4. Results

This chapter provides the results from the analysis. The chapter presents the profile of responding companies and the descriptive statistics of the different variables. The results from the hypothesis testing and the relationships between the variables are presented and the chapter ends with a summary of the results.

4.1 Summary Statistics

The demographics of the respondents are shown in Table 4.1.1. Almost 63 percent of the respondents have been working in the companies for more than five years. Over 60 percent of the respondents are working in senior management positions. The occupation category “Other” stands for 37.1 percent and consists of production- and process engineers, product manager, quality managers and project managers. Overall, the profile of the respondents shows that they are knowledgeable representatives for their respective company when it comes to lean manufacturing and performance, thus can be assumed to be suitable respondents of the survey.

Table 4.1.1: Demographics of respondents

Length of service in current company	**Frequency**	**Percentage**
More than 10 years	12	34.3%
Above 5 – 10 years	10	28.6%
Above 2 – 5 years	11	31.4%
0 – 2 years	2	5.7%
Occupation	**Frequency**	**Percentage**
Plant manager	2	5.7%
Production manager	14	40.0%
Logistics-/Material control manager	5	14.3%
Production planner	1	2.9%
Other	13	37.1%

The demographics of the companies are listed in Table 4.1.2. The main part (57.1 percent) had more than 500 employees. The companies are spread over several industries; however, two industries were not represented even though questionnaires were distributed to companies within the industry. These industries were: furniture and wood; and textile, clothing and footwear. Motor vehicle and accessories had the highest contribution, representing 17.1 percent of the responses, while rubber and plastic had the lowest (2.9 percent). The major part of the companies had Swedish owners (60 percent).

Table 4.1.2: Demographics of companies

Number of employees	**Frequency**	**Percentage**
More than 500	20	57.1%
150 – 499	15	42.9%
Industry	**Frequency**	**Percentage**
Motor vehicles and accessories	6	17.1%
Electrical and electronics	4	11.4%
Rubber and plastic	1	2.9%
Iron, steel and metal	5	14.3%
Machinery and equipment	4	11.4%
Paper, printing and packaging	3	8.6%
Food and beverage	2	5.7%
Pharmaceutical, medical equipment, cosmetics	3	8.6%
Chemicals and chemical products	2	5.7%
Other manufacturing	5	14.3%
Ownership	**Frequency**	**Percentage**
Swedish	21	60.0%
Foreign	14	40.0%

4.2 Analysis of Measures

To investigate the reliability of the measures, Cronbach's alpha was calculated using SPSS 18. The value of Cronbach's alpha for the independent variable (41 items) was 0.891 and for the dependent variable (seven items) 0.740. This means that the internal consistency is considered good (Sekaran, 2003).

4.2.1 Descriptive Statistics Independent Variable

An overview of the independent measures is shown in Table 4.2.1.1 and a detailed table of all items is found in Appendix C.

Table 4.2.1.1: Descriptive statistics independent variable

Operational constructs	**Mean**	**Stnd. dev.**	**Min**	**Max**
Supplier feedback (SUP_FEED)	4.11	0.738	2	5
Just-in-time Delivery (JIT_DEL)	3.18	1.158	1	5
Developing suppliers (DEV_SUP)	2.87	1.230	1	5
Involved customers (INV_CUST)	3.71	0.934	1	5
Pull (PULL)	2.89	1.331	1	5
Flow (FLOW)	3.36	1.087	1	5
Setup (SETUP)	3.19	1.010	1	5
Controlled processes (CONT_P)	2.52	1.254	1	5
Involved employees (INV_EMP)	3.23	0.984	1	5
Productive maintenance (PROD_M)	3.34	1.111	1	5

Ten operational constructs were used to measure the implementation of lean manufacturing, in total 41 items. The scale used was a 5-point Likert scale ranging from (1) no implementation to (5) complete implementation. It is only one operational construct, supplier feedback, which has a mean over four, which means extensive implementation. Just in time delivery, involved customers, flow, setup, involved employees and productive maintenance has an average of “some” implementation. Three construct has an average of little implementation: developing suppliers, pull and controlled processes. All constructs except supplier feedback has a range from one to five. Supplier feedback has a range from two to five. The overall mean of the ten operational constructs is 3.24, which indicates a moderate level of implementation of lean practices. The mean of the operational constructs are presented in Figure 4.2.1.1.

