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Behold in the industry essentials in different manufacturing industries

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Abstract

Due to the competitiveness of the industry, companies strive to perform better than their competitors or than they used to do. Therefore continually comparisons have to be made with quantitative indicators. Benchmarking is the comparison of companies in the same industry on a particular indicator. There will be looked to what the Key Performance Indicators (KPIs) per industry are, referred to as the industry essentials. When does which industry essential, needs to be measured to be able to perform a benchmark?

A research study has been conducted to explore the industry essentials in practice. Based on the developed research survey, industry essentials will be set for the researched industries. The industry essentials are set as ratio indicators so they are able to benchmark despite differences in the magnitude of a company. The drawback of an industry essential or any KPI is that differences in outcome can be subject to strategic choices of operational management rather than the malfunction of a company and should always be kept in mind. At last, a case study has been done to set a baseline for further benchmarking.

Keywords: General indicator, specific indicator, benchmarking, industry essentials, key performance indicator,

Introduction

The inducement of this research is the need for benchmarking from the industry, but also understanding what drives certain types of organizations in the industry - and where organizations should focus on in their own internal performance reporting. Organizations are asking themselves how they perform. This can be done

by reflecting their results and operational performances. Organizations are striving for the best and therefore, aim to perform better than their competitors and/or try to improve their own performances. Different features can be objectively and quantitatively measured, after which the results of a company can be compared to other companies. Indicators can also reveal the factors where an organization should be paying attention to, whether on improving or reforming operations within the company. This can also be expressed as industry essentials; the indicators which should be paid most attention to in a particular industry to measure operation performances on a tactical/strategical level. The inducement from an academic point of view for this research is to reveal general and specific indicators where organizations focus on when measuring their performances. Consequently, it raises the question whether companies can be compared with each other on a specific level. After which a benchmark will be performed with the proposed indicators. As can be summarized, the purpose of this study is to suggest multiple general performance indicators in order to benchmark organizations and provide insight in what specific key drivers belong to certain industries. Furthermore, specific performance indicators will be suggested for some companies on an industry level, after which it will be researched if organizations can be compared on a general level or if a more detailed level is needed. From the inducement and purpose of this research, a research question has been developed. This research question is divided into several sub-questions, which will be answered in order to provide an answer to the main research question. The questions are composed as followed:

Main research question:

- *What are the industry essentials in the manufacturing industry?*

Sub-questions:

1. *What are the general performance indicators to manage the operations of an organization on a strategic level, for instance in management reports?*
2. *Are the belonging specific performance indicators different according to the different types of industry?*
3. *Are the suggested general indicators comprehensive enough to judge a company's performance or are specific indicators per industry or sub-industry needed?*

Literature Review

Comparing a company can be on every conceivable item, but before selecting the right comparable, organizations must be compared as generic as possible. Porter (1985) appointed three main processes in organizations, which can be divided into; steering, supporting and primary processes. Primary processes can also be divided into several sub-processes, which follow the process of the production. Figure 1 shows a visualization of those processes (Porter, 1985). The idea behind disconnecting an organization in different processes is that a comparison can be made on

different levels in an organization. Within those subtracted processes a comparison or benchmark can be made.
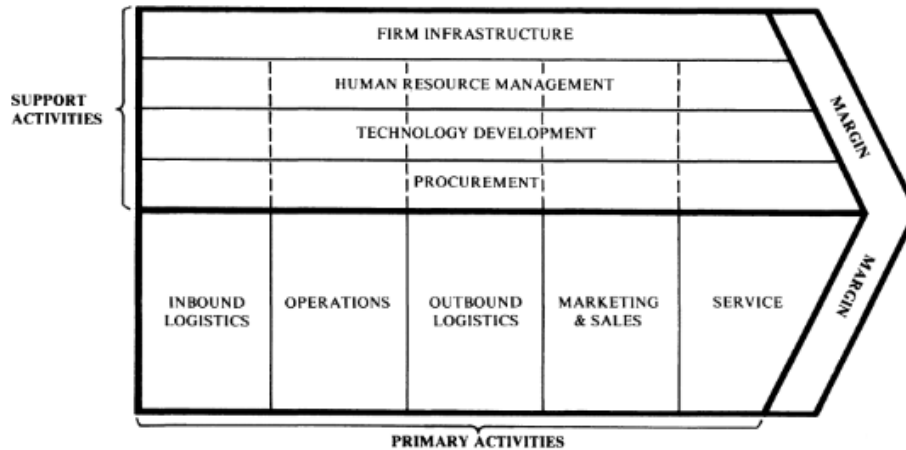

Figure 1: The generic value chain described by Porter (1985) with its different processes

David T. Kearns, CEO of Xerox Corporation started with benchmarking his own firm and came with the following definition for benchmarking (in 1988): *'Benchmarking is the continuous process of measuring our products, services and practices against our toughest competitors or those companies recognized as the leaders. Our goal is superiority in all areas-quality, product reliability, asset use, cost and customer satisfaction'* (Zairi, 1998).

Robert C. Camp, changed this definition to the following definition in 1989, which represents the best current view towards benchmarking: *'Benchmarking is systematic research into the performance and the underlying processes and methods of one or more leading reference organizations in a certain field, and the comparison of one's own performance and operating methods with these "best practices", with the goal of locating and improving one's own performance.'* (Camp, 1989).

The main core of benchmarking is comparing performances and their underlying factors, analyze differences and to improve those performances. The goal is to improve their own performance and/or accountability for performances (Pickering and Chambers, 1991). Benchmarking aims on reaching superiority on an operational level (Camp, 1989). According to Moore (2004), the first step in benchmarking is to define those processes and for which the benchmark metrics are desired, in this research called the industry essentials. Industry essentials are believed to reflect the performance objectives of an enterprise. Therefore, it is of great importance to select the right essentials for determining how the company behaves in comparison with other companies, which can be on a high-level but also be in their specific field of industry (Moore, 2004). For instances, benchmarking can occur on a management level but can also be done on a more industry specific level. A benchmark is then

made on one of those processes or even more detailed. Evaluations of processes occur in comparison to the best practices of others, in a group of firms in their industry (Ruiz and Sirvent, 2015). Benchmarking with the best in practice can identify the targets that can be set by management as goals and gives enterprises the opportunity to learn from others and develop plans to improve their own performance (Ruiz and Sirvent, 2015). Due to the different goals set for a benchmark process, different methods exist. A benchmarking process in an organization should be done according to the 'Juran 7-step Benchmark Process' since this process is generic and applicable to all types of benchmarking (Wood, 2009). The seven steps are enumerated below. According to Wood (2009), many companies stop after step four when performing a benchmark with their company in it, however, to maximize the value of the benchmark process and building a better understanding of the best practices, it is vital to complete all steps in order to attain world-class performance.

1. Preparation and planning
2. Data collection
3. Data analysis
4. Reporting
5. Learning from best practices
6. Planning and implementing improvement actions
7. Institutionalizing learning

One of those benchmark methods is BETTI, (Benchmark Tool To Improve the production performance) which was invented in 1995 (Verwij, 1998). This tool focuses on the three main processes described by Porter (1985) and developed indicators in order to benchmark performances on all levels. The reference points in this method will be used to propose the general indicators further-on in this research. What should be kept in mind is that benchmarking is not a strategy in itself, but it may attribute in achieving a strategy. Which means that there is a distinguish between operational effectiveness and strategy (Porter, 1996). Both are essential, but the two are different. It can be concluded that benchmarking does not focus on overall best-practices, but on relative best-practices since indicators have been chosen to compare data focused on a single reference point. Most important is to choose the right indicators for a company to perform a benchmark that are most important to review a company.

In this research on the made reference points, or the general indicators, statistics will be performed in order to show the quantitative side of the indicators. The boxplots, devised by John W. Tukey, are suitable to show this since it shows how the data is distributed (Mcgill et al., 1978). Boxplots show the extremes, second and third quartile and the median (Mcgill et al., 1978). Different variations of boxplots exist to show the distributed data, in this research the basic form will be taken, which is best suited for smaller datasets (Krzywinski and Altman, 2014). From the distributed data, organizations are able to see where they scored. Scoring weak on an indicator shows that in order to improve their operations, attention should be

paid to improve the indicator. The significance of boxplots increases when more data points are used. In the research of Krzywinski and Altman (2014) boxplots from five to 20 data points were examined, where five becomes less significant. In this research, a relatively small dataset will be used. As it can be noticed, further on in this research, that due to the absence of some data, some indicators do not have enough data to perform a significant enough boxplot. In order to still be able to perform boxplots, the scope has been set for this research that under four data points an indicator will not be taken into account to perform a boxplot on the obtained data. Figure 2 shows the significance of the different sample sizes as has been used in the research of Krzywinski and Altman (2014).
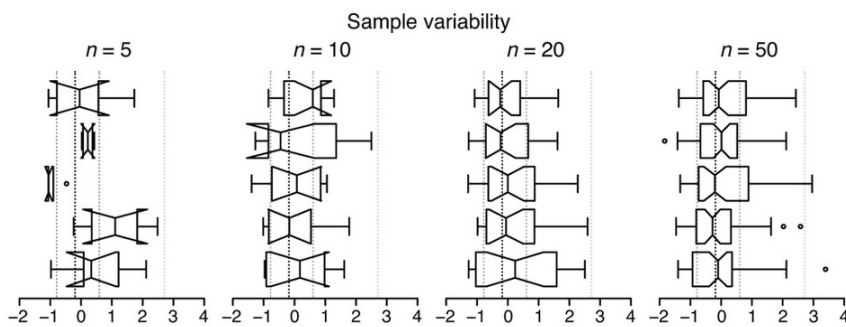
Figure 2: The distribution of boxplots, for four samples with sample size n = 5, 10, 20 and 50, from the research of Krzywinski and Altman (2014)

Methodology

This study aims to review industry essentials in order to make a faster judgment on the organizational performances. Therefore, a separation has been made in general and specific indicators. Those indicators judge performances respectively on a high level and on an industry specific level. Firstly data of different companies need to be investigated. From whom a hierarchical tree will be designed with the help of SBI encoding developed by CBS. Thereafter the tree will be filled with companies from a dataset. The three most active industries will be chosen to assimilate in this research and the rest will be let out of scope. Benchmarking will occur with the conducted general indicators from the BETTI set. After the general indicators, the specific indicators will be conducted. Finally statistical analysis will be conducted on the general indicators, whereas earlier mentioned, basic boxplots are chosen to display the statistics.

