practices (techniques) can relatively easily be adapted to different company and country circumstances but, lack systemic context and can therefore simply be misapplied.

Proposition 4: *The lean adoption of a firm is contingent on identification and understanding of determining factors (enabling and/or obstructing)*

One important aspect of this study was to evaluate and understand the relationship between determining factors and the lean adoption - a process of implementing lean practices in an organization. Our study accesses the lean practice adoption and the influence of the determining factors (the internal and external) (Ketokivi & Schroeder, 2004b; Luthans & Stewart, 1977; Morton & Hu, 2008; Raymond, 2005; Sousa & Voss, 2008).

The results of our research are more consistent with the contingency theory (Sousa & Voss, 2008), than a universalist conception of lean manufacturing (Egan, 1998; Morris & Lancaster, 2006). (Agarwal et al., 2012) empirically investigated 152 firms to understand the universalist and contingency phenomena of management practices and concluded that some management practices are more universal than contingent and vice versa.

For instance, it is evident from our analysis that the people related challenges such as low level of skill and training of employees have significant impact on lean adoption. The generic skill is inadequate and often creates a competency gap. According to (Mensah & Julien, 2011), ignoring the competency gap leads to resistant culture and low morale among employees. It is apparent from our study that SMEs rate employee resistance a major barrier to lean. A regular training program pertaining to lean implementation helps fill the competency gap. However, financial resources to fund the training programs by a professional trainer are scarce for SMEs. This factor also related to the commitment of the top management, who is responsible for allocating necessary financial and moral support for lean adoption.

Moreover, this study offers an integrated assessment of the determinants of the adoption of lean manufacturing practices in a food processing SME environment and provides evidence that several factors are likely to influence the lean adoption in firms. Furthermore, it is also important to note that firms may be better in adopting lean practices by investing in employee and skill development and the improvement of productivity.

As explained in the above general discussion section the sector specific factors have a significant influence on the lean journey. For instance, the food processing SMEs mostly produce based on forecast, not on make to order basis. The forecast lead time for production is often long which results in a huge difference between the production and actual demand. This leads to a large inventory of finished goods. This is one important obstacle of lean, which advocates limited or no inventory. Moreover, there are many variable combinations of lead times and production lead times that add complexity to an already complex business. For example, the shelf life of food products is short. The procurement lead time for raw material is long. And again the lead time for final packaging is short. These are unique characteristics of the food sector, which can't be ignored while planning lean implementation.

Proposition 5: *Food processing SMEs that implement lean manufacturing practices, experience better operational performance*

There are a number of studies that investigated the practice-performance relationship but none of them focuses on food processing SMEs (Dangayach & Deshmukh, 2001a, 2001b; Fullerton & Wempe, 2009a). Moreover, there is no consensus among researchers about the success of lean manufacturing irrespective of the sector and the sizes of the companies. (Engelund et al., 2009; Goncharuk, 2009; Jain & Lyons, 2009; Mahalik & Nambiar, 2010; Scherrer-Rathje et al., 2009; Scott et al., 2009). This empirical research agrees that food processing SMEs that use lean manufacturing practices, experience better operational performances. The analysis shows that the participating companies performed well in improving productivity and quality compared to other performance indicators listed. However, there are several internal and external determining factors, which influence the practice-performance relationship (Engelund et al., 2009; Lehtinen & Torkko, 2005; Simons & Zokaei, 2005; Upadhye et al., 2010). This is also the reason why the optimal paybacks from lean manufacturing implementation are not achieved by the firms. Furthermore, the performance indicators are correlated and difficult to study with a mutually exclusive condition (White & Prybutok, 2001). It is also important to note that there is a significant variation in different performance indicators. Similarly, the size of the company also plays an important role in the practice–performance relationship (Achanga et al., 2006).

6.3 Empirical contribution

This doctoral dissertation has provided empirical evidence on the association between lean manufacturing practices, operational performances, and determining factors based on the results from a survey and case study among food processing SMEs is Belgium, Germany and Hungary.

The key criticism of lean manufacturing research is the lack of focus on contingency and the ability to cope with variability, the lack of consideration of human aspects, and the narrow operational focus on the shop-floor (Hines et al., 2004). This research has attempted to fill some of these important gaps by assessing applicability and effectiveness of lean manufacturing in food processing SMEs. In general, many studies have explored lean constructs and tools, while far fewer have explored the crucial element of actually implementing these. The empirical contributions are achieved by investigating five theoretically grounded research propositions, which provide a better understanding of 'lean manufacturing in food processing SMEs'.

Firstly, the insight on institutional isomorphism (coercive, normative or mimetic) in the context of choosing an appropriate quality management practice in a different setting (food processing) contributes to the theoretical progress.