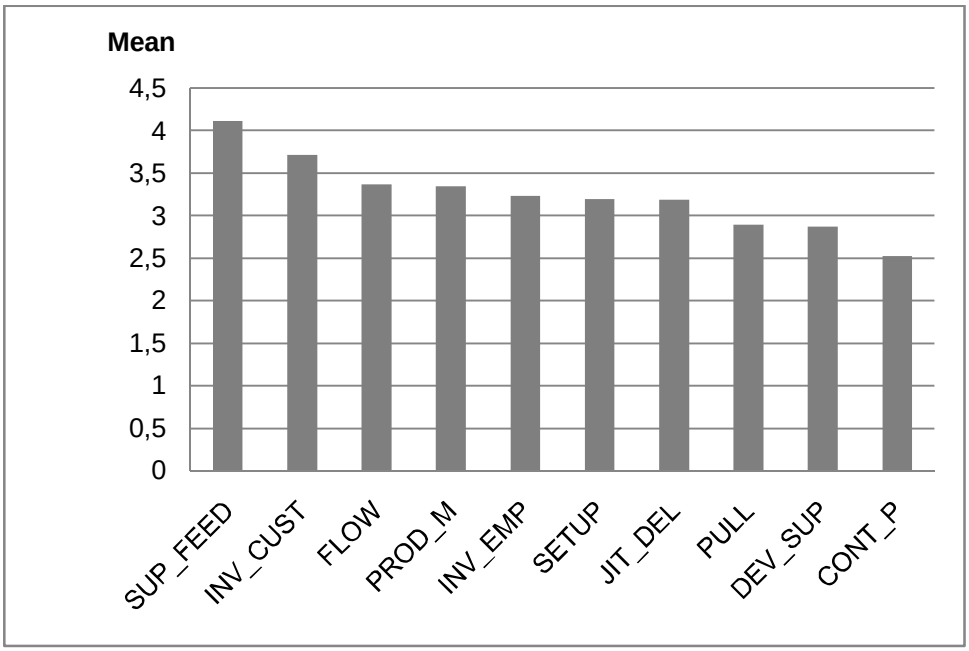

Figure 4.2.1.1. Mean value of the operational constructs

Mostly implemented is supplier feedback, as mentioned earlier, which means that the sample companies are frequently in contact with their suppliers, give them feedback on quality and delivery performance and strive to establish long term relationships. It is interesting to notice that supplier feedback had the highest mean of implementation, while supplier development only had little to some implementation. This might reflect the fact that it is easier to follow up and give feedback to suppliers compared to work with development and improvement.

For the construct involved customers, the item that scored the lowest was that customer frequently shares current and future demand. This might be the reason why JIT deliveries also had a moderate average score. Without good forecasts it is difficult to plan for just-in-time deliveries. Other items in the construct were close contact with customers, and feedback from customers on quality and delivery performance. They had extensive implementation and it would be very surprisingly if the mean had been less.

Flow in this survey is mostly based on layout and all items within the construct had similar means of some implementation. It seems that the manufacturing layout and equipment is based on product families and that products are classified into groups, or families, with similar process and routing requirements.

Maintenance of equipment had not surprisingly extensive implementation, but information about maintenance activities and planned maintenance still has a way to go. This is in line with Jonsson (1997) and Alsyouf (2009) who found that maintenance have low status in Swedish manufacturing companies and they found that half to one third of the maintenance time is spent on unplanned tasks and corrective actions.

When it comes to involved employees the overall mean is quite low, but there was some spread over the different questions. While the companies recognise shop-floor employees as problem solvers and as drivers for suggestion programs, there seems to be a lack of cross-functional training. This is an important issue to rise, as training is needed to be able to see the benefits with lean manufacturing and to work with improvements over functional areas. Fullerton et al. (2008) found that employee involvement was critical for a successful implementation of lean manufacturing and Olsen (2004) found it to be a top determinant when determining if a company can be considered lean.

For machine and equipment set up the companies are working towards lowering the time needed, but apparently not by letting the employees practice set ups. Here, the issue with training is repeated.

JIT delivery was implemented to the same extent as set up. A formal supplier certification program, suppliers that are involved in the product development process and JIT deliveries from suppliers were implemented to some extent. It is discussable whether supplier certification program and involvement in product development should belong to the construct JIT delivery instead of developing suppliers. The means of the items in the group are however within similar range and since lean manufacturing is measured as one variable, it does not make any difference in this study.