Functional requirements on comparing organizations

Plannings-methodologies and types of production are characteristics on controlling the main processes on a strategic level. The characteristics do not review perfor-

mance but can be an explanation of differences in results in the indicators and have to be taken into account when reviewing an organization. The following distinguishes are made for plannings-methodologies.

- All of the items below
- Make to order
- Make to stock
- Engineer to order
- Assemble to order
- Make, Engineer and Assemble to order
- N.A.

Production can also be classified in different types of production. The following types are taken into account:

- Discrete production
- Discrete assembly
- Discrete production and assembly
- Automated production
- Maintenance

Strategic decisions can be an explainable reason why differences in the results of the ratios do not necessarily mean that performances are poorer, but that it comes from a side effect based on the strategic choices made on features of the establishment of the primary process and therefore, cannot be held accountable for. Off course differences in products, for instance, high-end or low-end products can also show different results.

Hierarchical severance of industries

"Standaard Bedrijven Indexatie" (SBI) encoding has been conducted by the Centraal Bureau voor Statistiek (CBS) from the Netherlands and has been used to set up a hierarchical tree (Centraal Bureau voor de Statistiek, 2012). The SBI is a manner of indexation organizations hierarchically, according to their operational activities. The SBI has been used in this research to classify the organizations of which data has been used from a dataset of companies. After the set-up of the tree, the tree will be filled with the companies available from the dataset. Unfortunately, some companies are given an encoding that doesn't match their operational activities or products. The different classes are slightly changed into the following classes:

- Discrete Production, High-Tech
- Discrete Production, Non High-Tech
- Surface Treatment
- Maintenance

This resulted in a tree with in total 14 companies placed under the four types of industries. In Appendix A the original tree made with the help of the SBI encoding and its branches as anonymized companies can be found. From now on in this research, the following tree and classifications will be used in this research.
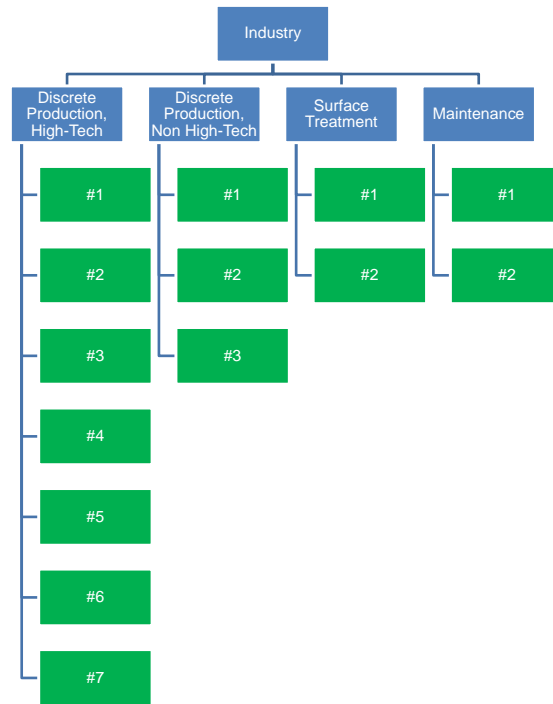

Figure 3: Hierarchical tree of selected companies used in this research

Conduction of General Indicators

Since organizations will be compared on a set of general indicators, a list has to be conducted of indicators. From the BETTI method and some other proposed indicators a list has been put together. Some other proposed indicators came from the research of Beelaerts van Blokland et al. (2012). This list is ranked by the view of experts. Five experts scored a set of over 100 indicators to their personal way of reviewing an organization. Ranking those indicators occurred with an operational excellence and innovation point of view. The 20 best general indicators that are, according to the questionnaires with experts, suited to compare the companies' performances, are conducted below:

- Delivery Reliability on order level
- Revenue per FTE
- Added Value per FTE
- Direct vs. Total FTE ratio

- Indirect vs. Total FTE ratio
- Overall Equipment Effectiveness (OEE)
- Planned Hours Actual Hours (PH AH) ratio
- Absenteeism ratio
- Rejection ratio
- Productivity Direct Personnel
- Personnel Expenses (incl. hired staff) per FTE
- Yield Costs ratio
- Machinery Utilization ratio
- R&D Expenses vs. Revenue
- Personnel Expenses (incl. hired staff) vs. Revenue
- Overhead Costs per FTE
- Net Margin
- Throughput factor
- Stock Turnover rate
- Added Value vs. Personnel Expenses (incl. hired staff)

The abbreviation FTE is used for Full-Time Equivalent, where not the number of employees is used but the number of full-time jobs. A more detailed explanation of those general indicators and how they will be calculated can be found in Appendix B.

Conduction of Specific Indicators

Specific indicators are depending on the determination of how controlling operations on a strategic level occurs. In each of the three initial branches, a company was visited to ask for their five most important indicators to watch for on the production floor. These indicators are chosen to tell companies whether their operations performed well. The opinion of an external operational excellence consultant will be used to verify whether these are the suited KPIs for the visited organizations.

Data collection and analyzing

Data will be collected from different sources. As much as possible will be retrieved from public data, thereafter a database will be used, which has been collected by consultants. Missing information will be collected as much as possible by sending questionnaires to companies that are selected by the hierarchical tree earlier in this research.

Statistical Analysis

A statistical analysis will be performed on the retrieved data of the general indicators. The statistical tool that will be used is the boxplot, developed by Mcgill et al. (1978). This tool has been chosen, since it is a widely used method to do statistics. It focuses on the upper and lower quarter of the median of the data and leaves odd

data excluded except for the extremes. Boxplots can be conducted in several ways; one of them is the "basic boxplot" which will be used in this research as mentioned earlier. For every performed "basic boxplot" five values need to be calculated from the data; minimum, maximum, lower quartile, upper quartile and the median. As mentioned in the Literature Review is that the bigger the data set is, the more accurate a boxplot is (Krzywinski and Altman, 2014). The data set in this research varies from only one data point to 12, since some data was not available. From the done literature review it has been chosen that less than four data points will not be significant enough to perform a boxplot (Krzywinski and Altman, 2014). Only on the general indicators with four or more data points, a boxplot will be performed.

Results

This chapter shows the results from the analyzed data from companies when available. The data from the companies varies from 2010 to 2014. When more years were available per company the most recent has been used in this research. First the results of the general performance indicators can be found. After which the results of specific performance indicators will be treated. On the end of this section, a benchmark will be performed with the proposed indicators which will serve as an industry example and as a zero measurement for further benchmarking.

General Indicators

In this section, the companies are benchmarked on the conducted general indicators set earlier on in this research. From some companies data was not present or measured, then Non-Applicable (N/A) will appear in the graphs. As earlier said, some general indicators are more measured than others, when this happened statistics will be applied to the data, which has been measured four or multiple times, in order to show their accurateness. In Table 1 the general indicators, how often they are measured and of which statistics had been made can be found. The graphs with the data of the indicators have been set out against the average of the different branches, where N shows the number of measurements per branch. Due to the limitation of data, the boxplots are made on all data combined. The graphs can be found in Appendix C and the performed boxplots can be found in Appendix D.

Table 1: Table with general indicators, how often they are measured and whether statistics are performed

General Indicator	# of measurements	Boxplots performed
Delivery Reliability on order level	8	✓
Revenue per FTE	12	✓
Added Value per FTE	11	✓
Direct vs. Total FTE ratio	11	✓
Indirect vs. Total FTE ratio	11	✓
OEE	1	✗
PH AH ratio	1	✗
Absenteeism ratio	7	✓
Rejection ratio	4	✓
Productivity Direct Personnel	4	✓
Personnel Expenses per FTE	5	✓
Yield Costs ratio	1	✗
Machinery Utilization ratio	2	✗
R&D Expenses vs. Revenue	3	✗
Personnel Expenses vs. Revenue	5	✓
Overhead Costs per FTE	7	✓
Net Margin	6	✓
Throughput factor	3	✓
Stock Turnover rate	8	✓
Added Value vs. Personnel Expenses	5	✓

Specific Indicators

This section gives an answer to the researched specific KPIs or industry essentials for the different branches. In every, of the three, branches a company has been visited to ask for their most important indicators. From the database, that has been used to fill in the general indicators, some specific indicators were able to acquire. Table 2 shows all the various industry essentials which are summed up, per specific branch. The industry essentials and their corresponding companies can be found in Appendix E. From the recommendations of the research of Beelaerts van Blokland et al. (2012) can be seen that the most important indicators where; *Gross Margin and Production Costs*, in this research the focus has been on the five most essential indicators per branch, where the two indicators are confirmed and three others are introduced.