Secondly, an empirical evaluation of the effectiveness of lean manufacturing in any setting through the prism of the contingency theory further contributes to the knowledge. It is worth mentioning that our findings contradict the claim by (Agarwal et al., 2012) that management practices, such as lean manufacturing, are more universal than contingent. This paves the way for researchers to further investigate this topic.

Thirdly, this study has filled an important research gap by evaluating the most used or prevalent lean manufacturing practices in food processing SMEs and the reason thereof. It has also pointed out the challenges of certain practices in the food processing context. These findings compliment the claims made by previous similar studies (Abdulmalek et al., 2006), (Lee & Allwood, 2003; White et al., 1999a), (Cox & Chicksand, 2008).
Fourthly, one important contribution is the understanding of the relationship between determining factors and the lean adoption, especially in the umbrella of contingency theory. The analysis of internal and external factors that influence the lean implementation are scrutinized and provide a better understanding (Ketokivi & Schroeder, 2004b; Luthans & Stewart, 1977; Morton & Hu, 2008; Raymond, 2005; Sousa & Voss, 2008).

Finally, the insight on the lean manufacturing practices implementation from three European countries and of the subsectors contributes to the literature. As explained earlier, the countries with different sociopolitical and economic factors may inhibit the transferability of quality management concepts, principles, and techniques (Mersha, 1997; Rungtusanatham et al., 1998; Voss & Blackmon, 1996; Voss et al., 1995). Similarly, the selected sub-sectors in this study - chocolate, confectionary, bread and meat processing sectors - also provide evidence of variation with respect to lean practices, performance and determining factors. The findings complement the previous research that different company and country circumstances may lead to a misapplication of lean practices due to the lack of a standardized framework (Lillrank, 1995).

6.4 Methodological contribution

We did not find any evidence from the previous literature that earlier studies used the triangulation method to investigate the applicability of lean manufacturing in food processing SMEs. This research adopted a mixed method approach (survey + case study) to contribute to the advancement of the methodology. The triangulation method provides a deeper understanding of processes that give a chance to test hypotheses and to get a good picture of locally grounded causality (Miles & Huberman, 1994). One of the most important benefits of mixed (triangulation) method is robustness and validity of the collected information. To quote (Duffy, 1987), "*Validation of empirically generated constructs can be obtained by comparison with interview and/or observation data; where discrepancies exist, additional probing can be done to determine whether the mismatch was because of a weakness in the instrument or to misinterpretation by the individuals taking the test*". Similarly, clarification of ambiguous responses during interviews can be detected by reassessing field notes and information which were overlooked initially but can be documented (Madey, 1982). This approach may inspire other researchers in the future to investigate sector specific research problems.

6.5 Knowledge transferability

Firstly, taking cue from the findings, and understanding the limitation of lean manufacturing implementation in food processing SMEs in its current form, this study proposes a lean manufacturing implementation framework tailored to the needs of food processing SMEs. This integrated lean implementation framework "house of lean for food processing SMEs" is based on (Hines et al., 2008) "Lean Iceberg model" with a contingency view. The managers will get a better understanding of several contextual factors inherent in the product, process, and plant that specifically hinder and/or help lean manufacturing implementation, which can help them in the decision making. The framework will help firms build a sustainable and comprehensive quality culture (integrating both safety and efficiency aspects) based on strong leadership, fact based decision making, training, and customer focus. Equally, the framework may be used within other business contexts such as large sized food processors. One more important value addition of this framework will be that quality management in the food sector will now broaden its scope and no longer narrowly focus on food safety issues.

Secondly, one of the objectives of this research was to assess the variation in the degree of use of individual lean manufacturing practices in the food processing SMEs. The findings demonstrated that food processing SMEs can implement lean practices in varying degrees depending on the specific product and process characteristics. The identification of easy and difficult lean practices provides a good starting point to plan for lean implementation in the food processing sector. One important finding is that process mapping is a valuable tool for food processing SMEs and can reveal wastes in the production process. This is followed by the easy to use practices (workplace organization, visual management), which need less effort than the tougher practices such as cellular layout and kanban.

Thirdly, the practitioners can benefit from the fact that the size of the company especially concerning available resources is an important factor which influences lean implementation. Similarly, issues related to country of operation especially the cultural boundaries, regulations, workers attitude, employment scenario need to be considered by the managers while planning lean implementation.

Fourthly, the managers will benefit from the added knowledge on how the nature of the production process and product in food sector influence the lean implementation or transformation in the firm and how to manage the unpredictability.

Finally, it is important that beside food safety, the managers in food processing sector should also include quality, cost, lead-time, and delivery as operational performance indicators. Moreover, integrating safety and efficiency as key performance indicators will certainly help firms gain competitive advantage in the market.