Pull production system had a mean just under “some” implementation. Worth noticing is that the question about Kanban lowered the overall mean and is used to a small extent among the sample companies. This is in line with Poksinska et al. (2010) who found that even though Kanban was used to a higher extent than TQM tools, the mean was even lower than in this study. Olsen (2004) found that Kanban as a JIT practice was one of the top factors to distinguish lean from non-lean firms, which suggests that Kanban is an important tool for lean manufacturing. The questions concerning that production is pulled by shipment of finished goods, and that production at stations is pulled by the current demand of the next station, scored somewhat higher than usage of a pull production system. This could imply that pull is used to some extent in parts of the material flow, but not implemented in the complete flow.

The construct developing suppliers contained items with means ranging from 2.0 to 3.94. On the lower scale were that the supplier manages the manufacturer's inventory, are contractually committed to cost reductions, and have close location proximity. On the higher scale of implementation were reducing number of suppliers, evaluate suppliers based on total cost instead of unit cost, and the use of corporate communication when issues. For location proximity, there are disagreements in the literature, whether it is a prerequisite for JIT deliveries or not (see for example Gilbert & Schonberger, 1983; Jun & Wataru, 2008; Wafa et al., 1996). According to Wafa, Yasin and Swinehart (1996) enhanced communication, information sharing and certification programs reduces the need for a close proximity to the manufacturing plant. Jun and Wataru (2008) found that the use of hubs and cross-docking creates a successful JIT system for remote suppliers. In this study however, the use of hubs or similar, such as vendor managed inventory, seem to be used to a very low extent. According to Schonberger and Gilbert (1983) single sourcing is characteristic of JIT, and it has some implementation in the companies analysed.

Least implemented is controlled processes, which includes the use of SPC, statistical techniques and process capability studies. The construct controlled processes also includes the use of charts to show defect rates on shop-floor and the use of fishbone diagram to identify root causes to quality problems. Statistical techniques such as SPC also had little implementation in the study by Poksinska et al. (2010), who suggested the reason was that time has passed for techniques and methods such as SPC and quality circles.

The implementation rate is overall on a moderate level. The result can be compared to a recent study in Malaysia by Wong et al. (2009) in the electrical and electronics industry, where the average implementation was closer to extensive, even though the constructs did not look the same. The authors found a difference between small and large companies, where the large companies, which were likely to be foreign owned multinational companies, had implemented lean practices to a higher degree. The ownership is not believed to have any effect on the result in this study, but a t-test will be carried out to control for ownership.

Looking at the single items a total of 13 items scored below average and is implemented to a "little" extent. These items include suppliers that have contractually agreements to annual cost reductions, are located in close proximity and manage the companies' inventories. The use of Kanban and practice for shortening setup times also scored low. Shop-floor employees that lead improvement efforts, cross functional training for shop-floor employees and posting equipment maintenance records on shop-floor, together with all items for controlled processes as mentioned above also had little implementation. The six items with lowest mean are presented in Figure 4.2.1.2.