Table 2: Industry essentials per branch

Discrete Production/ High-Tech	Discrete Production/ Non High-Tech	Surface Treatment	Maintenance
Intern Rejection ratio (of Revenue)	Productivity Direct Personnel	Absenteeism costs	Production Costs per produced hour
Extern Rejection ratio (of Revenue)	Occupancy ratio Personnel	Average Revenue per day	Gross Profit per Revenue
PC AC on materials	Backlog in production	% Personnel Expenses vs. Added Value	Forward Load
Delivery Reliability	Produced orders per day	% Orders too late	Occupancy ratio of personnel
Number of days orders sent too late	% Personnel present per day	Rejection Costs	Productivity of Direct Personnel
Absenteeism ratio	(almost) accidents per day		
	Number of Complaints (intern and extern)		
	Average age of Personnel		
	Number of over hours		
	Delivery Reliability on materials		
	Work in Progress		

Case Study

This case study will serve as a baseline measurement for further benchmarking in the future on the proposed indicators. In this research, the baseline measurement is an average of all the companies that have been used in this research. Since not all data has been known by every company and general indicators can correlate to each other, therefore, in this case study, the benchmark is made as an average on the reference points. Because benchmarking, according to Camp (1989), is to strive to let a company perform better and compare results with the best companies, the aim is to be above the benchmark since it is the average. The benchmark has been performed on the proposed indicators. In Appendix C the benchmark can be found, where it is included in the graphs of the results on the general indicators as 'Average with N as number of measurements.

Conclusion

Looking back on the research questions that came up in the Introduction some remarks can be made. Some of the data were not provided from the database or by questionnaires, however, it cannot be said that the data were not measured. Still some conclusions can be made on some of the general indicators, which are standing below. Thereafter the research questions will be answered.

- The OEE indicator is too complicated and not useful for benchmarking; because if one of the variables scores really low, the OEE will also be low while the rest can score high, then the score can still be the same with a company who scores average on all points. Therefore in terms of benchmarking it is better to have separate indicators instead of three combined to one.
- R&D Expenses were often not (publicly) available, sometimes because of it is included in a management fee which the company has to provide to the parent company since they conducted the R&D. The sort of products influences this cost post, so it cannot be said that this indicator is not usable but that it is recommended that further research should be done regarding the nature of their products and how types of industries influences this indicator.
- The Stock Turnover rate depends a lot on the services that are provided by the company, for instance, spare parts when maintenance service is included in their products. The Stock Turnover rate is more an explanation indicator instead of an indicator that can be used for benchmarking.
- PH AH ratio is a specific indicator for the Maintenance branch because the product they sell is a service. The service was in this research a maintenance order wherefore a certain prognosis has to be made in terms of hours and material that can be assigned to the customer's order.
- Throughput factor seemed not to be too relevant for the interviewed companies because the production of companies was based on order levels to the demands of a customer. In practice this lead to variance in orders, whereby throughput times were not generic but per order specific. When repetition plays a major part in the main process, the Throughput factor becomes an essential. It can be assumed that the Throughput factor is a specific indicator for companies who have a constant production process.
- Machinery Utilization ratio depends on the cost of the machine whether it turns out to be important or not. Sometimes, order based companies need specific machinery to retrieve certain orders, but not all of their orders need that machinery. This indicator needs further research in terms of the correlation between occupation of machinery and order retrieving. By the questionnaires, operational managers said there is more focus on occupancy of people and turned out to be more important as an indicator.

What are the general performance indicators to manage the operations of an organization on a strategic level, for instance in management reports?

The following indicators can be used to benchmark a company on a management level. Some general indicators about high-over costs are applicable to all kinds of companies and are listed below. What should be kept in mind is; due to the origin of the business of a company indicators can score differently.

- Revenue per FTE
- Added Value per FTE
- Personnel Expenses per FTE
- Overhead Costs per FTE
- Added Value vs. Personnel Expenses
- Net Margin
- Personnel Expenses vs. Revenue
- R&D Expenses vs. Revenue

Are the belonging specific performance indicators different according to the different types of industry?

The companies in this research use different industry essentials in different processes, although it can be said that some features are of great importance when it comes to KPIs that are used; People and Planning. A lot of the investigated companies worked on an order-based construction, therefore scheduling and meeting the schedule was of great importance. Meeting the planning was mostly conceived by the employees and therefore, their occupancy ratio is essential for smooth operations. The belonging specific indicators of some of the companies can be found in Appendix E.

Are the suggested general indicators comprehensive enough to judge a companys' performance or are specific indicators per industry or sub-industry needed?

Some indicators are less useful, others did not get enough data to calculate, so it is hard to say for some indicators whether they are necessary or not. Some specific indicators are used on the job floor and are set differently but in the end, can benchmark the same KPIs. For example Revenue per FTE versus Average Revenue per day. The new specific indicators were not an industry essential in every branch therefore, it can be said that the proposed general indicators are comprehensive enough and do not have to be supplemented with new indicators.

What are the industry essentials in the manufacturing industry?

Below a table has been conducted with the indicators in this research, some notes have been made per indicator whether it is a management, general or a specific

indicator and in their belonging branch. Some of the indicators have changed slightly to a more generic form, in order to avoid double indicators and to be usable for benchmarking rather than evaluating a single company.

Table 3: Industry essentials in the manufacturing industry

Indicator	Manag-ement	Generic	High-Tech	Non High-Tech	Surface Treatment	Maint-enance
Revenue per FTE	✓					
Added Value per FTE	✓					
Personnel Expenses per FTE	✓					
Overhead Costs per FTE	✓					
Added Value vs. Personnel Expenses	✓					
Net Margin	✓					
Personnel Expenses vs. Revenue	✓					
R&D Expenses vs. Revenue	✓					
Delivery Reliability on order level		✓				
Direct vs. Total FTE ratio		✓				
Indirect vs. Total FTE ratio		✓				
Absenteeism ratio		✓				
Rejection ratio		✓				
Productivity Direct Personnel		✓				
Intern Rejection ratio (of Revenue)			✓			
Extern Rejection ratio (of Revenue)			✓			
PC AC (on materials)			✓			
Average number of days orders sent too late			✓			
Occupancy Ratio Personnel				✓		✓
Number of over hours per day				✓		
(almost) accidents per day				✓		
Number of Complaints (intern and extern)				✓		
Delivery Reliability on materials				✓		
Work in Progress				✓		✓
Average Revenue per day					✓	
Production Costs per produced hour						✓

Recommendations

Below, a list has been conducted with recommendations conducted throughout this research.

- Visiting all companies to ask to fill in; the questionnaires and which are the industry essentials for them. Then look at the field of operation were a company is active in and can be compared with other companies on specific indicators.
- Adding more companies will result in the possibility of a more accurate statistical analysis.
- Further research how the R&D Expenses vs. Revenue indicator; is influenced by the products that have been produced and how the position of a firm in the value chain affects the indicator.
- Deeper research into a specific industry, how product types influence the industry essentials within a certain type of industry.
- Research into other branches than in the branches of this research whether the management and generic indicators remain valid for a wider scope of companies.
- Examine the 3C model on companies, developed by Beelaerts van Blokland et al. (2007), since a lot of indicators were already used for this research, unfortunately, there was too little data on the R&D variable to execute this and see how innovation influences the investigated industries.

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Appendix A
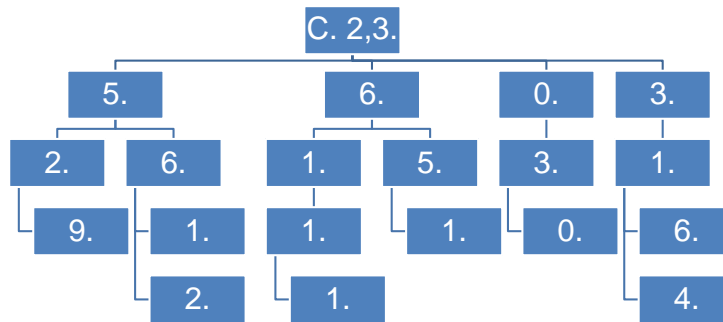
Figure 4: Hierarchical tree of selected companies, developed with the help of the SBI encoding of the CBS
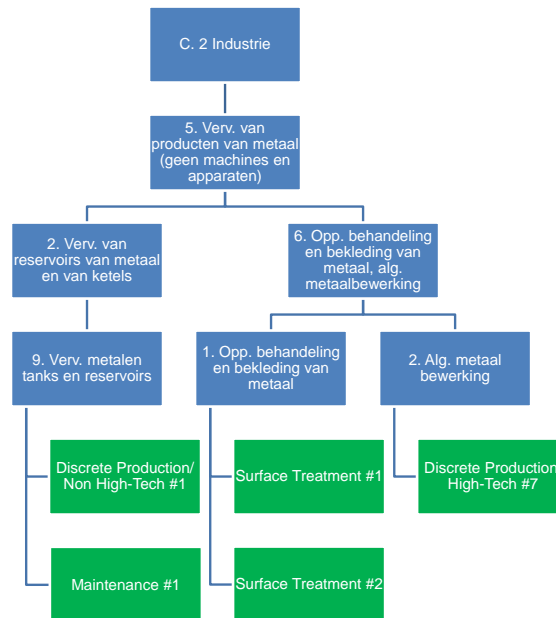
Figure 5: Hierarchical tree of branch "5" with annomized companies, developed with the help of the SBI encoding of the CBS
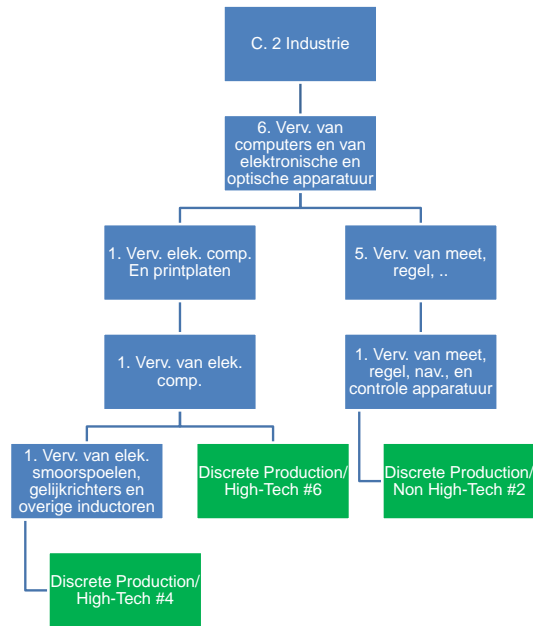
Figure 6: Hierarchical tree of branch "6" with annomized companies, developed with the help of the SBI encoding of the CBS
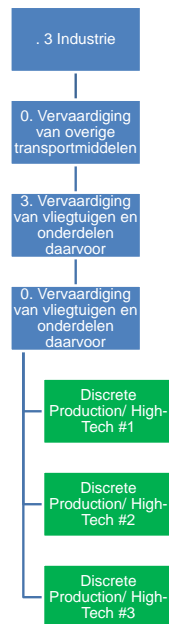
Figure 7: Hierarchical tree of branch "0" with annomized companies, developed with the help of the SBI encoding of the CBS
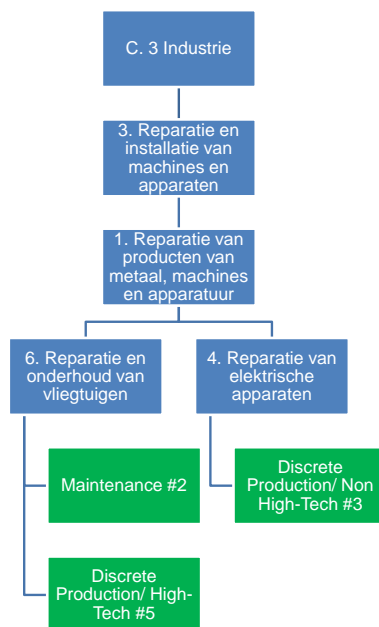
Figure 8: Hierarchical tree of branch "3" with annomized companies, developed with the help of the SBI encoding of the CBS