6.6 Policy implication

Lean manufacturing can significantly help the food processing industries-Europe's largest but uncompetitive manufacturing sector to regain market share. In this regard, the policy makers and public authorities in Europe can play a vital role in successful application of quality improvement practices such as lean manufacturing in food processing SMEs. It was possible for government agencies to enforce HACCP implementation in food companies across Europe, irrespective of the size of the companies. Similarly, the public authorities can promote lean implementation by encouraging and adequately supporting them. The main focus of such efforts should be to maximize the benefits derived from the lean implementation. Alternatively, by eliminating the obstacles by truly understanding the contextual factors: organizational factors (e.g., culture, training, resource, remuneration) and contextual factors (food product, process and plant). Particular importance may be given to the creation of collaborations among food processors and universities, research institution, and knowledge centers that will encourage the application of lean manufacturing, with emphasis on research, training, and development. These points provide a direction for the formulation of public policy related to small and medium sized food enterprises for the larger interest of the European economy and employment.

6.7 Limitations

These limitations may be taken into account in the interpretation of the findings. The small sample size and the low response rate affect the generalization of the results. The reason for the low response rate might be attributed to the specific characteristics of the food sector and the size of the companies. As the lean manufacturing practice deployment in food processing SMEs is generally low, the potential respondents (managers in food SMEs) may not be aware of different lean manufacturing concepts. This also may be the reason why (Mahalik, 2010) emphasized the introduction of lean manufacturing in the food sector in his editorial remark in the "Trends in Food Science & Technology" journal. In addition, one of the barriers to apply an advanced statistical test is the fact that we have a small sample size. Similar studies concerning quality management in food SMEs, such as (Scott et al., 2009), (Fotopoulos et al., 2011), (Kumar & Antony, 2008) also used descriptive statistics because of the small sample size. Above all, this study is a first attempt to understand the application and effectiveness of lean manufacturing practices in the context of European food processing SMEs and will pave the way for more research on this topic in the future.

Another potential limitation of the study results can be the homogenous sector (similar product category). The manufacturing practices implemented in one firm can be rapidly spread to another firm. This phenomenon can be a barrier to assess differences in firms operational performances.

This research is explanatory in nature (when the topic or context is relatively new – e.g., lean in food processing SMEs). Literature also suggests that for many researchers and practitioners in the food sector, quality improvement concepts such as lean and six sigma are new (Mahalik, 2010; Mahalik & Nambiar, 2010). Hence, we tried to explain the concepts in details with simple statistical analysis for those readers mainly working in the food SMEs.

It may be difficult to claim that this research is free of the biases due to self-reported practice and performance data. Moreover, the majority of the respondents were top managers - such as CEOs and general managers. This might have resulted in biased responses to some of the questions, such as whether a lack of the "commitment of the top management" was a barrier to the lean manufacturing implementation. However, this study draws some important conclusions and suggests potential areas for further work.

Finally, it normally takes a long time to reap or even assess the true benefit of lean implementation. It took Toyota, 40 long years to be where it is now with a single devoted objective of "continuous improvement". The limited time frame of the present research project also can be a constraint when assessing the benefits and barriers accurately.

6.8 Directions for future research

The aforementioned paragraph introduced some of the limitations of this doctoral research, which could be improved in the future to make the findings more generalizable to the larger population. Some of the possible ways to address the generalizability issue are listed below: One, the survey and case study research should also include large organizations to do a comparative analysis of differences in quality management practices in SMEs and large organizations.

Two, the current research is a first step towards the development of a profile of lean manufacturing implementation in the food processing SMEs context. This study does not suggest causal linkage. However, this study can act as a base to conduct further explanatory research to statistically establish the causal relationship between lean practices, operational performance and determining factors with a statistically significant sample size.

Three, furthermore, this study provides a stepping stone for several fertile areas for future research. An untested topic in the lean literature is implementation barriers related to organizational culture/managerial support and the impact of lean on employees (morale, productivity, physical and psychological safety etc.)

Four, there is a need for more replication studies in the quality management practices in different settings (e.g., sector, size, country).

Five, future research should also explore the relationship between QA and QI implementation, as this study has indicated an interesting intersection and interaction between the two.

Six, develop quality schemes integrating lean manufacturing practices and examine the feasibility and impact of possible governance structures (mandatory, voluntary or a mix).

Seven, some of the emerging research trends will include: integration of lean manufacturing with six sigma, agile manufacturing, and theory of constraints. Importantly, for the food processing industry, integration of lean manufacturing with other quality initiatives such as HACCP, ISO, BRC etc. will certainly gain attention in the near future, especially in the context of SMEs.

Eight, one of the areas that needs further exploration is the relationship between lean manufacturing and innovation. Does lean facilitate innovation or hamper it by following a structured and disciplined approach? This is a very promising area of research that needs investigation. Similarly, this research study showed that lean manufacturing in the food processing sector is gaining attention, but how it is going to be used at different levels of the food chain is the next challenge.