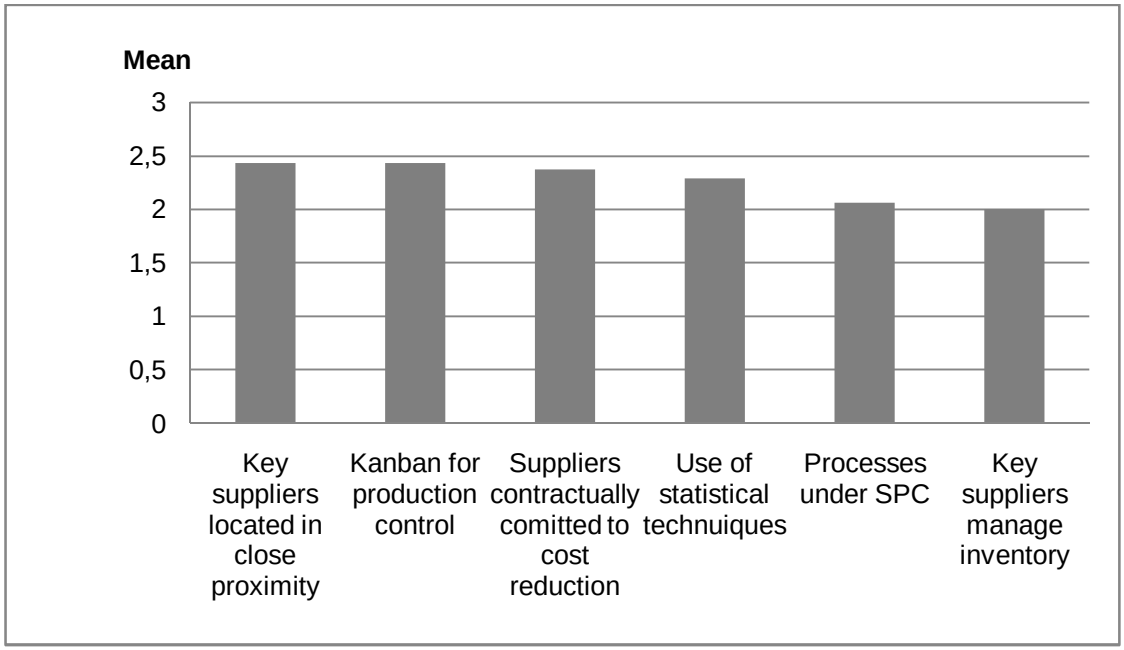

Figure 4.2.1.2. The six items with lowest mean

Six items have an average of extensive implementation, and they include the three items in supplier feedback as described above, frequent close contact with customers, feedback from customers on quality and delivery performance and finally regularly maintenance of equipment. The items are presented in Figure 4.2.1.3.

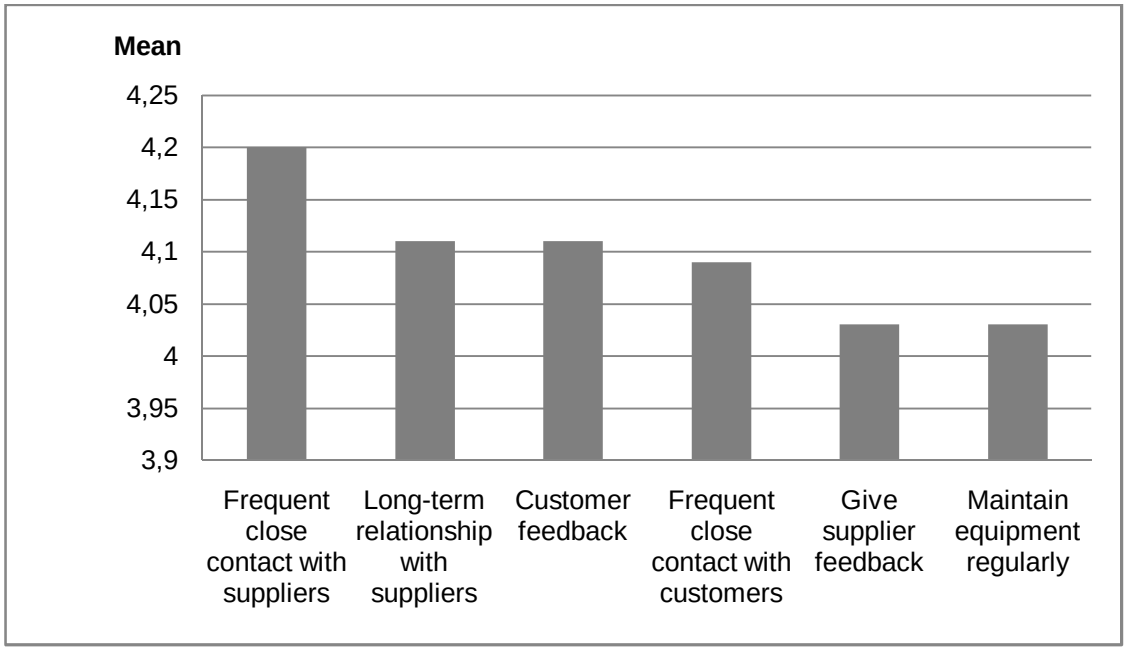

Figure 4.2.1.3. The six items with highest mean

4.2.2 Descriptive Statistics Dependent Variable

An overview of the dependent measure, performance, is shown in Table 4.2.2.1. Seven items were used to measure firm performance, both financial and non-financial factors. The respondent was asked to indicate the changes in performance in the last three years on a seven point Likert scale ranging from (1) decreased tremendously to (7) increased tremendously. Productivity and operating profit have a mean over five, which are the highest values, the rest of the items have a mean over four. The item with the lowest mean is sales growth (4.66). The overall mean is 4.84, suggesting that the firm performance has had a great increase during the last three years.

Table 4.2.2.1: Descriptive statistics dependent variable

Items	Mean	Stnd. dev.	Min	Max
Productivity	5.14	0.845	4	7
Cost savings	4.71	1.274	1	7
Product Quality	4.80	0.797	4	7
On-time delivery	4.86	0.912	3	7
Sales growth	4.66	1.235	2	7
Operating profit	5.03	1.124	2	7
Market share	4.69	0.718	3	6

A t-test was made for controlling for differences in performance with different ownership (Swedish or foreign). No differences were found.