Appendix B

$$Delivery\ Reliability\ = \frac{Well\ manufactured\ and\ on\ time\ delivery\ of\ orders}{Total\ order\ volume}*100\% \tag{1}$$

$$Revenue\ per\ FTE\ = \frac{Revenue}{Total\ FTE} \tag{2}$$

$$Added\ Value\ per\ FTE\ = \frac{Added\ Value}{Total\ FTE} \tag{3}$$

$$Direct\ FTE\ ratio\ = \frac{Total\ of\ Direct\ FTE}{Total\ FTE} \tag{4}$$

$$Indirect\ FTE\ ratio\ = \frac{Total\ of\ Indirect\ FTE}{Total\ FTE} \tag{5}$$

$$Overall\ Equipment\ Effectiveness\ = \{\frac{Actual\ production\ time}{Planned\ production\ time}*$$
$$\frac{Fastest\ processing\ time}{Average\ possible\ processing\ time}* \tag{6}$$
$$\frac{Well\ manufactured\ products}{Total\ production\ volume}\}$$

$$PH\ AH\ ratio\ = \frac{Total\ of\ Planned\ Hours\ of\ personnel\ spent\ on\ orders}{Total\ of\ Actual\ Hours\ of\ personnel\ spent\ on\ orders}*100\% \tag{7}$$

$$Absenteeism\ ratio\ = \frac{Total\ number\ of\ recorded\ absent\ days}{Total\ working\ days}*100\% \tag{8}$$

$$Rejection\ ratio\ = \frac{Products\ with\ outstanding\ issues}{Total\ production\ volume}*100\% \tag{9}$$

$$Productivity\ Direct\ Personnel\ = \frac{Total\ time\ direct\ personnel\ productive}{Total\ time\ of\ direct\ personnel}*100\% \tag{10}$$

$$Personnel\ Expenses\ per\ FTE\ = \frac{Personnel\ Expenses\ (incl.\ hired\ staff)}{Total\ FTE} \tag{11}$$

$$Yield\ Costs\ ratio\ = \frac{Total\ of\ material\ in\ product}{Total\ material\ (incl.\ waste)}*100\% \tag{12}$$

$$Machinery\ Utilization\ ratio = \frac{Time\ machinery\ occupied}{Total\ machinery\ time} * 100\% \tag{13}$$

$$R\&D\ Expenses\ vs.\ Revenue = \frac{R\&D\ Expenses}{Revenue} * 100\% \tag{14}$$

$$Personnel\ Expenses\ vs.\ Revenue = \frac{Personnel\ Expenses\ (incl.\ hired\ staff)}{Revenue} * 100\% \tag{15}$$

$$Overhead\ Costs\ per\ FTE = \frac{Overhead\ Costs}{Total\ FTE} \tag{16}$$

$$Net\ Margin = \frac{Net\ Profit}{Revenue} * 100\% \tag{17}$$

$$Throughput\ factor = \frac{Average\ net\ processing\ time\ per\ product}{Average\ total\ throughput\ time} * 100\% \tag{18}$$

$$Stock\ Turnover\ rate = \frac{Purchase\ value\ of\ Revenue}{Stock\ value} \tag{19}$$

$$Added\ Value\ vs.\ Personnel\ Expenses = \frac{Added\ Value}{Personnel\ Expenses\ (incl.\ hired staff)} * 100\% \tag{20}$$