6.9 Critical Reflection

After more than two decades of the origin of lean manufacturing, many researchers raise the question if lean manufacturing is still relevant in a modern, highly automated robotic industrial era. I believe the fundamental principle or thinking of lean manufacturing is relevant and very much sustainable. Lean thinking is not a passing management fad unlike other short-term quality initiatives. As (Hines et al., 2004) says 'lean is a way of life'. Lean is a powerful business strategy based on a continuous improvement ideology that aims to eliminate the waste in the production process. The challenge for organizations is to integrate lean manufacturing into their core business processes and operations rather than managing it as a separate initiative. In my opinion, the need for lean manufacturing will continue to grow as a powerful management initiative, as the complexity of modern industries further increase. It is possible that lean will evolve into a 'new package' considering the rapid technological advancement. In the future, lean manufacturing will be enriched by the continuous emergence of new useful tools and techniques, especially in the software, finance and healthcare applications.

Some interesting and important arguments came from the operation managers during this doctoral research. Statements like “we are too small to be lean, it’s for the large companies” or “food companies are way too complex to follow the lean principle” show the mentality of food SMEs. In my opinion, these statements are more an excuse than logic. The same small food companies are able to implement HACCP or BRC in their organization. The only reason for this is that HACCP is mandatory by the government and lean is not.

Furthermore, the support from universities and research institutions or government agencies can play a crucial role in raising the awareness and establishing an appropriate quality management system. Government agencies can help food SMEs to improve their process efficiency and effectiveness by facilitating subsidies to get support from experts and consultants. Similarly, universities and research institutions can offer support to SMEs to resolve the operational problems of the firms. However, there are two issues: one is whether policy makers are aware of the importance of the quality improvement methods and its benefits and two, whether the SMEs are aware of the existing support systems. There need to be some changes in the government policies (in redefining the roles and responsibilities of agencies) and required active involvement of academics (by organizing more conferences, seminars, and workshops tailored for SMEs). This would raise the awareness about the available support for SMEs to improve their operational efficiency and effectiveness.

SUMMARY

Lean manufacturing – a prominent quality management practice - utilizes fewer inputs and creates the same outputs while contributing more value to customers by eliminating waste in the process. Lean manufacturing has been proven to significantly improve companies' operational performance with respect to cost, quality and delivery, though predominantly in the automobile sector. Scientists claim that lean manufacturing has been applied to numerous industries to yield drastic improvements and there is no reason why food processing SMEs cannot take these advantages. Still, the applicability and effectiveness of lean manufacturing in food processing SMEs is still an intensively debated topic in the scientific literature. This doctoral research is undertaken because practitioners and scientists working with food processing SMEs expressed the need for a better understanding of lean manufacturing implementation. The prominent research problems addressed in this doctoral research are: 1) Why only a few food processing SMEs take advantage of lean manufacturing ; 2) Is there anything inherent to food processing SMEs with respect to plant, product, process and organizational behavior that influences the applicability and effectiveness of lean manufacturing? In other words, what are the determining factors that contribute to the variations in operational performance in food processing SMEs and importantly, how?

This doctoral research includes lean manufacturing, operational performance and determining factors to get a comprehensive understanding of the applicability and effectiveness of lean manufacturing in food processing SMEs. Moreover, plant size and country of origin (as control variables) are used to determine the degree to which lean manufacturing is used. The central contribution of this doctoral research is that it extends the contingency view in the operations management literature by investigating the determining factors and their relationship with lean manufacturing and operational performance.

To achieve the aim of this doctoral research, a triangulation method of data collection was used. In the first stage, a thorough literature review was carried out to find out the state of the art in quality management in food processing SMEs. In the second stage, an exploratory research (survey) was undertaken to identify the current status of quality management in food processing SMEs in three European countries (Belgium, Germany and Hungary). The database generated from the second stage of study was used to conduct an explanatory research (case study) in the third stage.

The key findings of this doctoral research are as follows: Firstly, food processing SMEs are currently focusing on quality assurance (food safety and quality) and less on quality improvement. This is most likely due to the severe governmental quality assurance requirements and the customers' (retailers) demand for quality assurance certification. In this way, little attention is still given to quality improvement, as lean manufacturing.

Secondly, lean manufacturing implementation improves the operational performance in food processing SMEs significantly, especially in relation to productivity and quality.

Thirdly, variations in the use of lean manufacturing practices are substantial and some practices are yet to be fully used in food processing SMEs. Respondents found it challenging to implement specific lean manufacturing practices such as Pull and Kanban in their production process. Furthermore, the lack of flexible and multi-functional equipment as well as the lack of resources in food processing SMEs make it less likely to implement cellular layouts.

Fourthly, the size of the company is positively correlated with lean manufacturing implementation. However, analysis does not provide us a consistent result with respect to the differences in individual lean manufacturing practices by country of origin. The scholarly argument about the universal applicability of quality management practices remains to be investigated in the future.