4.3 Testing of Hypotheses

To test if there was a relationship between the independent variable lean manufacturing and the dependent variable firm performance, a Pearson correlation analysis was carried out. Firm performance was also divided into financial- and non-financial performance to see whether a correlation existed between each of them and lean manufacturing. Financial items included cost savings and operating profit and the non-financial items were productivity,

product quality, on-time delivery, sales growth and market share. The result of the Pearson correlation analysis is presented in Table 4.3.1.

Table 4.3.1: Correlation between lean manufacturing and firm performance

	Lean manufacturing	Firm performance	Financial performance	Non-financial performance
Lean manufacturing	1			
Firm performance	0.636** 0.000	1		
Financial performance	0.557** 0.001	0.808** 0.000	1	
Non-financial performance	0.557** 0.001	0.921** 0.000	0.514* 0.002	1

** Correlation is significant at the 0.01 level

The result from the analysis shows that lean manufacturing has a significant positive correlation (r=0.636) with firm performance on a 0.01 level. Moreover, lean manufacturing is positively correlated to both financial performance (r=0.557) and non-financial performance (r=0.557) on a significant 0.01 level. This result supports a relationship between the independent and the dependent variable and the relationship is further investigated in a regression analysis.

Following relationship was tested in a linear regression analysis:

$$y = a + bx_1 + e \quad (1)$$

where y is firm performance, a and b are constants, x_1 is lean manufacturing and e is an error factor. The regression result is provided in Table 4.3.2.

Table 4.3.2: Result regression analysis lean manufacturing and firm performance

	Firm performance
Lean manufacturing	0.636 (p=0.000)
R^2	0.405
Adjusted R^2	0.386
F	22.418

The result shows that 38.6 percent of the variance in firm performance is explained by the independent variable lean manufacturing on a 0.01 significance level. The positive beta-value (0.636) means that an increase in lean manufacturing implementation will generate a positive impact on firm performance.

To test the hypotheses H1 and H2, firm performance was separated into financial performance (cost savings and operating profit) and non-financial performance (productivity, product quality, on-time delivery, sales growth and market share). Formula (1) was analysed two more times with a linear

regression analysis, but this time y was changed to y_1 financial performance and y_2 non-financial performance respectively:

$$y_1 = a + bx_1 + e \quad (2)$$

$$y_2 = a + bx_1 + e \quad (3)$$

The result is shown in Table 4.3.3.

Table 4.3.3: Result regression analysis to test the hypotheses

	Financial performance	**Non-financial performance**
Lean manufacturing	0.557 (p=0.001)	0.557 (p=0.001)
R^2	0.310	0.311
Adjusted R^2	0.289	0.290
F	14.836	14.865

The result shows that lean manufacturing has a positive relationship to both financial and non-financial performance and the relationship is significant to a 0.01 level. Thus H1 (Manufacturing companies that have implemented lean manufacturing will experience improved financial performance) and H2 (Manufacturing companies that have implemented lean manufacturing will experience improved non-financial performance) are supported. Lean

manufacturing explains 28.9 percent and 29 percent of changes in financial and non-financial performance respectively.

The findings from this study are in line with Cua et al. (2001 and 2006), Olsen (2004) and Shah and Ward (2003 and 2007) when it comes to the conclusion that lean manufacturing should be used as a total concept and not just implementation of some parts. The result from this study suggests that put together as a total concept, lean practices has a positive impact on firm performance.

Wong et al. (2009) found that the greatest benefits of implementing lean were reduced costs, improved productivity and reduced waste. In this study it was found that productivity and operating profit had the highest mean of the performance factors. Cost savings had the second lowest mean and one reason for this can be that implementation of lean practices initially causes costs and since the implementation on average was quite moderate there is no way of knowing how long the companies have been working with lean manufacturing. The economic downturn in recent years could have affected the sales growth which had the lowest mean of the performance factors.

4.4 Summary of Research Results

The result suggests that implementation of lean manufacturing in the sample companies is in average moderate and indicates “some” implementation of lean practices. The construct with highest mean is supplier feedback and the construct with lowest mean is controlled processes.

Firm performance is above average on the scale, which suggests that firm performance has had a great increase during the last three years. Productivity had the highest mean, while sales growth had the lowest.

The results indicate that lean manufacturing has a positive and significant relationship with each component firm performance, financial performance and non-financial performance respectively.