Appendix C
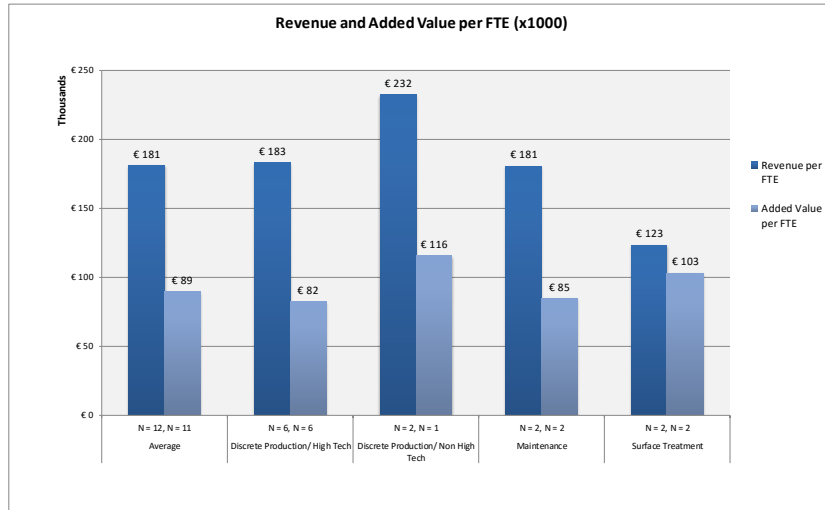
Figure 9: Revenue and Added Value per FTE
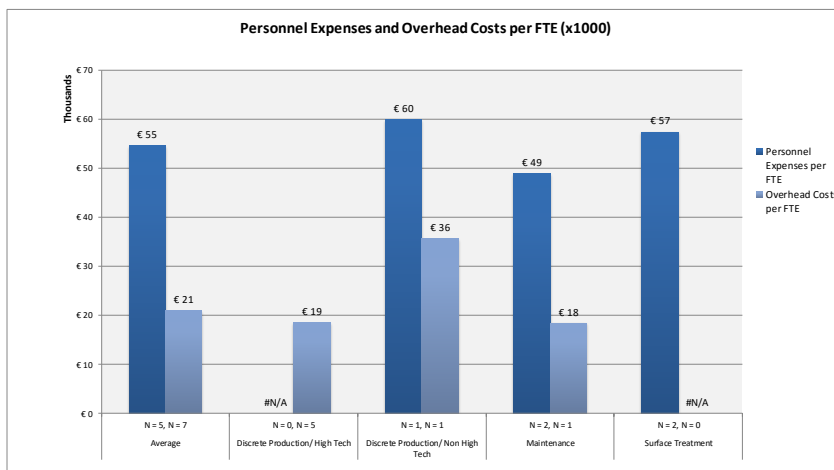
Figure 10: Personnel Expenses (incl. hired staff) and Overhead Costs per FTE
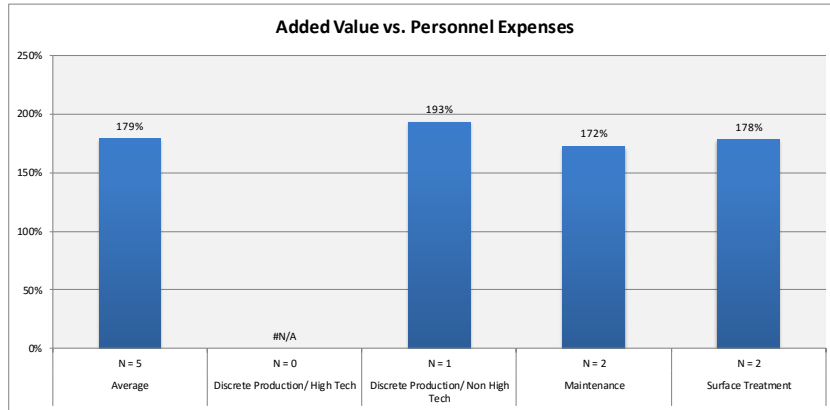
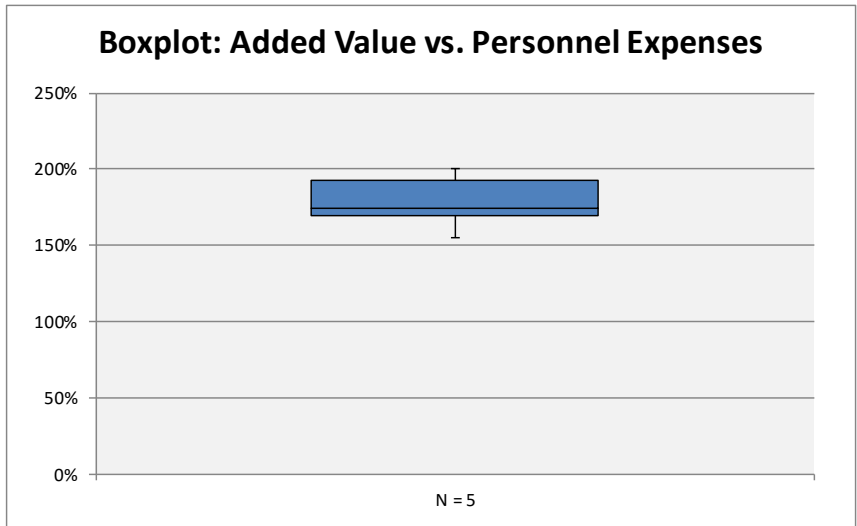Figure 11: Added Value vs. Personnel Expenses (incl. hired staff)
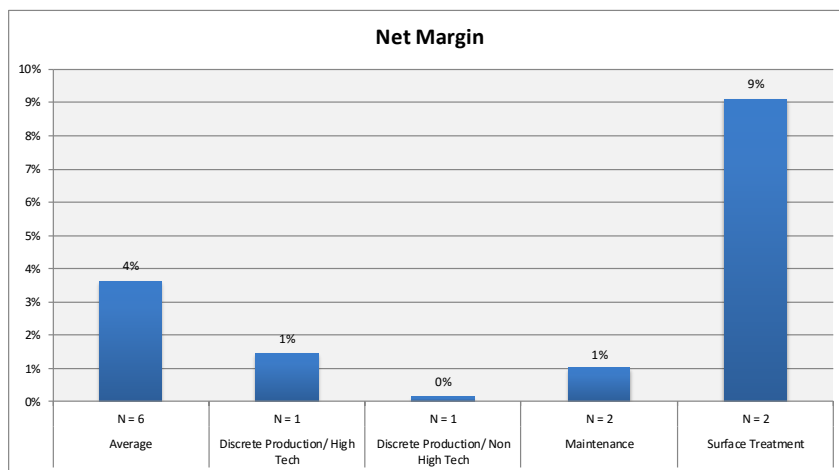
Figure 12: Net Margin
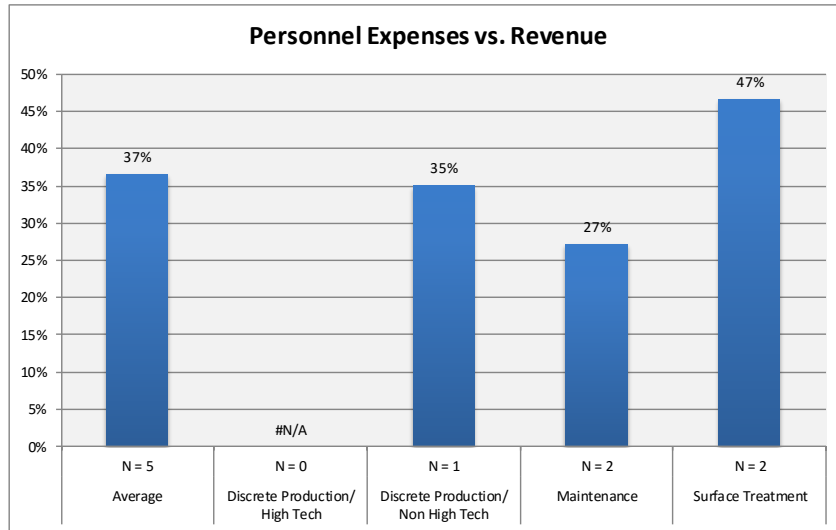
Figure 13: Personnel Expenses (incl. hired staff) vs. Revenue
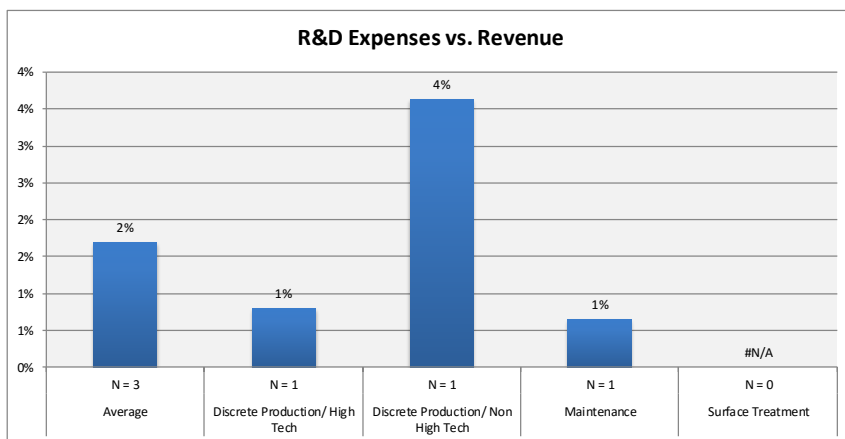
Figure 14: R&D Expenses vs. Revenue
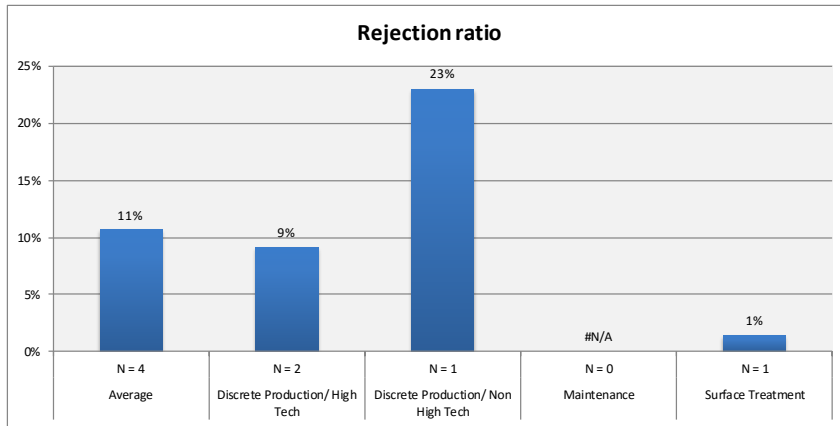
Figure 15: Rejection ratio
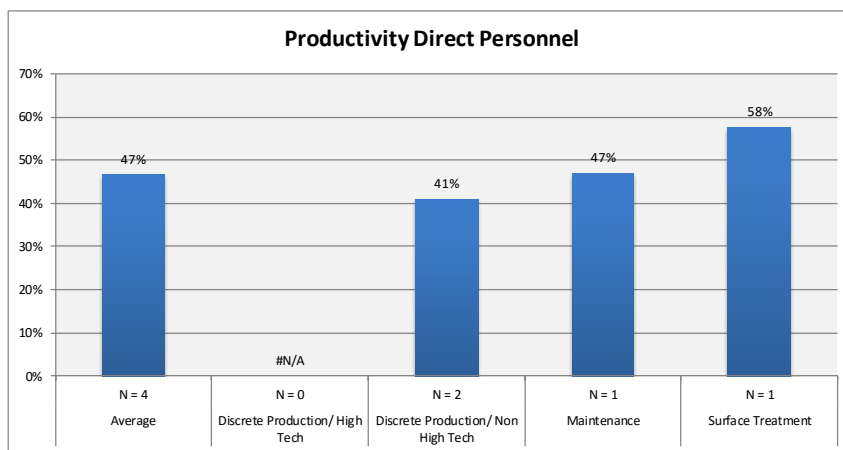
Figure 16: Productivity Direct Personnel
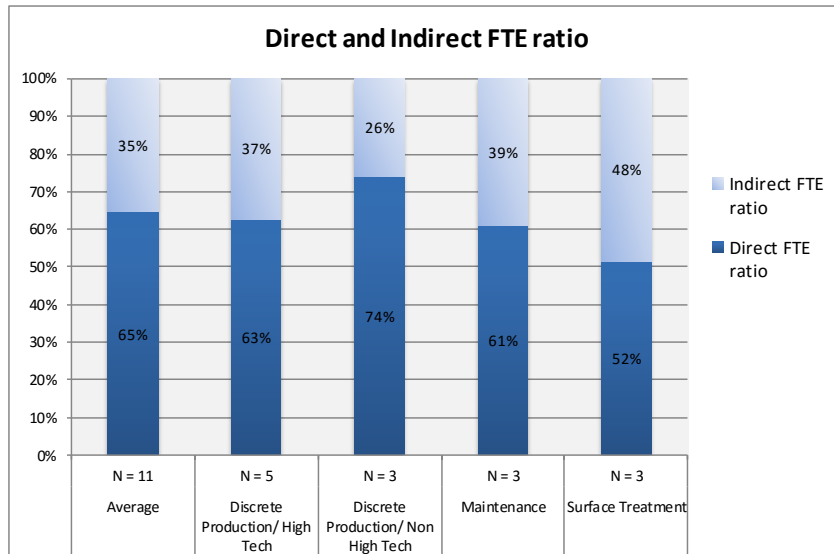
Figure 17: Direct and Indirect FTE ratio
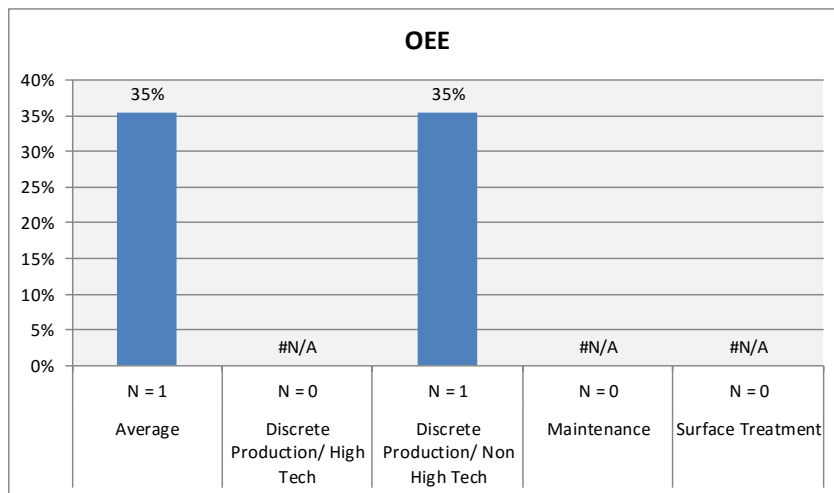
Figure 18: Overall Equipment Effectiveness (OEE)
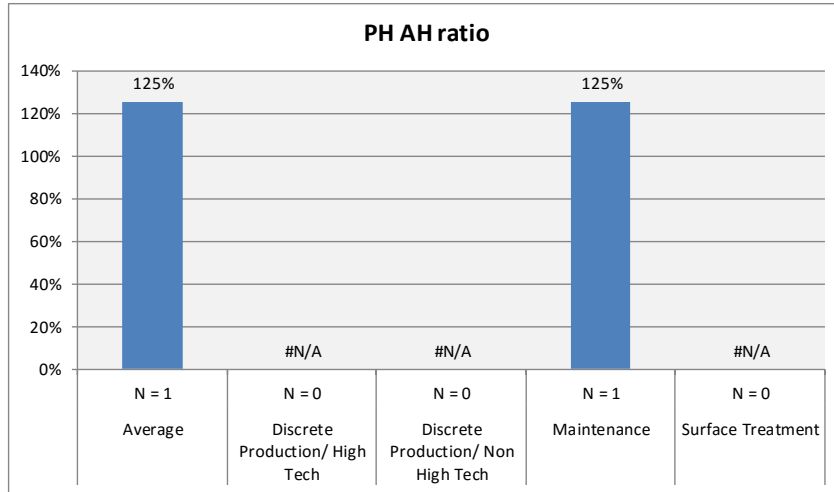
Figure 19: PH AH ratio
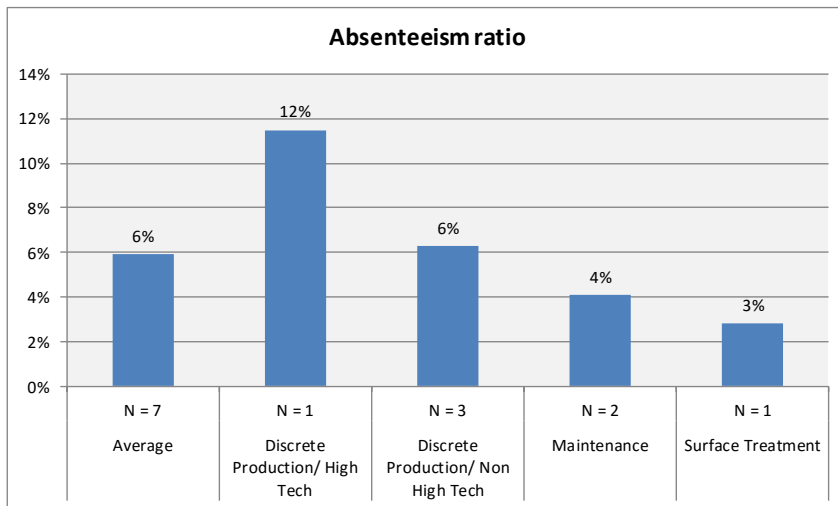
Figure 20: Absenteeism ratio
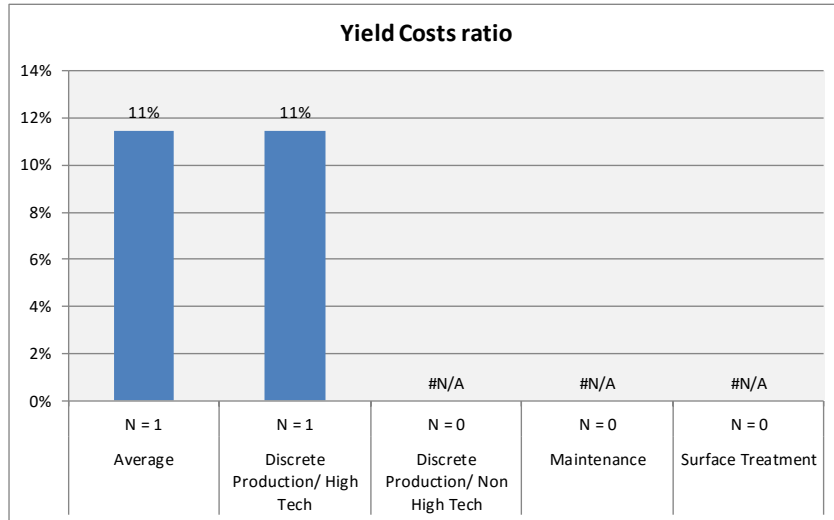
Figure 21: Yield Costs ratio
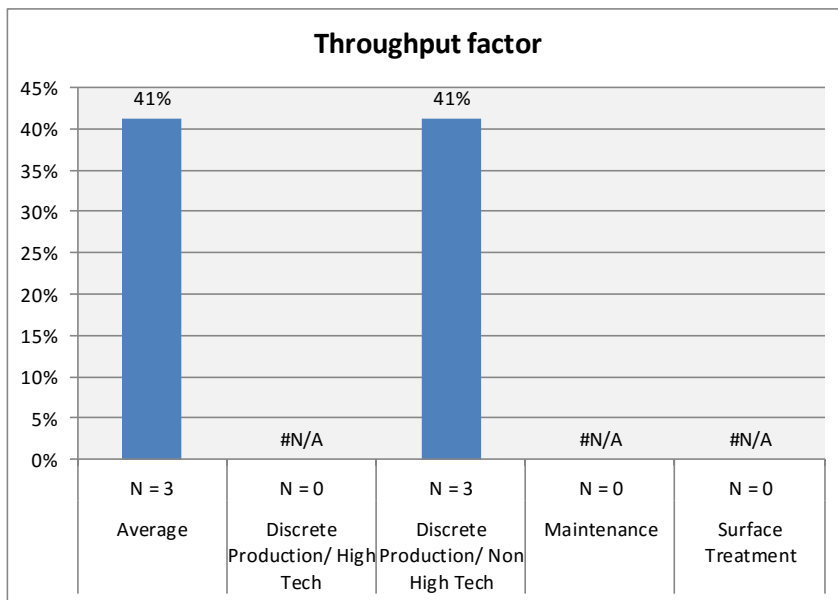
Figure 22: Throughput factor
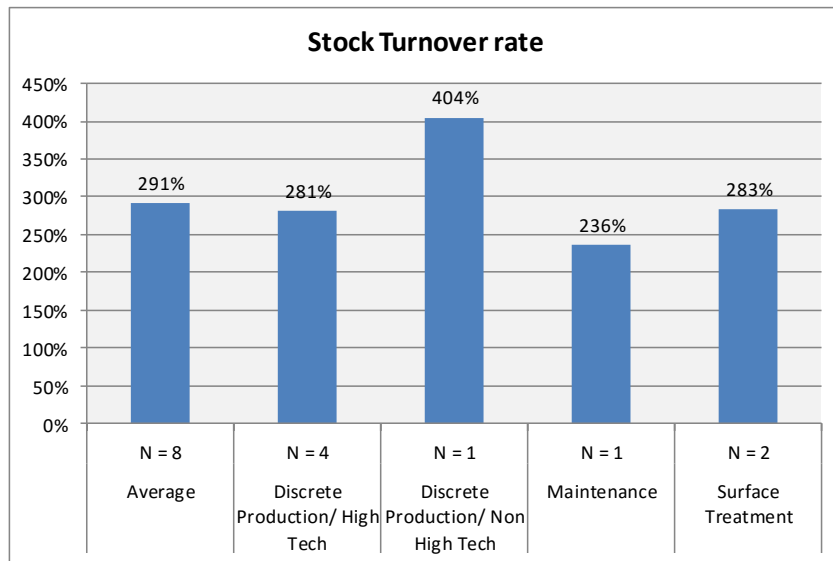
Figure 23: Stock Turnover rate
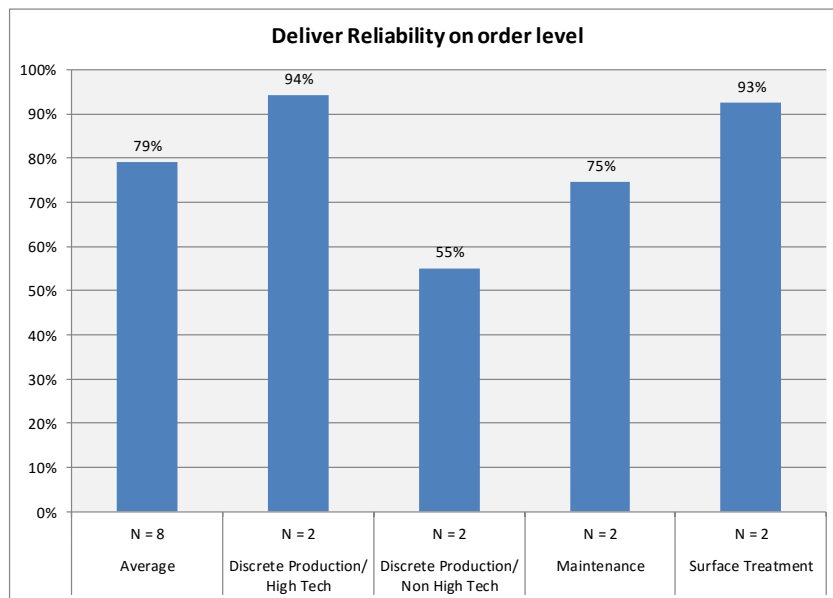
Figure 24: Delivery Reliability on order level