Fifthly, several determining factors are identified which are critical for the success of lean manufacturing implementation. Food processing SMEs that manage these determining factors effectively have a higher probability of implementation success. Factors such as commitment of top management, training, resources, organizational culture and structure are important for the success of lean manufacturing implementation. Additionally, these findings extend the knowledge about the design of training program and target audience of lean manufacturing. Training on soft skills is equally important as technical knowhow for the success of lean manufacturing implementation. Moreover, targeting the right audience (i.e., shop floor employees) for the training program is critical. The culture of the company (i.e., communication, respect, discipline) proves to be a very important determining factor for the success of lean manufacturing implementation as well.
Besides the above organizational factors, sector specific factors, such as the nature of process, product and plant structure, are also critical for lean manufacturing implementation in food processing SMEs. Product perishability, supermarket behavior, extremely volatile demand and supply, traditional production process and layout all play a significant role in

lean manufacturing implementation. Further, small companies with traditional layout and mandatory quality assurance requirements have difficulties in replicating lean manufacturing. Out of a wide range of determining factors (e.g. organizational structure, remuneration and "change agent") the most important is "change agent." It is crucial for companies to find a highly motivated "change agent" who can serve as a catalyst for change. Moreover, the lack of a well-structured implementation plan may be the reason why lean manufacturing is currently less successful in food processing SMEs.

In order to assist food processing SMEs in lean manufacturing implementation, this doctoral research proposes a framework - house of lean - that takes into consideration the needs and characteristics of food processing SMEs. It provides a step-by- step approach for lean manufacturing implementation in a food processing SME environment. The "house of lean" aims to present a structured approach to understand determining factors and to support food processing SMEs to reach their full improvement potential. Finally, European policy makers should consider the findings of this doctoral research regarding what makes food processing implement a particular QM practice as well as what are the potential advantages of those QM practices. Further, the findings of this doctoral research should assist them in choosing the right policy measures to support implementation, to improve awareness of the potential advantages, to enhance training opportunities with regard to lean manufacturing. As such, this doctoral research provides an important basis for stakeholders (companies, scientists and policy makers) in the field of lean manufacturing in their effort to improve competitiveness of food processing SMEs in Europe.

SAMENVATTING

Lean manufacturing is een prominent kwaliteitsmanagementsysteem dat minder input vereist terwijl een gelijke output wordt gegenereerd en tegelijkertijd meer waarde voor de klanten door verspillingen te reduceren in het productieproces. Lean manufacturing heeft zijn nut bewezen in het verbeteren van bedrijven hun operationele prestaties met betrekking tot kosten, kwaliteit en stiptheid, hoofdzakelijk in de automobielsector. Wetenschappers stellen dat lean manufacturing reeds werd toegepast in heel wat verschillende sectoren en dat voedingsverwerkende bedrijven ook zouden kunnen gebruik maken van deze voordelen. Niettemin is de toepasbaarheid en effectiviteit van deze managementbenadering bij voedingsbedrijven nog steeds onderwerp van discussie in de wetenschappelijke literatuur. Dit doctoraatsonderzoek is uitgevoerd omdat stakeholders en onderzoekers – die samenwerken met voedingsverwerkende KMO's – de noodzaak aangeven van het beter begrijpen van lean manufacturing. De belangrijkste onderzoeksproblemen die behandeld zullen worden in dit doctoraatsonderzoek zijn: 1) Hoe komt het dat slechts een aantal voedingsverwerkende bedrijven voordeel ervaren bij toepassing van lean-manufacturing; 2) Is er een intrinsieke factor in voedingsverwerkende KMO's met betrekking tot het bedrijf, het product, het proces of het organisatorisch gedrag die een invloed heeft op de toepasbaarheid en effectiviteit van lean manufacturing. Met andere woorden: Wat zijn de determinerende factoren die bijdragen aan variatie in operationele prestaties van voedingsverwerkende KMO's en hoe hebben deze een invloed?

Dit doctoraatsonderzoek omvat lean manufacturing, operationele prestaties en determinerende factoren om een uitgebreid inzicht te verkrijgen in de toepasbaarheid en effectiviteit van lean manufacturing in voedingsverwerkende KMO's. Tevens worden bedrijfsgrootte en land van herkomst (als controlevariabelen) gebruikt om de mate waarin lean manufacturing wordt toegepast, te bepalen. De belangrijkste bijdrage van dit doctoraatsonderzoek is dat het een uitbreiding biedt van de contingentiebenadering in de literatuur met betrekking tot operationeel beheer door de determinerende factoren en hun relatie met lean manufacturing en operationele prestaties te onderzoeken. Om deze doelstelling te bereiken werd tijdens de dataverzameling gebruik gemaakt van een triangulatiemethode. In eerste instantie werd een uitgebreide literatuurstudie uitgevoerd om inzicht te verkrijgen in *de state of the art* in kwaliteitsmanagement van voedinsgsverwerkende KMO's. In de tweede fase werd een exploratief onderzoek (vragenlijst) uitgevoerd om de huidige status van kwaliteitsmanagement in voedingsverwerkende KMO's in drie Europese landen (België, Duitsland en Hongarije) in kaart te brengen. De database die gegenereerd werd in deze fase werd ingezet om een verklarende studie (case study) uit te voeren in de derde fase.