Appendix D
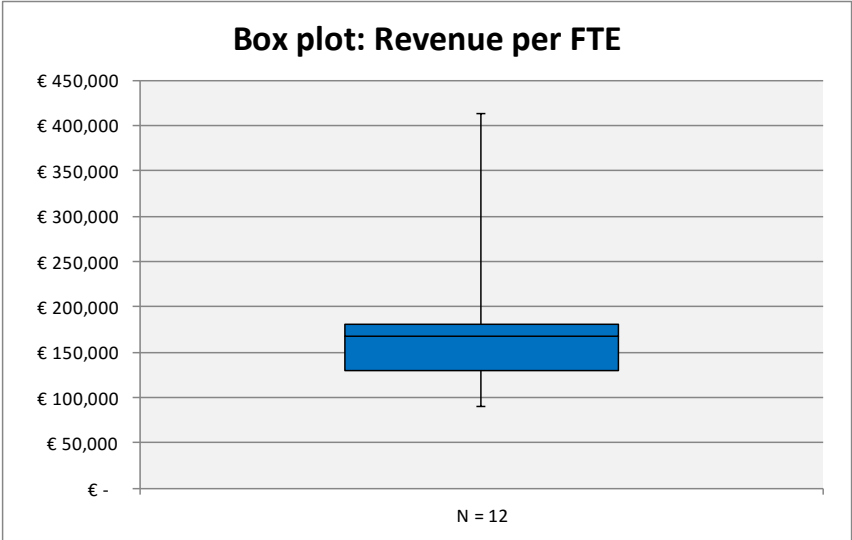
Figure 25: Boxplot: Revenue per FTE
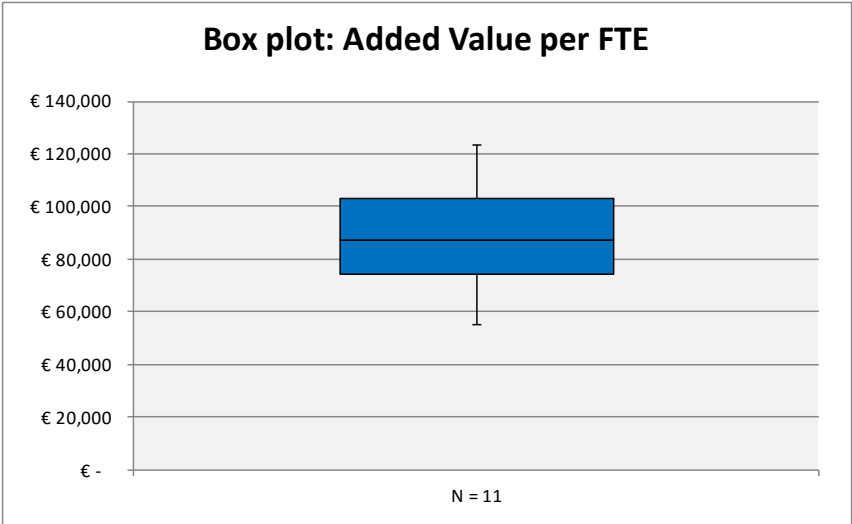
Figure 26: Boxplot: Added Value per FTE
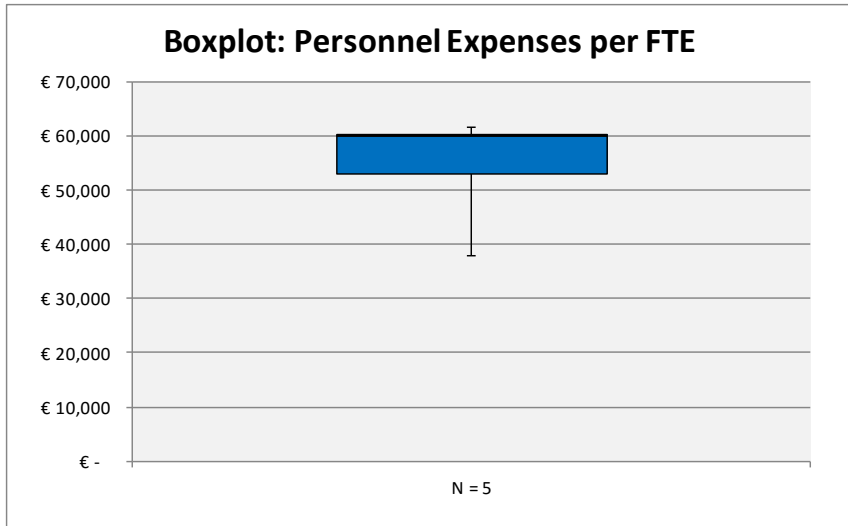
Figure 27: Boxplot: Personnel Expenses (incl. hired staff) per FTE
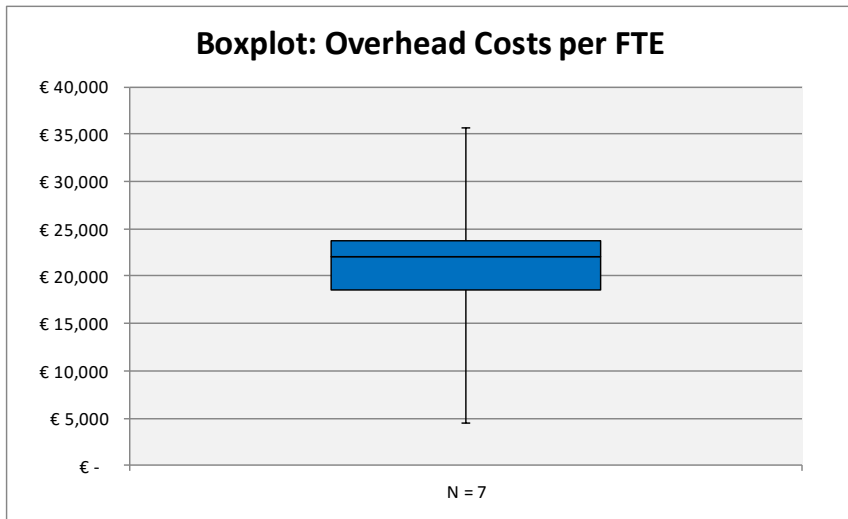
Figure 28: Boxplot: Overhead Costs per FTE
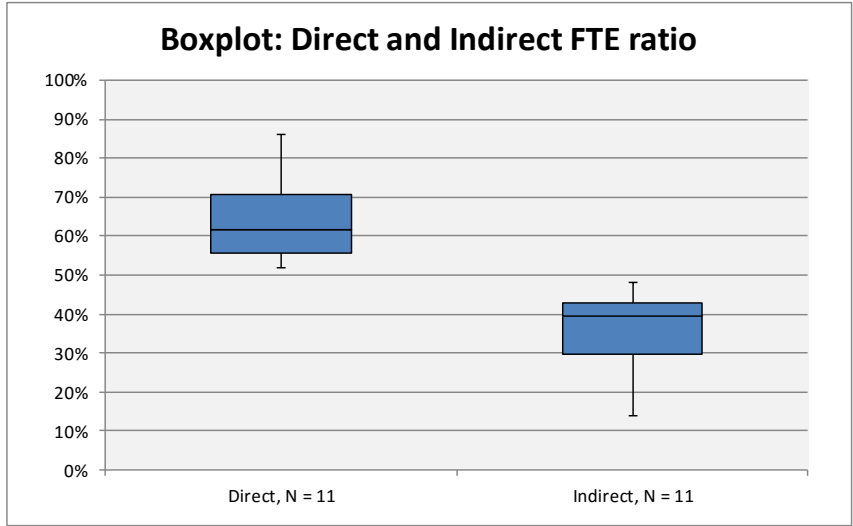
Figure 29: Boxplot: Direct and Indirect FTE ratio

Figure 30: Boxplot: Added Value vs. Personnel Expenses (incl. hired staff)
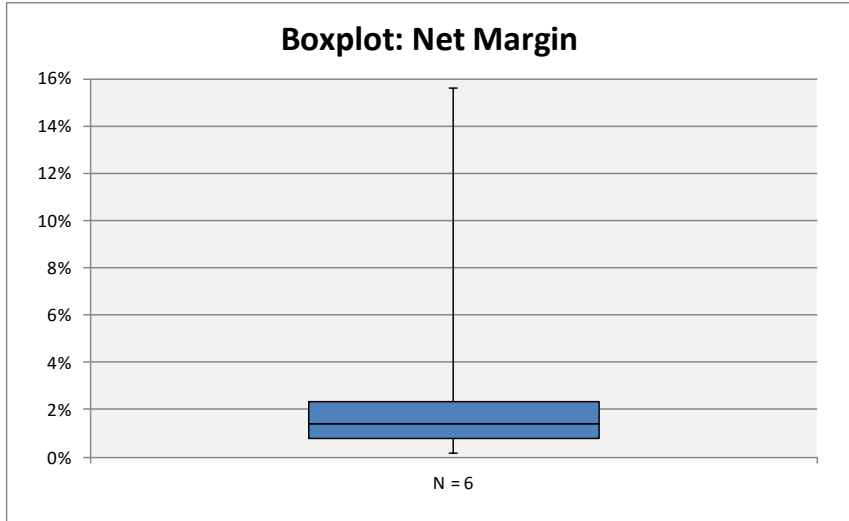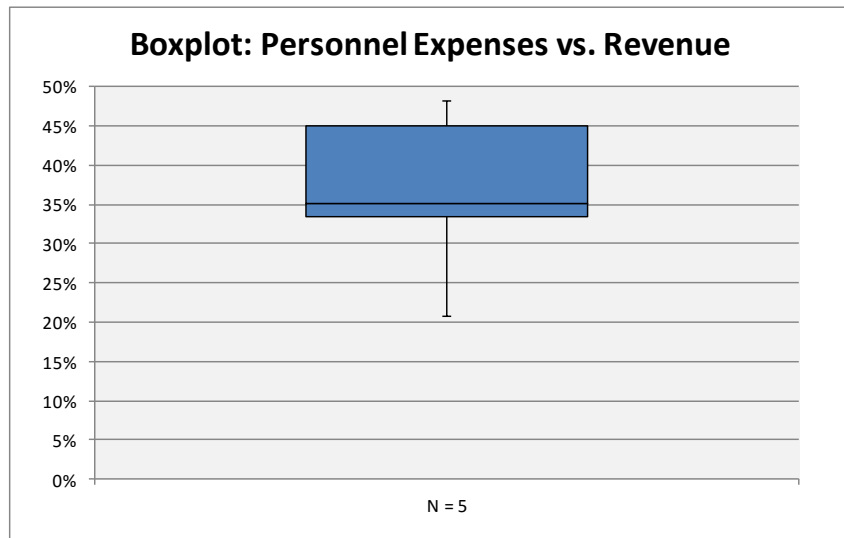
Figure 31: Boxplot: Net Margin