De belangrijkste bevindingen van dit doctoraatsonderzoek worden hierna beschreven: ten eerste ligt de focus bij voedingsbedrijven hoofdzakelijk op voedselveiligheid en

kwaliteitsgarantie, en veel minder op methodes ter verbetering van productiviteit en processen. Dit fenomeen wordt vooral toegeschreven aan de strenge kwaliteitsvereisten opgelegd door overheid en klanten (vooral supermarkten), die kwaliteitscertificaten eisen. Hierdoor wordt weinig aandacht geschonken aan kwaliteitsverbeterende methodes als lean manufacturing.

Ten tweede wordt vastgesteld dat het toepassen van lean manufacturing de operationele resultaten van KMO's in de voedingsindustrie sterk verbetert, voornamelijk met betrekking tot kwaliteit en productiviteit.

Ten derde wordt aangegeven dat belangrijke verschillen met betrekking tot het gebruik van lean manufacturing technieken optreden tussen bedrijven en dat een aantal technieken op dit moment nog niet ten volle benut worden in voedingsbedrijven. Respondenten vinden het uitdagend om lean technieken zoals Pull en Kanban te implementeren in hun productieproces. Het is ook waargenomen dat het gebrek aan flexibele en functionele uitrusting, evenals het gebrek aan middelen in KMO voedingsbedrijven het minder waarschijnlijk maken om cellulaire lay-outs te implementeren.

Ten vierde merken we dat bedrijfsgrootte positief gecorreleerd is met de implementatie van lean. Met betrekking tot verschillen in toepassing van individuele Lean technieken in relatie met het land van origine toont de analyse echter geen consistent resultaat. De wetenschappelijke bevindingen aangaande de algemene toepasbaarheid van kwaliteitsmanagementtechnieken blijft een onderzoekstopic voor de toekomst.

Ten vijfde worden in deze studie een aantal determinerende factoren geïdentificeerd die als kritisch worden beschouwd bij het succes van lean implementatie. Het bedrijf dat dergelijke factoren onder de knie heeft, vertoont een hogere slaagkans bij de uitwerking van lean manufacturing. De bevindingen bevestigen dat factoren zoals engagement van het top management, training, middelen, bedrijfscultuur en structuur belangrijk zijn voor het slagen. Bijkomend breiden onze bevindingen de kennis over de ontwikkeling van trainingsmodules en hun doelgroep uit. Training van soft skills is even belangrijk als technische kennis voor het succes van lean implementatie. Daarenboven is het zich richten tot het juiste doelpubliek (arbeiders) kritisch voor de training. De bedrijfscultuur (vb. communicatie, respect, discipline) is eveneens een zeer belangrijke determinant voor een succesvolle lean implementatie. Naast organisatorische factoren zijn ook sectorspecifieke factoren zoals de aard van het proces, product en bedrijf kritisch bij de implementatie van lean. Bederfbaarheid van producten, het gedrag van de supermarkten, volatiele vraag en aanbod, traditionele productieprocessen en lay-out spelen allemaal een significante rol in de implementatie van lean. Verder wordt vastgesteld dat kleine bedrijven met een traditionele lay-out en opgelegde kwaliteitseisen moeilijkheden ondervinden om lean te vertalen naar hun bedrijf. Uit een brede waaier van determinerende factoren (v.b. organisatorische structuur, verloning en "change agent") wordt "change agent" als de belangrijkste bevonden. Het is zeer belangrijk voor bedrijven om een gemotiveerde "change agent" te vinden die kan fungeren als katalysator voor verandering. Daarenboven zou het gebrek aan een goed gestructureerd implementatieplan voor KMO's de reden kunnen zijn van de vaak minder succesvolle implementatie van lean technieken in KMO's.

Om voedingsbedrijven bij te staan in de implementatie van lean manufacturing, wordt in het kader van dit doctoraatsonderzoek een "house of lean" voorgesteld dat de noden en kenmerken van KMO's uit de voedingsindustrie in beschouwing neemt. Het raamwerk verschaft een gestructureerde en stapsgewijze aanpak voor de implementatie van lean bij KMO's in de voedingsindustrie. Het "house of lean" heeft als doel om een gestructureerde aanpak voor te stellen om inzicht te krijgen in de contextuele factoren en om KMO's uit de voedingsindustrie te helpen excelleren en het verbeteringspotentieel ten volle te benutten.

Ten laatste zouden beleidsmakers in Europa notie moeten nemen van de bevindingen van dit doctoraatsonderzoek met betrekking tot wat ervoor zorgt dat voedingsverwerkende bedrijven kiezen voor een bepaald kwaliteitsmanagementsysteem en wat de potentiele voordelen van deze kwaliteitsmanagementsystemen zijn. Verder zouden de bevindingen van dit doctoraatsonderzoek moeten helpen om gepaste beleidsmaatregelen te nemen ter ondersteuning van de implementatie, om bekendheid van potentiele voordelen te verhogen en om trainingsmogelijkheden met betrekking tot lean implementatie te verhogen. Dit doctoraatsonderzoek verschaft aldus een belangrijke basis voor stakeholders (bedrijven, wetenschappers en beleidsmakers) in het domein van lean manufacturing om de competitiviteit van de Europese voedingssector op te krikken.

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- **Speaker at TEDx Ghent 2012**
- **Most Outstanding Thesis Award**, Vanderbilt University, 2009
- **Academic Excellence Award**, Vanderbilt University, 2009
- **GPED Award For Leadership and Citizenship**, Vanderbilt University, 2009
- **Young Leadership Award**, SBZ Associates and UNING, Geneva, 2008
- **James S. Rosemary Worley Award** for academic and social commitment, 2007
- **Ford Foundation International Fellowship**, USA, 2007

EXPERIENCE

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Scientific Researcher, *Present*

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Research Fellow, *September- December* 2009

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Research Associate, *March-May 2009*

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LIST OF PUBLICATIONS

Recent journal articles:

Dora, M.; Kumar, M.; Van Goubergen, D.; Molnar, A. & Gellynck, X. (2013). "Operational performance and critical success factors of lean manufacturing in European food processing SMEs", *Trends in Food Science and Technology*, 31(2), 156-164. (IF: 4.135)

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Questionnaire - IMSFood

The Department of Agricultural Economics, Ghent University is conducting a survey as part of the IMSFood project to assess the status and readiness of Belgian food Small and Medium-Sized Enterprises (SMEs) in implementing quality management practices within their companies. The results from the survey will be used for research purpose only. All responses will be treated with the utmost confidence. The approximate time to complete the questionnaire is 20 minutes. Thank you for your time to complete the questionnaire.

Section 1:

1. Name of the Company: ______________________________
2. How many employees does your company have?
   ☐ ≤ 10 ☐ ≤ 50
   ☐ ≤ 250 ☐ >250
3. What is your company's turnover (€)?
   ☐ ≤ 2 million euro ☐ ≤ 10 million euro
   ☐ ≤ 50 million euro ☐ >50 million euro
4. What is your current position within the company?
   ☐ CEO/ Director/ General Manager
   ☐ Departmental Head
   ☐ Quality manager
   ☐ Other (please specify) ______________
5. Please indicate which type of product you manufacture?
   ☐ Meat ☐ Chocolate
   ☐ Confectionery ☐ Bakery
   ☐ Packaged Fruits and vegetable
   ☐ Others (specify) _________
6. Indicate the top strategic objective of your company.
   ☐ Flexibility ☐ Quality
   ☐ Innovation ☐ Cost
   ☐ Others (specify) ___________
7. Select the two important criteria that helped your company to win customer loyalty:
   ☐ Wide Product range ☐ Quality
   ☐ Delivery lead-time ☐ On-time delivery
   ☐ Product Reliability ☐ Price
   ☐ Others (specify) ______________
8. What are the two most important areas of concern with respect to production cost?
   ☐ Energy cost ☐ Labour cost
   ☐ Quality control cost ☐ Transport cost
   ☐ Raw material cost
   ☐ Machine and new technology cost
   ☐ Others (specify) ___________

Section 2:

1. To what extent do you agree with the following statements when considering your company?

Please use the following scale: 1= strongly disagree, 2= moderately disagree, 3= slightly disagree, 4= neither agree nor disagree, 5= slightly agree, 6= moderately agree, 7= strongly agree.

No	Description	Strongly disagree			Neither agree nor disagree			Strongly agree
1	Our company is currently implementing lean manufacturing practices	1	2	3	4	5	6	7
2	Our company has been implementing many of the lean manufacturing practices even though we do not call it lean	1	2	3	4	5	6	7
3	Our company is currently implementing HACCP	1	2	3	4	5	6	7
4	Our company is currently implementing IFS	1	2	3	4	5	6	7
5	Our company is currently implementing BRC	1	2	3	4	5	6	7
6	Our company is currently implementing ISO 9000	1	2	3	4	5	6	7

2. To what extent do you agree with the following statements regarding the use of lean manufacturing practices when considering your company?

Please use the following scale: 1= strongly disagree, 2= moderately disagree, 3= slightly disagree, 4= neither agree nor disagree, 5= slightly agree, 6= moderately agree, 7= strongly agree.