Figure 32: Boxplot: Personnel Expenses (incl. hired staff) vs. Revenue
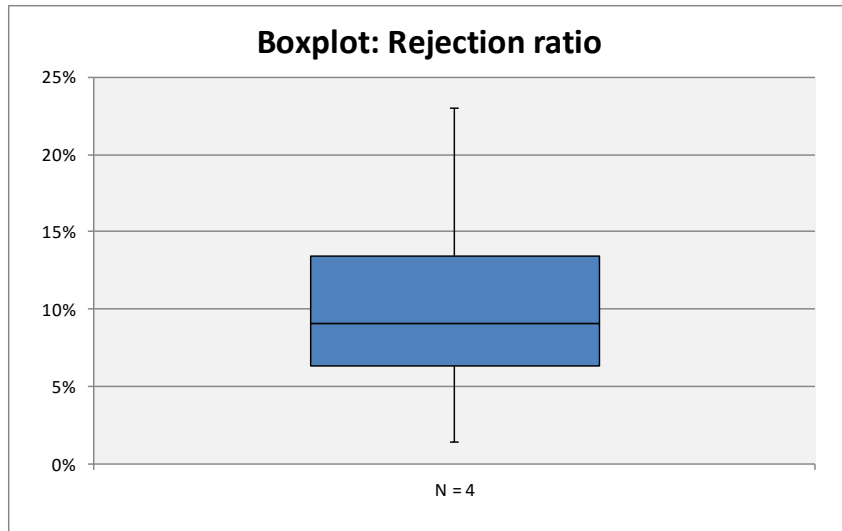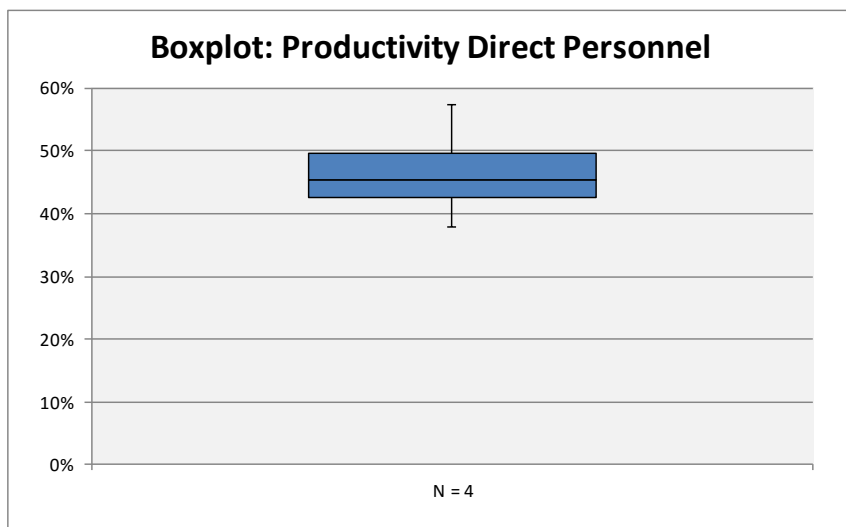
Figure 33: Boxplot: Rejection ratio

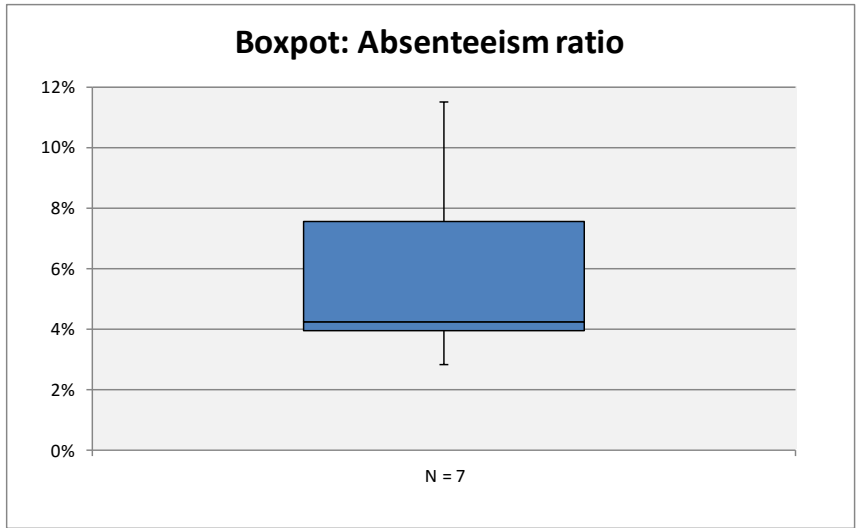Figure 34: Boxplot: Productivity Direct Personnel

Figure 35: Boxplot: Absenteeism ratio

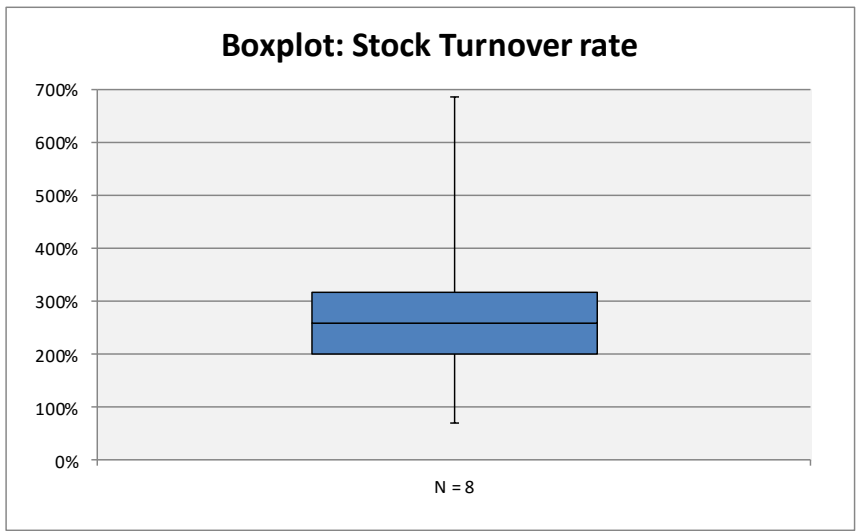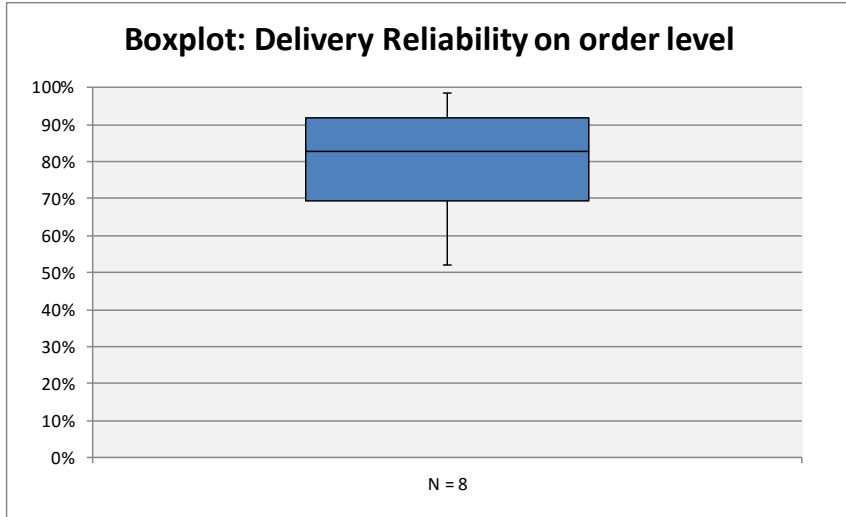
Figure 36: Boxplot: Stock Turnover rate

Figure 37: Boxplot: Delivery Reliability on order level

Appendix E

Table 4: Industry Essentials of the Discrete Production/ High-Tech branch

Industry Essential	HT #4	HT #6
1	Intern Rejection ratio (of Revenue)	Intern Rejection ratio (of Revenue)
2	Extern Rejection ratio (of Revenue)	Extern Rejection ratio (of Revenue)
3	Planned Costs Actual Costs (PC AC) (on materials)	PC AC (on materials)
4	Delivery Reliability	Delivery Reliability
5	Average number of days orders sent too late	Absenteeism ratio

Table 5: Industry Essentials of the Discrete Production/ Non High-Tech branch

Industry Essential	NHT #1	NHT #2	NHT #3
1	Productivity Direct Personnel	Backlog in production	Average age of personnel
2	Occupancy Ratio Personnel	Produced orders per day	Occupancy Ratio Personnel
3	Unknown	% Personnel present per day	Number of over hours
4	Unknown	(almost) accidents per day	Delivery Reliability on materials
5	Unknown	Number of Complaints (intern and extern)	Work in Progress

Table 6: Industry Essentials of the Surface Treatment branch

Industry Essential	ST #1
1	Absenteeism Costs
2	Average Revenue per day
3	% Personnel Expenses vs. Added Value
4	% orders too late
5	Rejection Costs

Table 7: Industry Essentials of the Maintenance branch

Industry Essential	MT #2
1	Production Costs per produced hour
2	Gross Profit per Revenue
3	Forward Load
4	Occupancy ratio of personnel
5	Productivity of Direct Personnel