No	Description		Strongly disagree		Neither agree nor disagree			Strongly agree	
1	Customers	We frequently are in close contact with our customers	1	2	3	4	5	6	7
2		Our customers give us feedback on quality and delivery performance	1	2	3	4	5	6	7
3		We regularly conduct customer satisfaction surveys	1	2	3	4	5	6	7
	Supplier Related	We frequently are in close contact with our suppliers	1	2	3	4	5	6	7
		Our key suppliers deliver to plant on just-in-time basis	1	2	3	4	5	6	7
		We take active steps to reduce the number of suppliers in each category	1	2	3	4	5	6	7
4	Internally related	We use the pull production system	1	2	3	4	5	6	7
5		We use Kanban, squares, or containers of signals for production control	1	2	3	4	5	6	7
6		Production at station is pulled by the current demand of the next station	1	2	3	4	5	6	7
7		Products are classified into groups with similar processing requirements	1	2	3	4	5	6	7
8		Products are classified into groups with similar routing requirements	1	2	3	4	5	6	7
9		Product families determine our factory layout	1	2	3	4	5	6	7
10		We are working to lower set up times in our plant	1	2	3	4	5	6	7
11		We monitor our production-cycle time to respond quickly to customer requests	1	2	3	4	5	6	7
12		Our employees practice setups to reduce required time	1	2	3	4	5	6	7
13		Our processes on the shop floor are currently under Statistical Process Control	1	2	3	4	5	6	7
14		We extensively use statistical techniques to identify process variation	1	2	3	4	5	6	7
15		We use charts to show defect rates on the shop-floor	1	2	3	4	5	6	7
19	Employee Involvement	Shop-floor employee undergo cross-functional training	1	2	3	4	5	6	7
20		Shop-floor employees are crucial to problem-solving teams	1	2	3	4	5	6	7
21		Shop-floor employees lead product/process improvement efforts	1	2	3	4	5	6	7
23	Total productive maintenance	We have a preventive maintenance plan in our firm	1	2	3	4	5	6	7
24		We dedicate a time every day to plan equipment maintenance related activities	1	2	3	4	5	6	7
25		We regularly post equipment maintenance records on the shop-floor	1	2	3	4	5	6	7

3. Please indicate the operational performance and other benefits realized due to implementation of lean manufacturing practices in your company.

Improved operational performance and other benefits realized		Strongly disagree		Neither agree nor disagree				Strongly agree
Operational performance	Stock/inventory reduction	1	2	3	4	5	6	7
	Productivity improvement	1	2	3	4	5	6	7
	Lead or cycle time reduction	1	2	3	4	5	6	7
	Improved product quality	1	2	3	4	5	6	7
	We improve our on-time delivery	1	2	3	4	5	6	7
Other benefits	We reduced our scrap rate	1	2	3	4	5	6	7
	We reduced our costs of production	1	2	3	4	5	6	7
	Our profitability increased	1	2	3	4	5	6	7
	Our sales improved	1	2	3	4	5	6	7
	Customer complaints reduced	1	2	3	4	5	6	7
	Employee complaints reduced	1	2	3	4	5	6	7

4. Please indicate the **barriers** you have faced during the implementation of lean manufacturing practices?

Barrier of lean practices implementation	Strongly disagree		Neither agree nor disagree				Strongly agree
Lack of top management commitment	1	2	3	4	5	6	7
Inadequate process control techniques	1	2	3	4	5	6	7
Availability of resources	1	2	3	4	5	6	7
Poor employee participation	1	2	3	4	5	6	7
Poor project selection	1	2	3	4	5	6	7
Lack of training	1	2	3	4	5	6	7
Lack of knowledge	1	2	3	4	5	6	7
Poor supplier involvement	1	2	3	4	5	6	7
Internal resistance	1	2	3	4	5	6	7
Poor delegation of authority	1	2	3	4	5	6	7
Highly perishable product	1	2	3	4	5	6	7
Variability in raw materials quality and supply	1	2	3	4	5	6	7
High variation of composition, recipes, products & processing techniques	1	2	3	4	5	6	7
Variable yield and processing duration	1	2	3	4	5	6	7
Variable product structure	1	2	3	4	5	6	7
Short (i.e. between one to eight hours) throughput time for batches	1	2	3	4	5	6	7
Long set-up times between different product types	1	2	3	4	5	6	7
Processing & packaging are separated due of food quality assurance	1	2	3	4	5	6	7
Processing equipment has sequence dependent cleaning time	1	2	3	4	5	6	7
Small and single site factories with 30 to 100 employees	1	2	3	4	5	6	7

5. Please indicate the critical success factors of lean manufacturing practices implementation in your company?

Leadership and management	1	2	3	4	5	6	7
Organizational culture	1	2	3	4	5	6	7
Skill of the workforce and in-house expertise	1	2	3	4	5	6	7
Financial capabilities	1	2	3	4	5	6	7

Thank you for your time!